# Effect of Essay-Style Lecture Quizzes on Student Performance on Anatomy and Physiology Exams

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***Abstract:*** A challenge facing many instructors of large (greater than 100 students) lecture sections is to encourage students to review course material on a regular basis. This 9-year study examined the impact of essay-style lecture quizzes on student performance in a two-semester anatomy and physiology course sequence. Results suggest quizzes improved student performance on regular hourly exams during the first semester of the course but not during the second semester of the course. In addition, lecture quizzes did significantly improve student performance on the Human Anatomy and Physiology Society (HAPS) comprehensive final exam. The "average" student, in years when quizzes were not given, ranked in the 56th percentile nationally; whereas, the "average" student, in years when quizzes were given, ranked in the 72nd percentile nationally on the HAPS exam. While very time consuming to grade and process, quizzes allowed the instructor to get to know more about the ability of individual students in the class, enabling the instructor to be able to write more valid letters of recommendation. In addition, all students received regular individual feedback from the instructor, making them feel less distanced from the instructor.

***Key words*:** anatomy and physiology, quizzes, standardized exam, student performance

## INTRODUCTION

One challenge facing many university professors is encouraging students to study on a regular basis rather than cram for lecture exams. This is especially true in large lecture classes where students may feel disconnected from the professor and where regular attendance and class participation are not included in the students' final grades. Inclusion of a series of lecture quizzes, especially if the quizzes are a significant part of the students' final grade in the class, may be a method of encouraging students to study regularly.

Quizzes have been shown to have a positive affect on attendance, reading, and student confidence, and may reduce student anxiety (Ehrlich, 1995; Ruscio, 2001; Sporer, 2001; Wilder et al., 2001). In addition, the feedback from regular quizzes allows students to identify areas on which to focus for exams (Sporer, 2001). Quizzes do not, however, appear to improve reading for comprehension (Johannessen, 1995) or on student performance on general biology exams (Haberyan, 2003).

The primary class for which the author has been responsible for the past 10 years is a sophomore-level, two-semester anatomy and physiology (A&P) sequence (A&P I and A&P II). This class is not part of our university's general studies curriculum and is specifically designed to meet the needs of students pursuing a wide variety of careers in the health sciences, including chiropractic medicine, dentistry, dental hygiene, medical technology, nursing, occupational therapy, optometry, osteopathy, pharmacy, physical therapy, physician, physician assistant, podiatry, and radiography. Therefore, students enrolled in this class should be self-motivated to do well since they must earn a minimum grade of "C" to be eligible to apply for professional school. The course is taught according to the guidelines and expectations established by the Human Anatomy and Physiology Society (HAPS). To be in accordance with these guidelines, a prerequisite of a least one semester of college-level chemistry was placed on A&P I in the fall of 1999. Since the spring of 1995 a comprehensive final exam written by this society has been

administered. When it is announced at the beginning of the first semester that the final exam at the conclusion of the following semester will be comprehensive over both semesters, many students are immediately overwhelmed. To break the material down into smaller units for study and review, as well as to encourage students in the class to keep up with the material, a series of essay-style lecture quizzes was initiated in the fall of 1997.

The purpose of this study is to examine the effectiveness of essay-style lecture quizzes on student performance in a college-level pre-professional anatomy and physiology class. The hypothesis was that regular quizzes would improve student performance on both regular hourly exams as well as on the HAPS comprehensive final exam.

## METHODS

A&P I was offered fall semester only; whereas, A&P II was offered spring semester only. Successful completion of A&P I was a required prerequisite for enrollment in A&P II. The lecture portion of the course was taught in 50-minute morning sessions on Mondays, Wednesdays, and Fridays. Each semester there were four, 50-minute exams composed of multiple-choice (80%) and fill-in-the-blank (20%) questions. Each exam was worth 10% of the final grade in the course. At the conclusion of the second semester, students took the HAPS comprehensive exam. This exam consisted of 100 multiple-choice questions and was worth 20% of the final grade in the course. The remainder of the final grade came from the laboratory portion of the course.

Starting in the fall of 1998, a series of short-answer, essay-style lecture quizzes was added. Each semester a total of seven 20-point quizzes was given, and the total of the best five grades on the quizzes was included in the student's final grade. Students were not permitted to make-up a missed lecture quiz since the lowest two grades were dropped. Exceptions were made for students with excessive absences due to extenuating personal circumstances or travel with athletic teams. The sum total of the lecture quiz grades was equal to that of a regular lecture exam. The dates of all quizzes were scheduled at the beginning of the semester and the first two quizzes were prior to the first lecture exam. The quizzes were given at the end of the lecture period and students had 20 minutes to complete each quiz.

The text used for this class has always been the most current edition of *Hole's Human Anatomy & Physiology* by Shier, Butler, and Lewis (McGraw-Hill Publishers). The lecture and laboratory sequence has been consistent over the years, as has the material covered on each lecture test. In addition, students had an outline of the lecture notes, which they purchased from the university's bookstore. The only difference over the years of this study was the method of delivery. In the 2002-2003 academic year the lectures were presented in Powerpoint® format, whereas in all previous years an overhead projector and transparencies had been used.

Statistical analysis was performed on all raw student grades with significance ascribed for $p<0.05$.

## RESULTS

The number of students completing both semesters of A&P ranged from 94 in the 2000-2001 academic year to 158 in the 1995-1996 academic year (Table 1). The mean composite ACT scores ranged from $22.0 \pm 3.6$ in the 1994-1995 academic year to $23.6 \pm 3.4$ in the 1999-2000 academic year (Table 1). The mean scores for each exam, plus the mean score for lecture quizzes when implemented, are presented in Table 2. The distribution of data from A&P I was normal and a t-test was performed on the overall exam average. The overall mean exam score for all lecture exams given in A&P I during years when quizzes were not given was $76.4 \pm 10.6$, which was significantly less than the overall mean exam score ($78.0 \pm 11.0$) for all lecture exams during years when quizzes were given . The distribution of data from A&P II was not normal. The Mann-Whitney rank sum test demonstrated that the overall median exam score during years when quizzes were not given (75.5) was not significantly different than the overall median exam score during years in which quizzes were given (75.4). The mean scores for the HAPS comprehensive exam are presented in table 3. The distribution of data for the HAPS comprehensive exam was not normal. A Kruskal-Wallis one-way analysis of variance on ranks showed that the median score on the HAPS test during years when quizzes were not given (53.0) was significantly lower than the median score during years when quizzes were given (58.0).

## DISCUSSION

Lecture quizzes had a significant impact on student performance on hourly exams in A&P I but not in A&P II. The addition of quizzes may have helped the students better understand the expectations of the instructor, which is why the quizzes had an impact on scores during the first semester of the course. By the second semester of the course, however, the students were more familiar with the instructor's expectations. Consequently, the lectures quizzes did not significantly affect performance on A&P II exams. The addition of lecture quizzes did significantly improve student performance on the HAPS comprehensive exam. A national percentile ranking, representing the percentage of individuals who scored below a particular raw score, is calculated for the HAPS exam. In years when lecture quizzes were not given, the "average" student in the class ranked in the 56th percentile nationally; whereas, in years when lecture quizzes were given, the "average" student ranked in the 72nd percentile

nationally. Students were not allowed to keep lecture exams for future study or review (exams were available for review in my office), but all students were allowed to keep their quizzes, and blank copies of the quizzes were given to students who missed quizzes. Therefore, reviewing the lecture quizzes from both A&P I and A&P II may have helped students prepare for the HAPS exam. The quantity of material covered on the HAPS comprehensive exam is certainly daunting, and students may see lecture quizzes as a way to more easily review the material than to attempt to review all their lecture notes.

***Table 1.*** *Profile of students completing A&P I and A&P II over the 9-year study period. Only students who completed both semesters of the course during the same academic year are included in the profile. ACT scores, which were not available for all students, represent mean composite scores (± standard deviation). The year in which a significant change in class structure was implemented is also presented.*

| Academic Year | Enrollment | ACT Score (n) | Change in class structure |
|---|---|---|---|
| 1994-1995 | 122 | 22.0 ± 3.6 ( 93) | |
| 1995-1996 | 158 | 22.3 ± 3.4 (136) | HAPS standardized test first administered |
| 1996-1997 | 117 | 22.8 ± 3.4 ( 99) | |
| 1997-1998 | 145 | 22.7 ± 3.6 (131) | Lecture quizzes first administered |
| 1998-1999 | 136 | 23.8 ± 4.0 (120) | |
| 1999-2000 | 110 | 23.6 ± 3.4 ( 92) | Chemistry pre-requisite placed on class |
| 2000-2001 | 94 | 22.1 ± 3.3 ( 83) | |
| 2001-2002 | 98 | 23.3 ± 3.9 ( 87) | |
| 2002-2003 | 108 | 22.6 ± 3.4 ( 95) | Powerpoint® lecture format introduced |

***Table 2.*** *Student performance on lecture exams and lecture quizzes (when given) in A&P I and A&P II. All scores are means (± standard deviation) out of 100 possible points.*

| ANATOMY AND PHYSIOLOGY I | | | | | |
|---|---|---|---|---|---|
| **Academic Year** | **Exam 1** | **Exam 2** | **Exam 3** | **Exam 4** | **Quizzes** |
| 1994-1995 | 80.6 ± 10.7 | 74.8 ± 13.67 | 7.8 ± 13.5 | 74.9 ± 14.6 | none given |
| 1995-1996 | 83.3 ± 9.3 | 75.8 ± 12.1 | 81.2 ± 12.5 | 73.8 ± 14.0 | none given |
| 1996-1997 | 74.3 ± 9.5 | 75.2 ± 9.5 | 67.4 ± 12.8 | 74.5 ± 13.3 | none given |
| 1997-1998 | 77.4 ± 8.6 | 71.4 ± 10.2 | 68.4 ± 12.7 | 70.1 ± 11.2 | 76.3 ± 12.5 |
| 1998-1999 | 85.9 ± 10.0 | 79.0 ± 11.8 | 73.4 ± 15.6 | 77.5 ± 11.9 | 79.3 ± 12.7 |
| 1999-2000 | 87.1 ± 9.4 | 81.6 ± 11.4 | 79.8 ± 12.4 | 77.0 ± 13.3 | 79.1 ± 12.6 |
| 2000-2001 | 84.0 ± 11.1 | 77.0 ± 11.6 | 75.6 ± 16.8 | 78.3 ± 12.2 | 78.8 ± 12.4 |
| 2001-2002 | 85.1 ± 10.6 | 80.2 ± 10.8 | 77.1 ± 13.6 | 81.4 ± 12.9 | 82.9 ± 9.5 |
| 2002-2003 | 83.5 ± 11.7 | 78.5 ± 13.1 | 73.7 ± 14.6 | 77.9 ± 15.0 | 76.0 ± 14.2 |
| **ANATOMY AND PHYSIOLOGY II** | | | | | |
| **Academic Year** | **Exam 1** | **Exam 2** | **Exam 3** | **Exam 4** | **Quizzes** |
| 1994-1995 | 78.4 ± 13.9 | 78.5 ± 12.8 | 77.4 ± 13.6 | 71.1 ± 16.1 | none given |
| 1995-1996 | 80.2 ± 12.6 | 77.2 ± 12.8 | 78.9 ± 13.2 | 71.4 ± 14.9 | none given |
| 1996-1997 | 65.2 ± 13.6 | 68.4 ± 12.7 | 69.9 ± 13.8 | 74.3 ± 11.5 | none given |
| 1997-1998 | 78.1 ± 11.8 | 77.2 ± 11.6 | 79.6 ± 10.7 | 70.0 ± 14.9 | 69.8 ± 13.9 |
| 1998-1999 | 75.3 ± 12.1 | 75.2 ± 13.1 | 82.8 ± 12.2 | 70.6 ± 14.9 | 71.7 ± 15.3 |
| 1999-2000 | 81.0 ± 11.5 | 71.8 ± 13.7 | 82.6 ± 11.8 | 77.0 ± 13.4 | 71.5 ± 15.1 |
| 2000-2001 | 76.3 ± 12.2 | 70.3 ± 12.9 | 76.5 ± 13.4 | 69.6 ± 13.3 | 73.7 ± 14.2 |
| 2001-2002 | 74.7 ± 12.4 | 78.6 ± 12.3 | 75.6 ± 12.6 | 73.2 ± 21.6 | 80.5 ± 12.6 |
| 2002-2003 | 71.2 ± 14.3 | 78.8 ± 12.5 | 75.4 ± 14.0 | 71.7 ± 14.5 | 72.9 ± 15.7 |

***Table 3.*** *Student performance on the Human Anatomy and Physiology Society (HAPS) comprehensive exam. Exam scores are means (± standard deviation) out of 100 possible points.*

| Academic Year | Exam Score |
|---|---|
| 1995-1996 | 51.0 ± 10.9 |
| 1996-1997 | 55.1 ± 10.3 |
| 1997-1998 | 56.4 ± 10.6 |
| 1998-1999 | 57.0 ± 11.1 |
| 1999-2000 | 62.1 ± 10.6 |
| 2000-2001 | 59.4 ± 11.1 |
| 2001-2002 | 60.8 ± 10.4 |
| 2002-2003 | 59.4 ± 12.2 |

While an attempt was made to maintain a similar level of expectation throughout the years of this study, it is certainly possible that more was expected of the students when they had quizzes and this resulted in subtle changes to the lecture exams to reflect these expectations. The quizzes required students to synthesize information into a written answer rather than select the proper answer from a list in a multiple-choice question or supplying a single word in a fill-in-the-blank question (Table 4). This could explain both the lack of impact of quizzes on student performance on hourly exams and the significant positive impact of quizzes on student performance on the HAPS comprehensive exam. In addition, the variation in class composition may have impacted the study. As professional programs changed the required prerequisites for student admission, more students were choosing to enroll in A&P I and A&P II as sophomores and juniors rather than as freshmen and sophomores. In addition, the requirement of a college-level chemistry course in 1999 also had an impact on class composition. This increased level of student maturity may have positively impacted student performance because a comprehensive final exam may not have been as imposing to sophomores and juniors as it may have been to freshmen.

One question that must be asked is whether or not the impact of quizzes was worth the effort on the part of the instructor. Essay-style quizzes are very time-consuming to grade even for a small class. A sincere effort was made to write constructive comments on each student's quiz paper, so it took me approximately 3-4 minutes to grade a single quiz paper. Therefore, depending on the size of the class and the complexity of the quiz, the time required to grade a single quiz for the entire class took anywhere from 6.5 and 15 hours. This does not include the time required to record and post the quiz grades, the time required to sort the papers to be handed back to the students during laboratory, and the time required to cope with absences and possible make-up quizzes. One significant benefit to the instructor, however, was the ability to learn much more about the capabilities of individual students by grading their written work. It was extremely difficult to get to know all the students in such large lecture sections. There were 8-10 laboratory sections associated with this course, but I typically taught only 3 of these sections. Therefore, grading each student's lecture quiz provided more information about each student in the class. Moreover, each student got individualized feedback. The students in my lab sections said they appreciated the written suggestions and comments on their quiz papers, and the instructors of the other lab sections reported similar comments.

The majority of the students in these classes are pre-professional, so they often will need a letter of reference to include in their application materials for professional school. If I agree to serve as a reference for a student, I must be able to write a valid, accurate, and defensible letter of reference for that student. If I cannot do this, it is my professional obligation to inform the student that I cannot serve as a reference for him or her. By grading written quizzes I learned which students could understand the question being asked and synthesize complex information into a concise answer. This was in sharp contrast to students who consistently did not answer the question asked or simply wrote everything they knew about the topic, hoping the answer I was looking for was in there somewhere. I also learned which students could construct coherent sentences, spell, and use proper grammar, in contrast to students who still did not know the difference between, for example, "it's" and "its" or "there" and "their." This enabled me to comment on the ability of the student to effectively analyze, synthesize, and communicate complex information rather than on the student's ability to simply memorize, recognize, and recite factual information.

In conclusion, it is up to the individual instructor to weigh the costs and benefits of essay-style lecture quizzes. The most significant cost to the instructor is the time required to grade and process the quizzes. The benefits to the student do not appear to be improved performance on hourly exams but instead individual feedback and better long-term retention of the material, as evidenced by the significantly higher scores on the HAPS comprehensive exam. In return, the instructor gets to know the students in his or her class better by reading their written work. As an instructor who regularly teachers large lecture classes, any method by which I can get to know more about each of the students in my class is well worth the time commitment.

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***Table 4.*** *Examples of quiz questions from A&P I and A&P II which require students to demonstrate critical thinking, analysis, and synthesis of the material. In italics following each question are its classification levels according to Bloom's taxonomy (Bloom, 1956).*

| | | |
|---|---|---|
| 1. | Describe the negative feedback mechanism used to lower blood levels of calcium to "normal" if blood levels of calcium increased. | *knowledge, comprehension* |
| 2. | Abnormal thirst and frequent urination are symptoms of diabetes mellitus, because the glucose in the urine creates an osmotic diuresis. Explain. | *knowledge, comprehension, application* |
| 3. | Anatomy and physiology are interdependent at all levels of organization. Explain the reason the phospholipid bilayer arrangement (anatomy) is necessary for the cell membrane to properly perform its function (physiology). | *knowledge, comprehension, analysis* |
| 4. | Olfactory epithelium and taste buds are both composed of epithelial tissue and neural tissue. If they are composed of the same two types of tissue, what is the reason the sense of smell diminishes as one ages; whereas, the sense of taste does not? | *knowledge, comprehension, analysis* |
| 5. | In amphibians, the heart is divided into only three chambers (two atria, one common ventricle), whereas in mammals and birds, the heart is divided into four chambers. Explain how this anatomical difference is physiologically advantageous for mammals and birds. | *knowledge, comprehension, analysis* |
| 6. | The following statements are from a newspaper advertisement for an exercise program (cost = $37) that guarantees rapid weight loss with only 10 minutes of exercise 5 days a week while eating 300 to 400% more food. "A study has proven that anaerobic exercise actually burns more than 5 times more calories than aerobic exercise. Aerobic exercise can typically burn 25% muscle and 75% fat for body energy. Anaerobic exercise burns 100% fat for body energy." The ad goes on to claim that "anaerobic exercise causes the body to create energy without oxygen because the demand for energy is so fast and large that the body must create it from numerous natural body chemicals." Identify two serious errors with the claims of this advertisement and explain the reason(s) these statements are not correct. | *knowledge, comprehension, analysis, application, synthesis, evaluation* |

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