Cat dissection vs. sculpting human structures in clay: an analysis of two approaches to undergraduate human anatomy laboratory education

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Received 9 August 2004; accepted in final form 2 December 2004

HUMAN ANATOMY LABORATORY INSTRUCTION can employ many different types of specimens, models, software programs, and websites to help students learn the material. However, it is difficult to know how these materials affect learning outcomes. This study compares the effect of two laboratory education approaches, a cat dissection vs. a human-clay sculpting experience, on the performance and attitudes of undergraduate students enrolled in a human anatomy course. This study examines the use of sculpting human anatomic structures from clay as an alternative to cat dissection, because like dissection, sculpting is an approach that engages the students in exploration of anatomical structures and relationships. Moreover, sculpting and cat dissection require a three-dimensional approach to human anatomy (as opposed to a 2-dimensional picture or computer simulation), and some variation in the size, shape, and position of structures will be apparent to the students when they compare their sculpted specimens.

A dissection or vivisection experience is a common part of teaching laboratories. Students may participate in dissections or manipulation of human cadavers, preserved cats, or other specimens. Human anatomy instructors often try to evaluate alternative approaches to laboratory education by comparing them to some sort of dissection/vivisection experience. Student performance in laboratories based on stereoscopic slide presentations (11), videodisks (1, 5), high-quality plastic models (2), and computer-based instruction (3, 7, 10) have all been compared with animal- or cadaver-based laboratory experiences with varying results. No differences in student performance were detected in some of the studies comparing non-animal alternatives to dissection/vivisection experiences (1, 2, 5, 11). Hughes (3) found mixed results when comparing a nonanimal alternative to traditional dissection, with students in the dissection lab performing better on some, but not all, aspects of the course. Predavec (10) on the other hand, found that computer instruction was more effective than traditional dissection. Conversely, Matthews (7) found a dissection experience to be more effective than a computer-based experience. Although the differences in these studies may well be attributable to the differences in interventions tested, it is also possible that the differences are due to important methodological variations.

Although there are many methodological differences across studies, the most critical variation concerns the measures used to assess outcomes. Differences in outcome assessments may contribute to different conclusions across studies. In science learning for example, Mayer and Sims (8) found that students in an experimental condition did not score higher on a posttest assessing recognition than control participants scored. These experimental students, however, did score higher than control participants on a higher-order test assessing the application of knowledge. The consistency of these findings across studies has led Kintsch (4) to argue that investigators need to be aware that different types of posttests will likely capture different types of knowledge.

In this study, the performance of students enrolled in a large undergraduate human anatomy course (~120 students), assigned to one of two treatment groups (cat dissection vs. human-clay sculpting) was assessed by using both lower- and higher-order examination questions. In designing the exam questions, consideration was given to the objectives of the human anatomy laboratory as taught at The Pennsylvania State University. In this introductory course, the goal was to provide students with a solid foundation in the principles of human anatomy that would enable them to apply those principles in
whatever situations come next in their careers. It is difficult to predict exactly what those future situations will be; the students in this course came from a variety of majors and are on career paths that will require varying degrees of proficiency in human anatomy. Therefore, the goal of the higher-order exam questions was to create new situations for the students to apply their understanding of human anatomy.

Using this range of exam questions, we tested the null hypothesis that there is no significant difference in exam performance between students assigned to a cat dissection laboratory and students assigned to a laboratory in which they sculpt human anatomic structures from clay. We also tested the null hypothesis that the different laboratory experiences would have no effect on student attitude toward the use and value of preserved animals in an educational setting nor on their willingness to take a subsequent human anatomy course. Our results indicate a significant difference between the two treatments with the human-clay sculpting group outperforming the cat dissection group on both lower- and higher-order questions. Importantly, neither treatment adversely affected student attitude. We discuss these findings in terms of how the human-clay sculpting experience might facilitate a deeper understanding of human structure/function relationships and promote a facile transfer of knowledge to human, rather than cat, anatomical problem sets.

METHODS

Course Description

In the fall of 2003, ~120 undergraduate students enrolled in an introductory human anatomy course (Biology 129) offered at The Pennsylvania State University’s main campus. This course has no prerequisites. Students enrolled in Biology 129 that semester consisted of 77% health/science majors (mostly kinesiology, nursing, and other allied health fields) and 23% nonhealth/nonscience majors. Laboratory sections were offered in pairs, with each laboratory room identically equipped. The labs were staffed by a mix of graduate and undergraduate teaching assistants supervised by a laboratory coordinator (J. R. Waters). Individual laboratory sections within each treatment group were taught by a mix of new and returning teaching assistants. Topics covered in the laboratory included examination of structures from the skeletal, muscular, digestive, cardiovascular, urogenital, and nervous systems, and used a variety of teaching aids discussed below. All of the anatomy students attended two 50-min lectures together each week. Laboratory sections met twice weekly for 115 min each meeting.

Experimental Design

The anatomy students were assigned to one of two treatment groups, based on which of the two laboratory rooms their section was assigned. Six of the seven laboratory sections were paired by treatment, with students in one room acting as the control group and students in the other room acting as the treatment group (the 7th section was another control group). The students in the control group studied the anatomy of the muscular system, the digestive system, and the cardiovascular system, primarily by dissecting a preserved cat specimen. Their dissection experience was supplemented with high-quality plastic human models (Fig. 1) showing corresponding anatomical structures. The students in this human-clay sculpting treatment group had access to the same supplements as the cat dissection control group and were also instructed to use the supplements as they sculpted anatomical structures. Four laboratory sections were assigned to the cat dissection control group, and three laboratory sections were assigned to the human-clay sculpting treatment group (16–20 students per section). Students were not told of their section assignment until the experimental portion of the course began. The laboratory portion of the course was divided into four units, with each unit culminating in a laboratory exam (Table 1).

The first and fourth units of the course served as pre- and postexperiment controls. For the first unit of the laboratory, all students studied the same human skeleton specimens and took the same laboratory exam. During the fourth unit of the course, all students studied the same preserved sheep brain specimens and exposed the same urogenital structures during a cat dissection, and again took a common laboratory exam. Cat dissections vs. human-clay sculpting experiences were compared during the two middle units of the laboratory. It was only during the second and third units of the laboratory course that the students assigned to the two groups had different laboratory experiences.

In the experimental portion of the course, students assigned to the cat dissection control group dissected large (18- to 20-in. long) cat specimens (2–3 students/cat) purchased from Fisher Educational Materials Division. Students assigned to the human-clay sculpting treatment group built the muscular system onto plastic human skeleton Maniken figures purchased from Zahourek Systems (Figs. 2 and 3), or when studying the digestive and circulatory systems, built clay sculptures of human structures into 9- by 13-in. aluminum baking trays (Fig. 4) using clay sculpting tools provided in the laboratory (Fig. 5). Students doing human-clay sculpting also worked in groups of 2–3 students per sculpture (Fig. 6).

The Pennsylvania State University, like many other institutions, lacks the ability to offer human cadaver dissection as a component of a large-enrollment undergraduate introductory human anatomy course. In such instances, when human cadaver dissection is impractical, it is common practice to use preserved cats as alternative instructional material. It is therefore important to note that this study was not designed to test the teaching efficacy of dissection vs. nondissection per se; rather it was to ask whether a clay-sculpting experience using human anatomical relationship might lead to different learning outcomes than a cat dissection experience when the purpose of the course was to learn human rather than cat anatomy, and students were subsequently exposed to human anatomical problem...
sets. We recognize an inherent bias in this study regarding the issue of knowledge transfer between different species (i.e., students learning on human-clay sculptures need only consider human anatomy, whereas students learning on dissected cats need to consider both cat and human anatomical relationships). Nonetheless, because of the widespread use of cat dissections as an instructional method in many human anatomy courses, we felt the experimental design reflected common institutional practice and warranted investigation in a manner consistent with how many human anatomy courses are currently taught.

**Evaluation of Student Performance**

Student performance was evaluated by using four laboratory exams. The first and fourth laboratory exams served as pre- and postexperiment controls, and each consisted of 50 laboratory practical questions (mostly knowledge and comprehension) covering the names of skeletal system structures (exam 1) and the names of nervous and urogenital system structures (exam 4). For exams 1 and 4, students in both treatment groups took identical laboratory exams.

The second and third laboratory exams were used to evaluate the experimental portion of the course. Each exam consisted of two parts: an evening practical exam, similar to the pre- and postexperiment control practical exams; and a short answer exam (taken earlier the same day) consisting of higher-order questions. The evening practical exams included questions that were identical for each treatment group and questions that were similar, but not identical for each treatment group.

The higher-order questions of each short-answer exam (taken earlier the day of the evening practical exam) presented identical questions to students from each treatment group (15 questions on the 2nd exam, 26 questions on the 3rd exam). These questions required analysis or evaluation of novel situations not covered in the lecture or laboratory. By presenting students with questions they never had a chance to practice, we strove to measure whether there was a treatment effect on the students’ ability to draw on their foundation of anatomical knowledge when analyzing a new situation. After the students leave this course, it is our desire that they will be able to apply what they have learned to a variety of situations that are

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**Table 1. Experimental design**

<table>
<thead>
<tr>
<th>Instructional Units</th>
<th>Laboratory Activity</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Control (4 sections)</td>
</tr>
<tr>
<td></td>
<td>Treatment (3 sections)</td>
</tr>
<tr>
<td>1*</td>
<td>Skeleton</td>
</tr>
<tr>
<td>2†</td>
<td>Cat dissection</td>
</tr>
<tr>
<td>3‡</td>
<td>Cat dissection</td>
</tr>
<tr>
<td>4§</td>
<td>Sheep brain and cat dissection</td>
</tr>
</tbody>
</table>

*Preexperiment control (human skeletal system), †experimental portion (muscular system), ‡experimental portion (digestive and cardiovascular systems), §postexperiment control (nervous and urogenital systems).

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During the second evening practical exam on the muscular system, all students were told that the exam would include eight muscles pinned on the high-quality plastic human models (Fig. 1). Thirty other exam questions were similar, but nonidentical for each treatment group. Students in the cat dissection control group were asked to identify anatomical structures pinned on dissected cat specimens. Students in the human-clay sculpting treatment group answered questions on the same anatomical structures, but pinned on clay sculptures. The third evening practical exam was structured in the same manner, but consisted of 39 related cat dissection/human-clay sculpture questions.

The higher-order questions of each short-answer exam (taken earlier the day of the evening practical exam) presented identical questions to students from each treatment group (15 questions on the 2nd exam, 26 questions on the 3rd exam). These questions required analysis or evaluation of novel situations not covered in the lecture or laboratory. By presenting students with questions they never had a chance to practice, we strove to measure whether there was a treatment effect on the students’ ability to draw on their foundation of anatomical knowledge when analyzing a new situation. After the students leave this course, it is our desire that they will be able to apply what they have learned to a variety of situations that are
dissimilar to the teaching laboratory environment. The higher-order questions were not meant to reproduce any “real world” situations, but instead, simply present the students with a novel problem. Examples of the higher-order questions included identifying muscles and organs in cross-sectional views, identifying injured muscles based on a patient reporting painful limb movements, and identifying the location of organs based on human surface anatomy (for a complete list of questions, see supplemental material at http://advan.physiology.org/cgi/content/full/00033.2004/DC1). The situations and examples covered by these questions were not discussed with the students in the lecture or laboratory portions of the course. The higher-order questions tested the student’s ability to transfer and use information learned in the laboratory to a new context.

Evaluation of Student Attitudes

Immediately before and immediately after the experimental portion of the laboratory, students were asked Lichert scale questions (as a 1–5 rating) for their opinions on the importance of using preserved animals in a teaching laboratory, and the value of a preserved animal dissection experience when learning the name and the function of a structure. They were also asked whether they would consider taking a dissection experience when learning the name and the function of a structure?” The mean response for each question was calculated within each treatment group. See METHODS for calculations.

Data Analysis

Anatomy exams. Student performance on the anatomy exams was evaluated by performing pair-wise comparisons on the mean exam scores between the cat dissection and human-clay sculpting treatments. To better detect small differences between exam scores, a z-test statistic was used for all comparisons. The z-test is more powerful than a t-test and is appropriate for pair-wise comparisons with large sample sizes. A P value was then calculated for each z-test statistic. The null hypothesis that the difference between the mean exam scores equals zero was tested (using an unbiased estimate of SD).

Student attitude surveys. For the student attitude surveys, the average response for each question was calculated within each treatment group, and then the null hypothesis that the difference between the treatment means equals zero was tested as described above.

RESULTS

Control Exam Scores

To ensure a nonbiased distribution of students within this study, we examined student performance on preexperiment and postexperiment exam scores (Fig. 7). Before the experiment, there were no significant differences between the laboratory exam scores of the students assigned to the cat dissection control group (mean = 76%, SD = 15.9%, n = 76) and the human-clay sculpting treatment group (mean = 80%, SD = 19%, n = 60). Similarly, the postexperiment exam scores of the cat dissection group (mean = 70%, SD = 20.3%, n = 76) were not significantly different from those of the human-clay sculpting treatment group (mean = 68%, SD = 19.2%, n = 59). We also examined student performance on four lecture exam questions, in which the students were asked to apply concepts discussed in lecture or to analyze a new situation. There were no significant differences (P = 0.25) in the ability of the students assigned to the cat dissection control group

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Start of Experiment</th>
<th>End of Experiment</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat dissection</td>
<td>2.5±0.02 (67)</td>
<td>2.0±0.02 (64)</td>
<td>0.0030</td>
</tr>
<tr>
<td>Human-clay sculpting</td>
<td>2.6±0.02 (54)</td>
<td>2.8±0.02 (47)</td>
<td>0.1800</td>
</tr>
</tbody>
</table>

Results are means ± SE of scores on a scale of 1–5 where 1 = very important/a lot and 5 = not very important/not very much. Number in parentheses is the number of students. Scores of two Lichert scale questions were averaged: “As an anatomy student, how do you feel about the use of preserved animals in teaching laboratories?” and “If you were in charge of this course how much would you use preserved animals in your teaching?” †P value for difference between beginning and end of experiment values within each treatment group. See METHODS for calculations.

<table>
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<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat dissection</td>
<td>2.5±0.02 (67)</td>
<td>2.2±0.02 (64)</td>
<td>0.0720</td>
</tr>
<tr>
<td>Human-clay sculpting</td>
<td>2.5±0.02 (54)</td>
<td>3.3±0.02 (47)</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

Results are means ± SE of scores on a scale of 1–5 where 1 = very important/very helpful and 5 = not very important/not very helpful. Number in parentheses is number of students. Scores of two Lichert scale questions were averaged: “In lab, we spend a lot of time learning the names of structures. How important is a cat dissection for learning how structures work?” and “In your opinion, how much does dissecting an animal in lab help if you need to learn both the name and the function of a structure?” The mean response for these two similar questions (both address student attitude) is shown. †P value for difference between beginning and end of experiment values within each treatment group. See METHODS for calculations.
Table 4. Attitude toward taking a future human anatomy course

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Start of Experiment</th>
<th>End of Experiment</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat dissection</td>
<td>1.3±0.01 (66)</td>
<td>1.2±0.01 (62)</td>
<td>0.2709</td>
</tr>
<tr>
<td>Human-clay sculpting</td>
<td>1.1±0.01 (50)</td>
<td>1.1±0.01 (45)</td>
<td>0.4641</td>
</tr>
</tbody>
</table>

Results are means ± SE of scores of 1 = yes, 2 = no. Binomial question: “If there was time in your schedule, would you consider taking another anatomy course after Biology 129?” †P value for difference between beginning and end of experiment values within each treatment group. See METHODS for calculations.

(mean = 76%, SD = 22%, n = 76) vs. the human-clay sculpting treatment group (mean = 79%, SD = 20%, n = 59) to answer these types of questions. These results indicate that students in all sections demonstrated similar ability in the course.

Experimental Exam Scores

Anatomy students traditionally rely on a good deal of memorization to learn the names and functions of anatomical structures. Most instructors hope that some higher-order learning occurs in the laboratory as well. In this study, both lower-order and higher-order exam questions were used to evaluate student performance.

Lower-order questions. For lower-order questions (knowledge and recall) given during the experimental portion of the laboratory course, there were significant treatment effects (Fig. 8). On questions asking the identity of specific muscles using a plastic human model (identical models were used in each treatment), students in the human-clay sculpting treatment group scored significantly higher (mean = 83.9%, SD = 19.9%, n = 62) than students in the cat dissection control group (mean = 56.3%, SD = 30%, n = 75). When students in the human-clay sculpting treatment group were asked to identify the same structures (pinned on human-clay sculptures) as students in the cat dissection control group (pinned on dissected cats), the students in the human-clay sculpting treatment group again scored significantly higher (mean = 81.1%, SD = 16%, n = 62) than the students in the cat dissection control group (mean = 74.2%, SD = 19.3%, n = 75). On the following laboratory exam using the same question format, students in the human-clay sculpting treatment group again earned significantly higher exam scores (mean = 87.2%, SD = 10.6%, n = 56) than the students in the cat dissection control group (mean = 69.1%, SD = 14.4%, n = 76). These data suggest that under these conditions, a human-clay sculpting laboratory experience is more effective than a cat dissection experience when students are required to recall the name or function of anatomical structures.

Higher-order questions. For higher-order questions (primarily analysis), there were also significant treatment effects during the experimental portion of the course (Fig. 9). For the second laboratory exam, students in the human-clay sculpting treatment group earned significantly higher exam scores (mean = 56.6%; SD = 30%; n = 64) than students in the cat dissection control group (mean = 20.1%; SD = 37.4%; n = 80). These questions required the students to analyze novel situations that had not been presented in the lecture or laboratory. The exam scores of the human-clay sculpting treatment group were also significantly higher (mean = 58.2%; SD = 21.6%; n = 62) than those of the cat dissection control group (mean = 49.0%; SD = 22.9%; n = 80) on the third laboratory exam. In this course, a human-clay sculpting experience seems more beneficial than a cat dissection experience when students were asked to apply their knowledge of human anatomy to a new situation.

Student Attitudes

Immediately before and immediately after the experimental portion of the course, students were asked their opinions about

Fig. 8. Laboratory exam scores (means ± SE) for lower-order questions (i.e., “Identify the pinned structure.”) during the experimental portion of the course. On the muscular system laboratory exam, students in the human-clay sculpture treatment group performed significantly better than students in the cat dissection control group when answering identical questions using high-quality plastic human models (P < 0.000001) and when answering similar questions pinned on human-clay sculptures vs. cats (P = 0.012). On the gastrointestinal/cardiovascular system (GI & CV sys) exam, the scores of students in the human-clay sculpting treatment group were again significantly higher than those of students in the cat dissection control group when answering similar questions pinned on human-clay sculptures vs. dissected cats (P < 0.000001).

Fig. 7. Laboratory exam scores (means ± SE) before and after the experimental portion of the course. For these topics, students had identical laboratory experiences and took identical laboratory exams. There were no significant differences in student performance (exam 1: P = 0.11, exam 4: P = 0.23).
the use of preserved animals in a teaching laboratory and about their feelings toward taking other human anatomy courses.

Before a cat dissection or human-clay sculpting experience, students assigned to each treatment had similar feelings about the importance of using preserved animals in a human anatomy teaching laboratory. After their respective experiences, students in the cat dissection treatment group considered animal use significantly more important than they indicated earlier, whereas students in the human-clay sculpting experience group did not significantly change their opinion (Table 2).

When asked more specifically for their opinion about the importance of a dissection experience when learning the name and function of structures, students again had similar attitudes before their sculpting/cat dissection experiences (Table 3). After these experiences, the students in the cat dissection group viewed dissection as a more valuable learning tool than they did at the beginning of the study \((P = 0.072)\), whereas students in the human-clay sculpting treatment group did not significantly change their opinion \((P = 0.0002)\).

The data suggest that at the beginning of the experiment, the students participating in this study showed no strong preference regarding the use of animals in a teaching laboratory; however, students participating in a cat dissection came to view dissection as more valuable, and students that sculpted human structures from clay viewed dissection as less valuable.

When asked whether they would consider taking a human anatomy course sometime in the future, students in both treatments indicated, on average, positive responses with no significant differences between treatments or within treatments from the beginning to the end of the experiment (Table 4). Neither laboratory experience had a significant effect on students’ willingness to take a subsequent human anatomy course.

**DISCUSSION**

**Student Performance**

Compared to students in the cat dissection control group, students in the human-clay sculpting treatment group were more successful at identifying anatomical structures and transferring what they had learned about human anatomy to new situations involving human anatomy problem sets. Furthermore, whereas students in the human-clay sculpting treatment group valued a cat dissection experience less than their classmates in the control group by the end of the experiment, there were no significant differences at any point in student attitudes toward taking future human anatomy courses. The results of this experiment suggest that a human-clay sculpting experience may be a more effective laboratory teaching method than a cat dissection experience as offered in The Pennsylvania State University’s undergraduate human anatomy laboratory course.

The performance differences observed between the control and sculpting treatment groups cannot be explained by a biased distribution of student aptitude between the two groups. Students in both groups performed equally well on laboratory exams before and after the experimental portion of the course and on both “dry exams” (the skeletal system) and “wet exams” (the nervous and urogenital systems). Students in both groups also performed equally well on a mix of application and analysis level questions asked during the lecture exams. Moreover, student performance differences between the groups cannot be explained by differences in student attitudes toward dissection. Before a cat dissection or human-clay sculpting experience, there were no differences among the students enrolled in this course in their attitudes about the importance or value of dissection or in their willingness to take future human anatomy courses. The treatment differences presented here appear to be the result of using two different approaches to human anatomy laboratory education. Possible explanations for these results include transfer of learning and how actively the students were engaged in the laboratory activities.

Transfer of learning occurs when students learn information or concepts in one context, such as the laboratory, and then transfer what they have learned to a different situation, such as an exam (9). The amount of similarity (also called distance) between the two contexts is referred to as near and far transfer. Near transfer occurs when the learning and testing situations are very similar, and far transfer occurs when the two contexts are less similar. Reasons that students may fail to transfer learning from one context to another include not recognizing the similarities between the two situations, or if the students do recognize the similarities, they are unable to successfully apply what they learned in the new context (6). The students in the human-clay sculpting treatment group may have found it easier to transfer what they learned in the laboratory context to that of the exam questions pinned on the human models, because the two contexts are so similar (both centered on the human anatomy). Students in the cat dissection group were required to transfer their learning between less similar contexts (cat anatomy vs. human anatomy) and had a more difficult time answering those questions.

Transfer of learning may also explain the performance differences between students in the cat dissection control group and the human-clay sculpting treatment group when answering the higher-order questions. Because the higher-order questions were novel situations to all of the students, they represented far transfer for both groups, but the distance of transfer was likely greatest for the students in the cat dissection control group, because these questions focused on human (as opposed to cat) anatomy. It would be informative to repeat this experiment.
with additional exam questions that focus on aspects of cat anatomy, and then measure whether or not transfer of learning is greater for the students in the cat dissection control group than the human-clay sculpting treatment group. A similar experiment testing distance of transfer could be conducted comparing the performance of students in a cadaver-dissection control group to that of students in a human-clay sculpting treatment group. If the differences in student performance observed here are due to transfer of learning, then one might expect a greater rate of transfer as the laboratory and testing contexts become more similar for the dissection group.

A human Maniken clay-sculpting experience was more effective than a cat dissection when the assessments asked content and higher-order questions about human anatomy, possibly because the human-clay sculpting experience engaged the students more actively. In the human anatomy teaching laboratories at The Pennsylvania State University, a cat dissection experience generally emphasizes the isolation and identification of anatomical structures. Students in the cat dissection control group may have focused on isolating structures only partially, identifying them, and then moving on to the next structure. This type of “hit and run” approach contrasts with that required of the students in the human-clay sculpting treatment group, who had to study the general shape and position of a structure in a text or a model, mold the structure of clay, and then place the structure in the correct position relative to the surrounding structures. The students that built clay sculptures of human anatomic structures may have been more actively engaged when studying anatomical relationships.

A human-clay sculpting experience may also present fewer distracters to human anatomy students. When studying structures in the laboratory, students in the human-clay sculpting treatment group started with nothing more than a human skeleton figure or empty tray as a foundation and then added only the anatomical structures they needed to learn. By contrast, students participating in a cat dissection must isolate the structures of interest from all of the surrounding structures. For example, a muscle may be hidden beneath other muscles, covered by connective tissue, and connected to blood vessels and nerves. Some, but not all of these structures may have been discussed at the time the student attempts the cat dissection, and the extra structures may distract the student from the one structure that needs to be identified. The problem of distracters may have also contributed to treatment differences during the laboratory examinations.

When the students were asked to simply identify structures that had been studied in the anatomy laboratories (lower-order questions) on human-clay sculptures vs. dissected cat specimens, it is possible that the students in the human-clay sculpting treatment group were at an advantage compared with their classmates in the cat dissection control group. In an effort to maximize statistical power, only a single approach (cat dissection or human-clay sculpting) was tested within each treatment group, so the students in the human-clay sculpting treatment group identified structures pinned on clay sculptures of human anatomy, and the students in the cat dissection control group identified the same structures pinned on dissected cat specimens. Students in the human-clay sculpting treatment may have had an easier time identifying pinned structures simply because the clay sculptures of human anatomic structures only displayed structures the students had studied for that unit. The students in the cat dissection control group were also required to identify pinned structures they had studied, but these structures were often surrounded by additional anatomic structures that had not been discussed. These additional structures may have acted as distracters when the students in the cat dissection control group were trying to answer questions pinned on cat specimens. However, the presence of distracters does not explain the differences in student performance on the low-order questions pinned on identical human muscular system models. For those questions, all students had studied the same human models (Fig. 1) before the exam, and the exam questions were pinned identically for both groups. The superior performance of the students in the human-clay sculpting experience group on the human model questions was more likely due to transfer of learning.

Student Attitudes

At the beginning of the experimental portion of the laboratory, students placed in the two treatment groups did not differ significantly in their opinions regarding the importance of using preserved animals to study human anatomy. After their respective laboratory experiences, the students’ attitudes toward the importance of using preserved animals to study human anatomy changed little for students that had been sculpting human structures in clay, but were significantly more positive for students that participated in a cat dissection (Table 2). When asked a more specific question about the value of cat dissection when one has to learn both the name and the function of a structure, student opinions again did not differ at the beginning of the experiment. However, after the experiment, the students in the cat dissection group saw the dissection experience as more valuable \( (P = 0.072) \), whereas the students in the human-clay modeling treatment group saw a dissection experience as less important \( (P = 0.0002) \) for learning both the names and functions of anatomical structures (Table 3). With no dissection experience, students seem indifferent, or to prefer nondissection approaches to learning human anatomy. After exposure to a cat dissection experience, students view dissection more positively. Similar results regarding dissection experiences were recently presented at the 2004 Annual Meeting of the Human Anatomy and Physiology Society Poster Session (K. Carlyle and G. Kawchuck: “A Comparative Study of Three Different Learning Mediums in the Anatomy Lab: Student Preferences”). When students are exposed to dissection, they come away with the opinion that it is an important part of the laboratory experience. It would have been informative to survey the students in the human-clay sculpting treatment group after they had been exposed to a cat dissection during the last unit of the laboratory course to see whether their attitudes changed as well.

No matter which approach was used in the laboratory, sculpting human structures from clay or a cat dissection, students’ attitudes toward taking a future human anatomy course did not change significantly. Their attitudes toward human anatomy as a field of study are probably based on the sum of their experiences, which includes their level of success mastering the material, their interactions with instructors and other students, and their general feelings toward the material covered in laboratory.
In conclusion, surveys on student attitudes toward cat dissection and human anatomy laboratories provide interesting feedback to the instructor, but they do not address the central question regarding undergraduate human anatomy laboratories: What are the most effective teaching methods? This experiment does not offer a definitive answer, and as with any study of this type, one must be cautious about extrapolating the results beyond the sample population, but the data do suggest that clay sculpting is an instructional approach worth considering in a teaching laboratory emphasizing the identification of human anatomical structures. Any teaching materials that engage students in activities in which they must interact with the material are worth investigating. Whether or not this level of engagement is possible to attain with computer simulations or other popular alternatives will remain unknown until more research is conducted by using a variety of teaching methods, across different student populations, which examine student learning on multiple levels.

REFERENCES