A Virtual Laboratory for Undergraduate Instruction in Domestic Animal Reproductive Physiology: Help or Hindrance?

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Abstract

A virtual teaching laboratory was created to augment lecture and dissection laboratories for Animal Science students taking a course in Reproductive Physiology and Lactation. Labeled photographic and quiz files were generated and loaded onto the student online course management system, Blackboard ™. Student use of quiz files, and the number of times they accessed a comprehensive quiz file (CQ) were monitored during the spring of 2006. Student use of online quiz files was positively, though moderately correlated with exam score, r= 0.351. Students using the practice quiz files increased their odds of receiving a higher grade by 17% with each additional practice quiz used (P=.0082). Similarly, students increased their odds of receiving a higher grade by 8% with each additional access to the comprehensive quiz file (P =.0183). It was concluded that a virtual lab consisting of photographic and quiz files had merit as a study aid for an anatomy section in domestic animal reproduction, but required a large commitment of time and use to be effective. Wet dissection of tissues was still considered necessary for optimal understanding and success in this course.

Introduction

Use of virtual or computer based laboratories for animal dissection/anatomy has been reported in secondary schools (Velie and Hall, 1999), collegiate health science curricula, and medical schools (Granger et al., 2006; Reeves et al., 2004; Walker et al., 2007). Arguments have been made both pro and con on the use of these teaching aids with some arguing that today's student has been surrounded by a lifetime of computers, the Internet, and media, and have different expectations than students of the past (Huang, 2004). Obviously the virtual lab is available 24 hours per day and 7 days a week, and negates the need to sacrifice animals to provide wet tissue. Samsel and coworkers (1994) concluded that computer assisted instruction was of particular use to novice learners, and offered an ordered approach to class material, which could be easily altered. Use of virtual labs containing video and interactive teaching modules to teach kidney function were perceived by students as "fun," and was considered a great way to interactively reinforce what had been learned in lecture and lab (Huang, 2004). However, regardless of administrative claims that virtual labs saved money (Scheckler, 2003), other authors felt that the dissection laboratory was the only place where three-dimensional structures are experienced, and reinforced by tactile, visual (Aziz et al., 2002; Mutyala and Cahill, 1996) and even olfactory perceptions. In our own experience, there has been at least one student who changed majors when confronted with the smell associated with dead tissue during a dissection laboratory.

Aside from reduced cost and unlimited access, reasons to make a virtual lab available to students would be to increase comprehension, and hence grade performance. Bukowski (2002) compared three consecutive classes of freshman taking human anatomy as part of a physical therapy curriculum. Class one was taught human anatomy using traditional cadaver laboratories with structured lectures (n=18); class two was taught using no structured laboratories or lectures, and were entirely self taught via a computerized learning module (n=17); class three was taught using structured lectures, and a self directed computer module for laboratory exercises (n=20). Students kept track of the total study hours spent in lecture, dissection laboratory, and/or self directed study. Statistical differences were not found (P > .05) among the three classes as measured by final anatomy course grade, total study hours, performance in the remainder of the physical therapy curriculum, or performance on the state licensure examination. It was concluded that computerized self study modules may be a viable alternative for traditional cadaver instruction to teach human anatomy. However, even though not statistically different (P > .05), students entirely self taught (class two) spent nearly 100 more hours in course preparation than class three which was taught by combination lecture/virtual dissection lab (226 vs. 129 hr.). Students taught by traditional lecture/cadaver labs spent 158 hours in study/preparation which was intermediate between the other two methods of learning. While

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there was no difference in grade or course performance between these classes, it is interesting that students, who had instructor contact either through lecture or laboratory, spent far fewer hours in study as compared to students who only had access to computerized material.

The Department of Animal Science at the University of Tennessee is similar to others, in that 90% or more of our entering freshmen declare pre-veterinary science as their major. As part of our core curriculum we offer a required core course entitled the Physiology of Reproduction and Lactation which is cross listed in the Department of Biochemistry and Molecular Biology (BCMB). The course has an approximate yearly enrollment of 70 to 80 students, and utilizes wet dissection laboratories to teach male and female reproductive anatomy of several farm animal species (cow, pig, sheep, horse, dog, and cat). Unlike human medical colleges, our students must familiarize themselves with the structural anatomy of multiple farm animal species, and in a context of two laboratory periods. This is especially challenging for many of our students, both Animal Science and BCMB majors, as fewer and fewer students live on farms, or have exposure to food animal species in their pre-college curriculums. Obtaining tissues to conduct these laboratories is becoming increasingly difficult due to the lack of abattoirs within a reasonable distance of the University: so that, we offer only wet dissection from cotyledonary (cattle) and non-cotyledonary (swine) animals.

Plastinated specimens provided by the school of veterinary medicine are available for other species comparison (dog, cat, sheep, and horse). Because our curriculum is no different than many others; cramped for time, and under pressure to add additional topics while still maintaining anatomy modules, we felt that the course might be improved by the addition of a virtual laboratory. It was speculated that it might be particularly helpful to the non- farm, or non-Animal Science students. However, we were not sure that if a virtual laboratory was available, whether, or to what extent, the students would make use of it; particularly in light of extensive visuals being presented in lecture, and the requirement of a text that was also extremely well illustrated. More important, we did not know if use of a virtual laboratory would influence class performance. Our hypothesis was that student performance as measured by examination score would be improved through access to a supplemental virtual laboratory, and would cover both lecture and dissection lab material. Therefore to test this hypothesis, a virtual laboratory was made and consisted of photographic and quiz files covering female reproductive anatomy and physiology. The objectives were to determine if exam grade covering female anatomy and physiology was affected by: 1) the number of practice quiz files used in preparation for the examination, or 2) the number of times a single comprehensive quiz file was accessed in preparation for the examination.

Materials and Methods

Digital slide sets depicting cotyledonary and non cotyledonary reproductive tracts from cattle and swine were made from whole, dissected, pregnant and non pregnant tracts. Slide sets were sent to the university Innovative Technology Center where they were labeled, grouped by species and portion of the reproductive tract. A series of practice quizzes was generated from each photographic file which allowed students to test their knowledge of both anatomy and function. Eight practice quizzes containing 1 to 13 questions were generated from photographic files (total 51 questions). An additional CQ file was made which consisted of 20 questions, randomly drawn from the 51 available questions in the quiz file (Figure 1). Each time a student accessed the CQ file, a different random sample of questions was generated

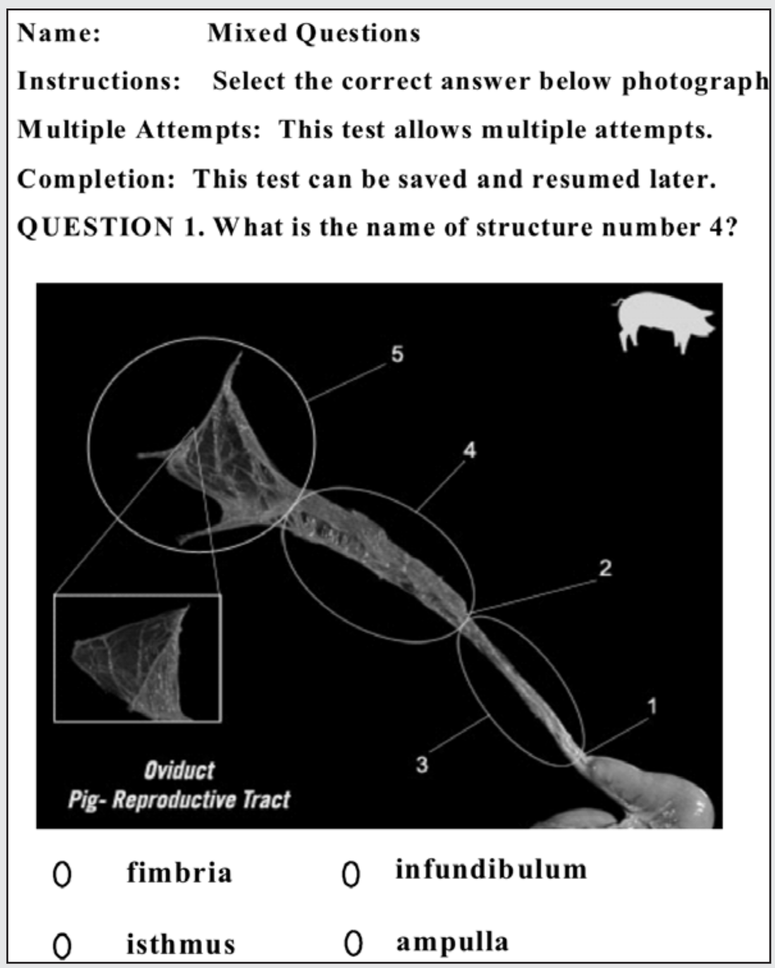

Figure 1. Example practice quiz question.

by the computer. Practice quizzes could be attempted multiple times, or saved for completion at a later date. Files were loaded onto the student online course management system, Blackboard ™. Use of quiz files was monitored during the spring semester of 2006 by a tracking option available in Blackboard™, yielding data from a class size of 69 students. Data was collected on: a) the number of quiz files attempted (from a possible total of 8); b) whether the CQ file was attempted (0 for no attempt, 1 if attempted); c) the total number of quiz files attempted (quiz files + CQ file); and d) the number of times the CQ file was attempted.

Scores from the first examination in the course covering gross anatomy and function were correlated to the number of quiz files used, and the number of times the CQ file was accessed in preparation for the exam. Examination questions were derived from lecture material, the virtual photographic files that depicted anatomical parts and virtual quiz files that covered anatomy and function of reproductive structures.

Data were analyzed by linear regression using the REG and LOGISTIC procedures of SAS (SAS, 2002). Exam scores were also converted to grade (A to F) per: A=score of 90 and above; B=80-89; C=70-79; D=60-69; F=<60. The REG procedure was used to establish the relationship between the dependent variable, exam score, and the total number of quiz files attempted (independent variable, Objective 1). Total number of quiz files attempted was the sum of regular quiz files used (0-8), plus CQ file usage (no=0, yes=1). A Pearson correlation coefficient was generated from this same analysis. For both Objectives 1 and 2, data were subjected to the LOGISTIC procedure to fit a logistic regression model for ordinal response data. This procedure estimates an odds ratio showing the odds of achieving the next higher value of the dependent variable (letter grade), with each increase in the independent variable (total quiz files used, and number of times CQ file was used in Objectives 1 and 2 respectively). Significance was declared at $P < .05$ for all analyses.

Results and Discussion

Objective 1

Photographic and quiz files were well received by students as measured by positive statements received during end-of-course student evaluations, and by the number of students using available quiz files. Nearly 80% (78.3%) of the class made use of the virtual quiz files to prepare for the anatomy examination. Only two students who used four or fewer quiz files received a score greater than 90 (A) on the exam, while 22 students using four or fewer files received scores less than 70 (D or F; Figure 2). Nine of the twelve students who received an A on the exam used all nine available quiz files. While the regression analysis of the data showed that exam grade was affected by total quiz file use ($P < 0.0082$), the correlation coefficient (P=.0031) was considered moderate, $r = 0.351$ (Figure 2). Correlation coefficients of 0.5 or greater are considered large, while those 0.3-0.5 moderate, and those 0.3 and below, small (Cohen, 1988). The odds ratio estimate was 1.17 (P=.0082), and was interpreted to mean that the odds of achieving the next higher exam grade was 17% higher with each additional practice quiz file used (Figure2).

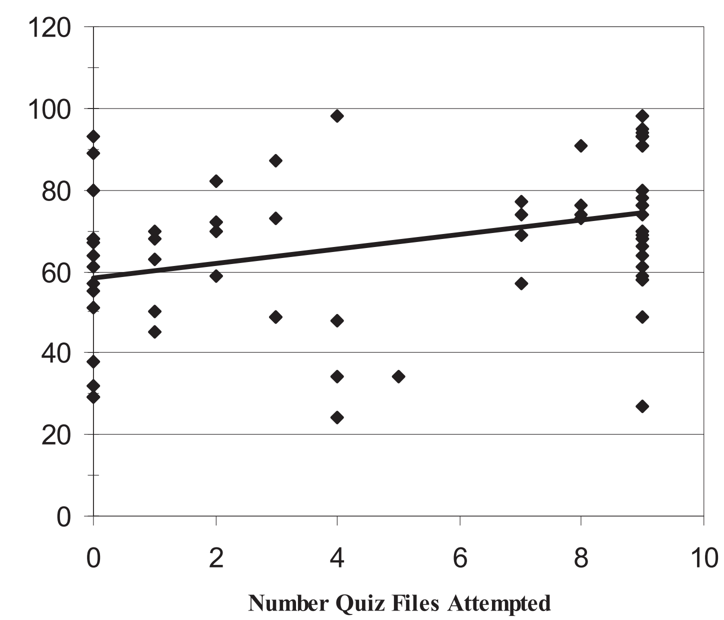

Figure 2. Scatter graph showing number of total quiz files attempted by students (x axis) vs. their corresponding exam score (y axis). Correlation Coefficient = 0.351 (P = .0031). Regression line through data reflects the odds ratio of 1.17 (P=.0082) which was interpreted to mean that a student increases his odds of achieving the next higher examination grade by 17% with each additional quiz file attempted.

Objective 2

Similar to the results found in Objective 1, letter grade received on the exam was a function of the number of times a student accessed the CQ file ($P < .0183$). Students receiving an A used the CQ file an average of nine times as compared to students who accessed the file an average of four or fewer times and received grades of D, or F. The odds ratio of the data was 1.08 ($P < .02$), and was interpreted to mean that the probability of receiving the next higher exam grade was increased 8% with each use of the comprehensive exam file (Figure 3). For example, a student who took the CQ file five times had a 15% probability of receiving an A grade, while if the CQ file was used 15 times that probability increased to 30% (Figure 3). Conversely, the probability of receiving a grade of D or F was 20% or less if the CQ file was used 10 times, and was less than 10% if the CQ file was used extensively, ≥ 25 times. Use of the comprehensive quiz file did not seem to greatly impact letter grades of B or C, and suggests that other study factors may influence comprehension of the exam material. It is obvious that just having access to a computer lab does not necessarily mean that a student will either make use of the study aid, or that casual access will influence examination grade.

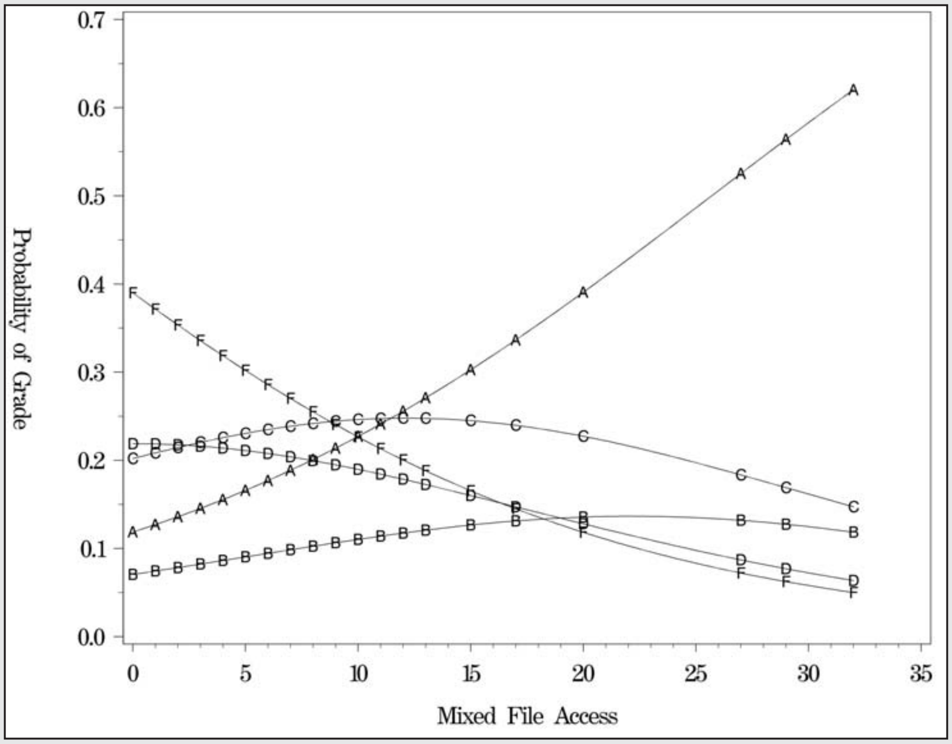

Figure 3. Probability of receiving a grade of A through F with each increase in use of a comprehensive quiz file. The odds ratio of 1.08 ($P < .02$) was interpreted to mean that the odds of receiving the next higher grade was increased 8% with each increase in file access. As this figure shows, the probability of receiving an A increases from approximately 12% with no access to over 60% with greater than 30 accesses. Similarly, the probability of an F decreases from approximately 40% with no access to less than 10% with over 30 accesses.

Our hypothesis for implementation of a virtual laboratory was that it would be widely used by students in the Physiology of Reproduction and Lactation course, and its use would improve exam scores. While 78.3 % of the class used at least one file, exam score was only positively influenced by use of more than half of available files, and much repeated use of these files. In short, success was correlated to the amount of time spent using the study aid.

One could then question whether virtual labs are of benefit at all when used as part of a laboratory based course. As reported by Russo (1997) and Scheckler (2003) a virtual lab composed of pictures, questions and/or interactive modules will lead students in an ordered manner through laboratory or lecture material. However the computer model is fixed, contains only specific outcomes, and does not contain elements of uncertainty which would be experienced in a traditional lab (Russo, 1997; Scheckler, 2003). Samsel and coworkers (1994) felt computer labs were of great benefit to students with little or no experience in the subject matter, especially when available before laboratory exercises, which we agree with. Linton et al. (2005) also echoed the need for an out of class computer lab to assist veterinary students studying head and cranial nerve anatomy, especially when instructors or cadavers were not available. Additionally, access to photographic files and/or plastinated specimens as are available here at the University of Tennessee, may aid students who are repulsed by the smell or slime associated with fresh tissues (Stewart and Henry, 2002). However, in the case of anatomy laboratories, actual hands on experience is still considered the foundation of three-dimensional learning in medical education (Granger, 2004; Granger et al., 2006). It is interesting that Rizzolo and Stewart (2006) documented the return to dissection labs at several medical schools after truncation or suspension of these classes left students unprepared for subsequent years in the medical curriculum. This need could certainly be extended to students in animal science who are targeting veterinary school, or careers in farm animal reproductive physiology (artificial insemination technician) where association with textures, size, and even smell will be needed not only for identification of tissue, but correct application of diagnosis, i.e. pregnancy or infection.

Can dissection laboratories be shortened? It would seem that the answer is probably not. First year medical students who dissected during alternate labs were observed to score statistically less on three of four written examinations as compared to students who dissected during every laboratory period (Granger and Calleson, 2007). Practical examination scores were mixed, with some scores higher and some lower among students dissecting alternately. It was concluded that the lower written test scores were a consequence of increased need for self study, and loss of a learning opportunity afforded in the dissection laboratory. Because the study was so recent, data is not available to determine if alternate dissection laboratories had an influence on residency training, and specifically in fields requiring dissection skills such as surgery, or obstetrics and gynecology (Granger and Calleson, 2007). Since the students in our program are by majority targeting careers in the veterinary medical field, the case for continued dissection laboratories is also very appropriate.

As to the underlying purpose of this study: Does implementation of a virtual lab in addition to a wet lab increase exam performance? The answer is not necessarily. We saw a statistical difference in grade performance only among those students who diligently used the computer files available, and made extensive use of the practice comprehensive file. Interestingly, among the twelve students who received a score of 90 or above on the examination, only one student used fewer than four of the available quiz files. Nine of the twelve students receiving an A used all of the available quiz files which included the CQ file. In contrast, of the twenty-two students who received an F on the exam, seven did not use any of the files. Thus those who found the added time to use the computer labs were rewarded. One caveat to a virtual lab is that it represents another layer of study material for the student. Use of this tool requires increased study time, and as we have presented here, is not necessarily going to influence examination grade.

As a curiosity to this finding, first exam scores were compared among our students taking Physiology of Reproduction in 2006 (included virtual lab) and those in 2005 (no virtual lab) using a one-way analysis of variance using the GLM procedure (SAS, 2002). Exam score was the dependent variable, and class year the independent variable. Surprisingly, the test scores of the 2005 class were on average seven points higher than the scores of the 2006 class ($P = .0134$). The examinations were not identical, but very similar, and it is difficult to compare students from different class years because performance among classes can vary greatly. However it is tempting to speculate that there may be a point where students simply cannot assimilate any more material or study aids.

Summary

A virtual laboratory consisting of photographic and quiz files was created and made available to students taking a college course in Reproductive Physiology and Lactation. Laboratory material covered the reproductive anatomy and function of the female. Online student use of photographic and accompanying quiz files was tracked during spring semester of 2006, and examination scores were found to be moderately correlated to quiz use ($r = 0.351$). While regression analysis showed that examination grade was significantly affected by use of quiz files ($P < 0.02$); 10 of the 12 students receiving a test grade of A used half or more (five to nine) of available quiz files, while 22 of 69 total students used four or fewer quiz files and received grades of D or F. Similarly, grade was only positively influenced by the number of times a student accessed the CQ file if it was used repeatedly ($P < .02$). Comparison of first examination grades between two successive classes in 2005 and 2006 found that students actually did worse on the exam when the virtual lab was included as a study aid. In conclusion, the use of a virtual laboratory will offer students a means for review after lecture and traditional dissection laboratories, however its use may not necessarily influence examination grade.

The virtual lab will continue to be available to students. Since students taking this course are predominantly pre-veterinary students, we feel the continuation of wet lab dissections is vital to their educational experience. It is through this medium that students can actually feel the composition and thickness of reproductive organs that they might encounter in a veterinary practice.

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