What Do Students' Behaviors and Performances in Lab Tell Us About Their Behaviors and Performances in Lecture-Portions of Introductory Biology Courses?

Randy Moore
Biology Program, University of Minnesota, 3-104 MCB, 420 Washington Avenue SE,
Minneapolis, MN 55455
Email: RMoore@umn.edu

Abstract: In a study spanning several years and including more than 1600 students, lab attendance was strongly correlated with lab grades (r = 0.64), lecture attendance (r = 0.49), and course grades (r = 0.60) in an introductory biology course. Regardless of the semester, lab attendance was lowest during the first week of the semester, and students who missed the first lab of the semester were significantly more likely to miss more labs and earn lower grades than other students. Students who missed labs, and especially those who missed more than one lab, earned disproportionately lower grades in lab and in the course than did students who attended all labs. These results indicate that (a) lab attendance is a strong predictor of grades in lecture and lab, (b) students most likely to attend lab are also most likely to attend lecture, and (c) first-week absenteeism can be used to identify students disproportionately likely to earn low grades, and (d) instructors can use lab attendance to quickly, easily, and accurately identify students at-risk for low grades.

Keywords: attendance, grades lab, lecture

Introduction

Class attendance is the most obvious and important indicator of academic engagement because it requires a conscious and ongoing effort that is directly related to students' academic success (Moore *et al*., 2003; Rumberger, 2001). Students *choose* to attend class Nevertheless, absenteeism in introductory courses is often high (e.g., 25 to 50%), even in classes taught by award-winning instructors (Friedman *et al*., 2002; McGuire,2003; Romer, 1993; Thompson, 2002). Romer (1993), who notes that absenteeism in introductory courses is "rampant," describes the situation this way: "A generation ago, both in principle and in practice, attendance at class was not optional. Today, often in principle and almost always in practice, it is" (p. 174).

Introductory science courses are often characterized by especially high rates of absenteeism (Friedman *et al*., 2001) and low grades (Congas *et al*., 1997). Many students skip science classes because they believe they can "make up" their absences by downloading or copying notes, reading the textbook, or talking with a classmate (Moore, 2003a). However, students usually cannot "make up" a missed lab because of the logistical problems associated with offering the lab experience (e.g., the restricted availability of equipment, reagents, and specimens).

Although there have been several studies of students' overall rates of class attendance in lecture portions of science courses (Burchfield & Sappington, 2000; Congas *et al*., 1997; Grisé & Kenney, 2003; Moore, 2003a, b; Sappington *et al*., 2002), there has been no analysis of how attendance in labs is associated with students' performances. This is probably due to the facts that (a) students' lab grades are usually embedded in their overall course grades (i.e., lab is usually not a separate course), and (b) lab instruction is often delegated to teaching assistants, not professors. Given the importance of lab experiences to a liberal arts education and students' introductions to (and understandings of) science, I wondered what an analysis of students' patterns of lab and lecture attendance might tell me about students' performances in introductory biology courses. For example, is there a pattern of absences during a semester, or are attendance-rates unpredictable? How do patterns of attendance in lab compare with those of lecture? Is attendance at labs as important to academic success as it is in lecture? Given the importance of a good start to academic success (Moore, 2004a, b; 2005a), are students who miss labs early in the semester more likely than other students to miss additional labs and/or earn low grades? And finally, how can instructors use these data to identify problems and help improve students' performances in introductory courses?

Methods

Site of the study. This study was conducted in a traditional introductory biology course at the Twin Cities campus of the University of Minnesota. The course, which was taught by various instructors, included two 75-minute lectures and one two-hour lab per week during each of the 13 weeks of the semester. This study included 1,682 students enrolled during six semesters from 2004-2006. These students had an average ACT composite score of 20 (this matches the national average; Hoover, 2003), an average age of 20, and an average gender-distribution of 47% females and 53% males. These students' ethnic diversity was as follows: 17% African American, 2% American Indian, 16% Asian American, 4% Chicano/Latina, 58% Caucasian, and 3% Other. I excluded students who withdrew from the course, students who received grades of incomplete, and students who failed the course because of academic misconduct.

The course and course policy. The course, its policies, and grade distributions were similar every semester of the study (i.e., the same grading policies, textbook, classroom, topics). Labs, which counted 33% of students' overall grade in the course, covered topics typical of a traditional introductory biology course (e.g., cells, genetics, molecular biology). All sections of lab enrolled 12 or fewer students and were taught by teaching assistants (TAs) who completed a weeklong orientation each semester to ensure similarstandards and pedagogical approaches to lab. Grades in lab were based on topics covered in lab (i.e., were not based on information presented in lecture). Similarly, grades in lecture were not based on any information presented in lab. Additional information about this course is provided elsewhere (Moore, 2003a, b).

Measuring attendance. Attendance was recorded at lectures by having students submit a short essay about a topic discussed that day in class. I measured attendance at every class except those at which we gave the three lecture-exams (i.e., at which attendance approached 100%). Attendance at labs was recorded by TAs at every lab by determining students' actual presence in lab (i.e., not with a sign-in sheet on which students could list friends who were absent). To be counted present at a lab, a student could be no more than 30 minutes late for the lab. If, for whatever reason, a student came to lab more than 30 minutes late, they were counted absent, but could still submit lab reports and do the required activities. Although students received no points for merely attending lab, attending lab enabled students to earn points by taking the weekly lab-quizzes and doing the lab activities (which prepared students for the next week's lab-quiz). Regardless of the semester, missing a lab and its quiz meant that students lost 7.7% (i.e., 1/13) of their possible lab grade. Students who missed three or more labs automatically failed the course. There were no minimum attendance requirements in lecture.

All labs began the first week of classes and continued until the end of the semester. This was announced in the class schedule (i.e., when students enrolled in the course) and was repeated at the first lecture (i.e., before the first lab). The importance of lab attendance was emphasized during the first lecture, in each of the first two weeks of lab, in the course syllabus, in the lab syllabus, and in the lab manual. In all instances, presentations of the attendance policy were accompanied by data showing that increased rates of attendance are associated with higher grades in lab (Moore, 2003a). These data were also posted prominently on large posters in and just outside lab (i.e., where students congregate before lab).

Students with "excused" absences (e.g., documented illnesses, emergencies) were allowed to reschedule their labs if they contacted their TA and made arrangements to attend a different lab section during the same week as their scheduled lab. Given the logistics of most labs (e.g., the availability of equipment, reagents, and specimens) and the questionable nature of many students' excuses (Sappington, Kinsey, & Munsayac, 2001), students were not allowed to reschedule their labs if they did not contact their TA before lab or if they could not document their emergency or illness (e.g., students who missed lab because of family vacations, leisure activities, or being hung-over were not allowed to reschedule a missed lab). All labs, lab quizzes, and grading practices were standardized during weekly meetings with the TAs. All labs in all semesters had similar exams, did the same experiments, and had identical grading policies.

Instructors' responses to students' absences. When students missed a lab, they were sent an e-mail notifying them of their absence, their total number of absences in lab, the course's attendance policy, and their probabilities of earning various grades in the course (based on previous semesters' data). These e-mails were sent 0.5 to 3 days after each absence (i.e., well before their next scheduled lab). When students exceeded the maximum number of allowed absences, they received an e-mail informing them that they had failed the course.

.

Results

I accommodated all students who requested that they be allowed to attend a different lab. That is, all students who contacted their TA to reschedule their lab and who provided the required documentation were allowed to do the lab and take the accompanying lab quiz. All students who were counted absent from a lab either (a) showed up more than 30 minutes after the lab had started, or (b) never came to the lab and did not contact their TA to reschedule the lab. Our method for determining absences (e.g., being more than 30 minutes late to lab, not turning in the assignments in lecture) was easily implemented and objective; it required no subjective judgments by TAs. For example, TAs did not have to judge students' levels of preparation, participation, or effectiveness in lab; they only measured whether the student was present in lab.

Attendance and grades. Students' average lab grade was 78%, their average course-grade was 72%, their average rate of absenteeism in lab was 2.9%, and their average rate of absenteeism in lecture was 30%. 19% of students missed no lectures, 75% of students missed no labs, and 17% of students missed no labs or lectures. The correlation coefficient (r) of lab attendance and lab grades was 0.64, lab attendance and course grades was 0.60, lecture attendance and course grades was 0.60, and lab attendance and lecture attendance was 0.49.

Table 1 shows the lab grades, course grades, and course-grade distributions of students who missed various numbers of labs. On average, students who missed no labs attended 78% of lectures, students who missed one lab attended 60% of lectures, students who missed two labs attended 41% of lectures, and students who missed more than two labs attended 34% of lectures. Students who missed progressively more labs earned progressively lower grades in lab and in the course.

Attendance patterns in lab. Students' patterns of lab attendance are shown in Figure 1. Regardless of the semester, absenteeism in lab was highest during the first week of classes. First-week absenteeism in lab averaged 4.90 + 0.11%, and first-week absences accounted for 12% of the total absences during the semester. Attendance at the second lab improved dramatically (i.e., absenteeism dropped from 4.9% to 1.6%; $p <$

0.001%), after which it gradually declined throughout the semester, reaching near-peak levels during the final two weeks of the semester. The average rate of absenteeism throughout the semester was 2.93 + 0.13%. The correlation coefficient for attendance over time throughout the semester was 0.22.

Students who missed the first week of lab earned an average lab grade of 59%, and more than half (i.e., 57%) of these students missed at least one more lab during the semester. For comparison, students who did not miss the first week of lab earned an average lab grade of 78%, and only 20% of these students missed a lab during the rest of the semester. Excluding the first week's absences increased the correlation coefficient for attendance over time throughout the semester from 0.22 to 0.70. When I asked an opportunistically-selected sample of students (N = 20) who missed the first week's lab why they missed the lab, the most common response (55% of respondents) was that they did not believe that anything important would occur that week; smaller percentages claimed that they had other conflicts (30%) or did not know that labs met the first week (10%).

Attendance patterns in lecture. Students' patterns of lecture attendance are shown in Figure 2. Attendance peaked during the first week of classes, after which it declined at an average rate of approximately 2% per week throughout the semester. The largest decrease in attendance occurred in the second week of classes, in which attendance dropped an average of 14% (i.e.,from approximately 90% to 76%).During every semester,there was a slight increase in attendance during the final week of classes (i.e., from an average of 56% in the penultimate week to an average of 63% during the last week). The correlation coefficient for lecture attendance over time throughout the semester was 0.85. Early morning (i.e., 8:00 a.m.) classes had attendance rates that were consistently approximately 8% higher than did classes offered later in the day. The correlation coefficients of lecture attendance over time (i.e., r = 0.81 and 0.85 for early-morning lectures and later lectures, respectively) and with grades (i.e., r = 0.71 and 0.63 for early-morning lectures and later lectures, respectively) were similar in both sections.

Discussion

Several studies have reported a strong correlation of lecture attendance and grades in introductory science courses (Launius, 1997; Moore, Jensen, Hatch, Duranczyk, Staats, & Koch, 2003; Street, 1975; Wiley, 1992), and data reported here are consistent with those conclusions. However, data in Table 1 also show that lab attendance is strongly correlated with lab grades. Of course, some of this is to be expected; after all, missing a lab automatically meant that students lost 7.7% of their lab grade (see above). However, students who missed one lab earned grades that were 14% (i.e., [(84-72)/84] = 14%) lower than those of students who missed no labs, and students who missed two labs earned lab grades that were barely half those of students who missed no labs (i.e., 48 vs. 84%, respectively). These results indicate that absences from lab (especially from two or more labs) may have a disproportionately greater impact on lab grades than can be accounted for by the points lost by the absences alone.

Our data also show for the first time that students who come to lab most often earn disproportionately higher grades than do students who miss one or more labs (Table 1). For example, the probability of earning a D or F increased from 18% among students who missed no labs to 47% among students who missed only one lab, and to 95% for students who missed two labs. Similarly, more than half (i.e., 57%) of students who missed no labs earned an A or B, but only 21% of students who missed one lab earned an A or B, and no student who missed two labs earned an A or B. In all instances, the lower overall grades far exceed that which can be accounted for by the points lost because of the students' absences from lab alone. This is probably due to the fact that students' poor rates of lab attendance are a surrogate for other poor academic behaviors. Indeed, students who miss labs are also most likely to miss lectures and ignore other opportunities to raise their grades (i.e., they are much less likely to attend help-sessions or submit extra-credit work; Moore, 2005b, in press).

TABLE 1. Lab attendance, lab grades, and course grades of students who missed various numbers of labs in an introductory biology course. Numbers in the table are percentages.

Number of Absences	% of Students	Lab Grade	Course Grade	Grade Distribution, % A	B	C	D	F
0	75*	84	77	19	38	25	8	10
1	16	72	67	7	14	32	20	27
2	4	48	47	0	0	5	15	80
>3	5	35	33	0	0	0	0	100

* For example, 75% of the students in the course missed no labs; these students earned an average lab grade of 84% and a course grade of 77%. 19% of these students earned an A, 38% a B, 25% a C, 8% a D, and 10% and F.

Figures 1 and 2 are the first large-scale (N = 1,682) quantifications of a common anecdotal observation of many science instructors – namely, that students' levels of academic engagement (as measured by attendance at lab and lecture) diminish throughout the semester. Although attendance in lecture and lab is strongly correlated with students' grades, the patterns of attendance in lecture and lab have distinctive differences, and these differences have important consequences.

FIG 1. Rates of lab attendance throughout a semester.

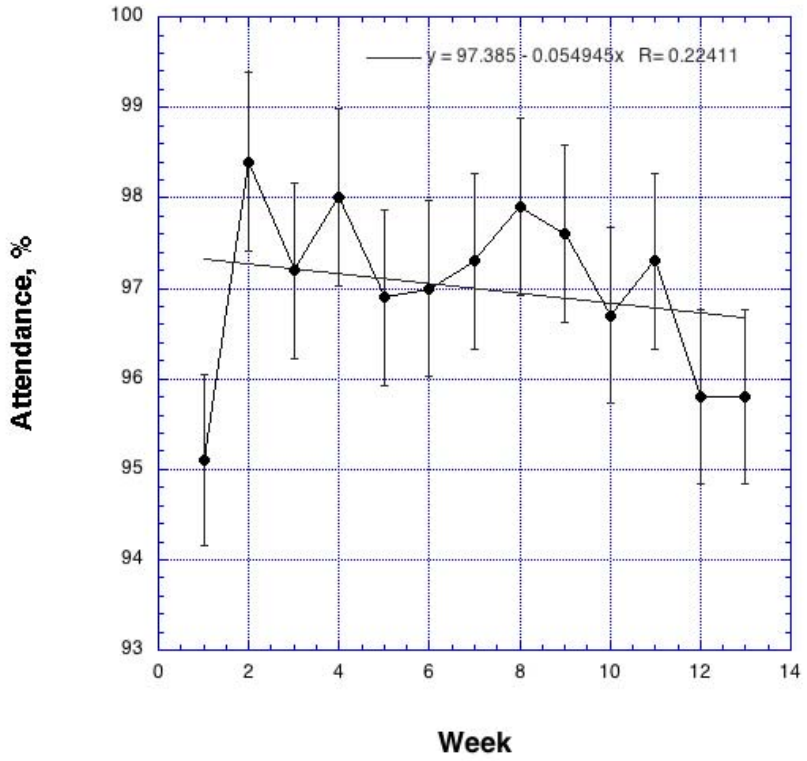
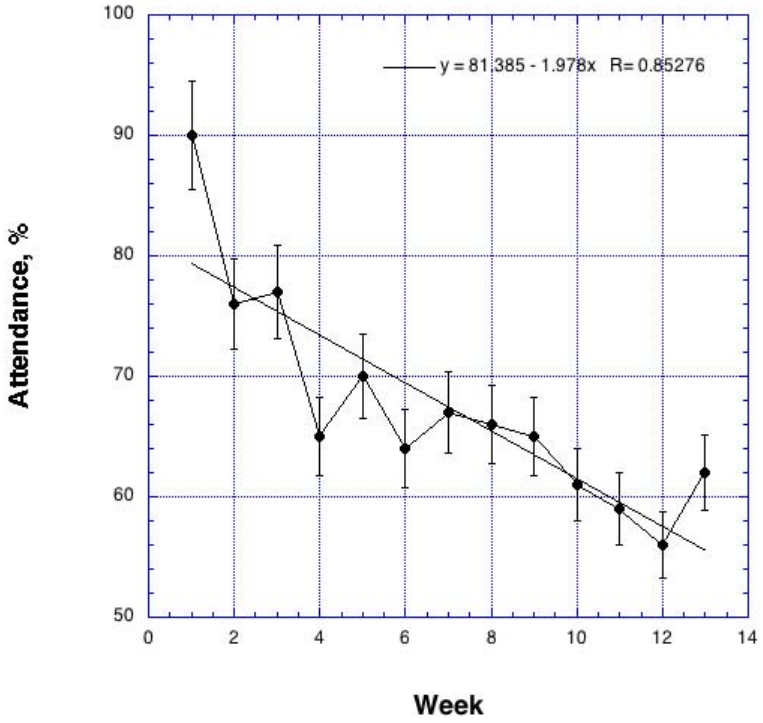


FIG 2. Rates of lecture attendance throughout a semester.



1. Students consistently attended much larger percentages of labs than lectures, despite the fact that lecture-based material accounted for twice as much of their final grades as lab-based material. That is, students are more likely to attend lab than lecture, and are therefore more likely to be exposed to information presented in lab than in lecture. These results suggest that, whenever possible, labs should be used to introduce the course's most important information.

2. Although attendance in both lecture and lab diminishes throughout the semester, the decrease is much more rapid in lecture. For example, the slope of the best-fit line for lecture attendance over time (Figure 2) decreases at a rate of approximately 2% per week, whereas that for lab attendance (Figure 1) decreases at a rate of less than 0.1% per week. These decreases were similar during Fall and Spring semesters, and are therefore not due only to the "Spring Fever" associated with the improving weather of Spring semesters. A more descriptive term for this gradual decrease in attendance throughout a semester might be "attendance fatigue." This fatigue is more than 10-times more dramatic in lecture than lab, possibly because either (a) there were weekly exams in lab, and/or (b) lab met only once per week, whereas lecture met twice per week.

3. In lab, attendance was lowest during the first week, whereas in lecture it was highest during the first week. The relatively poor attendance in the first week's lab was apparently due to some students assuming that "nothing important would happen" at that lab. In lecture, the high rate of attendance during the first week was presumably due to the fact that syllabi containing course policies and exam dates were distributed during the first week of classes. Many students apparently believe that the rewards for attending the first week's lectures (i.e., at which they receive the course syllabus and hear about course policies and exam dates) exceed those of other classes in the course.

4. Absenteeism in the first week's lab is a strong indicator of future problems in the lab and course. That is, students who miss the first week's lab are disproportionately more likely to miss at least one more lab and earn lower lab grades and course grades than students who did not miss the first week's lab. Instructors can use this information to design intervention strategies (e.g., notifications) to help educate students about the likely consequences of their academic behaviors.

Although academic behaviors such as attendance are strongly correlated with academic success in introductory science courses, correlation does not necessarily imply cause. For example, students' higher rates of lab attendance might help produce high grades, or students' desires to earn high grades might underlie their high rates of lab attendance, or both. Moreover, some students who attended every lab earned a poor grade, and some who missed one lab were able to earn an A or B. Nevertheless, the conclusions here are unmistakable; on average, (a) students who come to lab and lecture earn disproportionately higher grades than students who miss labs and/or lectures, and (b) lab attendance can be

used to easily, objectively, and accurately identify students at-risk for low grades in introductory biology courses.

For many students, the findings reported here are moot; these students come to virtually all lectures and labs, and usually earn higher grades than do students who miss lectures and labs.When instructors *can* improve attendance, students' grades often improve.But how can instructors do this? As most instructors know, it's not easy. This is probably due to the fact that students' attitudes about, and habits regarding,class attendance are formed in high school, where high rates of absenteeism are strongly correlated with academic disengagement and dropping out (Rumberger, 2001). For many high school students, absenteeism increases gradually; data reported here show that in lectures and labs of a college biology course, the same thing happens, and these increased rates of absenteeism are associated with lower grades (Table 1, Figures 1 & 2). It is often difficult to change these entrenched behaviors. Even failing a course because of poor attendance seldom changes students' behaviors; most students who repeat introductory courses because of poor grades repeat the same behaviors, and earn similarly low grades (Moore, in press). However, repeatedly using quantitative data such as those shown in Table 1 to emphasize the importance of attendance for good grades does improve the attendance rates of approximately 20% of students (Moore, 2003b).

References

BURCHFIELD, C. M., AND SAPPINGTON, J. 2000. Compliance with required reading assignments. *Teaching of Psychology* 27, 58-60.

CONGOS, D. H., LANGSAM, D. M., AND SCHOEPS, N. 1997. Supplemental instruction: A successful approach to learning how to learn college introductory biology. *J. of Teaching and Learning* 2 (1), 2-17.

FRIEDMAN, P., RODRIGUEZ, F., AND MCCOMB, J. 2001. Why students do and do not attend classes. *College Teaching* 49 (4), 124-133.

GRISÉ, D. J., AND KENNEY, A. M. 2003. Nonmajors' performance in biology. *J. of College Science Teaching* 33 (2), 18-21.

HOOVER, E. 2003, August 20. ACT scores hold steady from last year. Retrieved from http://chronicle.com/prm/daily/2003/08/2003082001n.htm

LAUNIUS, M. H. 1997. College student attendance: Attitudes and academic performance. *College Student Journal 31*, 86-92.

MCGUIRE, S. 2003. Teaching students how to learn chemistry. *Strategies for Success 40*, 4-5.

MOORE, R. 2004a. Class attendance and course performance in introductory science classes: How important is it for students to attend class? *J. of College Science Teaching 32* (6), 367-371.

MOORE, R. In press. Do introductory science courses select for effort or aptitude? In J. L. Mintzes & W. H. Leonard (Eds.), *Handbook of College Science Teaching.* Arlington, VA: National Science Teachers Association.

MOORE, R. 2003a. Does improving developmental education students' understanding of the importance of class attendance improve students' class attendance and academic performance? *Research and Teaching in Developmental Education 20* (2), 24-39.

MOORE, R. 2003b. Helping students succeed in introductory biology classes: Does improving students' attendance also improve their grades? *Bioscene 29* (3), 17-25.

MOORE, R. 2005. Pre-enrollment and post-enrollment predictors of the academic success of developmental education students. *J. of College Student Retention 6* (3), 325-335.

MOORE, R. 2004b. The importance of a good start. In I. M. Duranczyk, J. L. Higbee, & D. B. Lundell (Eds.), *Best practices for access and retention in higher education* (pp. 115-123). Minneapolis, MN: Center for Research on Developmental Education and Urban Literacy, General College, University of Minnesota.

MOORE, R., JENSEN, M., HATCH, J., DURANCZYK, I., STAATS, S., AND KOCH. L. 2003. Showing up: The importance of class attendance of class attendance for academic success in introductory science courses. *The American Biology Teacher 65*, 325-329.

MOORE, R. 2005b. Who does extra-credit work in introductory science courses? *J. of College Science Teaching 34* (7), 12-15.

ROMER, R. 1993. Do students go to class? Should they? *J. of Economic Perspectives 7* (3), 167-174.

RUMBERGER, R. W. 2001. Why students drop out of school and what can be done. Retrieved March 23, 2006, from http://www.civilrightsproject.harvard.edu/research/dropouts/dropouts_papers.php

SAPPINGTON, J., KINSEY, K., AND MUNSAYAC, K. 2002. Two studies of reading compliance among college students. *Teaching of Psychology 29*, 272-274.

STREET, D. R. 1975. Noncompulsory attendance: Can state-supported universities afford this luxury? *J. of College Student Personnel 16*, 124-127.

THOMPSON, B. 2002. If I quiz them, they will come. *The Chronicle of Higher Education 48* (41), B5.

WILEY, C. 1992. Predicting course grades from class attendance and other objective student characteristics. *College Student Journal 26*, 497-501.