ABSTRACT: The objective of this study was to determine if laboratory modules of an undergraduate animal anatomy course offered in distance education (DistEd) format were as effective as face-to-face (F2F) format in helping students learn. Students (n = 159) completed an anatomy pretest as well as a presurvey to assess prior DistEd experience. Alternating each week, laboratory topics were presented either as F2F or as virtual DistEd laboratories. Two laboratory examinations were administered and included material from both laboratory formats (DistEd and F2F). Questions from the pretest were also included and used to generate the posttest scores. At the end of the semester, students completed a postsurvey to determine if DistEd was a viable alternative to F2F. Student grades on each examination were compared using an ANOVA model that included main effects of presentation method (DistEd, F2F), semester (fall, spring), and their interaction. Learning was evaluated based on the performances of students on pre- and posttests using unpaired t-tests. There was an increase (\( P < 0.0001 \)) in anatomy post-vs. pretest scores for both semesters, indicative of student learning, although there was no effect of presentation method (F2F or DistEd). On exam 1, students achieved greater scores in fall 2008 (\( P < 0.0001 \)) on material presented via DistEd compared with that presented as F2F. However, in spring 2009 students scored better on material presented as F2F. There was no effect of presentation method on exam 2 scores for either semester. Based on the postsurvey, 79.3% of students in fall 2008 and 52% of students from spring 2009 agreed that DistEd laboratories were a viable alternative to F2F laboratories. The results of this study support the conclusion that anatomy material can be taught effectively by distance education methods.

Key words: anatomy, distance education, laboratory, teaching, undergraduate

INTRODUCTION

Computer-based courses and degree programs have become more common as an option for educating students (Barnes et al., 1999). Distance education (DistEd) may consist of teaching and learning methods that are presented mostly by printed or electronic media (Moore, 1973; Walker and Kelly, 2007; Hofmann and Miner, 2008). Using DistEd as a means of instruction has encouraged educators to reevaluate methods of material presentation and determine if the learning experiences associated with instructional methods such as DistEd are valuable (Besser and Bonn, 1996).

Many animal science programs require students to enroll in an anatomy course as part of a curriculum that will prepare them for various careers or for postgraduate education, such as veterinary school. Traditionally, students have learned anatomy through teaching laboratories utilizing preserved specimens; however, such laboratories are costly and labor intensive for faculty. Presentation through a DistEd format has been suggested as an attractive alternative to meet the needs of the students and reduce faculty workload once the format is implemented and running smoothly (Barnes et al., 1999). However, there has been concern regarding the effectiveness of replacing face-to-face (F2F) laboratories for anatomy instruction with laboratories utilizing a DistEd format (Besser and Bonn, 1996).

A limited number of studies have investigated the effectiveness of DistEd anatomy courses to train veterinary students (Theoret et al., 2007); however, none has examined the effectiveness of teaching animal anatomy to undergraduate students using a DistEd format. Therefore, the purpose of this study was to determine whether gross anatomy of animals could be taught effectively at the undergraduate level using a DistEd delivery style. The hypothesis to be tested was that stu-
Table 1. Method of presentation for laboratory lessons in fall 2008 and spring 2009

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Laboratory topics</th>
<th>Method of presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1-Body water and diffusion</td>
<td>Body water, osmosis, and diffusion</td>
<td>DistEd, F2F</td>
</tr>
<tr>
<td>L2-Brain and senses</td>
<td>Structures and functions of the sheep brain and cow eye</td>
<td>F2F, DistEd</td>
</tr>
<tr>
<td>L3-Bone and joints</td>
<td>Comparative skeletal anatomy—horse, goat, dog, cat, and rabbit</td>
<td>DistEd, F2F</td>
</tr>
<tr>
<td>L4-Cardiovascular system</td>
<td>External and internal cardiac anatomy of the sheep; describe blood flow</td>
<td>F2F, DistEd</td>
</tr>
<tr>
<td>L5-Muscles</td>
<td>Skeletal muscles of the horse</td>
<td>F2F, DistEd</td>
</tr>
<tr>
<td>Laboratory Practical 1</td>
<td>Covered laboratory topics 1 to 5</td>
<td>F2F, F2F</td>
</tr>
<tr>
<td>L6-Respiratory physiology</td>
<td>Anatomy of the respiratory system (sheep); inspiration and expiration</td>
<td>DistEd, F2F</td>
</tr>
<tr>
<td>L7-Blood</td>
<td>Principal components of blood; explain procedures for blood sampling in pigs</td>
<td>F2F, DistEd</td>
</tr>
<tr>
<td>L8-Endocrinology/blood typing</td>
<td>Major endocrine glands and tissues of the body; identification and function of major hormones produced</td>
<td>F2F, DistEd</td>
</tr>
<tr>
<td>L9-Urinary system</td>
<td>External and internal features and functions of the sheep and cow kidney</td>
<td>DistEd, F2F</td>
</tr>
<tr>
<td>L10-Digestive system</td>
<td>Anatomy and function of the digestive system; comparative anatomy of ruminants and nonruminants</td>
<td>F2F, DistEd</td>
</tr>
<tr>
<td>L11-Reproductive physiology</td>
<td>Anatomy and physiology of male and female reproductive system of the cow</td>
<td>DistEd, F2F</td>
</tr>
<tr>
<td>Laboratory Practical 2</td>
<td>Covered laboratory topics 6 to 11</td>
<td>F2F, F2F</td>
</tr>
</tbody>
</table>

DistEd = distance education; F2F = face-to-face.

MATERIALS AND METHODS

Approval was obtained from the university’s Institutional Review Board, and all participants provided written informed consent. No identifying information was used in data analysis, and participation in data collection was entirely voluntary.

Anatomy of Domestic Animals (ANS 206) is a required course for all students in the Department of Animal Science at North Carolina State University. This laboratory-based course is offered every semester and meets once per week for 2 h, with 3 separate laboratory sections for which the students can register. At the end of the course, students should be able to identify the major organs, bones, and muscles of the body and understand how the organs function. In each laboratory lesson, students are introduced to the gross anatomy of a major organ system, using one or more of the domestic animal species as examples for study.

The present investigation was conducted in the fall and spring semesters of 2008 to 2009. The same teaching assistant was responsible for actively teaching the laboratory lessons for both semesters; however, 2 different instructors supervised the teaching assistant in each semester. In fall 2008, 83 students were enrolled in ANS 206, with 67 of these students being female and 16 being male. Seventy-eight percent of the students were sophomores, 7% were freshmen, and 15% were juniors and seniors. In spring 2009, 76 students were enrolled in ANS 206, with 56 females and 20 males. Forty-six percent were freshman, 34% were sophomores, and 20% were juniors and seniors.

Laboratory lessons were presented as DistEd or F2F modules. In a given semester, students participated in the same laboratory each week, such that all students participated in a DistEd laboratory 1 wk and all students participated in a F2F laboratory the next week. In order that each content topic was presented either as a F2F laboratory or through DistEd over the 2 semesters in which the study was conducted, the presentation style (F2F, DistEd) was switched between the fall and spring semesters. For example, if Laboratory 1 was taught using DistEd in the fall, then it was taught F2F the next spring (Table 1).

Each F2F laboratory began with an introductory presentation made by the teaching assistant, which was followed by students viewing models and performing specimen dissections. Distance education laboratories were created using Blackboard Vista (Blackboard, Washington, DC) and Adobe Dreamweaver (Adobe Systems, San Jose, CA). Each DistEd laboratory had an introductory web page presenting the overview and objectives of the laboratory lesson; recorded video demonstrations of specimen dissections with narration, animation, and captions; and video demonstrations from various commercial sites that could be accessed by web link. After viewing the various videos, students were given assignments (some to be worked on individually and others designed for groups) or quizzes or both to be completed by the next week. The quizzes each week were presented in 1 of 3 different formats: self-testing video quizzes that could be attempted multiple times to help students review the information presented in the laboratory, online quizzes based on video demon-
strations provided by a commercial dissection program (Froguts Inc., Seattle, WA), and graded quizzes prepared and administered using Blackboard Vista. In addition, the commercial dissection program was made available so students could download the program to their personal computers, perform virtual dissections, and learn about various systems of the body. Unlike the F2F laboratories, students were allowed to return to the DistEd material throughout the semester for further clarification of laboratory objectives as well as to practice their virtual dissections during the course of the semester.

A presurvey was administered on the first day of class and was used to collect demographics, information on prior knowledge or experience with DistEd, and opinions of students on DistEd courses. A pretest consisting of 11 questions was also administered on the first day of class and was used to determine the extent of prior knowledge students had about anatomy. A postsurvey, given on the last day of the semester, was used to collect general feedback on the course and gather opinions as to whether ANS 206 in a DistEd format would be a viable alternative to an F2F version.

Two practical examinations were given during the course. Laboratory Practical 1 was given mid-semester and covered material from laboratory lessons 1 to 5. Laboratory Practical 2 was given at the end of the semester and covered material from laboratory lessons 6 to 11. The examinations were given in person and consisted of material from both DistEd and F2F laboratory presentations. The practical examination consisted of identification stations where students had to name the structures presented or identify their function and a short answer section that consisted of definitions or explanations. The 11 questions included in the pretest were also included in the appropriate Laboratory Practical examination. Performances on these 11 questions were considered to be the students’ posttest scores.

All statistical analyses were conducted using SAS (SAS Inst. Inc., Cary, NC). Chi-squared tests were performed to determine if differences existed in the proportions of students by sex or student classification. Unpaired t-tests were used to determine, within each semester, if student classification (freshman, sophomore) and sex (male, female) had an effect on final grade. Paired t-tests were performed on pretest and posttest scores to assess student learning for the fall and spring semesters. An ANOVA using the mixed procedure was used to determine if there was a difference in learning between DistEd and F2F formats. The overall model included pre- and posttest scores, presentation style (DistEd, F2F), and their interactions. An ANOVA was also performed to establish whether there was a difference between the scores on each of the laboratory practical examinations. The overall model for Laboratory Practical 1 and 2 included materials presentation (DistEd, F2F), the semester (2008, 2009), and their interactions. One-tail unpaired t-tests were performed to determine if students with prior DistEd experience had greater overall final grades. Data from the postsurvey regarding whether DistEd was a viable option were analyzed using a χ² test. Statistical significance was accepted at an α-level of P < 0.05.

**RESULTS AND DISCUSSION**

Final grade averages differed (P < 0.001) between male and female students for fall (77 vs. 82%, respectively) and spring (73 vs. 79%, respectively) semesters. Proportion of males in the class did not differ between seasons.

Although the proportion of freshmen differed with season, freshmen performed as well as sophomores in each season. There was no significant difference with regard to the overall final grade achieved for freshmen vs. sophomores in fall (79.6 vs. 80.3%, respectively) or spring (77.1 vs. 78.0% respectively) semesters. However, there was a significant difference (P < 0.01) in the proportion of freshmen as well as sophomores between the fall and spring semesters (6/72, 8% vs. 35/61, 57% for freshmen in the fall and spring, respectively; 66/72, 92% vs. 26/61, 43% for sophomores in the fall and spring, respectively).

An overall increase in posttest compared with pretest scores was observed for both semesters. The students in fall 2008 had an increase (P < 0.01) in posttest scores compared with pretest scores (88.0% ± 1.3% vs. 42.2% ± 1.9%, respectively). Similarly, posttest scores for students in spring 2009 were increased (P = 0.0004) compared with pretest scores (86.5% ± 1.7% vs. 40.3% ± 2.1%, respectively). Whereas there was no effect of method of presentation on pre- and posttest performance, there was significant increase in learning for the DistEd and F2F material for students in fall 2008 (P = 0.02) as well as in spring 2009 (P < 0.01), suggesting that learning occurred through both methods.

Despite having the same material taught both semesters, there was a difference (P < 0.01) in overall performance on Laboratory Practical 1 between the 2 semesters, such that fall 2008 scored better than spring 2009 (72.86 ± 1.26 vs. 67.54 ± 1.65, respectively). On Laboratory Practical 2, the average scores for the students in fall 2008 were 75.5% and for the students in spring 2009 were 72.8%, but there was no significant difference between the 2 semesters. On the Laboratory Practical examination 1, students achieved greater scores in fall 2008 (P < 0.0001) on the material presented in the DistEd format than the students in spring 2009 (Figure 1a). There was no difference between scores on material presented in the F2F format on Laboratory Practical 1. On Laboratory Practical 2 (Figure 1b), students from fall 2008 and spring 2009 averaged similar scores, and there was no significant difference between style of material presentation and semester.

Although student performance on the Laboratory Practical examinations differed among semesters, students performed similarly overall when tested on material presented in DistEd format vs. F2F format.
Students in the present study were able to repeatedly review material in the DistEd format, which may have allowed them to perform better on Laboratory Practical 2. Although it cannot be concluded in the present study that the availability of repeated review of material through DistEd always improved student performance, students taught using DistEd methods performed at least as well as those using F2F methods. Possibly, material presented in the spring semester was not taught as effectively as in the fall semester because the laboratory topics presented as either DistEd or F2F alternated between the 2 semesters. For example, the F2F cardiovascular laboratory taught in fall semester may have been more effective than the DistEd cardiovascular laboratory taught in the spring semester. Unfortunately, due to the limited number of questions on each laboratory topic, it cannot be established whether differences existed between presentation methods within each laboratory topic.

Theoret et al. (2007) conducted a study with first-year veterinary students and found that students learned anatomy equally well when instruction was provided by live instruction or video demonstration. Results of the present study also demonstrate that students can learn anatomy of domestic animals from computer-based material. Aly et al. (2004), Theoret et al. (2007), and Grizzle et al. (2008) suggested traditional dissections should remain a part of the anatomy course and that online teaching should be seen as a complement to traditional teaching that is more suited to clinical practices. Offering supplemental material through DistEd format may enhance learning, and therefore a blended or hybrid type of approach to anatomy should be evaluated. However, Josephson and Moore (2006) reported that use of a DVD-supplemented format for learning how to perform active anatomy dissections resulted in students scoring similarly on examination questions to those who were not provided the DVD-supplemented format.

Based on results from the presurvey, 25% of students in fall 2008 and 26% of students in spring 2009 had taken a course through DistEd before enrolling in ANS 206. However, this prior experience with DistEd had no effect on their final grade. For the fall 2008 semester, 79.3% of students agreed that DistEd laboratories were a viable alternative to F2F laboratories. In contrast only 52% (P < 0.05) of students from spring 2009 felt DistEd laboratories were a viable teaching alternative. Anatomy of Domestic Animals 206 is a 200-level course and is usually recommended to students in their second year or later. There was a greater number of freshmen in the spring semester class, and although this had no effect on overall grade performance, this group did not express the same positive attitude on the post-survey as the fall semester class. First-year students enrolled in an 200-level course tend to have trouble adjusting to the expectations of studying and learning in college compared with what they did in high school (Carew et al., 1997), and this may have contributed to the difference in attitude with the spring 2009 class. Investigating a similar hypothesis as the present study, Aly et al. (2003) also implied that the less experienced background associated with first-year undergraduates compared with upperclassmen is cause for the uncertainty with multimedia courseware packages. Aly et al. (2003) also noted that upperclassmen would appreciate computer-assisted learning software more because they would be more familiar with unconventional educational approaches.

Students that have adapted themselves to traditional teaching methods may dislike the transition to online teaching practices because it forces them to modify their learning styles (Aly et al., 2003). It seems that students in this study were overall more agreeable to a change in teaching style based on the fact that the majority of students from the 2008 and 2009 semesters agreed that a DistEd option is feasible for teaching anatomy, although notably more students from the fall 2008 semester expressed this opinion than those from the spring 2009 semester. The student body in fall 2008 was largely made up of sophomores; thus, they were more likely to adapt to alternate teaching methods.
than the freshman students in spring 2009. However, once the students in spring 2009 adjusted to the laboratory course format, they performed equally well on Laboratory Practical 2 and exhibited an equal overall grade performance, regardless of the method of materials presentation.

In summary, students appeared to perform similarly when tested on material presented using a DistEd format compared with F2F format. Most students across both the fall and spring semesters agreed that DistEd would be a viable option to live laboratories. However, freshman students may be less comfortable with the DistEd format compared with upperclassmen. The results of this study support the conclusion that anatomy material can be taught effectively by DistEd methods. Still, it may be necessary to investigate whether student learning styles may have had an impact on a DistEd teaching style or whether incorporating supplemental online resources into F2F laboratories would improve student learning and performance in an undergraduate gross anatomy course.

**LITERATURE CITED**


