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Use Of Electronic Anatomy Practical Examinations For Remediating "At Risk" Students

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ABSTRACT

Restrictive lab scheduling, an increasing number of human cadaver-based anatomy courses and a reduction in the curricular time allotted to anatomy courses have created problems with cadaver lab access at the University of New England. This paper describes a combination of anatomy testing and grading strategies to allow “at risk” (borderline failing) students an opportunity to remediate their lowest set of exam scores and pass their anatomy course. An alternative electronic practical exam for these students provided flexibility in lab scheduling, thereby increasing laboratory access for other students taking concurrent courses. Specifically, the electronic exams allowed for a reduction in the amount of time the cadaver lab is locked down for exam purposes.

Masters-level occupational therapy (MOT) and physician assistant students (MPA) and doctoral level physical therapy (DPT) students participate in a prosection-based human cadaver laboratory and take cadaver-based practical exams as part of their anatomy course. Students who were not performing at a passing level for their curriculum (69.5% for MOT & MPA, 79.5% for DPT) were given an opportunity to remediate their lowest set of multiple choice and practical exams using the previous year’s multiple choice exam and a new electronic practical exam. When the original cadaver-based practical and multiple choice exam scores were replaced with the remedial electronic practical exam and remedial multiple choice exam scores, 75% (24/32) of these students were able to successfully remediate their academic deficiencies and pass their anatomy course.

Key Words

computer-assisted, human anatomy, physical / occupational therapy, physician assistant

INTRODUCTION

The use of computers to replace cadaver dissection in anatomy education is a controversial topic. While there is strong evidence that electronic resources are a viable alternative to traditionally taught courses (Walsh and Bohn, 1990; Bukowski, 2002; Nicholson et al., 2006; Lockman et al., 2008) there is equally strong resistance to straying from the time-tested curricula (Ellis, 2001; Cahill et al., 2002; Older, 2004; Turney, 2007).

Often the call for electronic anatomy instruction comes from practical necessity due to increasing student enrollment, rising cadaver lab costs, curricular time constraints and a lack of adequately trained professionals (Bukowski, 2002; Older, 2004). Newer imaging resources are also driving anatomy toward electronic presentation. As Older (2004, p3) writes, "sophisticated clinical imaging is an essential pathway to precise study of structure and how it is maintained." Other authors have enhanced their traditionally taught cadaveric anatomy courses to include digital radiographic images, computed tomography images, magnetic resonance images, laparoscopic video, and three-dimensional (3-D) visualizations (Reidenberg and Laitman, 2002).

One would think that the more interactive the material, the better it would be learned, yet this is not always the case (Devitt and Palmer, 1999; Nicholson et al., 2006). It has been shown that virtual computer models can actually hinder anatomy education for low performing students (Garg et al., 1999). Computer-assisted instruction of anatomy has limitations, including suboptimal use of screen area, location of annotations and lack of interactivity by the user (Foreman et al., 2005). Some have gone so far as to say that computer-assisted instruction is little more than static text and images which do not exploit the advantages of the computer (Nicholson et al., 2006).

Anatomists are often strong advocates for continuing the traditional cadaver-based curricula because of the benefits dissection brings to the course. Dissection provides an understanding of the 3-dimensional position of structures; the feel of structures and the ability to identify them by touch; the practice of fine motor skills and observational skills; practice following detailed directions; a respect for life, death and the complexity of the human body; an active learning process which requires the undivided attention of the student; and visualization of individual anatomical variability. An opportunity to study biological variation underscores an important concept in medicine (Ellis 2001; Cahill et al., 2002; Older, 2004). In light of this specific benefit, some programs have instituted prosection-based anatomy courses. In these courses, students reduce the time devoted to dissection, yet still obtain an effective working knowledge of anatomical variations (Nnodim, 1990; Nnodim et al., 1996). This process is viable because the time saved not performing dissection is used by the students to view multiple prosected cadavers.

This prosection method of instruction is used for human gross anatomy courses for masters level occupational therapy (MOT), masters level physician assistant (MPA) and doctoral level physical therapy (DPT) students at the University of New England. The prosections are performed during the summer by first year medical students under the direction of a laboratory instructor. Typically each medical student is responsible for a single cadaveric dissection. The reduction in MOT, MPA and DPT student time devoted to the prosection-based course allows for additional cadaver-based courses to be run concurrently in the laboratory. Three simultaneous human gross anatomy courses run at the University of New England during the fall semester:

medical gross anatomy, occupational therapy gross anatomy and physical therapy gross anatomy. All of the MOT, MPA or DPT students (separated by program) participate in the same lab at the same time. The concurrent courses allow students participating in prosection-based courses to see more than 30 different medical gross anatomy cadaveric dissections, without having to dissect on their own. The MOT, MPA and DPT students can spend their lab time studying the structures and seeing as many different examples as possible. Even with this opportunity, there are still students who do not pass anatomy. These "at risk" students (borderline failing) were poorly performing students who are just under the pass-fail cutoff. The university strongly encourages student retention and remediation exams are often offered.

The concurrent cadaver-based courses lead to tight scheduling in the anatomy lab. Regular course exams create additional laboratory access issues due to set up time. Students who need to take examinations outside of scheduled lab time create even more lab access problems. There is limited time and space in the lab to accommodate for make-up or remedial practical exams. This paper discusses an alternative electronic exam for these remedial students to avoid laboratory time conflicts.

DESCRIPTION

<u>At Risk Students</u>

The DPT and MOT gross anatomy courses ran concurrently with the medical student anatomy course. These students have laboratories that alternate with the medical course laboratories each day, so that when the medical students were in lecture, the DPT or MOT students were in the cadaver lab (and vice versa). The MPA students in also participated in a prosection-based anatomy course, but this summer course did not coincide with the medical gross anatomy course and has no lab time conflicts.

The DPT, MOT and MPA labs were based upon a human anatomy prosection guide (Daly, 2008). Small student groups (6-13) were led by anatomy faculty and medical student instructors. During the lab, prosections, medical student dissections and plastic models, were freely available to the students. Outside of scheduled class time, and barring conflicts with medical student class time, DPT, MOT and MPA students had open access to the cadaver lab through a swipe card security system. The open lab ran daily from 5pm-midnight.

The students taking the prosection-based courses took a total of 4 equally weighted multiple choice and practical exams based upon upper extremity, lower extremity and back, head and neck, and thorax, abdomen and pelvis, respectively. The cadaver-based practical exams only consisted of identification-type questions in which the students could rotate freely in an un-timed format. More advanced anatomical knowledge was examined in the multiple choice exams outside of lab time.

Students who were not performing at a passing level for their curriculum by the end of the anatomy course (< 69.5% for MOT & MPA, <79.5% for DPT) were given an opportunity to remediate their lowest set of exam grades (multiple choice and practical). The remediation exam scores replaced the student's original exam scores and a new course grade was determined. The intention of this process was to attempt to keep competent, but marginal, students enrolled in their respective programs, while identifying poorly performing students to repeat the curriculum. Students who were significantly below the pass-fail cutoff (with no chance to successfully remediate even scoring 100% on exams) were not included.

Remediation Computer Practical Examination

High resolution images from the Color Atlas of Anatomy (Rohen et al., 2006) were scanned and used to create electronic practical exam. Images were cropped to remove all text labels. The leader lines and numbers in the margins were retained. Images were imported into Microsoft PowerPoint on individual slides and sequential page numbers were added to direct students. Simple labels to identify the structure or space, similar to the cadaver-based practical exams, were added. The corresponding (non-sequential) leader line number was indicated in the title of the slide. An arrow was added at the leader line number to direct the students to the specific structure to be identified.

At risk students were instructed that their remediation electronic practical exam would be based entirely on the Color Atlas of Anatomy (Rohen et al., 2006). The examination was restricted to topics covered in the prosection lab manual (Daly, 2008), but would not strictly adhere to specific chapters in the atlas. Students were given an additional 1 - 4 weeks (semester break) to study the course material that would be on the remediation exam. The upper extremity exam (least amount of material) had a potential of at least 142 images and 1590 labeled structures. The head and neck exam (most amount of material) had a potential of at least 389 images and 4642 labeled structures. Like the cadaver-based practical, students were responsible only for identification of structures. Similar to the cadaver-based practical, 50 labeled structures from the atlas were identified and students were expected to give answers corresponding to the atlas key.

Like Carmichael and Pawlina (2000), the electronic practical exam was carried to the exam room on a flash drive and presented on a computer. Students were able to take the exam at their own pace (un-timed) and had individual control of their computer. Because each student had an independent exam, they were able to move indicator arrows that obscured numbers or other structures and change the zoom ratio on the images without affecting other students. Regardless, during the electronic practical exam, a proctor was present to monitor the students.

Table 1 Prosection anatomy student numbers and failures

year	degree	# students in lab	# outright fail	# borderline fail	fail %
2004	MPA	50	0	2	0.040
	MOT	15	2	2	0.266
	DPT	11	0	2	0.182
2005	MPA	43	1	0	0.023
	MOT	26	3	5	0.308
	DPT	26	1	3	0.154
2006	MPA	49	0	0	0.000
	MOT	39	6	0	0.154
	DPT	27	0	1	0.037
2007	MPA	46	1	0	0.022
	MOT	37	2	5	0.200
	DPT	29	0	1	0.034
2008	MPA	51	2	0	0.039
	MOT	30	2	3	0.167
	DPT	36	1	8	0.250
	total	515	21	32	0.103

Table 1: The number of students who participated in the prosection anatomy courses at the University of New England, including the number of students who were below the pass/fail cutoff and percentage of the failing students who successfully remediated their anatomy course using the electronic practical exam.

Remediation Results

Thirty two DPT, MOT and MPA students over 5 years were given the opportunity to take the remediation exams. An additional 21 DPT, MOT and MPA students did not pass the anatomy course with sufficiently high enough grades to warrant remediation. A total of 515 students took these courses between 2004 and 2008 and the remedial (32) and failing (21) students represent 10.3% of the DPT/MOT/MPA population.

Two groups of data are presented below based upon the passing grade required by the masters and the doctorate curricula (< 69.5% for MOT & MPA, <79.5% for DPT).

The MOT and MPA students' original cadaver-based practical exam scores averaged 49.9 ± 11.1 SD (standard deviation, range 31-74 out of 100) and their original multiple choice exams averaged 55.4 ± 10.1 SD (range 40-68). The remediation exams resulted in the MOT and MPA student averages increasing to 69.9 ± 12.2 SD (range 44-87) on the electronic practical exam and 62.1 ± 10.8 SD (range 42-80) on the remediated multiple choice exam. The average change in exam scores was 20.0 points on the electronic practical and 6.7 points on the multiple choice exam.

The DPT students' original cadaver-based practical exam scores averaged 60.5 ± 13.6 SD (range 37-84) and their original multiple choice exams averaged 68.3 ± 9.4 SD (range 54-86). The remediation exams resulted in the DPT student averages increasing to 81.2 ± 10.1 SD (range 52-91) on the electronic practical exam and 81.3 ± 10.5 SD (range 54-96) on the remedial multiple choice exam. The average change in exam scores was 20.7 points on the electronic practical and 13.0 points on the multiple choice exam.

Table 2 Remediation student average original and remedial scores

	# students	original MC exam	original practical	original course grade	remedial MC exam	electronic practical	modified course grade	
MPA/	17	55.38	49.88	65.35	62.06	69.88	68.06	ave
MOT		10.13	11.06	4.68	10.83	12.16	4.00	stdev
DPT	15	68.27	60.47	75.39	81.30	81.23	79.63	ave
		9.41	13.61	4.37	10.53	10.06	4.46	stdev

Table 2: Remediation student average scores (and standard deviation) on original multiple-choice exam and cadaver-based practical exam resulting in grades below the pass/fail cutoff. Remedial average scores on multiple-choice exam and electronic practical exam resulting in the modified course grade. Original exam grades were replaced with remedial exam grades. Each set of exams made up no more than 25% of the course grade.

When the original cadaver-based practical and multiple choice exam scores were replaced with the electronic practical and remedial multiple choice exam scores, 75% (24/32) of the students were able to successfully pass the course. The MOT and MPA remedial students went from a course average of 65.4 ± 4.7 SD (range 52.1-68.8) to 68.1 ± 4.0 SD (range 58.2-71.6). The DPT remedial students went from a course average of 75.4 ± 4.4 SD (range 63.9-79.2) to 79.6 ± 4.5 SD (range 64.9-83.3). Those students who did not pass the course (8/32) either chose to withdraw from the program or chose to retake the course the following year.

DISCUSSION

The second time that a student takes any exam, it is expected that they will do better. There was an increase in the students' performance on the remediation exams versus their original exams. Scores on the electronic practical exams increased 20.4% and scores on the multiple choice exams increased 9.7%. This resulted in an average increase of the students' course grade by 3.4%. This increase in scores could be due to a variety of factors that were different for the remediating students. Remedial students were given an extra 1-4 weeks of study time to prepare for the remediation exams. The remedial exams also took place when the students were not taking other courses nor preparing for other exams.

The nature of the electronic practical exams might have given the students an advantage. Remedial students knew exactly which set of images would be used on the exam. The same types of questions were asked on the remedial exams (identification only), but it is unlikely that students would have been able to memorize the 140-389 images with 1600-4600 identified structures. It may have been that the electronic practical exams were significantly easier than the original cadaver-based practical exams. Yet even with the relative ease of the electronic practical, not all at risk students successfully passed the course. Eight of the remedial students still had to retake the course or withdraw from their program.

There are benefits and drawbacks to using electronic practical exams in anatomy courses. Some of the benefits include: a time savings because there is no need for set up or break down of computer-based practical exams; the ability to easily change exams from year to year; the ability to proctor multiple practical exams (extremities, head & neck, thorax, abdomen and pelvis) within a single exam session; increased exam security; and lack of laboratory access conflicts. Electronic practical exams may also be useful for high performing students who were absent on exam days.

A significant benefit of the electronic practical is that it did not require the cadaver lab to be locked down to ensure security of the exam process. Normally, it takes at least 2 hours to prepare a cadaver-based practical. Often, exam set-up is done the night before. Closing down the cadaver lab the night before an exam restricts access to the lab when many students want a final opportunity to study. The use of electronic practical exams for remedial students has allowed for increased access to the cadaver lab for both dissection purposes and student access for any of the ongoing courses.

Because of the nature of the remediation described in this paper, some at risk students needed upper extremity exams at the same time that others needed head & neck exams. It would be time intensive to set up four completely different practical exams in the cadaver lab. If these exams were scheduled to run concurrently, then the entire process would be confusing for both faculty and students. Because these remediation exams necessarily take place after the completion of a semester, lab access for exam purposes continued to be an issue as new courses also required use of the cadaver lab each semester. The use of electronic practical exams allows an instructor to set up and proctor multiple versions of different exams without the significant time expenditure or lab closure. In addition, the use of electronic exams has substantially reduced the required instructor set-up time for anatomy practical exams.

Similar to Carmichael and Pawlina (2000), the author specifies software, texts, and methods that have been used, yet other software and texts can be used to accomplish the same goal. The author chose to use the Color Atlas of Anatomy (Rohen et al., 2006) for a number of reasons. First, the atlas uses leader lines and numbers on the sides of the images rather than placing the numbers directly over the structures. This allows for easier viewing and identification of structures. The atlas also uses a numbered key separate from the images. The removal of the text from the images makes for cleaner electronic practical exams without giving any cues for identification. In addition, the atlas uses multiple cadavers. One of the major criticisms of computer-assisted instruction is the lack of anatomical variation and this issue can be easily resolved by using a multiple cadaver-based atlas. With the increased use of internet resources, Lippincott Williams and Wilkins, the atlas publisher, have even made the images available via their online resource.

The author chose to use Microsoft's PowerPoint program because of the ubiquitous nature of the program. The author found it was relatively quick and easy to import images, manipulate them and create an electronic exam. Students were familiar with the program and were able to change views and move arrows as necessary. It was critical that the students be allowed to have this discretion as the structure, leader line or number itself often would be obscured by the arrow.

It was also important that the leader line number of the structure to be identified was also listed again on the PowerPoint slide so that the student would not lose the exam question when the arrow was moved.

Exam security was relatively easy to maintain because of the electronic resources. Access to the electronic exams was restricted to specific computers by using flash drives for transport. By installing and deleting exams as they are taken and completed, the instructor was certain that the examinations were not accessed by the students ahead of time. If changes to an exam were desired, little effort is required to move an arrow and change the leader line number on a slide to develop an entirely new exam. There is not even a need for new images as each image typically has upwards of 25 items labeled. An instructor can create completely different exams from year to year with minimal effort.

The author chose simple identification tasks for the electronic practical exams, but this could be easily escalated to questions typically asked on any practical exam. Because the students would have prior knowledge of which resources are used, then would be fair to include any questions that relate to the material. Many advanced questions asked on practical exams first require the student to identify the structure indicated and then base their answer on that identification. The same can be done with electronic practical exams.

Electronic practical exams do have drawbacks. They lend support to a progression away from dissection-based anatomy courses. If cadaver-based course instructors choose to electronically test students, it seems likely that the students may alter their study efforts to focus on the format of the electronic exams rather than learning from the dissections. Dissection quality is bound to decline. To counteract this, would be necessary to encourage the students to spend time in the cadaver lab. The practical exams should be based upon student dissections, not a photograph from an atlas. As long as the students know that they will be tested on what they have seen and done in the lab, they are likely to do their best dissection and seek out good examples of structures. While this paper reports on electronic practicals that were based upon a published atlas, the students did not have the opportunity to dissect during the course. An ideal way to present the electronic practical in the future would be to photograph the prosections and create an exam from those images.

Electronic exams, as there are presented in this paper, may also not work as well with large groups of students. In order for students to proceed at their own pace and retain the ability to move arrows or change zoom, students need to have their own computer for the exam. Obviously, students should not have access to the internet or prior access to the computers to ensure exam security. Therefore, electronic exams such as this require the use of multiple computers, which can be cost prohibitive. Limiting the numbers of students taking the electronic exams offsets that financial cost. This paper discussed exams restricted to 4 students at a time. It was a simple task to proctor the remedial students and maintain the security of the exam in a controlled situation. With larger groups, significant time and effort must be spent distributing and securing the electronic exam. It makes less sense to deal with individual computers for a large number of students. With enough students taking the same exam, it is worthwhile to set up a cadaver-based practical exam.

In conclusion, this paper shows that it is possible to examine students using electronic resources while still maintaining the integrity of a cadaver-based laboratory course. While it may not be academically ideal to examine students using electronic resources, it is critical to be able to provide access to cadaveric laboratories that give the greatest benefit to the most students. Laboratory lockdown for individual students' exams can be now be eliminated.

NOTES ON CONTRIBUTORS

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