

Anatomy in Clay® Testing

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Abstract

The study of anatomy at the college level is typically carried out through vivisection or dissection. The Anatomy in Clay ® learning system seeks to provide an alternative to this costly practice by allowing students to engage the muscular and skeletal systems of the human body through the use of clay modeling. The present study seeks to examine the Anatomy in Clay ® technique is a valuable addition to instruction in the field of anatomy and a potential alternative to the practices of dissection.

Introduction

Many anatomy instructors view a traditional lecture style as the most effective method to teach anatomy. As with other fields, the traditional ‘sage on the stage’ approach is used. Other instructors and institutions use dissection, either of human cadavers (vivisection) or of animal subjects. The practice of vivisection brings with it a wide array of logistical and financial problems concerned with obtaining, storing, even disposing of the test subjects (Shigeoka, Bavis, Seveyka, 2000). Other institutions use models or visual aids to supplement or replace the dissection component of anatomy classes (Shaffer, 2004). As a career-focused institution of higher learning, Keiser University seeks to provide a hands-on approach to teaching, preparing its students for rewarding careers. To that end, the Anatomy in Clay® technique for teaching anatomy was examined as a way to enhance learner engagement with the human muscular and skeletal systems in the Anatomy and Physiology I and II courses. The Anatomy in Clay® process was examined as an addition to, not a replacement of, the regular Anatomy and Physiology coursework consistent with University policies and procedures. Data was collected and interpreted using the SPSS program for the epidemiological portion of the study and data interpretation.

The Anatomy in Clay® learning system provides an alternative to more costly approaches of teaching such as vivisection, and less hands-on approaches such as lecture. Students are provided with a scale replica of a human skeleton and length of modeling clay. Students use the modeling clay to construct muscle structures on their respective skeleton models, thus providing the student with a working knowledge of the size, shape, and connections of the muscles.

The current study sought to answer the question: Does the administration of the Anatomy in Clay ® technique assist students in better (1) internalizing and (2) retaining a working knowledge of the human muscular and skeletal systems?

Background

The teaching of human anatomy continues to be a very traditional, slow to change field. Most instructors feel that nothing will replace vivisection as the primary means for students to experience human anatomy, just as nothing will replace lecture as the primary means of conveying information (Bligh, 2000). A variety of visual aids and models exists, but many researchers feel that these are very limited, so many faculty members and researchers have begun examining new methods to teach anatomy and motivate their students.

Park, Schwartz, Witzke, Roth, Mastrangelo, Birch, Jennings, Lee, & Hoskins (2000) examined the use of Laproscopic cholecystectomy (LC) as a way of exposing second year medical students to living anatomy. The researchers found that not only did allowing students to view a live procedure have a positive effect on the students' knowledge base, but the experience also inspired the student group to continue in a difficult program. Interestingly, subsequent usage of recorded footage did not have a similar positive impact on other student groups. This would suggest that it is the experience of the procedure that students most connect with, rather than the technology, and that learning is more significant when the student is involved in the process.

Nasr (2007) reports "significant improvement in students' performance in anatomy laboratory using digital human cadaver dissection software" (30). However, he

recognizes that his experiment group had access to the digital software outside of class, while the students limited to traditional dissection did not continue the practice beyond school hours. Ultimately, he finds that it is “active involvement” (36) that increases student interest, and later performance, in the subject. This would seem to be consistent with other findings (Park et. al, 2000).

Waters, Van Meter, Perrotti, Drogo, and Cyr (2004) found that having students create clay models of various anatomical structures, “proved to be a more effective laboratory teaching method than a cat dissection experience” (32), even though it did not change students’ attitudes towards the study of anatomy.

Faculty members look towards technology as much as towards creativity (Shigeoka et al., 2000) for new ways to teach anatomy to a changing student population. As research has shown (Park et. al, 2000; Nasr 2007) technology alone will not improve student learning, rather engagement and interaction with material will create more interest in a student population. Creative solutions to the challenges faced by faculty may need to be brought forward, and it is with this in mind that we examine the Anatomy in Clay® technique.

Methodology

The present research study used comparative analysis to determine significant difference in learning and retention among students who used the Anatomy in Clay ® technique as compared to those who only received traditional instruction, including lecture, reading, and autopsy viewing. Research goals included:

To compare which group scored better on tests examining student knowledge of the muscular and skeletal system sections of the test.

To suggest if the Anatomy in Clay® technique was successful in enhancing student learning and retention of certain techniques and concepts in Anatomy and Physiology.

Participants

The participants were randomly divided into control and experimental groups. Randomization has been shown to yield results that are more consistent, and less susceptible to researcher biases (Campbell & Stanley, 1963). Each test group consisted of 25 students who consented to arrive one hour early to class. The experimental group remained an hour and a half after class for the administration of the Anatomy in Clay ® process.

Design

The first portion of the study consisted of four phases. Classes at Keiser University are condensed into a length of four weeks, so two pools of students could be examined in quick succession. Four groups of students were selected in accordance to their matriculation in Anatomy and Physiology I, a one-month interval was used after each group, due to the students' matriculation in Anatomy and Physiology II. A total of 100 students participated in the study. Each of the (test or control) groups consisted of 20-25 students, and the project study consisted of approximately 15 hours of directed study.

The students' majors were a mixture of Nursing, Nuclear Medicine Technology, and Occupational Therapy Assistance. Students enroll in Anatomy and Physiology before beginning their core classes, so no distinction was made between students in different majors as the students had not yet entered their core classes. This also limited the core classes as a source of external invalidity.

Measures

The study was divided into two sets of four phases. Each of the four phases was given to a complete set of students, and four sets of students were tested, these being two experimental groups and two control groups (two sets of administration and control groups were put through four phases). The overall length of the study was 16 months.

Phase I was the determination of a baseline against which to measure student learning. The researcher administered six different pretests. The pretests examined, individually, the following sections of the human body: head/neck muscles, upper extremities/thorax muscles, abdominal muscles, and lower extremities' muscles. An overall pretest of the skeletal system and muscular system was also administered. This same test was later administered 2-3 months after the course was completed to measure the overall retention of both the control and the experimental groups. The same pretests were administered to the control and study groups.

Phase II consisted of the actual, hands-on application of the clay to the skeletal models of each section of origin and insertion of muscles. This phase was administered to the students committed to arrive one hour before class and stay one hour after the

required four hours of regular coursework. This allowed time to proceed with the scheduled lecture required in the curriculum of the Anatomy and Physiology courses.

For the control group, Phase II consisted only of the theoretical discussion (lecture) of the skeletal and muscular system required by the university curriculum. This group did not participate in the Anatomy in Clay® technique. For the experiment group, Phase II consisted of the administration of the Anatomy in Clay® process.

Phase III was the administration of posttests covering the six categories selected and mentioned in Phase I to all students. The data gathered from a comparison between pre- and posttest results was used to determine student learning and retention during the Anatomy and Physiology courses. The same posttest was administered to the control and experimental groups.

Phases I, II, and III were administered over a sixteen-month period to eight groups of students in order to provide a longitudinal model for the study. Due to the one-month duration of classes, the study could effectively examine eight groups of students through Anatomy and Physiology I and Anatomy and Physiology II. Two sets of each a control and experimental group were used. Each set consisted of 20-25 students, for a total of 50 students in each group pair (control and experimentation). The study included a total of approximately 100 students, although not all the responses were included in the final calculations. In the final calculations, only 45 students were included in the experimental group, while only 42 were included in the control. Some results were discarded because of incomplete responses, or corruption of data.

Phase IV was administered to each group three months after the students' completion of Anatomy and Physiology II. This Phase consisted of an overall posttest

which focused on the skeletal and muscular systems and sought to measure, after a comparison with both baseline data and the results of the first posttest, the students' retention of theoretical material from the lecture portion of the Anatomy and Physiology courses. This Phase was completed over eight months, as the test was administered separately to each group. The same test was administered to the control and experimental groups.

Results

Aggregate results were used for final analysis of each test area (eg. Skeletal structure, upper extremities, and head and facial muscles, etc.) in order to limit inconsistencies resulting from distinct levels of preparedness of the distinct test groups. Deviations in the resulting data were occasionally too significant to provide effective results, so focus was placed on the sections that resulted in usable data sets. Independent t-tests, with a controlled variable for groups, showed a significant difference in Pre- vs. Post-Test scores for two areas, and a practical significance for a third. The results suggest that the Anatomy in Clay® process was successful in positively influencing student learning in these areas.

Head and Neck Muscles

For the head and neck muscles subsection, the students in the control group demonstrated lower baseline knowledge ($M = 37.12$, $SD = 19.28$) than the experimental group ($M = 45.02$, $SD = 16.68$), $t(85) = 2.021$, $p = .045$ (two-tailed). The results of the posttest show that learning gains were made between the control group ($M = 44.18$, $SD = 22.67$)

and the experimental group ($M = 58.14$, $SD = 18.89$), $t(85) = 2.021$, $p = .002$ (two-tailed).

Results suggest that the Anatomy in Clay® process assisted student learning, but further testing may be required given the significant difference in pretest scores.

Upper Extremities Muscles/Thorax

For the upper extremities muscles/thorax subsection, there was no significant difference between the baseline knowledge of the control ($M = 17.23$, $SD = 10.81$) and the experimental group ($M = 19.73$, $SD = 9.14$), $t(85) = 2.021$, $p = .246$ (two-tailed).

However, the results of the post-test show a significant improvement between the scores of the control ($M = 22.75$, $SD = 13.48$) and experiment groups ($M = 31.01$, $SD = 16.08$), $t(85) = 2.021$, $p = .011$ (two-tailed). The statistically significant gains among the experiment group suggest that engagement with Anatomy in Clay ® improved student performance in this area.

Abdominal Muscles

For the abdominal muscles subsection, there was no significant difference in the pretest scores for the students in the control group ($M = 29.82$, $SD = 24.24$) and the students in the experimental group ($M = 25.71$, $SD = 17.58$), $t(85) = 2.021$, $p = .366$ (two-tailed).

This suggests that the baseline knowledge of the two groups was similar; however, the high SD suggests that reliability of the baseline data may be suspect. Administration of the Anatomy in Clay ® process did not result in a significant change between the posttest scores of the control ($M = 33.20$, $SD = 34.23$) and the experimental ($M = 39.35$, $SD = 23.20$), $t(85) = 2.021$, $p = .230$ (two-tailed). No conclusions can be drawn about student

learning in this subsection.

Lower Extremities

For the lower extremities subsection, the baseline scores for the students in the control group ($M = 16.81$, $SD = 9.56$) and for the students in the experimental group ($M = 22.19$, $SD = 9.27$), $t(85) = 2.021$, $p = .009$ (two-tailed) were too different to provide usable data. The results of the post-test show significant improvement for both the control ($M = 22.43$, $SD = 8.96$) and experimental group ($M = 34.30$, $SD = 12.20$), $t(85) = 2.021$, $p = .000$ (two-tailed) groups. However, it is unclear if the change is a result of the administration of the Anatomy in Clay® process. No conclusions can be drawn about student learning in this subsection.

Muscular

For the muscular subsection, there was no statistically significant difference in the pretest scores of the students in the control group ($M = 23.89$, $SD = 13.86$) and those in the experimental group ($M = 23.51$, $SD = 16.16$), $t(85) = 2.021$, $p = .907$ (two-tailed). These scores allow for the creation of a viable baseline for comparison of the two groups. The posttest scores show statistically significant gains for this subsection for both the control group ($M = 43.21$, $SD = 25.89$) and the experimental group ($M = 47.92$, $SD = 23.48$), $t(85) = 2.021$, $p = .375$ (two-tailed). However, the significant SD renders it impossible to draw significant conclusions from the final data.

Skeletal Structure

For the skeletal structure subsection, the students in the control group demonstrated lower baseline knowledge ($M = 36.42$, $SD = 19.56$) than those of the experimental group ($M = 38.60$, $SD = 22.78$), $t(85) = 2.021$, $p = .633$ (two-tailed). This provides a viable baseline for comparison with the posttest scores. The posttest scores for this subsection indicated that learning gains were made between both the control group ($M = 51.82$, $SD = 22.00$) and the experimental group ($M = 61.35$, $SD = 15.27$), $t(85) = 2.021$, $p = .021$ (two-tailed). However, the more significant change occurred between the pretest and posttest scores of the experimentation group, and the most significant reduction in standard deviation also occurred within the experiment group. Results suggest that engagement with Anatomy in Clay® technique improved student performance in this area.

Discovery

By comparing the scores earned by the control and experimental groups on tests that examine student knowledge of the muscular and skeletal systems, the study was able to suggest areas where the Anatomy in Clay ® technique was helpful in enhancing student learning and retention of key concepts in anatomy and physiology. The study resulted in significant improvement in two areas, these being the Head/Neck Muscles and the Upper Extremities/Thorax. Other areas, such as the Lower Extremities and Muscular, showed marked improvement, but this improvement could not be attributed exclusively to the administration of the Anatomy in Clay® process. With respect to the sections detailing the skeletal system, results were obtained 2-3 months after the completion of the course and show a practically significant improvement. These results suggest not only an

increase in general performance, but also an increase in retention of the information over time.

The study also supports the findings of prior research (Nasr, 2007; Park et. al, 2000) which often state that students learn through interaction. The Anatomy in Clay ® technique addresses a variety of learning styles (eg. visual, tactile) in addition to the traditional auditory learning stressed in lecture-style classes. It may be that as a result of this multi-sensory interaction with the material, the Anatomy in Clay ® technique affects students more broadly and leaves a more lasting impression. This may suggest to future educators the importance of reaching out to the various ways students may learn or retain information.

Limitations

Although attempts were made to maintain the groups cohesive, and multiple groups were examined, some threats to internal validity remained unavoidable in the end. There may have been some experimental mortality as students who did not complete Anatomy I were prevented from advancing to Anatomy II, and were therefore unable to persist in the experiment. Some maturation may have occurred among student participants, but as the pairs of control and experiment groups were studied simultaneously and over a limited span of time, the effects of maturation may have been limited or reduced, given that maturation should have occurred similarly in both groups. Because the student population was assigned grades for class work, but not for the portion of work linked to the experiment, it is likely that the students' focus was on that work which impacted their grade. Additionally, students' hours of study outside the

classroom were not measured, and these hours may have differed significantly between the members of the control and experiment groups.

Attempts were also made to minimize external factors jeopardizing validity. Students were not tested multiple times, and members of the control group received treatment equally and simultaneously, which minimized the variables in the instrumentation tools, as well as the risk of multiple-treatment interface.

Further limitations in the gathering of data may be attributable to the following: Neither the experimental nor the control groups were being graded on the portions of the class relevant to the study, (these being the Anatomy in Clay ® section and the study-specific pre/posttests), so some students did not put forth full effort in answering the questions. Some students indicated through conversations with the instructor that they felt overwhelmed by the material and the posttests were taken for granted since these were not included in the class grade. Incomplete data was eliminated from the final calculations.

Finally, the Anatomy and Physiology courses are normally scheduled for students as the last courses before entering their core programs. Because the core programs only begin at certain points in the year, some students are left on academic gap, without classes, after their Anatomy and Physiology classes. A lack of persistent attendance in classes may account for some degradation of the skill base between the final class, and the beginning of the subsequent (core) classes, and may also account for some of the decline seen in the present study.

Suggestions for Further Research

Given that significant change was found in some areas but not in others, future research may examine why the Anatomy in Clay® process is more successful in teaching some groups over others. It is as yet unknown whether this difference is the result of more detail-oriented training exercises or if another variable will be found.

An intensive study, focused on a small group of participants, may serve to limit some of the uncertainties in the research tied to maturation and history. A focused, qualitative study would examine external factors influencing participant history, hopefully addressing questions of external validity.

A more extensive study may resolve questions of the research's applicability to further individual.

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