HOW DOES THE USE OF THE ANATOMAGE TABLE IMPACT STUDENT LEARNING OF ANATOMY AND PHYSIOLOGY CONCEPTS?

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2021

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ABSTRACT

Anatomy and Physiology is a class that relies heavily on visual models. In this study, the use of the Anatomage table was used during the skeletal system and muscular system units. A comparison group did not use the table for their lab in the first unit, and an experimental group used the table. During the second unit, the groups switched so that all students got to experience working with the table in at least one unit. Pre and post-test data, surveys, interviews, and retention tests were used as data collection tools. The results suggest that the Anatomage table has benefits for some students, especially in identifying and applying the knowledge acquired in the units. It had less of an impact on written test scores, especially in higher achieving students.

INTRODUCTION AND BACKGROUND

Context of the Study

Recently, the use of virtual programs in the anatomy and physiology classroom has become more common. The change to virtual learning because of the COVID-19 pandemic has made it so using real cadavers is not an option. Some teachers have been making videos of actual cadaver dissections, and others have changed to relying entirely on the virtual programs that are currently available. The program that will be used in this study is an Anatomage Table. Four different cadavers have been scanned into this table. They have different genders and different ethnicities and have different causes of death. This diversity of cadavers is not generally found in other virtual programs.

This table comes with many different tools that go beyond just the corpses themselves. It has numerous histology slides that can be viewed and a variety of different animals scanned in for more variety in dissections. It also has a study card/quiz tool that can help students identify the different parts of the human body. It also has some preset labs for students to go through for each body system. In the current curriculum, the table and its many tools are used as frequently as possible.

Sidney High School applied for a grant to get this technology in the anatomy and physiology classroom. Several grants were given out across the country to get this technology in high schools for anatomy and physiology education. One of the caveats to the grant was that it had to be used at all education levels. The local hospital has used the table to practice procedures and train emergency medical responders. Since the table has

these practical applications in the community, it leads to the following question: What are ways to use this tool to help students understand anatomy and physiology?

A large portion of students are interested in working in the medical field at Sidney High School. Since there is such high interest, it is a vital tool to use in the classroom as there is no access to real cadavers. This table has a variety of tools that are great for studying the anatomy of a human being. Specific organs can be highlighted for the students to identify. This table also has the bonus of showing how the human body's reality looks different from the textbook pictures. Integrating all of the tables features into the class curriculum brings up the following questions: How does the use of the more realistic model impact student understanding of anatomy and physiology? How would the use of these tools to study (instead of note reviews) impact student knowledge?

In today's world, a lot of jobs are becoming increasingly dependent on technology. This generation of students is particularly well adapted to all the uses of electronics. Students tend to be more engaged when working with technology; this raises the question of how will using the table impact student engagement. While the table's use in labs is intriguing, it has one significant hindrance to its use in the classroom. This tool takes more class time than a traditional lab, and as class time is limited, it is necessary to use the table efficiently to increase its educational value. Another aspect the study will address is if the time spent using the table worth the educational benefits.

The results of this study will improve the anatomy and physiology/ biomedical science instruction by ensuring that it is an effective instructional tool that the students find helpful. It specifically examines how the Anatomage table impacts student

knowledge of body structures and their ability to recognize and label them during a test or practical exam. By doing this project, more knowledge will be gained on how to use the cadaver table more effectively and see its impact on student test scores.

The purpose of this study is to improve the anatomy and physiology lab instruction. This study examined how student learning is impacted by the use of the virtual cadaver table. The labs are already set up in stations for different topics. There is always a station for labeling, one where they talk about diseases of the system being studied and three practical applications/examinations. The study's goal was to see how being able to view the different systems on an actual human body helps them understand the system and its functions.

Focus Questions

The focus question was, How does the use of a virtual cadaver table impact student learning of anatomy and physiology concepts?

The sub questions include the following

1. How is student engagement impacted by the use of the virtual cadaver table?
2. How does the use of a virtual cadaver table affect student retention of material?
3. What are student perceptions of the use of this technology and its contribution to their education?
4. How do students feel about using the table outside of class time, as it typically takes longer to complete labs on the Anatomage Table?
5. How do lab grades change for students using the table vs. students who do not?

CONCEPTUAL FRAMEWORK

There are not many studies out there that specifically look at the usefulness of the Anatomage table in high school education. It is used more often at the college level, and the technology is relatively new. One study was done at the University of Nebraska with their medical students to see the Anatomage table's usefulness in their different classes. It addressed student attitude about using the Anatomage table and showed that most of the students from the study found that it was helpful (Custer & Michael, n.d.). It was found that using the table for 1-3 hours a week seemed to be the best for the students. Another result of this study found that students felt it helped prepare them better for their medical field careers (Custer & Michael, n.d.).

The Anatomage Table has been used at different Universities around the world to educate medical students. It has been found to improve test scores and create more efficient labs (Taoum et al., n.d.). The table has been used as a diagnostic tool as well. Diagnostic medical scans can be opened with the table and rendered in 3D. The research done on this makes the technology relatable to the real world as it has applications in the medical field. It has already been used to measure tumors and find damage in trauma patients (Taoum et al., n.d.). However, other 3D body programs are being used in the classroom.

Other studies have focused on evaluating visualization software and how it impacts student learning (Jamil et al., 2019). These software programs are similar to the Anatomage table and one of its primary uses. It showed that students with poor spatial ability did not benefit from the 3D visualization software they were using (Jamil et al.,

2019). They did a test on multiple intelligences to see what kind of learners were in their group. It is essential to keep in mind that students who do not have great spatial ability may struggle with learning from visual software programs. All of their findings were statistically significant, showing that 3D visualization did help with comprehension.

Some virtual anatomy studies in the classrooms include similar lab formats to what is used in the current anatomy and physiology classroom. The labs are station-based and show that the method used in this study of the Anatomage table is an effective way for students to learn. It also includes student perception of the helpfulness of the technology. Using cadavers and visual references in the lab is perceived as more helpful than independent study (Goldina, 2018). The data from this study was primarily qualitative and obtained from student surveys. The study used a numerical rating system for a student survey and displayed their data in a bar graph. This method showed each question broken down into a separate graph based on student responses.

Since student attitudes are one of the things addressed in the current research question, the concept of perceived learnability needs to be addressed. Although the study is done at a college level, there are still correlations to the high school classroom. The subject matter must be something students believe they can grasp. Studies have been done that aimed to change the way anatomy and physiology was taught, with one of the interventions being the use of computer-based animations and simulations to improve instruction (Eagleton, 2015). The simulations used in this study are close to the function of the Anatomage table. It showed that students thought that the use of the simulations made the material easier to comprehend.

First, it talks about addressing the different learning styles and relates them to emotions and feelings. It focuses primarily on Vygotsky's theories on how scientific tools and sociocultural are needed for learning (Eagleton, 2015). Another part of the research is a survey of student perceptions of how the technology is beneficial to address students' learning satisfaction. The emotional level of frustration with the technology will also be an essential factor to the project. In the current anatomy and physiology classroom, using a blended learning style referenced in the paper reinforces how the class is set up.

There are a variety of different ways that material is presented in each unit. There have been studies that looked at mixed instruction used in the classroom monitored for this study. This year has also presented a unique position where there are multiple platforms that students are using to receive instruction. Some studies have been done that compare to face to face, online, and combined instruction. Ideas discussed in these studies provide a framework for the lesson plans used in the current study. There are blending platforms in the lesson plan for blending in lecture and class activities with a virtual cadaver table (White, 2019). The results show that students had mixed feelings about which type of instruction was best. The exam results showed that a combination of the two delivery methods resulted in better student performance (White, 2019).

The splitting up of the treatment groups in this study was unique. The treatment and non-treatment groups swapped in different units. Since all students should get the opportunity to use the Anatomage table, it is a good strategy for use in a high school anatomy classroom. The study split the subjects into three different groups of students. One set of students did not use any supplemental visual material, and another group only

uses regular hands-on dissections. One group does a mixture of the two. One problem encountered in the research was class size because the groups need to be as diverse as possible to make the research better.

Just as the study conducted by the University of Nebraska where it talks about one of the advantages of the Anatomage table being the 3D manipulation and dissection, others also point out the importance of 3D models in education. An article talks about the benefits of using 3D models rather than just 2D ones in instruction. It states the 2D drawing tends to oversimplify the structures because of a lack of depth (Kuehn, 2020). The study used 3D images sent to students to help them understand the 3D relationships of the different anatomical structures. At the end of their study, they had students fill out surveys in which most indicated that the 3D images helped with understanding. The cadaver table does an excellent job at showing the depth and complexity of the human body. There are no perfect-looking pictures of organs that are depicted in textbooks. You can also remove layers as you dissect the cadaver giving the depth that the 2D images lack. Since this study shows the usefulness for people going into the medical field, the table's use will hopefully produce a similar result for the high school students.

There are quite a few studies for 3D visualization models of the human body and their use in medical school classrooms. The results of these studies range from a significant improvement in test scores to no noticeable difference. The studies that involved the use of the Anatomage table were mainly focused on student attitudes toward using them in the classroom, and it was mostly met with positive results.

METHODOLOGY

To test if the use of the Anatomage table improved student understanding of the material, the use of the table was studied over two academic units. The first unit of study was the skeletal system, and the second was the muscular system. Each unit had two labs, two activities, and lectures. At the end of each unit, all students will be given the same unit test. Tests were scored and compared from the treatment and non-treatment groups to find any differences in content knowledge. The treatment and non-treatment groups will swap roles in each unit.

Demographics

There are twenty-two students in the class, and they were split up into groups of eleven students based on different learning modalities. To account for this in group formation, each of the students took a learning style test or a test to measure visual/spatial ability. This survey's results were used to even out the number of high spatial ability students and low spatial ability students. By doing this, the impact of the treatment on students with different learning abilities can be monitored. It also eliminates a potential source of error in the data that could arise from putting all visual learners in one group and none in the other, causing the data to be skewed. The students who took the class had to score a B or better in biology class to take the course so there is a high level of academic achienvment amoung the students. Their academic achievement level was a secondary measurement use in the organizing of the groups. For example there were two students with IEPs in the study, and they were put into different groups so that the data would be less skewed dut to academic achievement.

Treatment

The treatment group used the Anatomage labs for their respective units. The Anatomage labs will have multiple stations/parts to them, just like the traditional lab. It will differ in that all the lab stations will be done at the table. There will be a labeling component that will be done using presets that have been set up for the students to use. The students color code and label the different bones/muscles and save the image to the table to be graded later. One of the stations has a quiz component integrated into this portion of the lab based on the system's images that were chosen. A sample virtual cadaver lab that includes these criteria can be found in the appendix. There is only one Anatomage table the students worked in groups of two to three while doing the lab.

There is at least one case study per lab related to the system being studied. Each case study will show the 3D MRIs of the patient's disease and display the doctor's report from the patient. There are other parts to the lab that involves manipulating the human cadaver to see how the parts of the system are related and demonstrations of physiological principles. An example of a physiology application on the Anatomage Table is its function in the cadaver options that allow the student to see the normal blood flow through a human and what happens when an artery or vein gets clogged. Students in the treatment group have to do at least one of the activities/experiments from the regular lab because they cannot be replicated or correlated to anything on the virtual table.

Each class period is fifty-five minutes long, and the different lab activities were given specific amounts of time for completion. Students were given twenty minutes to

manipulate color and label the cadaver. The case study portion was fifteen minutes, and the physiology activity was ten minutes allowing time to switch between programs, save their work, and shut down the machine. These labs take two class periods to accommodate for having only one Anatomoge table, so the next day, students had another case study and played three rounds of the quiz game for the system.

Data Analysis and Strategies

This study used data from every student in both groups. All students participated in the survey and the interviews as it is such a small sample size. The small sample size makes this manageable with the time allotted for class. Since the research project will span two units' time frame, the data that came from the study was collected on multiple occasions. Typically, the units are three to four weeks long, so most of the study was done over a period of about three months, with the retention test being given a month later.

As the project progressed, student interviews were done at the end of labs as assessments for sub-questions 1, 3, and 4. The interviews were recorded at the end of all of the labs. The labs happened over two class periods because all the different stations were incorporated plus the constraints fo having only one Anatomage table for students to work on, and student engagement was measured for both groups at random points throughout the class periods. Lab scores obtained during the study were collected at two different points within each unit for a total of four different lab scores for the project's duration. The data from the two different summative assessments was gathered at the end of each unit and then a final summative assessment to test for retention.

The first part of the data will be the information used to sort students into groups creating an experimental and comparison set of data. The information from the learning styles surveys and put in a data table (Figure 1). The table will keep the information organized and in an easy-to-view format for the creation of groups. The next set of data will be collected from a pre-test which will be scored. This quantitative data will put in an Excel sheet for analysis and graph creation. Short answer question results will be stored in a file folder for comparison after the post-test.

Student engagement was measured throughout the different lab periods. All of the labs took about two class periods to finish, and engagement was randomly checked at three points in time during class to see if students are on task and working on the lab. The data from this portion of the unit was observational. While monitoring the lab, there were three random times per lab day that were checked. One checkpoint was towards the beginning of the lab, one about halfway through, and the last one was checked towards the end. Observations were recorded in the teaching journal and are discussed later. Student surveys were used as a measurement tool as well for this factor in the research. These surveys will be kept in paper copy or online in Google forms. Most of the data will be qualitative, and any numerical or ranking responses were inputted into an Excel document.

For summative assessments, results were put into an Excel spreadsheet, just like the pre-test. The short answer questions were filed in a folder to compare the pre-test questions and, eventually, the retention test questions. The test score data were entered into an Excel spreadsheet that has been made into graphs. That will show the relationship

between student performance with the use of the table to student performance without it. Standard deviation was calculated for each of the summative assessments to examine the variation in test scores among groups.

Student surveys were collected for answering the time question of the project; part of them will be designed so that there is a scale that students can use to rank their responses. There will also be space for them to leave comments that were kept as paper copies. The numerical data was used to create graphs depicting student opinions. For the comment part, student quotes were included to show a pattern from the responses. The quotes represent the data collected from the surveys.

Throughout the project, student interviews were conducted after labs and at the end of the retention test. They were integrated into the lab stations, and a camera was set up to record these interviews as students go through them. The files that were created during this project were stored in a computer folder that was made for the project. The use of significant quotes from the data will be qualitative, but students who make similar comments could be organized into groups.

Table 1. Research matrix showing how each set of data collection answers the main topic questions and sub-question.

	Data Collection Methodologies						
Data Collection Matrix	Survey	Interview	Pre-test	Lab scores	Test	retention -	Final
Research Questions							
Main Topic How do the use of a virtual cadaver table impact student learning of anatomy and physiology concepts?	1	1, 2	3	4	4, 5	6	1
Sub-question #1 How is student engagement impacted by the use of the virtual cadaver table	1	2		4			
Sub-question #2 How does the use of a virtual cadaver table affect student retention of the material?			3	4	5	6	1
Sub-question #3 What are student perceptions of the use of this technology in their learning?	1	1, 2					1
Sub-question #4 How do students feel about using the table outside of class time, as it typically takes longer to complete labs on the Anatomage Table?	1	1		4			1
Sub-question #5 How do lab grades factor into student learning and retention for students using the table vs. students who do not?				4	4, 5	6	1

The data that addresses the study's central question will come from all of the different data collection sources. It has been split into quantitative and qualitative sources that will give me data on each stage of the research project. For sub-question one, it was primarily

qualitative data that is obtained through observation. Data was also obtained for these questions through student surveys that were used to determine student perceptions of their engagement. The information that was gathered from lab scores is used to support the main question of this study. The reasoning behind this is that students who are engaged tend to perform better on activities and assignments.

The second sub-question has to do with student retention on the material. The pre-test was a source of data for this question because it shows the information the students have already retained from previous classes, and it was used for comparison to the retention test. The correlation between these two scores gave insight into the answer to this question. The other data sources show the retention of information throughout the treatment and its value to the students. Qualitative information obtained from student interviews was used at the end of the research to answer this question.

The third sub-question deals mostly with student perception; this has been based on qualitative data from student surveys and interviews. There were some numerical ranking questions on the student surveys that will be put into a graph. Sub-question four is also measured with the qualitative data from student surveys and interviews. Lab scores can also be a potential point of data to make sure that the time is worth the educational outcome.

For the fifth sub-question, lab scores were compared to the test scores to determine any correlation. The information collected from these instruments' use shows the relationship between practical application and actual comprehension of the material. This data set will show the progress through the treatment, and data from the post-test and the

retention test will be used to answer it. An interview question was included that addresses this portion of the research. The qualitative data that was gained by the interview process was used to support the claims related to this question.

To establish the validity of the assessment, a group of science educators looked over the assessment that was used. The unit plan was made at the beginning of the school year and was approved by the administration. It met all of the standards that needed to be covered in the unit. It also had an added medical emphasis. They also review the lab procedures to ensure that students were getting the same content in each group. They agreed that the labs had the same content presented in different ways. This ensured that the results would be primarily affected by the Anatomage Table's use as there was only one critical instructional change.

All of the students were given the same review guide and the same learning outcomes at the beginning of the unit. These outlined all the information that they would be responsible for understanding. The performance in the lab and scores on the lab sheets were all consistent, showing that they understood the material. The results are reliable because they showed that their scores were very close to what the student performed, with slight differences due to the experimental variable.

The research methodology received an exemption from Montana State University's Institutional Review Board (Appendix A).

DATA ANALYSIS

The following data from the experiment will be presented in the order in which it was gathered. The different learning styles that were assessed to form the experimental and comparison groups was analyzed first. An interview followed the lab score and performance tasks to understand student perceptions of the lab. Then the summative assessment data was analyzed from both the skeletal and muscular system units. Next, the pre-test and retention test scores were reviewed to see if there was any impact on student understanding. The last bit of data that will be reviewed comes from the surveys that were given at the end of each unit.

Data Analysis

Learning styles

The first set of data collected found that most of the students were visual learners and that very few were predominately tactile learners. Figure one shows that there is also a high number of auditory learners in the class. There were also quite a few students that were tied in two different learning styles. Many of the students had the same score in two different lerning styles. The student survey results showed that a combination of visual and tactile or tactile and auditory was common in the selected study group. There were no students that were both tactile and auditory learners in the sample. This trend could be because it is a scarce combination. After all, the learning styles of auditory and tactile are very different from each other.

Table 2. Student ranking in each of the different learning styles.Blue is the lowest score, green is the second highest and yellow is the highest, (*N*=22).

Visual(15)	Tactile (5)	auditory (7)
32	30	18
28	28	20
30	30	24
26	24	24
18	16	24
20	26	28
30	24	30
36	28	24
30	36	18
22	18	9
30	24	16
24	26	18
22	19	20
28	28	30
26	24	28
32	26	22
26	16	16
28	26	18
28	30	36
24	22	28
24	21	18
32	14	32

The table shows the rankings of each student put down for each statement on the survey. The highest learning style score is in yellow. The second highest is in green, and the third score is in blue. Some of the numbers are significantly higher, being in the high twenties' low thirties for a score. The reason for this pattern has to do with the rankings that the students chose. Choices, where students picked the seldom category, were only worth one point, the sometimes categories were worth three, and the often category was

worth five. Students who picked seldom more often had lower numbers in all categories than students who picked the category often and sometimes more frequently had a high number in all the categories.

Many students said that they prefer to see information written on the board and then have it supplemented by visual aids, making sense with the overall pattern shown in the data. There was high ranking in other visual categories, such as being good at solving jigsaw puzzles and remembering things by picturing them in their minds, which is one of the questions that point to them being visual learners. It was rare for a student to score low in the visual learning style category.

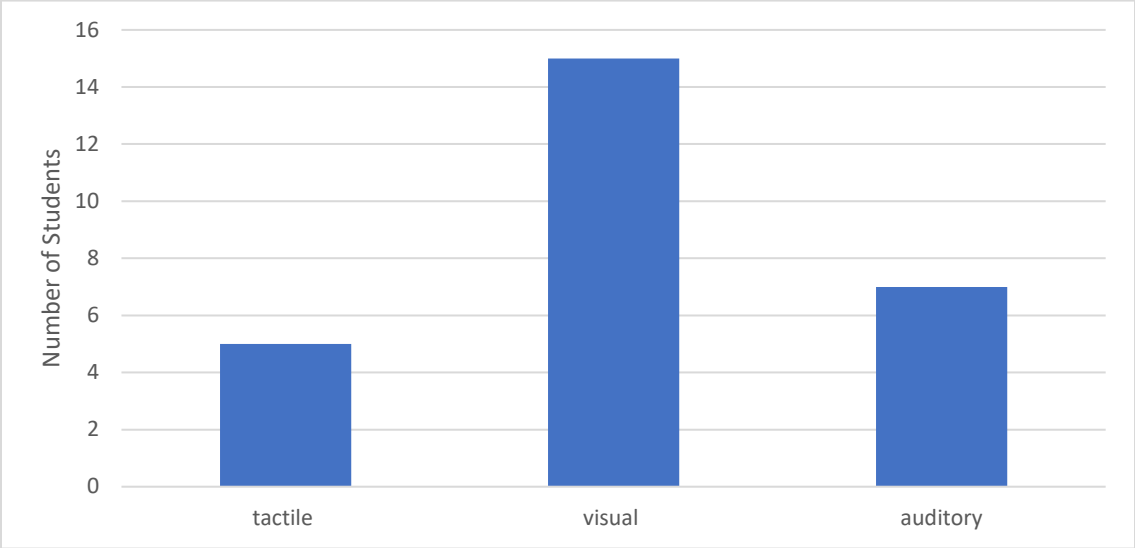

Figure 1. Different types of learners based on a learning style survey that was taken in class, *N*=22.

The second-highest category of learners was auditory—a few students tied in both the auditory and visual categories as their learning style of choice. In the auditory category, there were a few patterns. A lot of students said they require explanations of diagrams and graphs, which is an auditory characteristic. The following highest rank

characteristics were listening to news rather than reading it and saying words aloud to help with spelling. More students had their lowest scores in the auditory category than any other learning style. This learning style category is usually the lowest as many people have trouble remembering things if they are only told to them.

The tactile category was most students' secondary learning style. Statements that got the highest ranking on the questionnaire include making posters, working with models, and practicing skills. The following highest-ranking statement was that they enjoyed working with their hands and making things. The option that students tended to rank lower was gripping objects in their hands during learning periods. There were a few students who tied in the categories of visual and tactile learning.

Pre-test Results

The pre-test results showed that there was not much knowledge of the skeletal system going into the unit. The highest score was 25%, and the lowest was and 8%. Since anatomy and physiology are only briefly addressed in the lower grade levels, the results are not surprising. The questions that had the most correct answers dealt with the names of the leg and arm bones. There were almost no correct answers on the microscopic bone portion of the pre-test. The data makes sense as this is not something covered in other science subjects. It showed that the students were familiar with some bone names but not confident about those bones' locations.

Lab Scores

The subsequent evaluation comes from the lab scores that the student received during the unit. Each group had a different set of activities. The experimental group had a

lab that centered around the Anatomage table. These labs included labeling and coloring the different parts of the skeletal/ muscular system, quizzes, and analyzing case studies. Since there was only one Anatomage table, students were split into groups when using it. During the wait time to use the table, there were vocab activities for the students to complete.

The comparison group had a set of activities that involved looking at 2D diagrams of the systems to identify the parts and other hands-on concepts that were related to the topic. They were given several sets of diagrams to reference in the pre-lab reading and labeled them at one lab station. Large versions of the diagrams were provided for the students. The hands-on activities were related more to the physiology part of the system that was being studied. For example, students measured muscle fatigue and muscle sized during contraction and relaxation in the muscular system unit. Instead of case studies, these students got disease fact sheets where they filled in the information. An example of these lab sheets can be found in Appendix C.

In both units, the students who used the Anatomage table got better lab scores than the student using the 2D model. The virtual cadaver seemed to make it easier to identify the different parts of the systems. The most significant gap in scores came from the labeling portions of the lab. A comparison of this data can be seen in figure four. Reasons for this pattern in the data include that 3D models are often easier to understand than 2D because there is more detail. The digital version on the cadaver has more detail and can be manipulated, making it easier to identify structures. The information collected

during this part of the research supports a sub-question relating lab score to the overarching question of improving student understanding.

Survey Results

After the students had completed the lab, they took a short survey about what they thought of the lab procedures and whether they found it helpful. The results showed that many of the students found the labs helpful, especially the one that used the Anatomage table. Stating that "it was helpful for visualizing the stuff we talk about in class." The majority of the the students that used the Ananatomage table said that they felt comfortable using it an that the quiz tool was helpful -very helpful for them. Many students expressed that they had a better idea of where the different muscles/bones were located. There was some great feedback on which parts of the lab were helpful and which were not. For example some of the case studies that were used were not found to be as helpful for students as other parts of the lab. The feedback will be used to make improvements to the lab for future classes.

Next, the summative assessment data was collected. The test was split into a written test consisting of multiple-choice, short answers, and fill-in-the-blank. Then there was a practical part that involved identifying different muscles and their locations. This activity involved looking at both 2D and 3D models of the human body. That was scored separately from the practical test scores. By separating the parts of the test, it allows for the impact of the concepts to be compared on two different levels. The data can show if the use of the table impacted the concepts of how the system worked or the concepts of where the parts of the system were located in the body. The following few figures will

compare these test scores for both the comparison and experimental groups. The data collected showed some interesting results.

Summative Assessments Analysis

The first set of data for this portion of the research comes from the skeletal system unit. In Figure 8 it shows the data from the comparison group that did not get to use the Anatomage table. There are a few observations that can be made. First, two students in the comparison group showed a significant gap in test scores from the practical to the written portions of the test. Another two students did not do as well on the practical test as they did the written. The differences could largely be attributed to student learning style, which means that the student who scored better on the practical is not visual/kinesthetic. In two cases, students scored a 100% on the practical score despite not using the table. These results mean that even with the lack of a 3D model, the students were able to identify and locate the structures of the skeletal system. These students were able to adapt to the use of the picture models and apply them during the exam.

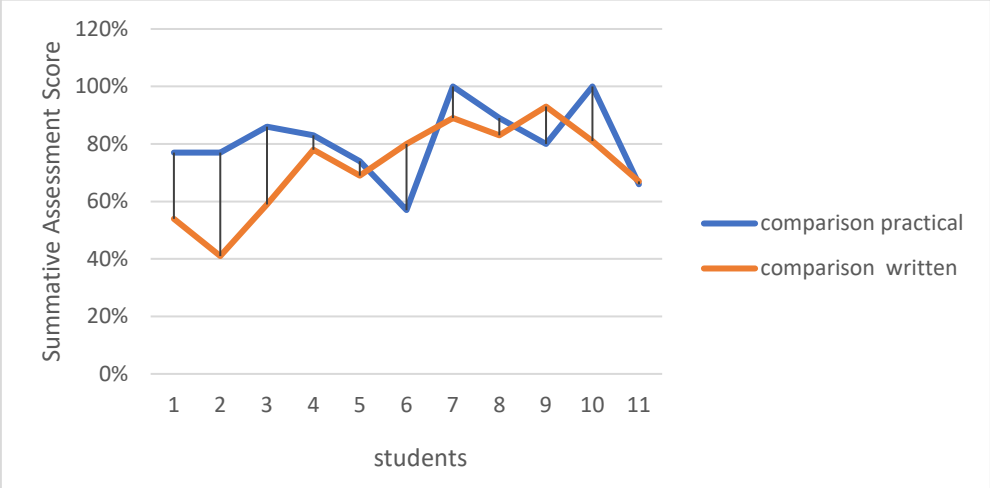

Figure 2. Student written and practical test scores for the skeletal system unit for the comparison group. The score is plotted on the y-axis and the students are on the x -axis, (*n*=11).

The written test scores of these individuals are lower, giving them the potential to improve those scores in the following unit when they use the table. None of the students scored the same on both exams. These data could be explained by the different learning styles used to split the students into groups. There is no strong correlation between the practical and written tests. The overall understanding of the concepts, including both identification and application, is not equally understood in the comparison group. This data contrasts nicely with the data from the experimental group's test scores.

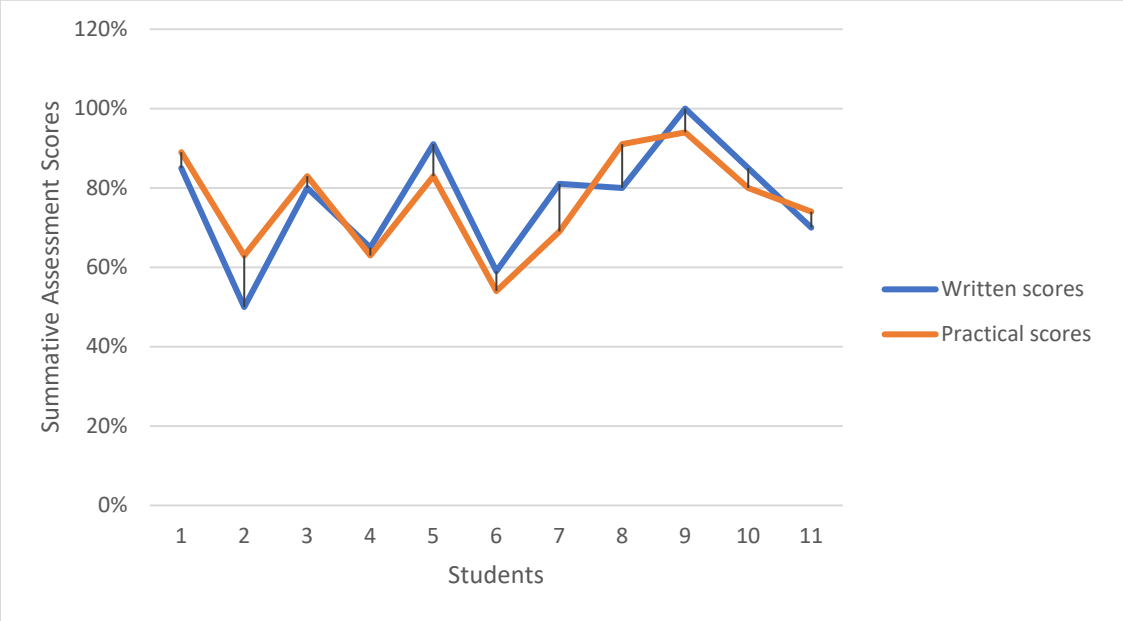

Figure 3. Written and practical test scores for the experimental group. With their score on the y-axis and the students on the x-axis, (*n*=11).

The experimental group data shows that the student in this group had similar scores on their practical and written exams as did the comparison group. Similar to the previous unit, there are some discrepancies in practical test scores and written test scores. For example, there are still two students with a broader gap in scores than the others. Student 2 in figure 3 did better on the practical test than on the written. Also, student 5 on figure 3 had a gap but did better on the written than the practical. The student with the

highest score did better on the written as well. Some of these differences could be due to different learning styles and different levels of academic achievement in school. For the written test, students have been preparing most of their academic careers for them, so it would be expected that those scores would be affected minimally by using the Anatomage table. The practical scores are where the most change would be expected. One pattern in that data that supports this is that students in the comparison group did better on the practical test when they switched to the experimental group. However, the scores were roughly the same for the test averages.

The skeletal system unit's summative assessment showed that students who used the table scored lower on the practical than students who did not. These results could have been because the comparison group was a bit uneven on levels of academic achievement. There were three high-achieving students in the class, so it could not be split up evenly. It also showed that the experimental group students scored higher on the written test than the comparison group. The student who used the table showed a better grasp of concepts in written form rather than in the practical. It still shows the learning of the concepts, but they can apply them better in the written context. The next set of collected data was from the muscular system summative tests. Once again, there were two exams, a practical and a written. When we look at the results, there are a few patterns that stand out. The comparison group will be analyzed first. Two students scored a 100% on the practical without the use of the table. The reason for this may stem from the different learning styles of the students. As mentioned previously, some students may be visual learners but struggle with the spatial ability required to learn using 3D models.

There are several significant gaps in test scores from written to the practical. These students showed a much lower understanding in their written scores. In three of the cases, the practical score was higher than the written. In one case, the written was better than the practical. It would seem in this unit that identification was stressed a little more, creating these incidences. It indicated that this student benefited from the 2D models that were available to them in this unit. Another observation that can be made is that some students scored relatively close for both tests. One student scored consistently low on both the written and the practical, showing about the same understanding in each without the table. If we contrast that with their scores using the table from the previous unit, there is a drop in level of understanding. The other student test score that was close scored similarly when looking at the previous unit's data. Another student that had performed well on both tests in the previous unit did not do as well on the written when they were in the comparison group. This may be due to less engagement in lab activities when not using the table.

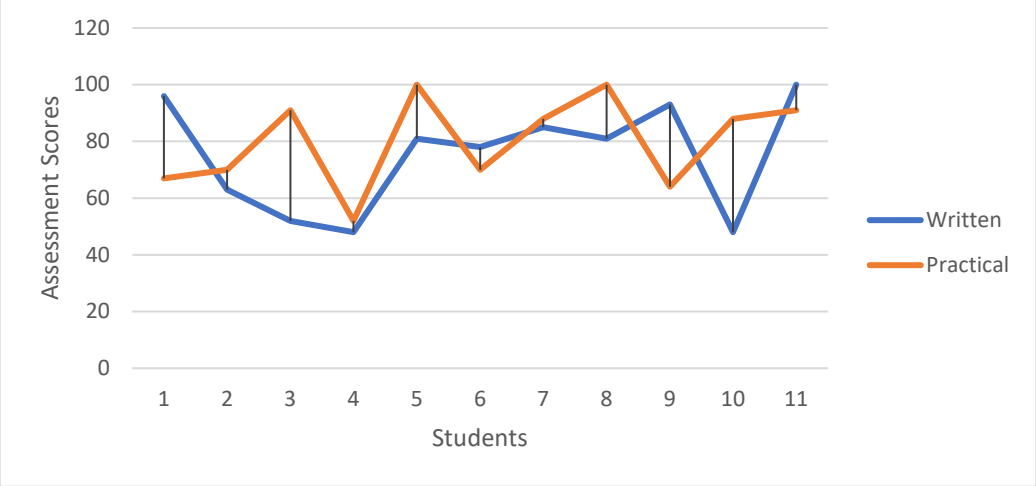

Figure 4. Students' written and practical test scores for the muscular system summative assessment. These scores are for the comparisons group that did not use the table, (n=11).

The first notable pattern in the experimental data is that four students scored a 100% on the practical test without using the Anatomage table. It shows an improvement from the previous unit where these students did not use the Anatomage Table for their labs. Included in these four students are the two students who scored a 100% on the practical without the table. The data from the other two students show that the use of the table helped them to identify structures better. The results, however, did show a lower score on the written test for some of the students. These data show that while the table may have helped them with their identification and practical application of the knowledge, it was not helpful for them in grasping the vocabulary and other information presented in the unit. There was also a more significant gap in test scores between written and practical than there was in the previous unit for this group. The gap further supports that the table did not improve the understanding of the concepts on the written test as well as hoped. There was also a noted gap in the test scores in the previous unit

but with different students. This could relate back to the different learning styles that were represented in this group.

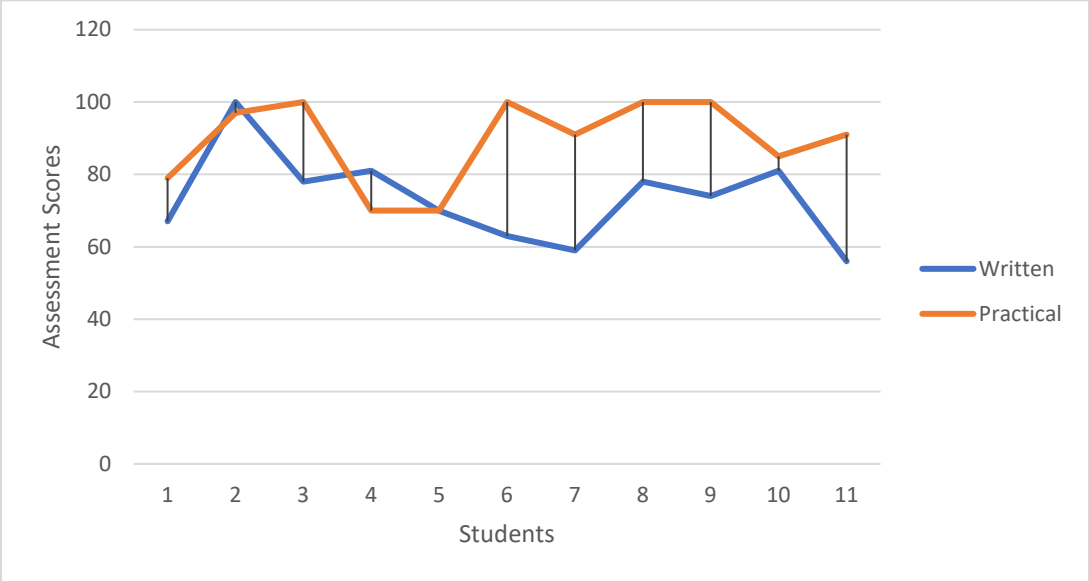

Figure 5. Students' summative asssessment scores from the experimental group. Both written and practical exams are included to assess impacts of learning styles, (*n*=11).

When the data from both groups are examined over the units, the experimental group for the skeletal system had scores that lined up way better than they did in the muscular system unit when they were the comparison. The overall test performance was better when they used the table. When they used the 2D models, the scores varied more from test to test. This information supports the idea that using the virtual cadaver table improved their overall understanding of the information in the unit. Further evidence of this pattern is shown by the gaps in test scores that did not happen when they used the table for their labs.

The group that did not use the table in the first unit showed higher scores on the written portion of the test than they did in the second unit. Once again showing that the use of the table may not be as beneficial for the vocabulary and concepts in written exams. The notable increase in practical scores is indicative that the incorporation of the table into the lab helps in identification and basic medical knowledge. There is a little more variation in scores in the second unit as well. The gap between the scores on the test got a little wider. Some students did poorly on the written test regardless of the use of the table.

Average Scores

The averages on the summative assessments had an interesting result. The muscle system unit summative assessment showed that students who used the Anatomage table scored higher on the practical test than the comparison group. They were scoring about two percentage points higher. While the scores are close, this still shows that using the table may give a slight advantage in understanding concepts. The gap is more significant in the practical test scores, with the experimental group outdoing the comparison by almost eight percentage points. This result was expected as the Anatomage table was meant to help students understand the concepts. The experimental group averaged nine percentage points more than the comparison. This data shows that students who used the table had a much better understanding of the muscles' location and names. Compared to the first unit on the skeletal system, there was a much more significant gap than the previous unit. The written test scores showed a smaller gap of 1.64%, which is lower than the 4% from the previous unit.

The skeletal system averages show that the comparison group outscored the experimental group on the summative written exam. It was showing that the Anatomage table did improve understanding of concepts outside of identification. The activities that involved looking at microscope slides and case studies were helpful. However, The practical showed results that did not match the expected outcome. Even though the labs were particularly identification heavy, it did not show in the results. The experimental group did not do as well as the comparison on the practical exam. There were two test scores of 100% that significantly affected the average. If you remove the scores from these two students, the experimental group only scores better by .13%. Even without the outliers, the results are not in line with what was expected.

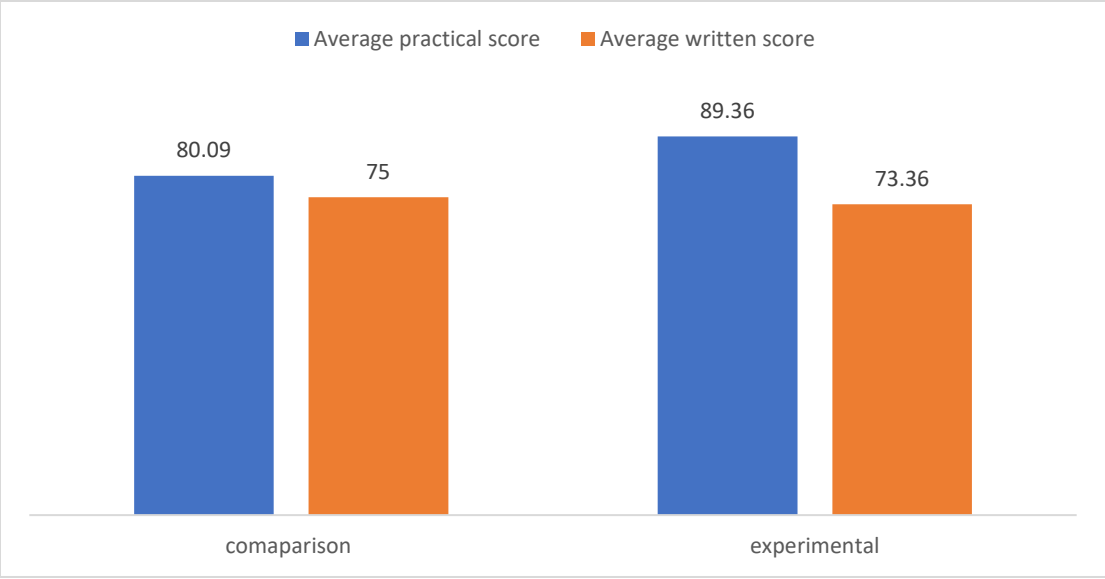

Figure 6. Average test scores on the muscular system unit. The data was split up into the experemental and comparison groups, (*N*=22).

After the summative assessment was obtained, the students were interviewed. Though each student was interviewed independently, their responses were similar to each other. The first question that was asked was whether or not they found the technology helpful. All of the students replied with yes. Their responses to the follow-up question that asked why they thought that varied. A few students stated that manipulating the cadaver helped them understand where the different muscle/bones were in relation to each other. Others said they liked that they could make their own quizzes for studying muscles that they struggled to identify in class. One student said that it was helpful for understanding fractures because she could see in the case study what the ex-rays looked like and read about how it was treated.

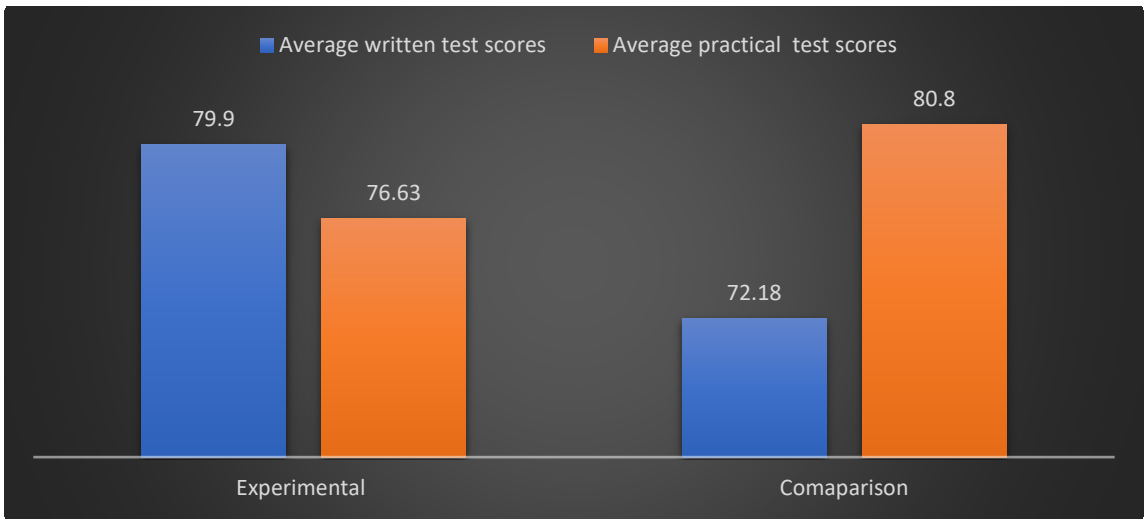

Figure 7. Average test scores for the skeletal system unit. The data is split up into the experimental and compairison groups.

Interview Analysis

The following interview questions dealt with the time that it takes to do the Anatomage labs. Most students recognized that it took longer for them to get through the lab. A few believed that it took about the same amount of time. One student thought that

eliminating the case studies would have made it a better lab and cut down on time. There was agreement among a few of them that the skull pin part of the lab was not helpful to their learning of the system. The functions of the table that students found most helpful were the quiz function in helping them memorize where the muscles or bones were. It forced them to recall the information in a fun competition that they could have with their classmates. They also said that the coloring app and the writing app on the table were helpful because "we can help each other and explain where to find the muscles."

In the interviews done with the student who did not get to use the tables, some students said they found "the diagrams to be confusing sometimes" and that they sometimes struggled to know what the diagram wanted them to label. When asked further questions on this, it was discovered that these students were using the small diagrams on their sheet and not the ones made more prominent to avoid some of the confusion they were having. Some of the activities they found helpful because they got to feel the physiological results of the lab activities for themselves.

In summary, student interviews said that students felt that the coloring of the different bones and muscles helped them the most. One student said that "it helped them to remember where the muscles were." All of the students in the experimental groups agreed that it was a helpful tool for their learning. Many of them enjoyed using the quiz feature on the Anatomage table and wanted to use it in all of their labs. When the students did not use the table, they still enjoyed the activities but said the 2D labeling was more difficult. The information gathered from the interviews shows that the student finds value in using the Anatomage table as a tool in their learning.

The surveys taken at the end showed that students found both the Anatomage table and the regular labs helpful in similar degrees. In the experimental group, students mostly ranked it in the helpful range to the very helpful range. The same was done for the comparison group. The survey results were the same, with the majority of the response being in the helpful to very helpful range. One student in each group marked down somewhat helpful for their responses for both units. The survey also indicated that the student who used the table felt comfortable with the technology and understood most of the available functions.

Retention vs. Pre-test

At the beginning of each unit, the students were given a pre-test to gauge their understanding of each topic. Anatomy was covered in 7th-grade life science, and a bit of it is also included in the health curriculum. Therefore, a little bit of base knowledge on these topics is expected. The pre-test scores were low as expected, with most of the questions being about the bones of the arms and legs being marked correct. There was no prior knowledge of the cellular side of the skeletal system and the diseases that can occur. Figure ten shows the pre-test scores of all of the students in the class. As shown in figure 10, the pre-test average for the experimental group was less than 20%. The student in the comparison group had a higher pre-test score than those in the experimental. These scores may be why there is not a sizable difference in the retention test scores. The retention

scores indicate that the experimental group had better retention of the material than the comparison.

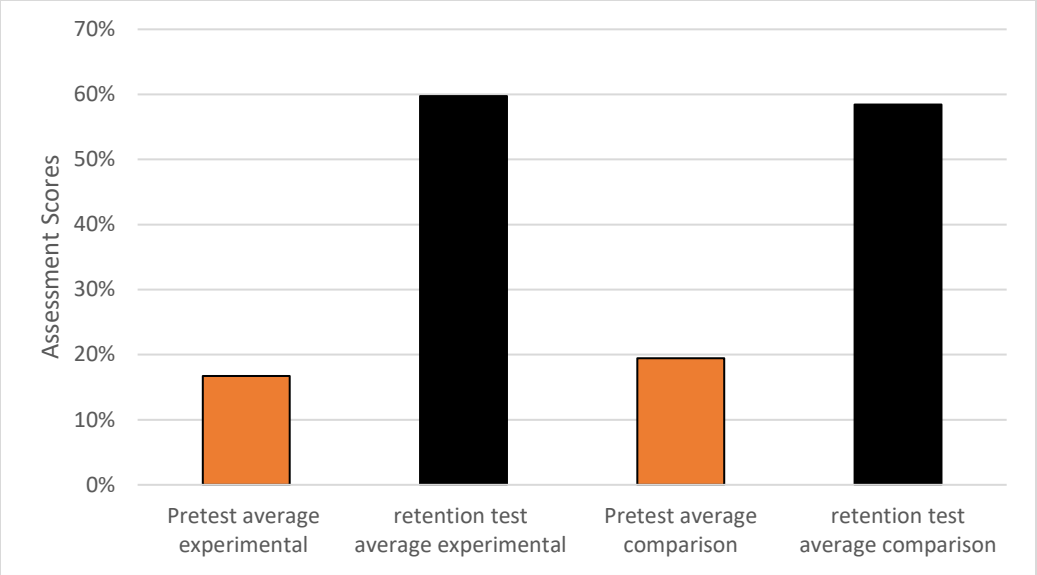

Figure 8. Retention test and pre-test scores of the compairsion and experimental groups for the skeletal system unit.

In the second unit, the results of the pre-test were slightly different. The students seem to have a better grasp on the location of muscles from the beginning. As a result, there were slightly higher scores than with the skeletal system pre-test. The scores make sense because health class was taken during their freshman year and fresher in their memory than 7th-grade life science. Once again, though, it was the muscles of the arms and the legs that they knew the best. They also showed that most of them understood that ATP was made in the mitochondria and used to make muscles. The area that showed the least amount of prior knowledge was the muscles at the cellular level and the muscles of the head and torso. The muscular unit shows a pattern that is similar to the skeletal

system. The experimental group has a lower average score and does better on the retention test than the comparison group. Both pre-test scores remained below 20%.

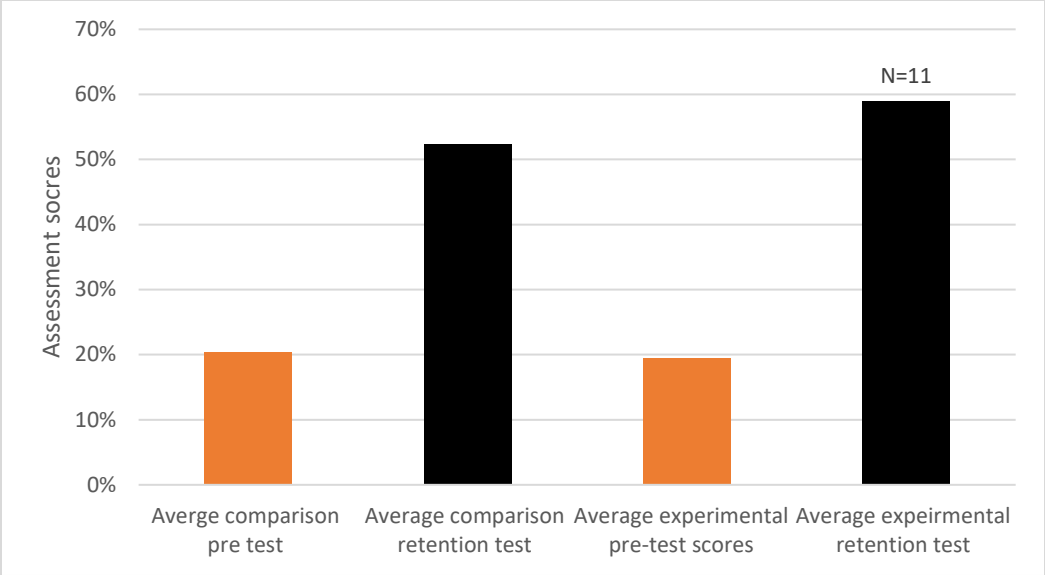

Figure 9. Average retention and pre-test scores for all of the students. It is split up by the comparison and experimental groups.

In each of these units, the retention test was given a month after the end of each of the units. Both of the retention test results show that they gained more knowledge than they had entering the class even though the test scores were not excellent. Many showed improvements in being able to identify the structures of the skeletal and muscular systems. There was also some slight improvments in student understanding of physiology concepts. In order to see how the table impacted the retention, the score has been split up by those that used the Anatomage table and those that did not. These data show that the students that used the table had better retention than those that did not. The difference is notable on both graphs. It also shows that in both cases, the student in the experimental group scored lower on the pre-test. This means that they made more significant knowledge gains than those in the comparison group.

Summary

This conglomerate of data had several key points. First that the Anatomage table did improve some of the test scores. There was an overall improvement in practical scores in one of the units and improved written scores in the other. The different effects of using the table may have been due to the different learning styles represented in each group. The second is the pattern seen in lab grades. The most considerable difference in the lab scores came from the labeling portion of the lab. Students who used the table scored better than students who used the 2D models. In the other activities done in the lab, the grades were similar. In the experimental group, they did case studies, and in the comparison group, they did other hands-on measurements and experiments related to the system.

Thirdly, the data collected concerning student attitudes towards using the Anatomage Table in the lab showed that many students felt that it was beneficial. Any criticizing the student did was about specific portions of the lab that they thought were not as applicable as the others. Students felt that they were more engaged in the material, and it was an overall positive response. After they took the test, they still felt that the table was helpful to them. Lastly, the retention test data showed the student who used the table scored higher on the retention test than when they did not.

CLAIMS, EVIDENCE, AND REASONING

Claims

The purpose was to see how the use of the Anatomage table impacted student learning. In the first portion of the data collection, the students were sorted into their respective groups for treatment and non-treatment (Figure 1). The data collected showed that students using the table performed better on the summative assessment, with a few exceptions. Scores on the practical test were better when the table was used. The use of the virtual cadaver table shows a positive relationship between summative test scores and lab scores. Data obtained from this research supported that most students benefit from using a virtual cadaver table, especially in practical skills.

Student's attitudes toward the cadaver table were overall positive (Figures 3-6). A big takeaway from the student's surveys was the students' attitudes are towards the use of the table were all really positive. Students felt like they were learning more, and we enjoyed getting to use technology in the lab. They also indicated that it added to the understanding and learning of concepts in the unit that they used the Anatomage Table. The survey data supported the use of the table and showed that the regular labs still had value.

The data collected for the student surveys and interviews was another important result of this study. The experiment has helped create a more comfortable atmosphere of using the Anatomage table in labs and lessons. It has been beneficial in making a proper timeline for labs to be completed. The student feedback has also created new ideas for

future labs on the table. Students shared parts of the lab that they felt helpful like the coloring label activity and parts that were not like when they found the MRI in the skeletal system lab confusing. The direct quotations can be found in the interview and survey analysis.The labs will be better suited to help students understand the material and more relevant to them.

One significant factor that impacted the collection of the data was the pandemic. Many students had to miss school for being quarantined or getting COVID-19. Students were required to attend classes virtually if they were just quarantined and had the option of joining them if they tested positive. The attendance on the online platform was not excellent, and as such, some students may have missed content. The online version of the table did not have many of the features that help in identification and understanding.For example the app does not have the interactive quiz feature that student said was very helpful. Students who could do the lab in person had a different table experience than those who attended in person. This situation played a significant role in how the results turned out. Other factors that would affect the results come from different levels of academic achievement. Some students work harder outside of class to understand the concepts that they are being taught.

Value of the Study

The potential significance to colleagues is to show the usefulness of virtual cadavers in teaching anatomy and physiology and any biomedical class. The Anatomage Table is used across the country as a learning tool in a few select schools. A few medical

schools have virtual cadaver tables that they use in labs and lectures to teach. Other high schools got the same grant that our school did and used the tool in their classrooms. This study shows the benefits of using the virtual cadaver table on student education and how its implementation in anatomy and physiology impacts how students understand the human body. It expands their use using the information collected by the study to get other schools to help get a grant to purchase the table's educational technology.

Since this study focuses on the use of a specific technology, it also has commercial implications. The Anatomage company also benefits from this research as it shows that their product is an effective tool for understanding Anatomy and Physiology. Each year the company has a conference where they get feedback form teachers on their tables. They can use this research to show that students who used the table retained the information well. This is a great advertising point for selling their products to schools. It also shows a slight improvement in student learning that can be used as well.

The study should be repeated in a time when there is not a pandemic. An unfortunate result of slowing the spread of the disease created a weird virtual/online teaching format that could have impacted student learning. During the study, there were multiple students out for either quarantine or catching COVID-19. These students did not have as much access to the table as a consequence which impacted the results. Another improvement that could be made is in how the groups were split up. Academic achievement is another factor that needs to be considered when splitting up the groups. One of the groups in the study was lopsided with high achieving students, which affected the results as well. This would create a better comparison and make the groups more

diverse, making the data more reliable. Other units could be used for this study to see if using the table impacts the learning across more subject areas.

Some limitations of the research are the small sample size. There were several reasons for this constraint. Class sizes had to be small to allow for social distancing and made it so that only one Anatomy and Physiology section could be offered this year. Since the sample size was not large a lot of the results were not statistically significant. The data was more meaningful to both me and the students when each individual data point was represented. Students could see how their scores went up or down base on the lab tools they used. The study was also limited by time. The school switched to the four-day week this year, which impacted the time that could be spent on each unit. Other limitations include student attendance and academic motivation. Both of these impacted the results of the study and caused some of the observed trends.

Impact of Action Research on the Author

The research had helped students to become more familiar with technology and its application in future careers. It has made the instructor more comfortable using the table in labs for the Anatomy and Physiology classes. The table's use helps students retain the content better, thus establishing the classroom's Anatomage tables' effectiveness. There will be more labs that involve the use of the table in future classes. It also created the opportunity to change and edit some of the lab activities associated with the table to improve them based on student feedback. There still needs to be some improvement in with the issue of class time. The information gathered from this study can be used to make the labs shorter and more effective for student learning so that it may take less time

to complete the labs during class. Students remained engaged during the lab period by getting to use technology.

In the future, the Anatomage labs will be modified based on the results of this research. One improvement that will be made is that more time will be spent in the beginning familiarizing students with the function of the table to cut down on lab time. The labeling and coloring portions of the Anatomage table lab will be included in every lab rather than the 2D paper versions. There will be modifications to the case studies in the lab to cut down on time. Also, the case studies will reflect what students found useful when preparing for the summative assessments. This research will make the Anatomy and Physiology labs more effective for student learning.

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APPENDICES

APPENDIX A

IRB

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects FWA 00000165

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FROM: Mark Quinn *Mark Quinn KB*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: January 5, 2021

RE: *How the Use of the Anatomage Table Impacts Student Understanding of Anatomy and Physiology* [EK010521-EX]

The above research, described in your submission of January 4, 2021, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information

obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit a Request for Expedited Review Application.

APPENDIX B

SURVEY AND INTERVIEW QUESTIONS

Likert Survey questions Treatment group

How comfortable do you feel using the Anatomage Table?

1	2	3	4
Not comfortable	somewhat comfortable	comfortable	very comfortable.

Why?

Do you feel that the use of the table helped you understand the material?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

Can you give an example?

How much did you think that quiz tool helped you on the exam?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

How helpful do you think the use of technology is in your education?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

Why?

How helpful were the case studies in learning the material?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

Can you give an example?

Likert Survey Questions comparison group

Do you feel that the use of the lab helped you understand the material?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

How much did you think the lab helped you on the exam?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

How helpful were the lab stations in learning the material?

1	2	3	4
Not helpful	somewhat helpful	helpful	very helpful

Interview Questions

Do you think using technology improves your learning? Why or why not?

Do you think that the use of the cadaver table contributes to your understanding? and give an example.

How do you feel about the time it takes to complete a lab on the virtual table versus the time for a regular lab?

What are the main functions of the table that you find most helpful?

If the Anatomage table were more accessible after school, would you use it as a study tool? What feature would you use?

Compare a lab with the Anatomage table vs. one without. Which do you think is better and why?

APPENDIX C

SAMPLE OF ANATOMAGE LAB ACTIVITIES

Anatomage Table 6.0 Appendicular Skeleton
Student Guide

Bones of Appendicular Skeleton

Step 1: Tap the Explore tool icon and then the Highlight tool.

- ➔ Take turns tapping on each bone listed in the table below. The first tap highlights the bone, a second tap isolates the bone, and a third tap brings back all the bones. When the bones are isolated, you can rotate and view them from all angles.
- ➔ Close this menu before moving on to the next step.

Step 3: Double-tap on a bone to open the Action Menu (or a single tap on a bone and then  tap the Action Menu icon).

- ➔ Use the Action Menu to apply a different flat color to each individual bone and use the pen tool to circle groups of bones in different colors. Note: once the Action Menu is open, you can tap directly on the next bone, and the Action Menu will remain open.

Bone	Labeling Color
Clavicle	
Scapula	
Humerus	
Radius	
Ulna	
Carpals	
Metacarpals	
Phalanges	

- ➔ Save a screenshot using the camera icon.

Bone	Labeling Color
Ilium	
Ischium	
Pubis	
Femur	
Patella	
Tibia	
Fibula	
Tarsals	
Calcaneus	
Metatarsals	
Phalanges	

APPENDIX D

SAMPLE OF SUMMATIVE ASSESSMENTS

Muscle System Written Test Sample Questions

1. The outermost layer of the connective tissues surrounding a skeletal muscle is the
    a. Epimysium
    b. Endomysium
    c. Sarcomysium
    d. Perimysium
2. Myofibrils are composed mainly of
    a. Perimysium and endomysium
    b. Facia and tendons
    c. Troponin and tropomysosin
    d. actin and myosin
3. A sarcomere is best described as
    a. A part of the sarcoplasmic reticulum
    b. A unit within a muscle fiber
    c. A group of muscle fibers
    d. A group of fascicles
4. Tawanda finishes a sprint and suffers great pain in her calf muscles. Her muscle cramps are most likely due to a temporary deficit in
    a. ATP
    b. ADP
    c. Actin
    d. Myosin
5. At a neuromuscular junction
    a. Troponin and tropomyosin exchange places
    b. Neurotransmitters are released
    c. Intercalated discs are synthesized
    d. Actin and myosin filaments slide past one another
6. A functional connection between a neuron and a skeletal muscle is a
    a. Synapse
    b. Neuroma
    c. Dendrite
    d. Fascia
7. A muscle fiber exposed to a series of stimuli of increasing frequency combines individual twitches, which results in
    a. A latent period
    b. Complete sustained contraction
    c. Muscle tone
    d. Flaccid muscles

Sample Practical Test Questions

Identify the bones numbered/ lettered on the model

Patient 3: *52 y/o female experiencing severe shoulder pain after being slammed into the sand by a wave, learning how to boogie board while on vacation. Identify the type of fracture and list all of the bones visible in the X-ray*