DIFFERING PEDAGOGICAL METHODS IN THE TEACHING OF PIG HEART ANATOMY

By

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A thesis submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE IN KINESIOLOGY

WASHINGTON STATE UNIVERSITY
Department of Kinesiology and Educational Psychology

MAY 2024

To the Faculty of Washington State University:

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ACKNOWLEDGMENTS

I would like to begin by acknowledging the committee that got me where I am today. When I felt lost, confused, stuck or alone, each one of them was there to help me in different ways throughout my graduate career.

Dr. Danielson, the researcher and educator that did not hesitate to take me under his wing and be a part of my committee despite never having met me before. He has taught me many different perspectives and techniques in teaching and learning, he has made me think critically about details of my study that I hadn't even considered, and he has always been available to answer all my questions with kindness and immense detail. Dr. Danielson, thank you for your amiability and guidance during my graduate career.

Dr. Morgan, the professor that made me recognize my passion for not only human anatomy but teaching as well. He gave me the opportunity to exercise my knowledge of the human body by teaching peers and working closely with other students who shared the same love for helping students learn and grow. He showed me how to be engaging in the classroom, how to use proper studying techniques, and how to do what you're passionate about doing, even if it takes a few years and different career paths. DM, thank you for your life advice and the model that you've become for me.

Dr. Connolly, the mentor that has been through all of my academic struggles with me. He welcomed me into his lab five years ago and has seen me during my best and worst times in academia. He showed me compassion when I struggled with my work, he took time to have countless meetings with me to guide me when I was lost, and he has never given up on me. His door was always open for me, regardless of the number of times I just ended up sitting and crying to him about how overwhelmed I felt or the struggles I was facing. I came to him when I was failing his class, when I was having troubles in the lab, when I didn't know what I was doing, and most importantly, when I felt like giving up. I know I didn't end up being the star student that I wanted to be for him, and that I could never fill the shoes of his previous mentees, but this never stopped him from caring for me. I truly would not be the person I am today without the support and inspiration that he has continued to give me. Dr. Connolly, thank you for being my anchor during my time at WSU.

I also want to acknowledge the team that helped me with carrying out my study. Olivia Sinn and Natalie Wilson: you two were there for me during all the learning sessions and then some. There was no hesitation from you when I asked for help, and you were eager and happy to work with me on my study. You always prioritized assisting me and even moved schedules around to be there when I needed you. Thank you both for your positive attitude and willingness to work with me. Noah Dooley: the data man. Thank you for translating data, for being on top of getting work finalized on spreadsheets, and for taking the time to make sure my data had been properly input. I am so grateful to have seen you flourish in the lab with your go-getter determination. Will Yaku: my counterpart in lab. You've gone through the same struggles as I, and have never hesitated to share advice. You were always there to discuss classes, academic topics, assignments, and go through the motions with me. I am so thankful to have had you as a resource and a friend. And thank you to the EPPL team. Each time I walked into

lab, my day always got better. The team created a positive environment and always checked in to see if I needed any help. The sense of community in the EPPL is always abundant, and I am so thankful for the times I've spent there.

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Abstract

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May 2024

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Learning modalities play a critical role in shaping educational outcomes, specifically in undergraduate anatomy education. This study examines the effects of two prominent modalities, lecture-based learning and hands-on dissection, in enhancing students' understanding of pig heart anatomy and their self-confidence perceptions. A cohort of 49 undergraduate students enrolled in a human anatomy course participated in the study, which utilized a randomized control design. Participants were divided into two groups: a laboratory dissection learning group and a lecture learning group. Pre and post-tests were administered to assess pig heart anatomy knowledge, and self-confidence questionnaires were administered to assess perceived self-confidence during the intervention. Additionally, retention tests were conducted two weeks post-intervention to evaluate overall retention of the given material. Statistical analyses, including Mann-Whitney U tests, revealed significant differences between the two groups. The lecture group exhibited greater improvements in pig heart anatomy test scores compared to the dissection group in the change in scores from the pre to post test. Despite similarities in baseline knowledge, the lecture group's familiarity with the instructional modality may have contributed to their superior performance. Additionally, significant differences were observed in retention pig heart anatomy test scores as well. There were no significant differences found in the change in self-confidence rates from the pre, post, and retention timeframes of the intervention between groups, but a significant difference was found in the post-test mean scores of the self-confidence questionnaire. This study challenges prior literature that supports the superiority of kinesthetic learning in anatomy education. Further research is needed to evaluate pedagogical practices that provide the most benefits to undergraduate students in anatomy education.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

Dedication

The entirety of this thesis study is dedicated to the one woman in my life who has toughed it all out. I hope you look back on this research and recognize how proud I am of you.

CHAPTER ONE: INTRODUCTION

Learning is a skill that continuously develops throughout one's life. Even if not in a formal educational setting, professions, parenting, and engaging in hobbies are all opportunities to both learn and teach (Krumboltz, 2009). For example, learning to knit through self-teaching may involve trial and error in finding the best way to practice the skill. If watching videos is unsuccessful for the learning, then listening to step-by-step tutorials, or physically making mistakes while knitting is in progress may prove to be more effective for the individual. Regardless of the modality of learning, all provide an opportunity for the growth of knowledge. These three modalities of learning are visual, auditory, and kinesthetic, otherwise known as VAK (Pashler et al., 2008; Suryono et al., 2021).

Visual learning incorporates visual aids, such as diagrams, pictures, and slideshows, into lessons and skills. Individuals that demonstrate learning through visual modalities account for approximately 65 percent of the population (Bradford, 2004), and tend to recall material in images. In addition to these learning techniques, it is also common to pick up on the instructors' non-verbal cues in educational settings (Gilakjani, 2012). A simple gesture to the screen or head nod while speaking about specific material can aid in visual learning. Because body language cues and images are most beneficial to visual learners, working in face-to-face groups where the members can express ideas in drawings and expressions seem to be integral to group projects running smoothly (Dwyer, 1998). Auditory learning is conveyed through speech, tone of voice, emphasis, and speed of the information given (Gilakjani, 2012). Audiobooks and podcasts are both modern modalities of auditory learning. In academia, students who learn best through auditory stimuli benefit most from listening to the instructor lecture, as opposed to visual learners who benefit from the slide show aspect of the lecture (Bacro et al., 2013). Kinesthetic learning involves hands-on lessons or activities that allow the learner to be physically involved with the task at hand. This type of learning is highly recommended to be incorporated within curriculums at educational levels to motivate and encourage students to learn new material, as well as translate the hands-on skills learned into real-world applications (Mobley & Fisher, 2014).

Various pedagogical methods have been utilized in medicinal education for the purpose of creating optimal learning environments for students (Farimani et al., 2022; Erkonen et al., 1992; Shim et al., 2018; Hayes et al., 2017). The utilization of kinesthetic learning seems to be the most common and effective teaching method to enhance student learning in modern medicine (Johnston et al., 2015: Ranganath & Josphine-Priya, 2015; Samarakoon et al., 2013; Kharb et al., 2013; Lujan & DiCarlo, 2006; Hernandez et al., 2020). Herblum et al., recently compared exam scores between first-year medical students who participated in a kinesthetic learning workshop to those who continued with their typical study habits and learning techniques. The students' regular study habits included auditory learning activities, visual learning activities, kinesthetic learning activities, or a combination of the three. It was found that students participating in the kinesthetic learning workshop scored significantly higher on their final exam compared to standard learning students (Herblum et al., 2023).

Modern hands-on learning in medicine can include a number of activities to engage students. These can include creating clay models of organs and body parts, moving paper cut outs of muscles into place on an outline of a body, or dissecting a specimen. These practices are especially helpful in medicine and anatomy to aid in the understanding of anatomical landmark locations, identification of anatomical structures, and functional mechanisms of movement.

In contrast to kinesthetic learning, which has been shown to aid in learning and overall learning outcomes in academia, auditory learning has been observed to be the least effective teaching method for medical students (Kharb et al., 2013; Lujan & DiCarlo, 2006). This can likely be attributed to the average attention span during lectures being anywhere from 10 to 15 minutes (Bradbury, 2016). In addition to previous findings clearly suggesting heightened effectiveness of kinesthetic learning, there is also evidence that this learning method induces the highest levels of self-confidence and satisfaction compared to auditory and visual learning (Almasri, 2022). Furthermore, several studies have suggested that participating in academic hands-on exercises result in significant increases in self-confidence and self-esteem levels for students prior to taking exams (Widiasih et al., 2022; Utomo & Maratus, 2021).

While these studies promote and highlight the benefits of kinesthetic learning, it is not always practical to incorporate into lesson plans, specifically in anatomy and physiology. As such, the default format of lesson plans in these academic settings tend to involve slideshows and lectures. Being so, giving learners different opportunities to utilize multiple modalities of learning within one course may benefit the learner (Busan, 2014; Hernandez et al., 2020; Ranganath & Josephine, 2015). Despite kinesthetic learning producing a higher learning rate, individuals that tend to gravitate towards visual learning methods are possibly more likely to produce higher retention rates, compared to individuals that practice kinesthetic and auditory study habits (Padidar et al., 2015). Retention of information is crucial in the medical field, as information learned early in medical programs is heavily applied and repetitive in nature for practical application and in clinical settings (David & Brachet, 2009).

Because higher overall learning rates correlate to kinesthetics, and higher retention rates are shown mainly through visualization, implementing dissection into early medical courses may have the capability to increase both factors. Dissecting organs can help reveal their anatomical structure while also allowing the student to locate the structures based on their hands-on dissection, as opposed to only receiving visual stimuli of a diagram. As an approach to anatomy education, dissection has mainly been researched for the general structure and placement of muscles in the human body (Johnson, 2002; Dinsmore & Zeitz, 1999). However, the dissection of a specific organ has the potential to give students a different perspective, specifically learning distinct landmarks and structures. The heart itself is just one example of an organ with layers and numerous structures within itself. Dissecting this organ not only reveals its internal mechanisms, but also allows for the conceptualization of heart functions such as oxygenation of blood through each chamber (Lee, 2010). Unlike the stomach or liver where the physiological processes are not readily shown in a cross section, the heart consists of vessels and chambers which demonstrate the inner workings of the circulatory system, and overall is optimal to teach organ structures.

Although dissecting a human heart would be ideal to investigate incorporating kinesthetic learning, there are other, more pressing uses for these hearts. Each year in the United States, over 4000 heart transplants are performed (Mertin et al., 2024). If an opportunity arises in which an organ donor passes and is able to donate their heart, it almost always is immediately transplanted into a patient in need (Marsia et al., 2018). Thus, a practical way to introduce human heart anatomy to young college students can be through dissecting pig hearts, which are in vastly greater supply than human hearts (Pierson et al., 2020). Pig hearts are an optimal source to introduce students to the anatomy of human hearts. Both types of hearts share various commonalities including the size, structure, and function (MICDS, 2021). When examining the structures specifically, two atriums and ventricles, four valves, and an aorta are found in both human and pig hearts (Crick et al., 1998). Ergo, learning the pig heart anatomy through dissection can be seamlessly translated into human heart anatomy without the need for destruction of human hearts. Doing so has the capability to allow students to familiarize themselves with these unique structures through pig heart dissection and may increase learning due to the kinesthetic approach being taken. While there have been mixed results on the effectiveness of specifically dissection for students who prefer kinesthetic learning modalities (Hernandez & Vasan, 2018 ; Hernandez et al., 2020), targeting one organ as opposed to an entire human specimen has the potential to help students learn more specific material on a more focused scale.

Research Questions

Research Question 1: Will visual or hands-on learning produce a greater increase in tests scores on a pig heart exam?

> Hypothesis 1.1: While change will be observed in both groups, the hands-on group will show a greater increase in test scores.

Research Question 2: Will visual or hands-on learning produce higher pre and post-test self-confidence rates when teaching the anatomy of a pig heart?

Hypothesis 2.1: Visual learning, specifically in the format of slide shows, will result in higher self-confidence scores prior to the intervention, while hands-on learning, specifically in the format of dissection, will result in higher self-confidence scores post intervention.

Research Question 3: Will visual or hands-on learning produce higher retention rate test scores on a pig heart exam?

Hypothesis 3.1: Hands-on learning, specifically in the format of dissection, will result in higher retention rate test scores

Thesis Overview

Due to the many students in higher education, kinesthetic approaches to teaching and learning should be considered for further integration into curriculums. Dissection can add this hands-on element to students in the medical field. Past research suggests that incorporating hands-on activities in medical education may increase test scores and overall learning capabilities. While whole body and limb dissection are commonly practiced, dissection of a singular organ needs to be examined more extensively. Additionally, self-confidence rates prior to and post dissection have seldom been researched. This thesis project will be presented via a thorough review of literature, detailed description of project methodology, and complete manuscript to be submitted for publication.

CHAPTER TWO: REVIEW OF LITERATURE

In this chapter, previous research that supports exploring various pedagogical methods for dissection will be discussed. The three modalities of learning and their incorporation into education and medicine will be the first topics examined, followed by self-confidence and the role it plays in each modality of learning. The comparison between physical dissection and virtual reality simulated dissection will be debated, concluding with discussion of similarities and differences between the human and pig heart, which is central to the research questions of this thesis project.

Learning Modalities

Three learning modalities are recognized as pertaining to teaching. They include visual, auditory, and kinesthetic (Gilakjani, 2012 ; Kayalar, 2017 ; Prithishkumar & Michael, 2014). While individuals tend to gravitate towards only one of these, it is common to learn through a combination of two of the modalities (Marschark et al., 2013 ; Jeral, 2010). Marschark et al. (2013) describes this type of learning as multidimensional and a continuum. This implies that individuals learn on a spectrum, with all learning modalities being utilized, but one taking precedence. While some learners benefit most from utilizing a singular learning modality, the most effective blend of methods is determined by the individual (Marschark et al., 2013).

Discovering the method of learning that is effective is critical for student success in an academic setting. This provides the individual with tailored studying techniques, so as to not waste time learning in a way that is not advantageous towards their academic success. Alleviating stress that accompanies difficult classes or poor instructors by finding their own learning strategy is also a benefit, along with encouraging learners to continue and enjoy education (Kayalar, 2017). Discovering an individual's primary learning modality can be found through standardized assessments, or more subjectively, by asking the individual their preferred modality of learning (Marschark et al., 2013). Determining one's learning preference can be identified through giving the individual a plethora of resources and having them decipher which modality they preferred. These can include diagrams, podcasts, lectures, or the use of plastic models.

Massa & Mayer (1994) conducted a study to decipher the learning discrepancies in visual and verbal learners through the use of multimedia materials that depicted either pictures or words. To no surprise, they found that the participants who declared themselves to be visual learners tended to rely more heavily on images, and auditory learners relied on words. However, there was no correlation between these learning techniques and overall performance (p. 333). Individuals tend to describe themselves as a visualizer or verbalizer. While this cut-and-dry modality of learning may be advantageous for some learners, there has been evidence to support the multidimensional construct between the two (Pashler et al., 2008). Additionally, Pashler's findings were consistent with the previous study, since they also found no evidence to support the notion that learning modality affects performance (Massa & Mayer, 2006). In efforts to engage the variation of learning modalities, Rogowsky et al. (2015) examined the relationship between method of learning preference and test scores. The participants first declare they way in which they learn, in this case either visual or auditory, and were then given both a visual and verbal comprehension test. The study concluded that there was no significant relationship between these two variables (p. 70). This notion was also found in a study conducted by Knoll, et al. (2017), where there was no association found between recall performance and preferred learning modality (p. 554).

There are diverse materials that are used to aid visual learners in their education. These can include photographs, sketches, videos, and photo-elicitation (Ortega-Alcázar, 2012 ; Bradford, 2004). Photo-elicitation specifically involves the in-depth use of photographs to have individuals recall memories and facilitate knowledge that would not have normally been brought up (Ortega-Alcázar, 2012). Shams & Seitz (2008) showed that visual learning techniques including pictures and video clips improve perceptual skills, recognition, and discrimination (p. 414). Because the awareness of one's learning modality is beneficial, it is assumed that utilizing the mode of learning with the matching learning method is favorable to the learner (Bryant & Goswami, 1986 ; Delhommeau et al., 2005 ; Suryono et al., 2021). While this may be true, Knoll et al (2017) argued that regardless of what type of learning individuals identified with, retention rate was higher for material that was presented in pictures rather than words. This was one of the few significant relationships, indicating that the type of learning was more important than what the participants perceived their learning method to be.

They also described the ability to know one's learning type as ineffective for the retaining and learning of information (p. 554).

Visual learning methods that students may use in classrooms are notes, drawings and diagrams. Students can structure their notes in a way that most effectively helps them remember and recall material. The organization of these notes can help students emphasize main points or identify any missing information they may need (Saunders et al., 1995). Infographics are another tool that helps students learn best though visual stimuli, as well as incorporating pictures and words, especially supportive in an online classroom (Yarbrough, 2019). Online learning has become more common as technology advances. Computer games can aid in online, or even in person learning through interactive visual stimuli. Allowing students to receive constant, fast paced images and concepts in an interactive software that blends visual and kinesthetic learning. This relates back to the learning style continuum, and may aid in students ability to apply multiple learning techniques into their studies (Airi & Anderson, 2017 ; Scoresby & Shelton, 2011).

Auditory learning may also be included in computer programs. Auditory learning is perceived through hearing and verbal communication. Individuals who learn best though listening absorb tone, pitch, inclination, and loudness along with the words being spoken (Kayalar, 2017). Auditory learning is conveyed through not only speech, but also tone of voice, emphasis and speed of the information given (Gilakjani, 2012). Audiobooks and podcasts are both modern modalities of auditory learning. In academia, these learners benefit most from listening to the instructor lecture, as opposed to individuals that more commonly utilize visual learning, who benefit from the slide show aspect of lecture (Bacro et al., 2013). This learning modality can be defined as “any change in the listeners ability to perform an auditory perceptual task contingent upon observed or known experience auditory training describes the nature of this experience leading to the learning” (Moore, 2007). While visual learning may be a beneficial modality for students, it can be difficult to learn without an auditory aspect. Having adequate listening skills is crucial to academic achievement, maintaining personal relationships, and working and communicating efficiently with coworkers and peers. Engaging in auditory learning enhances the capability to effectively receive information, and process auditory signals accordingly (Kayalar, 2017). These individuals tend to find written directions more challenging to follow as opposed to verbal directions. They are skilled listeners and learn abstract concepts through repeating spoken content, reading aloud, and whispering new information to themselves to vocalize ideas. Problem solving is conveyed through discussion, where listening and explaining verbally are key components in resolving conflicts (Kayalar, 2017). Many benefits may come from this modality of learning, including drastic improvement of children's listening and language skills, performance in listening tasks, (Moore & Amitay, 2007) and a rapid learning rate for a prolonged period of time (Hawkey et al., 2004 ; Jones & Holding, 1975). While these skills are abundant, excessive noise or unnecessary speaking in settings in which the learner tries to focus can easily distract them from absorbing prominent information (Kayalar, 2017).

Kinesthetic learning involves hands-on lessons or activities that allow the learner to be physically involved with the task at hand. This type of learning is highly recommended to be incorporated into curriculum on an educational level to motivate and encourage students to learn new material, as well as translate the hands-on skills learned into real-world applications (Mobley & Fisher, 2014). Kinesthetic learning activities in the classroom involve physically engaging in classroom exercises. These can include working with modeling clay to physically create a construct or idea, tossing a frisbee to a classmate to depict transfer of control, or even using manipulatives to solve math problems (Begel et al., 2004). This modality of learning strengthens concepts and allows students to connect abstract ideas together (Tranquillo, 2008). Participating in hands-on activities prepare individuals for jobs that require fine motor skills. Working with one's hands engages muscle memory in order to complete a task related to the profession (Tranquillo, 2008). McGlynn & Kozlowski (2017) found that kinesthetic learning improves the engagement of a student in learning and increases their overall happiness while participating in the activity (Ike & Anderson, 2018). Bodily movement and aerobic activity greatly affect the hippocampus region of the brain. The hippocampus encompasses the learning and memory systems, which implies that physically moving may create greater learning capabilities. Participating in hands on activities strengthens memories and muscle memories of a specific task (McGlynn & Kozlowski, 2017). Because the average attention span during lectures can range anywhere from 10 to 15 minutes (Bradbury, 2016), having students engage in kinesthetic activity increases ability to focus on given information and avoid further mundane distractions (Tranquillo, 2008 ; Richards, 2019). Engaging in kinesthetic learning in the classroom, however, is not always practical. Lack of funding, materials, and time, an excess number of students, activities that may illicit a multitude of distractions to students, and classrooms that lend minimal space to conduct activities are all common barriers that hinder the ability to use kinesthetic learning in the classroom (Richards, 2019 ; Horst et al., 2009 ; Yahya & Noor, 2015 ; Ramirez & Gordy, 2020). These are the main reasons why the default format of lesson plans in this academic setting tends to involve slideshows and lectures.

Varying levels of education illicit different dominant learning modalities (Syofyan & Siwi, 2018 ; Atienza et al., 2002 ; Suryono et al., 2021). Beginning at an elementary school level, classrooms tend to favor more kinesthetic learning activities. While learning math, it is common for the students to use manipulatives to move around and further grasp mathematical concepts. Reading and writing can be taught kinesthetically through writing words and letters on whiteboards, or filling out missing words or sentences in a workbook (Koçakoğlu, 2010 ; Moustafa, 1999). Science fairs are prevalent in grade school, and often require the students to create a hands-on project to investigate various scientific constructs (Leasa et al., 2020). Kinesthetic learning is often used at this education level in order to keep students engaged due to the low attention span of the young children, and to encourage children to interact with their environment to promote basic motor control skills (Koçakoğlu, 2010).

High school students engage in predominantly visual learning techniques (Padidar et al., 2015). This is likely attributed to the use of slideshows in order to relay information to the students in a productive manner. Ike & Anderson (2018) recommends that comics and films should also be integrated into high school curriculum. These visual tools appear to facilitate attention and strengthen comprehension abilities. Visual learning tactics like these can also aid in the ability to recall messages and main points for students at this age level (Ike & Anderson, 2018 ; Darch & Eaves, 1986). It is important to design visual lessons in a manner that benefits students and does not distort or exaggerate facts. When teachers at this level create visual lesson plans, it is imperative that the content is engaging. In order to benefit the students to their best ability, pictures, diagrams, graphs and other infographics should be displayed on slideshows whenever possible, as opposed to only using sentences as a visual aid (Ike & Anderson, 2018 ; Dwyer, 1968).

In a higher education setting, a mix of auditory and visual learning mechanisms are the two primary ways that material is presented (Amitay et al., 2005). In a typical college lecture, students must pick up on vocal cues as well as gather information from slideshows. Kinesthetic learning is frequently disregarded, especially in colligate educational settings and formats (Tranquillo, 2008). The need to relay course content via these modalities can likely be attributed to the limited amount of time that is allotted to teach and learn this information, or the practicality of instructing large class sizes (Satterthwait, 2010). Some courses offer weekly lab sessions in efforts to add in a kinesthetic element to the learning process. While this is beneficial for students to gather different perspectives on the material given, laboratory settings are only offered to certain courses, deeming auditory and visual learning in lectures predominant.

The use of visual aids in colligate settings is more advantageous for students compared to the sole auditory aspect of instructor-provided lecturing (Muralidhara et al., 2013). Linder et al. (2009) administered scientific articles to college aged students in an auditory group who listened to the article, and a visual group who read the article. Both groups then took a test immediately after the material, and 30 minutes after the material. The visual (reading) group outperformed the auditory (listening) group by 12.8% (p. 6). Vaishnav & Chirayu (2013) began noticing this as a pattern in higher education and determined that redesigning and restructuring courses can help optimize students learning (p. 3). It is also recommended that videos and enhanced visual effects on slideshows be utilized for students to actively learn and be given transitions into topics via these visual aids (Alkooheji & Al-Hattami, 2018). As recognized in previous studies (Culp et al., 2020 ; Lujan & DiCarlo, 2006), kinesthetic learning seems to be just as, if not more, effective than visual learning. There is a high positive correlation between academic success and kinesthetic learning in higher education, as there is a low positive correlation for auditory learning and academic achievement (Vaishnav & Chirayu, 2013). Because of this, it is imperative that kinesthetic learning be continually integrated into college courses, labs be expanded, and a greater combination of learning modalities in classrooms be utilized.

Incorporating the Various Learning Modalities in Medicinal Education

In efforts to create the most effective learning environment for students, many pedagogical methods have been utilized in medicinal education (Farimani et al., 2022; Erkonen et al., 1992; Shim et al., 2018; Hayes et al., 2017). Namely the utilization of kinesthetic learning seems to be the most common and effective teaching method to enhance student learning in modern medicine (Johnston et al., 2015: Ranganath & Josphine-Priya, 2015; Samarakoon et al., 2013; Kharb et al., 2013; Lujan & DiCarlo, 2006; Hernandez et al., 2020).

Ibrahim & Hussein (2016) conducted a study to determine the different preferences of learning modalities in nursing students. It was found that out of the 6300 students that were surveyed, 40% favored visual learning. Kinesthetic learning was the second most preferred, at 30.5%, and auditory was slightly the least preferred style, at 29.5% (p.3). This could be attributed to the ease of accessibility to visual content for the nursing students, or the mass of content that must be delivered in a short amount of time. While kinesthetic and auditory learning were a mere one percent away from each other, kinesthetic learning received more supportive comments from the students due to the need for hands-on practices and applications used in the nursing career. Auditory learning was the least preferred method, likely because of the need for auditory processing, or minimal effort to physically engage. The order in which these learning modalities are preferred in nursing students is also supported by Frankel (2009), who reported that, even with a smaller sample size of 61, visual, kinesthetic, and auditory learning were preferred in that order. These totaled at 54.0%, 26.9%, and 19.1 % respectively (p. 26).

As suggested previously, individuals may learn through a blend of multiple modalities. Lujan & DiCarlo (2006) surveyed 166 first-year medical students regarding how many and what type of learning modality suits them most. The majority of students, at 63.8% of the population, shared that they preferred multiple modes of learning. Kinesthetic and visual techniques were the combination that the medical students preferred the most. The students who preferred one modality were largely partial to kinesthetic, leading the three of them by 29% (p. 89). Daud et al. (2014) supported this finding with another survey of medical students. Among a sample of 100 medical students, kinesthetic learning was the most common preference for unimodal learning. 67% preferred kinesthetic, 18% preferred visual, and 15% preferred auditory (p. 44).

Busan (2014), however, found conflicting results, stating that 73% of medical students (n=230) preferred a single learning modality. Of these, only 26% stated that they learned best through multiple modalities. The results of the single learning modality students also show differing results in the preference of kinesthetic learning. Of the 73% who only preferred a single modality, visual learning consisted of 45%, auditory learning was at 36%, and kinesthetic learning was the least preferred modality, at 19% (p. 104). Identifying students' favored modalities can help in diminishing the notion to teach and test all students in a similar manner and provide an insight into how to help each student learn to the best of their abilities through providing the student with appropriately guided material, or challenging them by incorporating the learning modality they relate to the least. (Lujan & DiCarlo, 2006).

The problem with students who prefer kinesthetic learning in medicine, however effective the modality may be, is the constant nature of their need to interact with the environment. When these students attempt to learn in a lecture setting, they often come across as disruptive due to the disfavor of auditory and visual learning, putting these students at a disadvantage in the classroom. Students who learn best though kinesthetic modalities of learning thrive during clinical and internship hours, where they must use hands-on application for tasks and activities administered (Busan, 2014). One solution for this issue is to integrate practical exams into lecture / classroom material. Performing experiments, dissections, or clinical exams of a patient should be used as an addition or alternative to multiple choice or written exams (Busan, 2014). If kinesthetic learning is the preferred learning modality for higher education medical students, but visual learning is the most utilized in higher education, the question remains of which is most beneficial in specifically learning anatomy. Hernandez et al. (2020) found kinesthetic learning to benefit students learning thoracic anatomy. In medical schooling, familiarity of basic and advanced anatomy and the ability to maneuver around and work on various boldly structures is critical. Students tended to retain more knowledge of the placement of organs when participating in a hands-on activity. These included crocheting organs to the approximate size and shape of real organs or molding them out of clay. In both instances, students had to correctly place the organs in their designated spot in the thoracic area. One reason this method is so effective in anatomy is because of the 3D mental imaging that needs to occur in order to create an understanding of spatial awareness of the organs, as well as to conceptualize shape, position, and form in relation to other structures (p. 1635). These hands-on activities not only enhance students' retaining of information, but also received a positive reaction from the students, eliciting enjoyment of the learning modality provided. Creating a physical version of anatomical structures promotes the transfer of mental images to a real-life object, enhancing students' ability to create a concrete memory of the organs in different perspectives.

Anatomical knowledge is typically assessed via multiple choice and written exams, along with practical application exams (Hall et al., 2013 ; Older, 2004). These practical exams can include skeletons, plastic models, and cadavers. Through hands-on learning of anatomical structures, students deepen their understanding of organ placement in relation to the structure of the remaining human anatomy and can recall the visual of the model that was created or handled in 3D images to demonstrate the learning on an exam (Hernandez et al., 2020).

Self-confidence in Learning

Self-confidence also plays a role in academic success (Madill & Latchford, 2005 ; Muralidhara et al., 2013). When working with simulation-based learning, self-confidence is a significant predictor of engagement and academic satisfaction (Almasri, 2022). Gitatenia & Lasmawan (2022) found that self-confidence has a significant positive relationship with the desire to learn, and the desire to learn also has a significant positive relationship with kinesthetic learning. This means that when students engage in kinesthetic learning, they may develop a greater interest in education and therefore a higher academic self-confidence rate (p. 2). Gholami & Bagheri supported this finding with evidence via survey of tactile, or hands-on learners, being more confident in academic settings and are able to solve problems in a more efficient manner in difficult situations (p. 705).

Learning techniques seem to have a significant effect on the emotional intelligence of students. There are many components to emotional intelligence, however it is, in whole, the capability of controlling, expressing, and being aware of one's emotions (Trait, 2004). Students who prefer to learn through hands-on activities have a higher emotional intelligence compared to students that learn mainly though visual (6.1%), or auditory stimuli (8.35%) (Lesa et al., 2017). Self-confidence is a fundamental part of emotional intelligence, as higher self-confidence helps the student report fairly and realistically to peers and educators regarding performance on exams or learning activities (Vărăşteanu & Iftime, 2013). Karabağ & Dinç (2017) states that a mix of easily accessible material and good preparation can effectively increase students' self-confidence in academic skills. In medicine specifically, web-based simulations can be utilized to increase students' self-confidence levels (p. 267). Mainly in skills such as performing intramuscular injection, inserting a catheter, urinary catheterization, and handling excessive bleeding (Onder & Sari, 2021 ; Rodriguez-Diez et al., 2014 ; Rashisi et al., 2015 ; Erol & Zaybak, 2020). When students' self-confidence is high, they tend to evaluate themselves often during activities and learning exercises through mistake identification and repetition of misunderstood material. This mentally prepares them for better learning outcomes, so as to not diminish their sense of self-worth or self-confidence (Delaram & Toutounchi, 2009).

Wu, et al. (2007) observed the self-confidence ratings of 302 medical students performing various clinical skills. The skill that had the highest self-confidence rating was blood pressure, while identifying a diastolic murmur had the lowest self-confidence rating. This is likely due to the frequency of the skill being practiced, as well as the level of difficulty the skill requires. Skills that had the greatest differences between self-confidence and ability to correctly perform the task at hand included detecting a breast mass in a female patient, detecting a thyroid nodule, and distinguishing a mole from a melanoma (p. 1729). While self-confidence is an objective measure and cannot be indefinitely analyzed, this study suggests areas of medical training that need an increase in practical training to improve students' self-confidence and abilities. Self-confidence in medical training also has the tendency to decrease if skills are not practiced regularly (Arraez et al., 2004). Avisar et al. (2013) found that not only self-confidence, but preparedness and recollection in CPR skills and knowledge were lowered after one year, and significantly lowered after two years. The average self-confidence score for CPR knowledge after one year was 20 out of 27, (74%) while that number decreased to 17 out of 27 (63%) after two years from becoming CPR certified (p. 626). This is a validation of the two-year recertification requirement for CPR courses.

Teaching Dissection in the Classroom

Dissection has been a critical component of medical training for centuries. Jacques Dubois was a medical teacher during the renaissance. He believed heavily in learning through dissection. One infamous quote of his from his anatomical manuscripts is still discussed in medicine today, "*It is much better that you should learn the manner of cutting by eye and touch than by reading and listening. For reading alone never taught anyone how to sail a ship, to lead an army, nor to compound a medicine, which is done rather by the use of one's own sight and the training of one's own hands*" (Sylvius, 1555). Thus, establishing the landmarks of the human body and learning the physical language of medicine are essential skills to develop through dissection (Krych et al., 2005).

Dissection is a form of kinesthetic learning that most students enjoy and thrive with (Johnson, 2002 ; Dinsmore & Zeitz, 1999 ; Ghosh, 2017 ; Hall et al., 2013). When given the opportunity, medical students prefer to dissect as many specimens as they are given the opportunity to base on a study done by Johnson (2002). Medical students were separated into two groups and got to either dissect a lower and upper extremity, or only dissect one extremity and learn about the other via traditional learning methods. While both groups performed similarly on the exam, the students who dissected only one extremity argued that they had not learned both extremities to a satisfactory level (p. 42). This supports the theory of hands-on learning enhancing self-confidence levels, but no relationship between leaning modalities and performance. The students that were not allowed to complete an entire hands-on learning experience were less confident in their knowledge of the material presented, despite the lack of discrepancies in the test scores of both groups. Education of anatomical sciences that does not integrate dissection into the curriculum is unable to provide students with the adequate experience needed to progress successfully in their medical program. Pawlina & Lachman (2004) reviewed the opinions of senior medical students and found that the majority of students feel as though they only obtained general and occasionally misleading information regarding structure and orientation of the human body. Dissection allows students to either verify or dispute their previous knowledge of anatomy. Giving students the opportunity to dissect human specimen not only helps them develop academically, but also psychologically. It promotes sensitivity towards issues regarding death, while also desensitizing students to the nature of working on a real human body (p. 10).

Azer & Eizenberg (2007) gathered 475 first- and second-year medical students' opinions on learning through dissection. The statements that solicited significantly more 'agree' or 'strongly agree' than 'disagree' or 'strongly disagree' in the study were: Dissection deepens my understanding, provides three-dimensional perspective of structures, helps me to recall what I learnt, provides understanding of effects of trauma, makes learning more interesting, enhances my respect towards human body, dissection classes complement my learning of anatomy, I prefer dissection classes over any other approach, and I would be disadvantaged if I did not attend dissection classes (p. 178). This supports dissecting to be practiced within collegiate anatomical and medical school curriculum and suggests that students prefer dissection as a learning modality as opposed to traditional learning methods. Burgess et al. (2012) tested students learning pre and post cadaver dissection. Before dissection, 42 students resulted in a median of 9 out of 20 on the anatomy exam, and a median of 19 out of 20 in 39 students' post-dissection (p. 459). Videos of dissection, however, do not improve tests scores for anatomy exams (Mahmud et al. 2011). Dissection videos have been implemented in undergraduate medical education mainly due to the high student to cadaver ratio. In a recent study, 93% of undergraduate medical students recommended that dissection videos be included in curriculum. They deemed the videos helpful to their learning and favored their use.

Medical students highly favor dissection as a learning tool for learning relationships between the physical human body and textbook information, being able to work effectively in teams, and learning to cope with death and familiarize themselves with corpses (Flack & Nicholson, 2018). Medical students at Otago Medical School believe that dissection assists in professional development, and positively impacts personal growth. This taught students how to properly manage their emotional intelligence in order to not have their emotions interfere with handling and treatment of physical human bodies. The three topics that the students believed they learned the most about when participating in dissection were anatomical structures, a three-dimensional concept of the body, and differentiating and relating textbook learning to real-life learning (Flack & Nicholson, 2018).

When dissection is taught, it is often practiced in small group settings (Hall et al., 2013 ; Older, 2004 ; Disnmore & Zeitz, 1999). This can likely be attributed to the sparce resources available combined with the increasing number of students in medicine. When students are separated into groups, often times peer teaching is encouraged and practiced (Hall et al., 2013). Teaching is one of the most successful ways to retain information when learning new concepts (Krumboltz, 2009 ; Widiasih et al., 2022), and can be practiced in dissection lessons. Nnodim (1997) Divided 80 medical school students into two groups: one that was peer taught, and the other that was self-taught. The peer teaching group scored significantly higher on the post-study exam than the self-taught group. The students in the peer teaching group enjoyed this type of setting and expressed that teaching and learning through their peers allowed them to further their communication skill in addition to learning the material being discussed (p. 115).

Krych et al. (2005) proposed that peer teaching in dissection should focus on enhancing anatomical knowledge as opposed to memorizing it. Peer-teaching in anatomy was shown to result in positive feedback from students and provide students more time to ask questions and deepen their understanding (p. 299). Manyama et al. (2016) concluded that students who participated in peer teaching during cadaver dissection showed a higher mean score on the post-test compared to students who were taught by an instructor. The research attributes this improvement to multiple factors, including the unfamiliarity of peer teaching which may have resulted in paying closer attention and asking more questions in the group as opposed to the comfortable, traditional environment of an instructor lead dissection (p. 10). In contrast to these studies, Bentley & Hill (2009) followed a similar procedure and showed no significant improvements in peer teaching as opposed to instructor lead teaching. No one group scored significantly higher or lower than the other on a post-test, and students' opinions on peer teaching were collectively neutral (p. 147). Johnson (2002) also found conflicting results, stating that peer teaching was successful in the students learning of material, however the students preferred to learn via a professional instead (p. 42).

Dissection and Self-confidence

Esterl et al. (2006) examined the effects of a 'medical boot camp' on fourth-year medical students that were preparing to begin specializing in surgery. This bootcamp involved various clinical sessions that were designed to enhance the students' knowledge in medicine, as well as increase their confidence for beginning their surgical internship. The four topics for the clinical sessions were anatomic dissection, patient management, technical skills, and administrative skills. While there were no scores or exams, students instead were given time to practice the necessary skills that would be utilized in their surgical training. Upon completion, students rated themselves as more confident in performing every single task that was practiced (p. 266). This is most likely attributed to the hands-on learning that the students were participating in. During the bootcamp, there were no slideshows or lectures, but rather practical experience working with objects.

Practicing surgeons were surveyed and it was found that one of the eight factors that most influenced decision making in the operating room was self-confidence (Williams & Smink, 2015). Techniques to increase self confidence in an operating room setting should begin with familiarity and confidence in dissection. Because of the closely related procedures of dissecting a cadaver and performing surgery, self-confidence gained in dissection is self-confidence gained in the operating room. Increasing self-confidence in dissection could involve many types of learning processes. Namely, increasing frequency of cadaver dissection times (Baker et al., 2012

; Williams & Smink, 2015), and utilizing peer teaching (Williams & Smink, 2015). Procedure oriented cadaver courses have been shown to increase operative self-confidence as well as surgical technique (51a). This method of dissection focuses on specific operation procedures instead of general dissection for furthered learning of human anatomy.

Self-reflection was analyzed during a dissection section in a study done by Masill & Latchford (2005). It was found that the two factors that had the highest positive correlation with each other were 'other lab group member coping best' and 'my ideal self in the dissection lab'. This relationship suggests that when working as a team, students strived to cope as well as they perceived other students to be doing so. These students relayed that they performed to the best of their abilities in dissection, while also rating their self-confidence as 'high' in the dissection practice. While student self-confidence was high in dissection, the students reflected on the need for further development in anatomical knowledge (p. 1643).

When introduced to human dissection in medical school, students reported to have learned that they had more confidence than previously through regarding dissection, and developed respect for the donor body, classmates, and surgeons (Flack & Nicholson, 2018). One medical student from a study done by Flack & Nicholson (2018) claimed that "*Dissecting is the sort of thing that I get very anxious about and doubt my ability to handle it. By telling myself that I was going to do dissection and be strong, I was able to gain greater self confidence in dealing with these things. I think this is valuable for my future medical training – if I put my mind to it, I can keep my anxiety under control*" (p. 332). Additionally, the student's confidence grew as dissection was practiced more frequently. Klein (2006) Describes acquiring self-confidence when practicing a task as a significant part of increasing the motivation needed to continue to participate and grow in the skills practiced (p. 291).

Selcuk et al (2019) states that in order to gain confidence, skills and experience prior to operating on a live patient, it is imperative that medical students receive adequate training in dissecting human specimen not only in residency, but also at the post-graduate level in order to retain their comfortability with said skills. The trainings need to be organized via surgeons and anatomists to have students absorb the most relevant material (p. 72). The relationship between overall performance of a task and self-confidence is meaningful to observe and produces positive results when utilized in dissection. Medical students (n=25) underwent training in endoscopic submucosal dissection in a study done by Huang et al. (2023). Pre and post training, students were evaluated on practical endoscopic submucosal dissection knowledge, operative skill, and self-confidence. Each of these categories increased significantly prior to the training, with endoscopic submucosal dissection increasing by 45%, operative skill increasing by 49%, and self-confidence increasing by 42% (p. 8). Due to the nature of this dissection and the direct relation to the student's specialty in medicine, it seemed to show great relevance in the preparation for surgery, as well as raising students perceived abilities to perform the dissection tasks.

Locketz et al. (2017) asked medical post-graduate students to dissect a temporal bone. Easy, intermediate, and difficult subtasks were incorporated into the dissection. Participants were divided into four groups based on their current year of post-graduate studies. Second year post-graduate students retained the lowest scores, with a 75% on easy subtasks, 78% on intermediate subtasks, and an unusually low score of 32% on advanced subtasks. Fifth year post graduate students had significantly less variation in their scores regardless of difficulty level. All scores for the fifth-year postgraduate students were between 88% and 93% (p. 1146). Because all participants had completed their medical school training and were familiar with hands-on skills via their clinical training, it is evident that scores improved based on year due to the continued years of experience in dissection. The fifth year post graduate students scored higher on the temporal bone dissection most likely due to the repeated hands-on practice that occurred in their post-graduate years.

Performing medical simulations is a key part of medical training (Chuang et al., 2018 ; Ghosh, 2017 ; Older, 2004). These simulations can involve live patients, plastic models, or miscellaneous specimen. Because of extensive practice and physical capabilities, students tend to perform well during the simulations. Even though their performance may reflect self-certainty, many medical students report high levels of anxiety at the time the simulation is being performed (Esterl et al., 2006). This can be remedied by the continued use of simulations, and an increased familiarity that follows the continual use of the simulations.

While dissection is a crucial step in students ability to perform well beyond their medical training, it can also illicit various emotional reactions (Arráez-Aybar et al., 2004 ; Penny, 1985 ; Finkelstein & Mathers, 1990 ; Druce & Johnson, 1994) that have the potential to affect future relationships between medical professionals and their patients (Bastos & Proenca, 2000). Anxiety is not only the most common emotional reaction students report prior to and during a dissection (Arráez-Aybar et al., 2004), but also unfortunately the most common reason for the reduction of cadaver dissection in medical education (Aziz et al., 2015). Reduction of cadaver dissection anxiety may be remedied through repeated exposure to the cadaver (Arráez-Aybar et al., 2004), which contradicts the argument for lessening cadaver labs in medical education training. This type of anatomical education needs to be continued in medical training due to the vast improvement in surgical knowledge and techniques it provides for the medical students (Selcuk et al., 2019). Doing so allows for students to perform detailed practice of dissecting various anatomical regions prior to working on live specimen, which can increase surgical self-confidence (Sharma et al., 2016).

Virtual Reality Learning in Dissection

Dissection virtual reality simulations skills directly translate to dissection skills in cadavers and live human operation (Andersen et al., 2018 ; Boscolo-Berto et al., 2021). Introducing virtual reality simulation into medical training has the potential to give medical students dissection experience without the demand for real cadavers.

Virtual reality trainings may outweigh the need for these real cadavers, time allocated in the operating room, and the constant maintenance and sterilization of a surgical laboratory / operating room (Francis et al., 2012 ; Fang et al., 2014 ; Nash et al., 2012). Zhou et al (2013) demonstrated that medical students achieved higher practical exam scores on cadaver dissection after training with virtual reality anatomical simulations. Additionally, these students caused fewer minor injuries to the cadaver as opposed to students who learned dissection skills via traditional teaching methods such as slideshows and lectures (p. 320). Virtual reality simulation is no substitute for physical cadaver experience; however, it does help students increase their fine motor skills and surgical techniques more readily than traditional learning methods (Locketz et al., 2017). Wiet et al. (2002) Assessed cadaver dissection performance in medical students after randomly separating them into a physical dissection group or a virtual reality dissection group. The trainings of both groups spanned over two weeks. After the training, students were tested on dissecting a physical cadaver, and no significant differences were observed in final test scores between both groups (p. 81). While these findings suggest that neither modality of dissection was superior to the other, it is important to consider the physical abnormalities the students may face on live dissections and familiarizing themselves with this may be more effective in real cadavers. Virtual reality and physical cadaver dissection can also work together to enhance student's confidence in surgical skills. Students who work with dissection via virtual reality simulations prior to physical dissection showed an increase in self-confidence and performance (Arora et al., 2014).

Codd & Choudhury (2011) looked further into the discrepancies of learning anatomical sciences via traditional learning methods such as slideshows, textbooks, and lectures versus hands-on physical activities. Various medical students were asked for their feedback on these learning modalities. Students perceived traditional learning methods to be complementary to the hands-on dissections, and even suggested them as a supplementary leaning option next to physical dissection instead of a replacement for them (p. 123). Each modality has its own advantages, and therefore one should not replace the other when teaching medical students' anatomy and proper dissection techniques. Integrating both modalities ensure the material is being learned in an effective manner, while appealing to the majority of students who are in favor of physical dissection being the main teaching modality, and the students who may prefer learning through visual or auditory cues prefer the traditional teaching methods. Virtual dissection has the potential to be seen as a combination of all learning modalities. Audio instructions are being given in the simulation, all necessary anatomical landmarks and structures are being seen in the virtual reality, and dissection is taking place, albeit not physically, but this still gives kinesthetic students opportunities to work first-hand. Incorporating virtual reality into surgical training programs adds extensive, comprehensive experience that aid medical students in their learning process, while simultaneously reducing the need for group dissections (Piromchai et al., 2015).

Because not all students learn in the same way, specifically in anatomy, medical professionals and instructors are pushing for a combination of teaching methods in medical school training (Ghosh, 2017). It is vital that dissection be continued as a main tool for teaching in anatomy courses, as it is one of the building blocks of gaining fundamental practice for familiarizing students with the human anatomy. Dissection aids in the development of sufficient clinical skills, retention rates, non-traditional interdisciplinary technical skills, and validates the proficiencies of trained medical professionals (Ghosh, 2017). Because of the recent cutback of time allotted for cadaver-based training, the design of medical education curriculum needs to be transformed and should be cautious of the extent that the dissection time is cut back. Utilizing this type of hands-on training enhances the safety of patients, as this allows for the medical professionals to acquaint themselves with the realistic composition of the human body (Alasmari, 2021 ; Older, 2004).

In order for clinical application to be adequately practiced, identifying basic elements and structures of gross anatomy via cadaver dissection is vital. This has been established to be the ideal study tool to understand the 3D relationship and composition of anatomical structures, while traditional learning methods are more useful for comprehending the vocabulary of medical terminology (Bergman, 2015). Virtual reality dissections can supplement for an unavailability of cadavers, and have same learning outcomes as a traditional cadaver dissection (Gunderman & Wilson, 2005 ; Biasuttoet al., 2014 ; Cornwall & Stringer, 2009). Andersen et al. (2016) expressed that mastoidectomy skills learned via virtual reality simulations are transferable to human cadavers (p. 1886). Being so, virtual reality dissections can be practiced advancing necessary experience in medical training. Doing so also reduces the demand for bodies donated to science, and has the potential for those bodies to be put to use in organ transplantations instead (Kolla et al., 2020 ; Lee, 2010 ; Sengupta et al., 2006).

Zhao et al. (2011) examined the differences between learning human anatomy and reducing size of injury while dissecting via traditional training methods vs virtual reality dissection. They found that the test scores in the virtual reality group were significantly higher, by 38%. Supervised virtual reality teaching improved students' performance of temporal bone dissection significantly vs traditional teaching methods (p. 362). While both teaching modalities resulted in students gaining a basic understanding of the material, the virtual reality group scored 35% higher than the traditional teaching group in learning the mastoid cavity appearance alteration, identification of specific injuries, and the skeletonization of anatomical structures (p. 362).

The relationship between an interactive physical plastic anatomy model and a virtual reality model was investigated in a study done by Wainman et al. (2021). These teaching modalities seemed to have students obtain the same level of understanding. Using this interactive model as a tool to enhance education has the potential to benefit students who are visually impaired (p. 797). Either modality has potential to advance student skill set and therefore, it is integral that some type of dissection, whether it be software or cadavers, needs to be implemented in medical education. Students' ratings of learning via virtual reality were higher than that of plastic models (Roh et al., 2021). The students stated that practicing operations with virtual reality technology would further develop their surgical skills and introduce new study techniques. They also advocated for an increase in virtual operation simulations for future students, as the program enhanced their learning (Roh et al., 2021).

Hands-on learning can also be taught in other ways than cadavers. Lisk et al. (2015) divided first year medical students into a 2D learning group, and a 3D learning group. The 2D learning group utilized visuals and paper handouts, while the 3D learning group was given white fabric gloves. They were then asked to draw all hand and wrist bones in black, tendons and muscles in red, and nerves in green on the glove and instructed to perform various hand movements while wearing the glove. After which, all students were asked various questions regarding the relationship between hand anatomy and actions, and general hand anatomy. The 3D learning group exhibited higher post and retention test scores than the 2D learning group. The students in the 3D group also highly recommended (90%) that this tool be used for future medical students (p. 146). This supports findings of kinesthetic learning benefiting medical students in more ways than just skill improvement on cadavers. Creating various hands-on activities can expand students' exposure to various study methods, and thereby greatly benefiting ones' personal learning.

Medical students have provided copious amounts of feedback when participating in virtual reality dissection (Zhao et al., 2011 ; Wainman et al., 2021 ; Roh et al., 2021 ; Kolla et al., 2020 ; Lisk et al., 2015). These comments help determine the impact of this new and innovative teaching modality. Boscolo-Berto et al. (2021) found that 70% of the students in this study reported the use of virtual dissection to be more engaging than traditional learning modalities, and advantageous to their medicinal education (p. 476). Kolla et al. (2020) reported not only increased test scores for students who participated in virtual dissection, but also that 95.8% of students in the study preferred virtual dissection over lectures and deemed it more helpful to their learning (p. 1208).

Self-confidence levels in virtual reality learning should also be considered. Locketz et al. (2017) revealed that 10 out of 12 medical students' self-confidence in performing a cortical mastoidectomy increased significantly after completing a virtual reality rehearsal simulation. The remaining two students remained neutral about the virtual simulation and stated that it did not hinder their ability or take away any skills in performing a cortical mastoidectomy (p. 1147). Mickiewicz et al. (2021) held several sessions of virtual reality surgery training. After each session, students filled out a self-confidence questionnaire, and were evaluated based on the duration of the session, mistakes made, and over performance of the surgery. 67% of students reported that they felt as though they had made significant progress in their surgical skills throughout the sessions. 100% of students also reported higher self-confidence rates in their last session as opposed to their first. The student's main comments regarding the study were that virtual reality simulations should be routinely used in medical training, as it provides a safe and structured environment to practice complex practical skills (p. 1119).

The Human Heart and the Pig Heart

Pig hearts are ideal in introducing students to the anatomy of human hearts. Both types of hearts share various commonalities including the size, structure, and function (MICDS, 2021). When examining the structures specifically, two atriums, two ventricles, two vena cavas, a tricuspid valve, ventricular septum, pulmonary artery, and an aorta are found in both human and pig hearts (Rodrigues et al., 2005 ; Crick et al., 1998). Not only are there common structures among both hearts, but the positions of the structures are also similar. The pulmonary trunk and the aorta are both oriented the same way in both species, as the pulmonary trunk left of the aorta, and the aortic valve is in the center of the heart. The mitral valve and tricuspid valves are on the right and left side of the hearts, respectively (Rodrigues et al., 2005). Taking a closer look at these shared structures, the two vena cavas are the superior and inferior. The superior vena cava is located on the top right of the heart and is the largest central systemic vein in the mediastinum (Sonavane et al., 2015). The inferior vena cava is located on the bottom right of the heart and is associated with various congenital and pathologic functions (Similie et al., 2015).

The two atriums are the right and the left. The right atrium can be found in the upper right quadrant of the heart, while the left atrium is in the left quadrant of the heart. The right atrium includes a venous component, an appendage, and a vestibule (Lang et al., 2022). It receives deoxygenated blood from the vena cavas, among other structures, and drains the myocardium. The superior vena cava is attached to the right atrium via the superior wall (Lang et al., 2022). The left atrium receives oxygenated blood from the lungs and pumps that blood into the left ventricle. The left atrium is smaller and narrower, but also longer and more curved than the right atrium (Whiteman et al., 2019). The two ventricles are also the right and the left. The right ventricle is located in the lower right quadrant of the heart, while the left ventricle is in the lower left quadrant of the heart. Both ventricles pump blood throughout the body. The right is differentiated from the left by a thinner wall around it, as it typically pumps at a lower pressure than the left ventricle. It is also separated from the left via an interventricular septum, which acts as a wall between the left and right side of the heart (Sheehan & Redington, 2008).

The aorta is the largest artery in the body for both humans and pigs, and receives blood from the left ventricle to distribute to the arteries. The tricuspid valve sits in between the right atrium and the right ventricle. It is the largest of the four cardiac valves (tricuspid, pulmonary, mitral, aortic), and because of its size, has a lower velocity to pump out blood. This valve controls blood flow from the right atrium to the right ventricle (Dahou et al., 2019). The pulmonary artery travels through the aorta, similar to a string through a loop. It gathers blood from the right ventricle and pumps it to the lungs. This is the only artery in the body that carries deoxygenated blood (Townsley, 2012).

Finally, the ventricular septum is a wall that separates the right side of the heart from the left side for both humans and pigs. While the entirety of the septum's function is not fully understood, it has been hypothesized that it causes ventricle to ventricle interaction (Boettler et al, 2005). While the human and pig heart share many commonalities, enough to have a pig heart safely transplanted into a human even, (Mohiuddin et al., 2015) there are several minute differences. One being the left azygos vein, which drains into the coronary sinus in pigs, as humans do not possess this feature. The pig heart also receives oxygenated blood from two pulmonary veins, while the human heart receives oxygenated blood from four veins (Lelovas et al., 2014).

Although dissecting a human heart would be ideal to investigate incorporating kinesthetic learning, there are other, more pressing uses for these hearts. Each year in the United States, approximately 2000 heart transplants are performed (Everly, 2008). If an opportunity arises in which an organ donor passes and is able to donate their heart, it almost always is immediately transplanted into a patient in need (Marsia et al., 2018). Thus, a practical way to introduce human heart anatomy to young college students can be through dissecting pig hearts, which are in greater supply than human hearts for instructional purposes (Pierson et al., 2020).

Summary

There are three different learning modalities, visual, auditory, and kinesthetic, each with individual advantages and disadvantages. Incorporating each modality in some way may be most beneficial for learners in all levels of education. Self-confidence is an important factor in how well teaching methods are received, and varies based on the task at hand, and how well the student receives the material presented. Teaching dissection in the classroom can be crucial to students understanding of the human anatomy, and is highly encouraged to continue to be taught, even though the dissection is slowly disappearing from undergraduate curriculums. Because of this, other methods (e.g., virtual reality, animal hearts, etc.) may allow dissection into classrooms without excess time and monetary barriers. The pig heart and human heart have a plethora of similarities that may allow for the transfer of knowledge via dissection from the human to pig heart. This literature review supports the need for the study of physical dissection vs traditional teaching methods in learning heart anatomy.

CHAPTER THREE: METHODOLOGY

Participants

Participants (N=39, minimum participants being 32, with an estimated withdraw rate of 20%) included first- and second-year Washington State University students who were 18 years of age or older. Participants must have been currently enrolled in human anatomy (KINES 262) at the Pullman campus and have signed a written consent form to be involved in this study. No exclusion criteria was presented, as this study analyzed learning modalities for all types of students, regardless of educational background or prior knowledge. Participants received extra credit for the KINES 262 course as compensation for their participation. Approval for this study was sought and obtained from Washington State University International Review Board prior to participant recruitment and any study procedures.

Procedures

Participants were randomly divided into two groups: a kinesthetic learning group and a visual learning group. Randomization was conducted through assigning each participant a number, and utilizing a random number generator to determine which group they belonged to. Both groups filled out an online self-confidence questionnaire housed on Qualtrics prior to taking a pretest on pig heart anatomy. The self-confidence portion of the questionnaire included five questions that evaluated the subjects' perceptions of how well they would perform on the pretest. Questions were constructed based on the Rosenberg self-esteem scale (Rosenberg, 1965), which is the gold standard for self-evaluation and reflection in psychological research.

Questions were written in the format of the Rosenberg self-esteem scale, as strongly agree, agree, disagree, and strongly disagree were the four options participants had to choose from for each question. These questions would assess confidence levels in the following aspects: Identifying the different structures of a pig heart, scoring a 70% or higher on the pig heart exam, understanding how blood flows through the heart, determining which chambers receive deoxygenated blood in the heart, and identifying the major artery of the heart. The pretest assessed participants' prior knowledge on pig heart anatomy and depicted a diagram of a pig heart with arrows indicating 10 major anatomical structures of the heart. Participants labeled each landmark to the best of their abilities and the test was scored out of 10 points, one point per each structure.

Study participants were assigned to one of two groups of 16-20 participants per group. The kinesthetic learning group was divided into teams of two to three participants per group to conduct pig heart dissection. The division of the kinesthetic groups was intended to mimic laboratory settings in higher education, as it is common for large anatomy classes to be separated into small laboratory sessions. This reflected student groups that work together in each laboratory section. The instructor began the session by explaining the 10 anatomical landmarks of the pig heart that the participants would be identifying. The instructor then demonstrated the proper dissection techniques while each team followed along and collaborated to dissect the pig heart and pinpoint each anatomical structure. The groups utilized one preserved, intact pig heart, and dissected it with a surgical steel scalpel on a dissection table. While highly encouraged to follow closely along with the instructor, additional pig hearts were available to students who improperly dissected the specimen during the session. The participants could obtain a new pig heart for dissection any time should the need arise and at the instructor's discretion.

The visual learning group was taught pig heart anatomy in a lecture style format, a common classroom format for an undergraduate anatomy course. Specifically, this consisted of one group (of ~16-20) that met for one session. The instructor presented a slide show that included pictures and diagrams of the 10 identifiable structures of the pig heart but did not include the diagram used during pre and post testing. Both the kinesthetic and visual learning groups had a 40-minute time allotment for the instruction session.

The instructor for both groups remained the same, as well as the material being taught. A key point script was incorporated for the instructor, as to not stray from the material, or give one group an advantage over the other.

Immediately following instruction, both groups were then asked to take the self-confidence questionnaire for the second time. All participants then completed the posttest, which was comprised of the same content as the pretest. A demographic survey was then administered to all participants, as to not create a self-bias if filled out prior to participating in the study. The demographic questionnaire included age, race, sex, if the participant has taken an anatomy class prior to KINES 262, what their experience or familiarity with anatomy is, and open-ended questions regarding their general attitude towards anatomical sciences and future career aspirations.

Pretest scores were then subtracted from the posttest scores to determine the overall change for all study participants. Pre and posttest self-confidence questionnaires were examined to determine any improvement or decline among the participants responses. This was determined via the cumulative score of the questionnaire. Two weeks after the learning sessions, a retention self-confidence and pig heart anatomy test was administered. This included the same material as the pre and posttest. If participants were unavailable to complete the retention test on the given day, they were given one week to make up the test. This timeframe of one week does not interfere with participants who take the test at the original date due to the ideal time of retention tests given being anywhere from two to three weeks (Haynie, 1994). Retention scores were compared to posttest scores to determine any increases or decreases in learning. These procedures were repeated as time allows for the Spring 2024 semester.

Data Management

Qualtrics, an online survey platform, was utilized for collection of participant data throughout this study. After each participant completed each self-confidence and anatomy test, their scores were compiled into a Microsoft Excel spreadsheet to record and organize the participant responses. Any participant who failed to complete the entirety of this study still had their data recorded, however it was not incorporated into the statistical analyses of this study.

Data Analysis

Self-confidence scores were derived from the scoring of the Rosenberg self-esteem (Rosenberg, 1965) scale, whereas the higher the cumulated score, the higher the self-confidence rate. Participants scored themselves out of three for each of the five questions, with strongly agree= 3, agree=2, disagree=1, and strongly disagree=0. The scores for each question was then added together to find the cumulative score for the participant. Because the Rosenberg self-esteem scale determines low self-esteem as 50% or less out of the maximum total points, any cumulative score less than 7 on the self-confidence questionnaire was defined as low self-confidence. Any score 7 or above was defined as a normal range for self-confidence, similar to the Rosenberg self-esteem scale, which equates 50% or higher as a normal self-confidence range.

Descriptive statistics were calculated for all variables of interest in the proposed student. Because differences in test scores are on an ordinal scale, the Mann-Whitney U test and a repeated measures test are the most appropriate to utilize for all research questions. The pre test scores for both the visual and hands on learning groups were subtracted from the post test scores for each participant in order to determine the overall difference in test scores. These values were then compared via a Mann-Whitney U test to determine differences between the kinesthetic learning and visual learning groups. The Mann-Whitney U test and all other statistical analyses for this study were examined via IBM SPSS software, and an alpha of 0.05 was used to indicate statistical significance for all analyses. Comparative graphs and figures were created to depict results.

CHAPTER FOUR: MANUSCRIPT

Abstract

Learning modalities play a critical role in shaping educational outcomes, specifically in undergraduate anatomy education. This study examines the effects of two prominent modalities, lecture-based learning and hands-on dissection, in enhancing students' understanding of pig heart anatomy and their self-confidence perceptions. A cohort of 49 undergraduate students enrolled in a human anatomy course participated in the study, which utilized a randomized control design. Participants were divided into two groups: a laboratory dissection learning group and a lecture learning group. Pre and post-tests were administered to assess pig heart anatomy knowledge, and self-confidence questionnaires were administered to assess perceived self-confidence during the intervention. Additionally, retention tests were conducted two weeks post-intervention to evaluate overall retention of the given material. Statistical analyses, including Mann-Whitney U tests, revealed significant differences between the two groups. The lecture group exhibited greater improvements in pig heart anatomy test scores compared to the dissection group in the change in scores from the pre to post test. Despite similarities in baseline knowledge, the lecture group's familiarity with the instructional modality may have contributed to their superior performance. Additionally, significant differences were observed in retention pig heart anatomy test scores as well. There were no significant differences found in the change in self-confidence rates from the pre, post, and retention timeframes of the intervention between groups, but a significant difference was found in the post-test mean scores of the self-confidence questionnaire. This study challenges prior

literature that supports the superiority of kinesthetic learning in anatomy education. Further research is needed to evaluate pedagogical practices that provide the most benefits to undergraduate students in anatomy education.

Introduction

Learning is a skill that continuously develops throughout one's life, even if not in a formal educational setting. Professions, parenting, and engaging in hobbies all represent potential opportunities to both learn and teach (Krumboltz, 2009). Regardless of the modality of learning, the plausibility for growth of knowledge remains a critical objective. In academic settings, there is one modality of learning in particular that is typically favored (Kędra & Žakevičiūtė, 2019). This allows students to have constant exposure to a single learning modality more frequently than others, which can lead to disadvantages in learning and comprehension of classroom material (Romanelli, Bird, & Ryan, 2009).

In considering the accepted learning modalities (Pashler et al., 2008; Suryono et al., 2021), visual learning incorporates visual aids, such as diagrams, pictures, and slideshows, into lessons and skills. In addition to these learning techniques, it is also common to pick up on the instructors' non-verbal cues in educational settings (Gilakjani, 2012). Because body language cues and images are most beneficial to individuals who learn best through visual cues, working in face-to-face groups where the members can express ideas in drawings and expressions seem to be integral to group projects running smoothly (Dwyer, 1998). Auditory learning is conveyed through speech, tone of voice, emphasis, and speed of the information given (Gilakjani, 2012). In academia, students who prefer auditory learning benefit most from listening to the instructor lecture, as opposed to visual learners who benefit from the slide show aspect of the lecture (Bacro et al., 2013). Kinesthetic learning involves hands-on lessons or activities that allow the learner to be physically involved with the task at hand. This type of learning is recommended to be incorporated within curriculums at educational levels to motivate and encourage students to learn new material, as well as translate the hands-on skills learned into real-world applications (Mobley & Fisher, 2014).

Various pedagogical methods have been previously utilized in medicinal education for the purpose of creating optimal learning environments for students (Farimani et al., 2022; Erkonen et al., 1992; Shim et al., 2018; Hayes et al., 2017). The utilization of kinesthetic learning appears to be the most common and effective teaching method to enhance student learning in modern medicine (Johnston et al., 2015: Ranganath & Josphine-Priya, 2015; Samarakoon et al., 2013; Kharb et al., 2013; Lujan & DiCarlo, 2006; Hernandez et al., 2020). Modern hands-on learning in medicine can include a number of activities to engage students, including creating clay models of organs and body parts, moving paper cut outs of muscles into place on an outline of a body, or dissecting a specimen.

In contrast to kinesthetic learning, which seems to benefit most learners, auditory learning has been observed to be the least effective teaching method for medical students (Kharb et al., 2013; Lujan & DiCarlo, 2006). This can likely be attributed to the average attention span during lectures lasting 10 to 15 minutes (Bradbury, 2016). However, kinesthetic learning is clearly effective and there is also evidence that this learning method induces the highest levels of self-confidence and satisfaction compared to auditory and visual learning (Almasri, 2022).

Furthermore, several studies have suggested that participating in academic hands-on exercises result in significant increases in self-confidence and self-esteem levels for students prior to taking exams (Widiasih et al., 2022; Utomo & Maratus, 2021). Because higher overall learning rates correlate to kinesthetics, and higher retention rates have been shown through visualization (David & Brachet, 2009), implementing dissection into early medical courses may have the capability to increase both factors. Organ dissection can help reveal anatomical structure while also allowing the student to locate the structures based on the hands-on procedure, as opposed to only receiving visual stimuli of a diagram. As an approach to anatomy education, dissection has mainly been researched for the general structure and placement of muscles in the human body (Johnson, 2002; Dinsmore & Zeitz, 1999). The heart is just one example of an organ with layers and numerous structures within itself. Dissecting this organ reveals its internal mechanisms and allows for the conceptualization of cardiac functions such as blood oxygenation through each chamber (Lee, 2010).

One practical way to introduce human heart anatomy to undergraduate college students can be through dissecting pig hearts, which are in vastly greater supply than human hearts (Pierson et al., 2020). Both species of hearts share various commonalities including the size, structure, and function (MICDS, 2021). When examining the structures specifically, two atriums and ventricles, four valves, and an aorta are found in both human and pig hearts (Crick et al., 1998). Therefore, learning the pig heart anatomy through dissection can be seamlessly translated into human heart anatomy without the need for destruction of human hearts. Doing so has the capability to allow students to familiarize themselves with these unique structures and may increase learning due to the kinesthetic approach being taken. While previous studies have shown mixed results on the effectiveness of singular appendage or whole-body dissection for students who learn best though hands-on activities (Hernandez & Vasan, 2018 ; Hernandez et al., 2020), targeting a singular organ as opposed to an entire human specimen has the potential to help students learn more specific material on a more focused scale. Being so, utilizing a pig heart for a comparison between dissection and lecture learning techniques may show more accurate results due to the simplicity of a single organ instead of integrating multiple organs and body parts in a single learning session.

Methodology

Participants

Participants recruited for the current study (n=49) were undergraduate students attending a large university in the pacific northwest United States currently enrolled in a large human anatomy course. All participants were at least 18 years of age and provided written consent to be involved in this study. No exclusion criteria were implemented in participant recruitment, as the purpose of this study was to analyze learning modalities for all types of students, regardless of educational background or prior knowledge. With 60 participants beginning the study, a total of 49 (Male= 19, Female= 30) completed it in its entirety. All study participants received extra credit within this anatomy course as compensation for their participation. IRB approval (#20174-001) for this study was sought and obtained prior to participant recruitment and study procedures.

Procedures

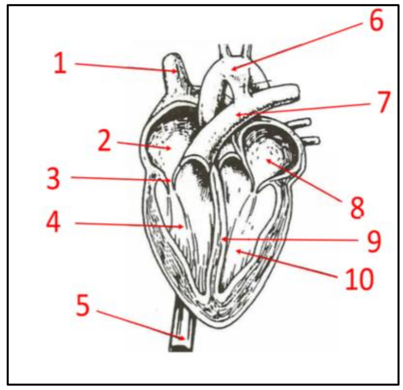

Fig. 1. Pig heart anatomy test, retrieved from https://www.purposegames.com/game/WbGirFIppRw

Participants were randomly divided into two groups: a laboratory dissection learning group and a lecture learning group. The groups were randomized though assigning a number to each participant and entering the numbers into a random number generator. This then divided participants into two random and initially equal groups. Both groups completed an online self-confidence questionnaire (Qualtrics) prior to taking a pretest on pig heart anatomy. The self-confidence portion of the questionnaire included five questions that evaluated the subjects' perceptions of how well they would perform on the pretest. Questions were constructed based on the Rosenberg self-esteem scale (Rosenberg, 1965), which is the gold standard for self-evaluation and reflection in psychological research and has been used in numerous psychological studies (Robins et al., 2001 ; Gnambs et al., 2018 ; Rosenberg, 1965 ; Schmitt & Allik, 2005). Questions were formatted to be answered as, strongly agree, agree, disagree, and strongly disagree. These questions assessed confidence levels in the following aspects: Identifying the different structures of a pig heart, scoring a 70% or higher on the pig heart exam, understanding how blood flows through the heart, determining which chambers receive deoxygenated blood in the heart, and identifying the major artery of the heart. The pretest assessed participants' prior knowledge on pig heart anatomy and depicted a diagram of a pig heart with areas for participants to indicate 10 major anatomical structures of the heart (figure 1). Participants labeled each landmark to the best of their abilities and the test was scored out of 10 points, one point per each structure.

The dissection lab learning group was divided into four clusters of four to five participants for the purpose of conducting pig heart dissection. The instructor began the session by explaining the 10 anatomical landmarks of the pig heart that the participants would be identifying. The instructor then demonstrated the proper dissection techniques while each team followed along and collaborated to dissect the pig heart and pinpoint each anatomical structure. While highly encouraged to follow closely along with the instructor, additional pig hearts were available to students who improperly dissected the specimen during the session. Although there were no occurrences of such, participants could obtain a new pig heart for dissection any time should the need arise.

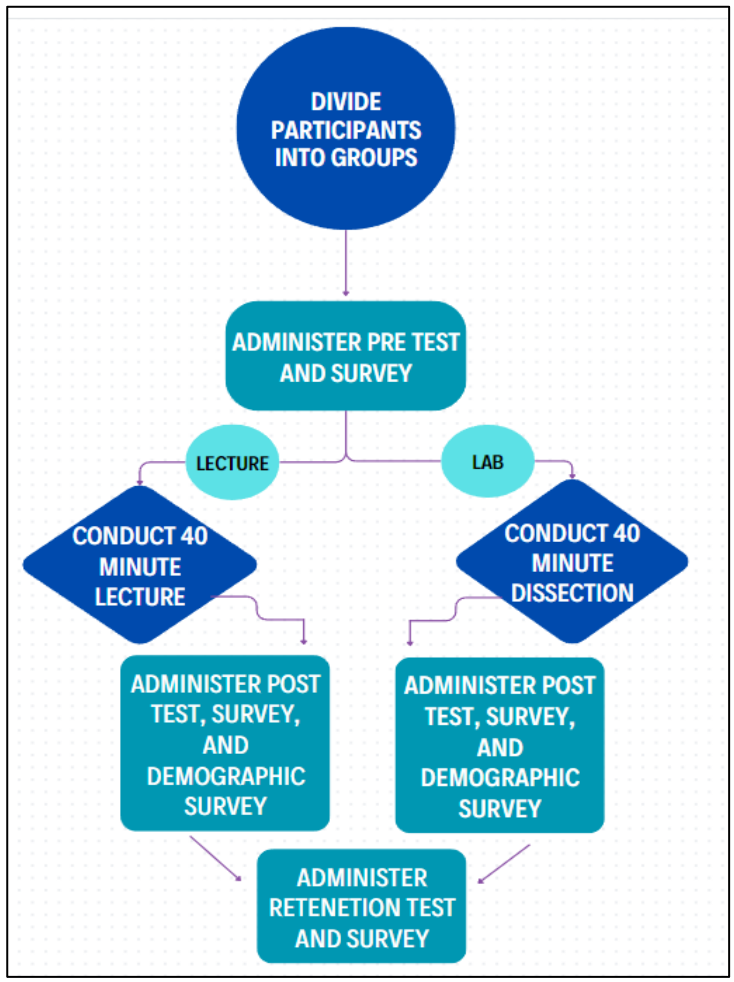

Fig. 2. Procedure study design process

The lecture learning group was taught pig heart anatomy in a lecture style format with slideshows, a common environment for an undergraduate anatomy course. The instructor presented a slide show that included pictures and diagrams of the 10 identifiable structures of the pig heart but did not include the diagram used during pre and post testing. Both the lab and lecture learning groups had a 40-minute time allotment for the instruction session, with the same instructor for both groups. A key point script was utilized for the instructor for both sessions, as to not stray from the material, nor give one group an informational advantage over the other. Questions from participants were interjected during the learning session. They were then asked again at the conclusion of the learning session, however no participant contributed at that time.

Immediately following instruction, both groups were asked to take the self-confidence questionnaire for the second time. All participants then completed the posttest, which was comprised of the same content as the pretest. Finally, a demographic questionnaire was administered to all participants, so as not to create a self-bias if filled out prior to participating in the study. Figure 2 depicts the process of which these procedures will be administered.

Pretest scores were subtracted from the posttest scores to determine the overall change for all study participants. Pre and posttest self-confidence questionnaires were examined via cumulative score to determine any improvement or decline among the participants responses. Two weeks following the learning sessions, a retention self-confidence and pig heart anatomy test were administered via email, which was comprised of the same material as the pre and posttest. These tests were completed at the participants leisure in an uncontrolled environment. If participants were unable to complete the retention test on the given day, they were given one week to make up the test. Retention scores were compared to posttest scores to examine increases or decreases in overall learning.

Self-confidence scores were derived from the scoring of the Rosenberg self-esteem (Rosenberg, 1965) scale, with higher cumulated scores indicating higher the self-confidence rates. Participants scored themselves out of three for each of the five questions, with strongly agree= 3, agree=2, disagree=1, and strongly disagree=0. The scores for each question were then added together to find the cumulative score for the participant, as done in previous literature (Peng et al., 2019 ; Hughes & Black, 2006 ; Martín-Albo et al., 2007).

Because the Rosenberg self-esteem scale classifies low self-esteem as 50% or less out of the maximum total points, any cumulative score less than 7 on the self-confidence questionnaire was defined as low self-confidence. Likewise, any cumulative score 7 or above was defined as a normal range for self-confidence.

Data Analysis

Descriptive statistics were calculated for all variables of interest in the proposed student. These were analyzed using IBM SPSS 29 with an alpha value of .05 to indicate statistical significance for all analyses. Participant demographics were examined via Chi-Square tests in order to quantify the p-value and determine any differences in participant characteristics between groups. Independent Samples T Tests were performed for the descriptive statistics of the raw scores of the pig heart test and self-confidence ratings, and Cronbach's alpha was used to determine reliability.

Mann-Whitney U tests were utilized for all research questions; will visual or hands-on learning produce a greater increase in tests scores on a pig heart exam, will visual or hands-on learning produce higher pre and post-test self-confidence rates when teaching the anatomy of a pig heart, and will visual or hands-on learning produce higher retention rate test scores on a pig heart exam. The pretest pig heart anatomy scores for both the lecture and lab learning groups were subtracted from the post test scores for each participant in order to determine the overall difference in test scores. The same procedure was repeated for the retention and post-test scores. These values were then compared via Mann-Whitney U tests to determine differences between the lab learning and lecture learning groups. Scores of the pre-test self-confidence questionnaires were also subtracted from the post test scores for each participant in order to determine the overall difference in test scores. This process was repeated for retention and post-test scores. These values were then compared via Mann-Whitney U tests to determine any differences between groups.

Results

Participant characteristics and descriptive statistics were calculated for each learning group and were cross examined between the two groups. Table 1 shows the total number and percentage of each descriptive among groups. The majority of participants in both groups were white (65.3%) females (61.2%). A defining characteristic of both of the populations was the presence of first-generation students, of which only 28.6% were identified as in both groups.

Each learning group had equal first-generation participants at seven per group. Participant characteristics otherwise did not differ significantly among groups. The age of participants also showed no significant differences among groups.

Changes in pre to post test scores between the lab group (mdn= 3) and lecture group (mdn= 7) (figure 3) were significant, as $U= 124$, $z= -3.5$, $p= < 0.001$, and $r=0.49$. This indicates a significant difference in the increase of pig heart anatomy test scores among groups. Additionally, the change in post to retention scores between the lab group (mdn= 1) and lecture group (mdn= -1) (figure 4) were also significant, as $U= 462$, $z= 3.36$, $p= < 0.001$, and $r= 0.48$. These results support the indication of significantly different changes in pig heart anatomy scores between the post and retention tests, which suggests that the lecture group responded better to their intervention relative to the lab group. The range of these scores for pre to post-test were valued at a maximum increase of 10, meaning the individual improved by 10 points, to a maximum decrease of -1, in which the individual regressed by one point in their post test score. The range was similar in both lecture and lab groups (figure 3). Figure 4 shows a range of increasing by five points, to decreasing by a near entirety of 10 points.

Table 1. *Participant characteristics stratified by learning group (N= 49)*

Participant Demographics	Lecture Learning Group (N = 27)	Lab Learning Group (N = 22)	P-value
Age, mean years ± SD	19.0 ± 1.2	19.5 ± 1.2	.193
Race (N=49), n(%)			.707
White	18 (66.7)	14 (63.8)	
Asian	4 (14.8)	2 (9.0)	
Hispanic	3 (11.1)	4 (18.2)	
African American	1 (3.7)	2 (9.0)	
Native American	1 (3.7)	0 (0.0)	
Sex, n(%)			.386
Male	9 (33.3)	10 (45.5)	
Female	18 (66.7)	12 (54.5)	
First Generation College Student, n(%)			.650
Yes	7 (25.9)	7 (31.8)	
No	20 (74.1)	15 (68.2)	
Obtained Prior Anatomy Education, n(%)			.386
Yes	18 (66.7)	12 (54.5)	
No	9 (33.3)	10 (45.5)	
Future Career Aspirations, n(%)			.103
Physical Therapist	7 (25.9)	10 (45.5)	
Athletic Trainer	6 (22.2)	1 (4.5)	
Occupational Therapist	5 (18.5)	1 (4.5)	
Strength Coach	3 (11.1)	1 (4.5)	
Chiropractor	1 (3.7)	4 (18.3)	
Other	5 (18.6)	5 (22.7)	

P-value calculated using an independent samples t-test for age and a chi-square test for all other categorical variables. Starred bolded values indicate statistical significance ($p < 0.05$)

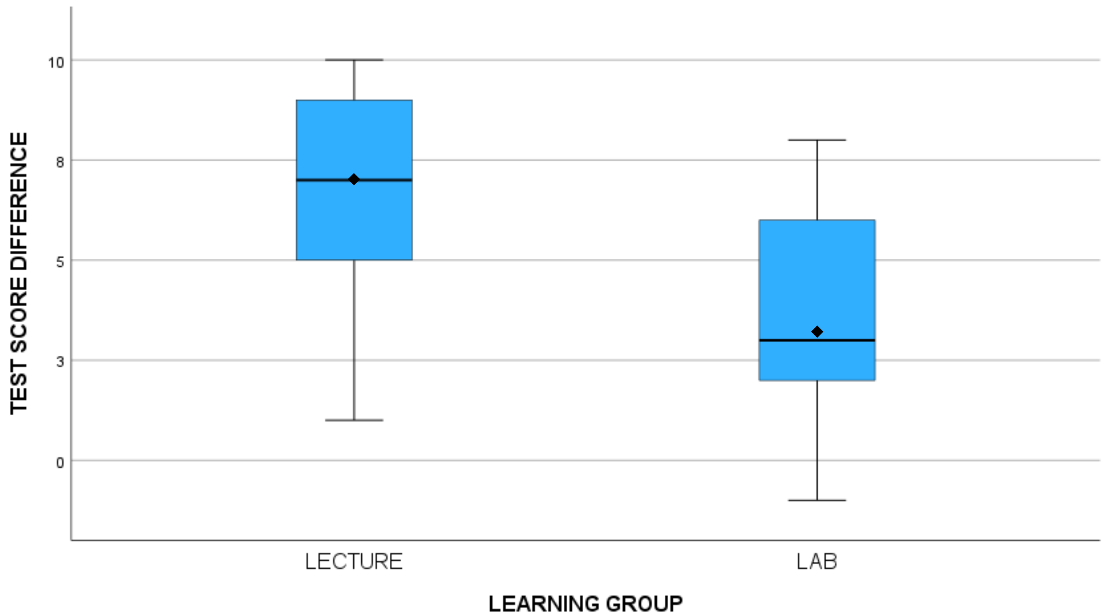

Fig. 3. The change in pig heart anatomy test scores from pre-test to post-test among groups. Black diamonds indicate means of each group. Black lines illustrate medians of each group. Blue boxes represent the inter-quartile range, as the 2nd and 3rd quartiles. Gray whiskers depict the range in which differences in test scores fall, as the 1st and 4th quartiles

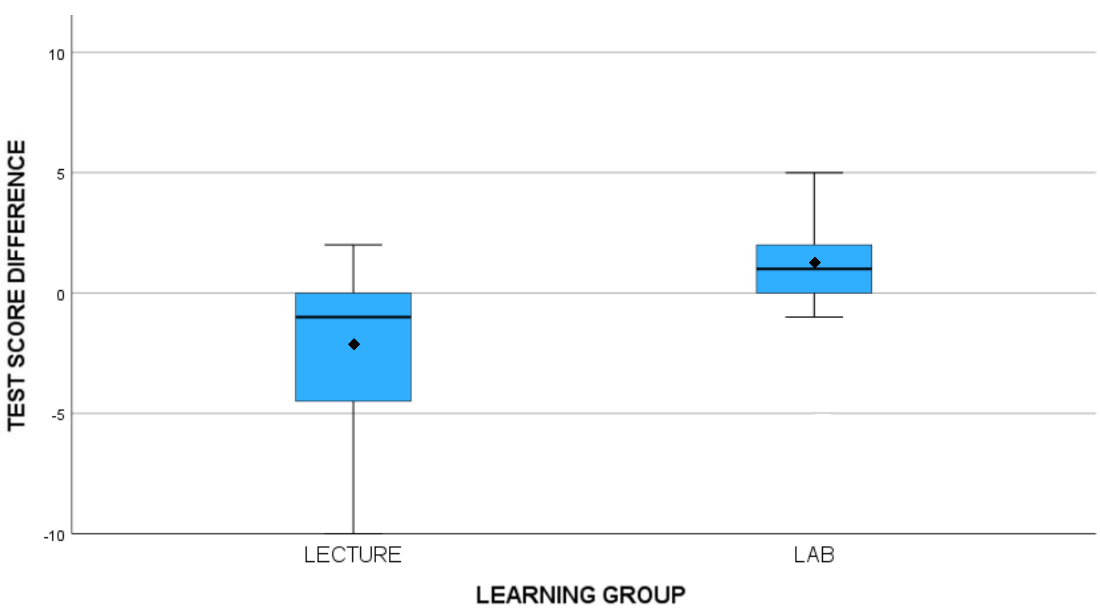

Fig. 4. The change in pig heart anatomy test scores from post-test to retention test among groups. Black diamonds indicate means of each group. Black lines illustrate medians of each group. Blue boxes represent the inter-quartile range, as the 2nd and 3rd quartiles. Gray whiskers depict the range in which differences in test scores fall, as the 1st and 4th quartiles

The lecture group showed a greater change in test scores between both pre to post and post to retention, and the mean score for the lecture group was significantly higher than the lab group. Pre-test scores depicted a baseline knowledge for pig heart anatomy, in which neither group showed a significant difference in scoring higher on the pre-test (table 2).

Pre to post-test self-confidence scores between the lab group (mdn= 4) and lecture group (mdn= 5) (figure 5) were found to not be significant, as U= 228, z= -1.397, p= .162, and r= -0.2. This indicates no difference in increase or decrease of self-confidence test scores among groups. Variances among groups ranged from gaining 11 points on the self-confidence questionnaire to losing one point after the pig heart learning sessions were administered (figure 5). Similar to the pig heart anatomy test results, the mean score of the post-test self-confidence questionnaire was the only significant finding in this regard (table 3). Low self-confidence scores are comprised of any score below half of the total maximum score of the questionnaire. In this case, 7 or lower qualifies as a low self-confidence score.

Table 2. *Average raw test scores and standard deviations among groups in pre, post, and retention tests, scored out of 10 points (N= 49)*

Pig Heart Test Scores	Lecture Learning Group (N = 27)	Lab Learning Group (N = 22)	P-value
Pre-test mean score ± SD	1.9 ± 2.5	2.2 ± 1.8	.608
Post-test mean score ± SD	8.7 ± 1.5	6.0 ± 3.0	**<.001***
Retention Test mean score ± SD	6.3 ± 3.8	7.1 ± 2.8	.395

P-value calculated using an independent samples t-test for age and a chi-square test for all other categorical variables. Starred bolded values indicate statistical significance (p < 0.05)

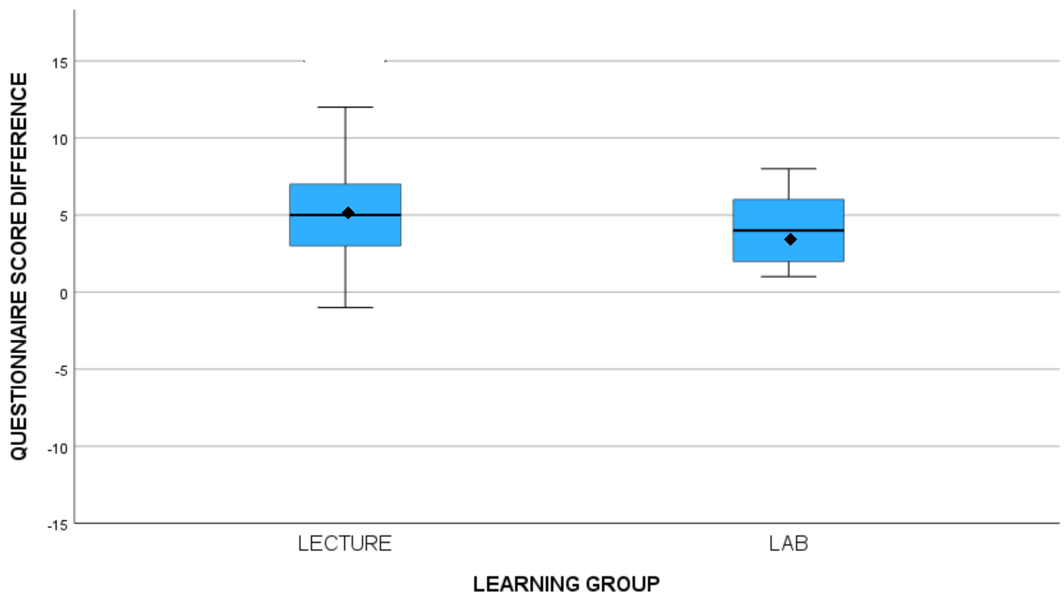

Fig. 5. The change in self-confidence questionnaire scores from post-test to retention test among groups. Black diamonds indicate means of each group. Black lines illustrate medians of each group. Blue boxes represent the inter-quartile range, as the 2nd and 3rd quartiles. Gray whiskers depict the range in which differences in test scores fall, as the 1st and 4th quartiles

The lecture group consisted of 15 out of 27 (55.6%) participants being deemed as having low self-confidence prior to the pig heart learning session, and zero out of 28 (0.0%) after the learning session based on the post-test self-confidence questionnaire. The lab group began with 16 out of 21 participants (72.7%) being categorized with low self-confidence during the pre self-confidence questionnaire, and 3 out of 21 (13.6%) during the post self-confidence questionnaire. The retention test showed similar results as the post test, with the lecture group consisting of one out of 27 (4.0%) and the lecture group having two out of 22 (9.1%) participants remaining in the low self-confidence range. No significant differences were found between groups in relation to low self-confidence categorizations (table 4).

Table 3. *Average raw self-confidence questionnaire scores and standard deviations among groups in pre, post, and retention tests (N= 49). Scored out of 15 points*

Self-Confidence Questionnaire Scores	Lecture Learning Group (N = 27)	Lab Learning Group (N = 22)	P-value
Pre-test mean score ± SD	6.1 ± 3.3	5.4 ± 2.8	.433
Post-test mean score ± SD	11.9 ± 2.1	9.3 ± 2.6	**<.001***
Retention Test mean score ± SD	11.1 ± 2.3	9.8 ± 2.0	**.029***

P-values calculated using an independent samples t-test. Starred bolded values indicate statistical significance ($p < 0.05$)

Table 4. *Number of participants categorized as low self-confidence in pre, post, and retention tests (N=49).*

Low Self-Confidence Allocations	Lecture Learning Group (N = 27)	Lab Learning Group (N = 22)	P-value
Pre-test	15	16	.248
Post-test	0	3	.084
Retention Test	1	2	.581

P-values calculated using an independent samples t-test. Starred bolded values indicate statistical significance ($p < 0.05$)

While this study yielded partial significant results, it is important to interpret them within the context of the moderate reliability indicated by Cronbach's alpha values ranging from .64 to .72 (table 5). This suggests that the consistency of measurements within the study may be somewhat limited. A Cronbach's alpha below .70 is typically considered less than desirable for establishing strong reliability. Therefore, caution should be exercised when generalizing findings or making conclusions based solely on these results. Future studies may benefit from employing additional measures to enhance the reliability of data collection methods, such as increasing sample size or refining measurement instruments to improve internal consistency.

Table 5. *Cronbach's alpha determined for all variables.*

Variables	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pre-test Self Confidence Score	47.27	79.20	.55	.50	.64
Post-test Self Confidence Score	42.43	90.00	.32	.18	.72
Retention Self Confidence Score	42.57	88.33	.60	.42	.64
Pre-test Heart Anatomy Score	56.06	94.60	.45	.40	.68
Post-test Hearth Anatomy Score	50.59	91.62	.40	.18	.69
Retention Heart Anatomy Score	51.39	80.03	.45	.24	.68

P-values calculated using an independent samples t-test. Starred bolded values indicate statistical significance ($p < 0.05$)

Discussion

This study examined the outcomes of student learning via tests scores and self-confidence ratings for two learning modalities, kinesthetic through a dissection lab and visual through a slideshow and lecture, in undergraduate anatomy students. Previous studies have been conducted to examine learning differences between lecture and dissection in order to support the notion that one is more beneficial for students than the other (Vaishnav & Chirayu, 2013 ; Syofyan & Siwi, 2018 ; Suryono et al., 2021 ; Padidar et al., 2015). However, few past studies have conducted these experiments within an undergraduate student population. When medical graduate students are given the opportunity to dissect a specimen, the student has prior knowledge of the human body or specimen they are dissecting (Hernandez et al., 2020 ; Kharb et al., 2013). Because the medical student has already obtained a general understanding of the structures being dissected, their learning may not have as great of an impact as with undergraduate students who have little to no prior knowledge on specimen. In turn, it is plausible that conducting this study on undergraduate students would increase the likelihood of producing a greater understanding of anatomy shown through test scores. Additionally, self-confidence has been measured in medical students when they are dissecting a specimen, and is shown to increase after concluding the dissection (Wu et al., 2007 ; Esterl et al., 2006).

The main research questions pertaining to the existing body of literature included examining which learning modality would produce a greater increase in test scores for the pig heart anatomy exam from pre to post, and post to retention, and which learning modality would produce higher pre and post self-confidence scores.

Due to the ever-increasing number of students pursuing undergraduate degrees, it is critical that kinesthetic approaches to teaching and learning be considered for further integration into curriculums. While the findings of this study suggest that students score higher on tests when taught in a traditional lecture format, integrating hands-on activities in undergraduate education has the possibility to familiarize students with that learning method and in turn, give them the opportunity to practice their kinesthetic learning techniques for dissection and other activities. Additionally, student self-confidence rates have seldom been researched in this context. Gauging students' self-confidence levels surrounding the modality of learning may help determine if that specific technique is helpful in boosting their self-confidence in learning, or harmful in discouraging the student from participating in that learning method.

Many previous studies (Culp et al., 2020 ; Mobley & Fisher, 2014 ; Satterthwait, 2010 ; Huang et al., 2023) have supported the theory that learning through hands-on approaches can be more beneficial to students' academic performance than through a lecture format. The findings of the current study suggest the opposite, challenges the existing research findings, and begs the questions of the true benefits of dissection for undergraduates. It also provides confounding results in self-confidence ratings as opposed to prior studies (Almasri, 2022 ; Widiasih et al., 2022 ; Gitatenia & Lasmawan, 2022).

The primary finding of this study was that the traditional lecture format method of delivering material is most beneficial in terms of overall score change for students based on their pig heart anatomy test scores, but has no effect on self-confidence levels. Evidence supporting a relationship between teaching modality and test score change, both pre to post (U= 124, z= -3.5, p= < 0.001, and r=0.49) and post to retention (U= 462 , z= 3.36, p= < 0.001, and r= 0.48),were found within the current study (figure 3).

Significant improvements were observed in test score performance for the lecture learning group compared to the lab learning group from the pre to post intervention pig heart anatomy test. The lecture group began the study by scoring an average of 1.9 (±2.5) points out of 10. Immediately after which, scored an average of 8.7 (±1.5) points during the post-test. The lab group began the intervention with an ever so slightly higher test score at 2.2 (±1.8) points. While this was not determined to be statistically significant, the difference between each group's improvement was, with the lab group averaging a score of 6 (±3) for the post-intervention pig heart anatomy test. The lecture learning group demonstrated greater positive and overall change from pre to post anatomy test scores (table 2). This is likely due to academic material being communicated in a lecture format throughout the student's educational career, but not dissection. It is possible that students in the current study may have been unfamiliar with or haven't had the opportunity to participate in hands on learning in this manner. Because of the need to process information in a new way during participation in kinesthetic activities (Begel et al., 2004 ; Tranquillo, 2008 ; Pinzon et al., 2017), or an unfamiliarity of learning through dissection, participants may have scored lower in the lab group based on these ideologies. The lecture group had been exposed to the classical format of watching a lecture, while the lab group may have not been exposed to prior dissection. Being so, the lecture group was learning in a usual academic setting.

Significant improvements were not observed in the difference of test scores from pre to post or post to retention self-confidence ratings (figure 5). However, when comparing only the post test scores between groups, the lecture group scored significantly higher than the lab group (lecture group mean self-confidence score of 11.9 ± 2.1 points, and lab group mean self-confidence score 9.3 ± 2.6 points). It is possible that undergraduate students may become intimidated by the idea of dissecting an organ, which they may not have seen or done before. When intimated by a new activity in an academic setting, Salim found students to have a decline in self-confidence rates and increase in anxiety levels (2015). This may be why self-confidence were lower after the intervention in the dissection lab group.

Additionally, it is likely that the post-test self-confidence scores in the lecture group were higher than the lab group because the lecture group students had been learning material through the same way that it was delivered in the intervention. A recent study done by Sadler showed support for this statement, as they found that experience teaching in a certain format was a defining factor in the self-confidence levels of new teachers (2013).

There were no observed differences in baseline knowledge on the pig heart anatomy test (table 2) or self-confidence scores between the lecture learning group and learning group (table 3). This indicates that both groups began the study with similar prior pig heart anatomy knowledge, and that no group had an initial advantage over the other. Regarding retention test scores, there seemed to be no significant differences between groups when completing the pig heart anatomy test two to three weeks prior to the intervention (figure 4).

The findings of both lecture and lab scores were contrary to Shakeri et al., who identified that 70% of approximately 6200 medical students preferred kinesthetic learning techniques in order to perform higher on exams opposed to visual learning (2022). However, the participant demographics of the current study were undergraduate students as opposed to medical students, which may contribute to the differences observed between studies. Another plausible rationale for the differing conclusions could be the overall interest of the students. When similar studies are done in the medical student or nursing population, the participants are all declared to a major or specialty (IE heart surgery, general practitioner, nurse). While in the current study, all participants had undeclared majors. Previous studies have found that if a student has a higher interest in their coursework, they are likely to show higher self confidence in their learning abilities, regardless of if a quantifiable test score reflects as such (Lester et al., 1989 ; Hong et al., 2017).

Strengths and Weaknesses

This study aimed to determine differences in test scores and self-confidence perceptions during material delivered through lecture versus a laboratory dissection. The study concluded that undergraduate students taught via a traditional lecturing format perform better on exams and have higher self-confidence ratings after attending a lecture than students that learn through an unconventional kinesthetic modality, such as dissection.

Additionally, because the pig heart anatomical structures are closely related to the human heart anatomical structures, the students who participated in this study were able to gain knowledge on general heart anatomy. All participants were currently enrolled in an undergraduate anatomy course, and this study was completed prior to the participants beginning the cardiac unit in said anatomy course. Being exposed to heart anatomy prior to the cardiac unit may help the students in connecting the knowledge gained in this study to the coursework given in their undergraduate anatomy class.

However, there are several limitations to the current study. First, the findings are limited to students enrolled in a single human anatomy course at one campus. This sample may vary from other undergraduate student populations across other universities and their reciprocation of knowledge based on delivery method. Approximately 25% of the course enrollment participated in this study. It is possible that this sample was not representative of the remaining 75%, and therefore, the study was also limited to the 25% sample.

Second, the present study only assessed the dissection of a single organ. Previous studies have dissected whole or partial limbs, or have had multiple sessions dissecting various organs or body parts (Seluk et al., 2019 ; Gunderman & Wilson, 2005 ; Ghosh, 2017). Perhaps if students were given the opportunity to dissect a heart initially and then repeat the dissection process for other organs, they may become accustomed to this method of learning and potentially increase their anatomy and self-confidence scores due to the increased familiarity.

Third, some participants may have a more extensive background and prior knowledge in anatomy than others. This factor introduces a potential bias, having prior anatomical understanding and familiarity with anatomical concepts could influence their comprehension of instructions, performance on tasks, and even their pig heart anatomy test scores. Consequently, results may not accurately represent the general population or overestimate the effectiveness of interventions for individuals lacking prior anatomical knowledge. To mitigate this limitation, future research could consider stratifying participants based on their level of anatomical expertise or implementing control measures to account for this potential confound.

Finally, because the anatomy tests were completed online, there was no proctoring done for cheating during the pre, post, and retention tests. While discouraged, it is entirely possible that participants could look up answers to the anatomy test and claim them as their own. This factor has the capability to greatly skew results based on the number of participants that completed the pig heart anatomy tests to the best of their ability and the number of participants that true test scores were unable to be interpreted if answered with assistance. Going forward, an online proctoring software could be used, or have the participants take the tests on paper in order to mitigate possible cheating.

Conclusion

This thesis represents an effort to investigate student learning and self-confidence perceptions on visual and kinesthetic delivery of material. While a kinesthetic learning modality is generally found to be beneficial for learning and retaining academic material, differing results are found in this study, specifically in dissection. The post-test self-confidence ratings were higher in the lecture group, which had previously been familiarized with the learning modality executed. This study focused on the comparison of test scores and self-confidence scores among students learning through lectures and dissections. Preliminary baseline results depict no differences between groups in both anatomy test scores and self-confidence scores. While both groups' anatomy and self-confidence scores increased after the intervention, the lecture group proved to show a significantly greater increase in scores for both variables compared to the lab group. Retention scores were also examined, but no differences among groups were determined.

CHAPTER FIVE: CONCLUSION

This thesis study aimed to investigate the effectiveness of different learning modalities, with kinesthetic learning conveyed through dissection and visual learning through lecture-style instruction, in undergraduate anatomy education. The findings presented in this study provide valuable insights into the impact of these modalities on students' test scores and self-confidence levels. While the results were contrary to some existing literature, they contribute significantly to our understanding of effective teaching methodologies in anatomy education. The general consensus of previous literature found kinesthetic learning, particularly through hands-on activities such as dissection, is emphasized as a highly effective method in medical education. However, the findings of this study revealed unexpected results, challenging the current ideology that kinesthetic learning is universally superior in educational settings.

Contrary to expectations, the lecture-style instruction showed greater efficacy in terms of improving students' test scores on pig heart anatomy exams compared to hands-on dissection. Additionally, self-confidence ratings were found to be higher after the intervention in the lecture learning group, indicating a positive perception of learning outcomes. The discrepancy between the current study's findings and existing literature highlights the complexity of educational research and the need for context-specific analysis. While kinesthetic learning has been widely advocated in medical education, its effectiveness may vary depending on factors such as prior experience and familiarity with specific instructional methods.

Despite the contradictory findings, this study provides valuable insights into the dynamics of learning modalities in undergraduate anatomy education. It highlights the importance of exploring diverse instructional approaches and tailoring teaching methods to meet the needs of diverse student populations.

While the findings of this study may challenge conventional practices, they underscore the need for continuous exploration and adaptation in educational settings. By embracing an understanding of learning modalities and leveraging evidence-based pedagogical strategies, educators can create more effective and engaging learning experiences for students in anatomy education and beyond. Through this experience, I was able to gain critical insight for effective strategies in pedagogy, as well as work closely with the population that I intend on instructing during my future career. As a strong advocator for the utilization of hands-on activities in classrooms, I believe this study was supplementary to the existing body of literature, even if the results conflict with teaching methods that I have used in the past and seemed to be beneficial to students.

An overwhelming challenge I faced during this study was the dropout rate of participants. Roughly half of the human anatomy class had signed up to take part in this study, but there was about a fifty percent dropout rate. This lead to fewer completed tests, and therefore less data to analyze and apply to studies with larger sample sizes. There were, however, great successes produced by this study. One of which was giving undergraduate students an opportunity to become familiarized with general heart anatomy and set them up for success when the cardiac unit is taught in their anatomy course. Being able to work with students to prepare them for class material has also provided me with valuable experience in teaching and communication classroom material.

The overall takeaway from this study for me was that in certain settings, hands-on learning activities may not be as beneficial in undergraduate anatomy education as previously anticipated. I aspire for future studies to analyze dissection in undergraduate education on a consistent, longitudinal basis to determine if repeated dissection creates a linear relationship to improvements in tests scores, self-confidence, and overall student learning.

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APPENDIX

APPENDIX A: WASHINGTON STATE UNIVERSITY IRB APPROVED KEY POINT SCRIPT

Key Point Script:

Self-Introduction:

- Name, year in college, teaching experience, career plans, why I decided to conduct this study

Briefing on pig heart anatomy and relationship to human heart anatomy:

- Overview of all pig heart structures
- Overview of all human heart structures
- Relationship of structures and translation of hearts to result in pig-to-human heart transplants

Pig heart structures:

- Superior vena cava location & functions
- Right atrium & location & functions
- Tricuspid valve & location & functions
- Right ventricle location & functions
- Inferior vena cava location & functions
- Aorta location & functions
- Pulmonary trunk location & functions
- Left atrium location & functions
- Interventricular septum location & functions
- Left ventricle location & functions

Wrap up:

- Describe how blood flows through the heart and how / where it becomes oxygenated
- Highlight the aorta as the largest artery in the body and the main artery for the heart
- Reiterate each structure and its location both independently and in relation to the other surrounding structures
- Ask for, and answer any questions

APPENDIX B: IRB APPROVED INFORMED CONSENT

WASHINGTON STATE UNIVERSITY
Department of Kinesiology and Educational Psychology
Research Study Consent Form

Study Title: Differing Pedagogical Methods in the Teaching of Pig Heart Anatomy

Principle Investigator: Chris Connolly, PI and chair of the proposed thesis committee, 509-335-7605, c.connolly@wsu.edu

We are asking you to take part in a research study being done by Hannah Farrington at Washington State University (WSU). Your participation in this study is completely voluntary. You may choose to not answer specific questions and are free to discontinue participation at any time.

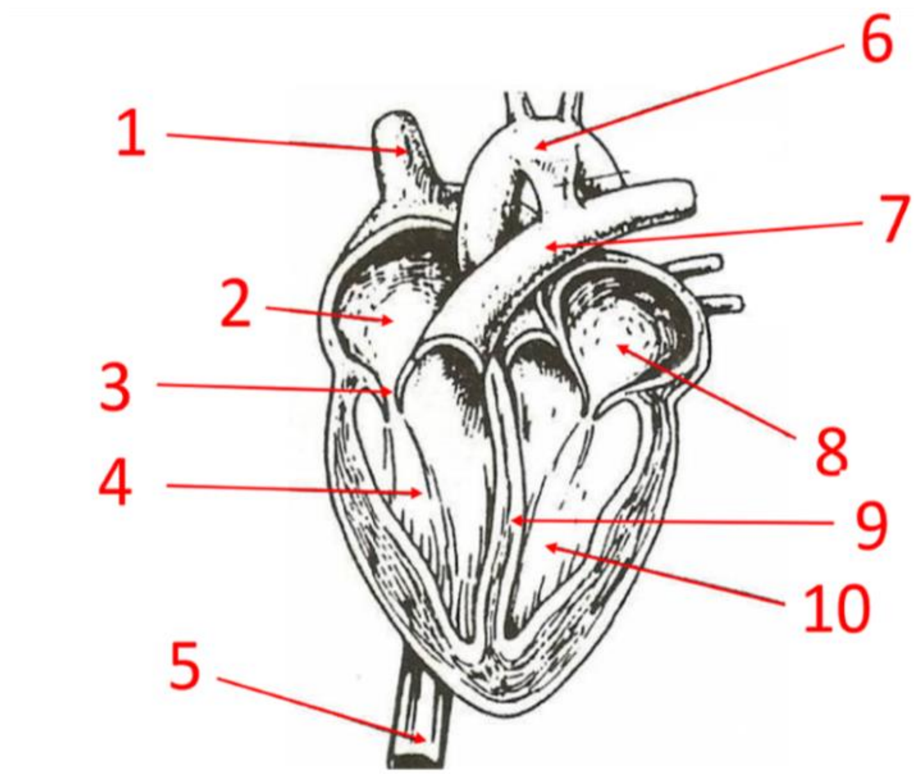
If you choose to be in the study, you will complete a learning session focusing on pig heart anatomy, a self-confidence questionnaire, a test regarding anatomical structures of the pig heart, and a general demographic survey. These questionnaires and tests will help us learn more about the effectiveness of anatomical teaching methods on undergraduate performance and self-confidence. The questionnaire will take about 20 minutes in total to complete. The session will begin by administering a pre-test regarding the pig heart and self-confidence, which will take about 10 minutes. After which the pig heart anatomy lesson will take place, for 40 minutes. The learning session will then conclude by the administration of a post-lesson pig heart exam, self-confidence questionnaire, and a demographic questionnaire, again lasting about 10 minutes. The entirety of the study will last approximately 60 minutes from start to end. Two weeks post-study, a retention test will be given out. This will include the same information as the previous two tests. You will be offered 15 points of extra credit for the KINES 262 course (Human Anatomy) for participating in the study and completing the tests and questionnaires.

You may be asked to learn the pig heart material via a method commonly used in undergraduate education, being a slideshow / lecture format, or a less common method, being dissection. There is always a possibility of misuse of the dissection tools and may be a risk of injury. To avoid this, safety and proper dissection tool handling will be discussed prior to any usage of the tools or dissection. The instructor is CPR / First Aid certified. In the event that a participant becomes injured, a first aid kit will be readily available, as well as a certified individual to help care for the injured individual. While highly unlikely, if a participant requires medical attention beyond first aid, the instructor will be made aware of where AEDs are in the building and will call 911 for severe health emergencies. We will keep your answers confidential and will not share your information with anyone outside the research team. You can skip questions that you do not want to answer or stop at any time. This research is not likely to provide direct benefits to subjects.

Questions? Please contact Hannah Farrington at Hannah.farrington@wsu.edu. If you have questions or concerns about your rights as a research participant, you can contact the WSU Human Research Protection Program (HRPP) at irb@wsu.edu. This study has been certified as exempt by the WSU HRPP.

If you would like to participate in this study, please click the “Agree” button to continue to the participation portion of the study.

APPENDIX C: PIG HEART ANATOMY TEST



1: ____

2: ____

3: ____

4: ____

5: ____

6: ____

7: ____

8: ____

9: ____

10: ____

APPENDIX D: SELF-CONFIDENCE QUESTIONNAIRE

Self-Confidence Questionnaire

Please answer the following questions regarding your perceived self-confidence in the following areas:

1) I can identify the different structures of a pig heart.

Strongly Disagree   Disagree   Agree   Strongly Agree

2) I will score a 70% or higher on the pig heart exam.

Strongly Disagree   Disagree   Agree   Strongly Agree

3) I understand how blood flows through the heart.

Strongly Disagree   Disagree   Agree   Strongly Agree

4) I can determine which chambers receive deoxygenated blood in the heart.

Strongly Disagree   Disagree   Agree   Strongly Agree

5) I can identify the major artery of the heart.

Strongly Disagree   Disagree   Agree   Strongly Agree

APPENDIX E: STUDENT DEMOGRAPHIC SURVEY

Student Demographic questionnaire (optional, answer as few or as many as wanted)

1) What is your age?
   a. ____
2) What race do you identify as?
   a. ____
3) What gender do you identify as?
   a. ____
4) Are you a first-generation college student?
   a. ____
5) Have you had any prior anatomy education?
   a. ____
6) If so, what kind of education and for how long?
   a. ____
7) Are you transferring from a different major / program?
   a. ____
8) If so, which major / program?
   a. ____
9) What are you most looking forward to learning about in KINES 262 (Human Anatomy)?
   a. ____
10) How often (per week) do you attend KINES 262 (Human Anatomy)?
   a. ____
11) How often do you attend KINES 262 (Human Anatomy) labs?
   a. ____
12) Did you attend optional, additional lab study times?
   a. ____
13) If so, how many?
   a. ____
14) What career do you plan on pursuing after college?
   a. ____
15) Are you currently enrolled in BIO 251 (Introduction to Human Physiology), BIO 315, (Gross and Micro Anatomy), BIO 353 (Advanced Human Physiology), or BIO 354 (Human Anatomy for Health Occupations)?
   a. ____