Does the Number of Hours Studied Affect Exam Performance?

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ABSTRACT

Many college instructors inform their students that they need to spend at least 2 h studying outside of class for every hour of lecture. We decided to determine if the number of hours students studied influenced exam performances in Introductory Soil Science (SC240) at Colorado State University and Soils and Fertilizers (URH125) at Front Range Community College, Larimer Campus (Fort Collins, CO). One hypothesis was that the hours studied would significantly ($P < 0.05$) affect exam scores as determined by regression models. Our second hypothesis was that ratio of hours studied to lecture hours to achieve a 90% score will be 2.0 (e.g., it will follow the Carnegie Rule). For four SC240 semesters and two URH125 semesters, we asked the students "How many hours did you study for this exam?" on each of the 10 lecture exams given each semester. For each individual and overall exam regression analyses, exponential rise with a no-limit or 50-point (the points possible on each exam) maximum gave a significant ($P < 0.05$) fit to the data. The r^2 values ranged from 0.12 to 0.61. Utilizing regression models, we found that students would have to study from 3.0 to 4.4 h to earn an average score (38–40 points out of 50) and 4.5 to 6.4 h to earn 45 points (90%). The hours studied to receive a 90% exam score to lecture hour ratio ranged from 1.5 to 2.1.

SEVERAL FACTORS influence student performance on exams. These include hours studied, careful textbook reading, a quiet study environment (Perlmann and McCann, 2002), quality of lecture notes (Baker and Lombardi, 1985), self confidence (Okpala et al., 2000), and stressful life events (De Meuse, 1985).

Most teachers would probably agree that the more a student studies for exams outside of class, the better their exam scores. Conflicting results, however, have been reported regarding the relationship between exam performance and the hours studied. Eikeland and Manger (1992) found that for first semester Norwegian university students, increasing study hours did not improve class performance. Using a *production–function* statistical model to predict course grades in a macroeconomics course, Okpala et al. (2000) found that time spent studying did not significantly affect the educational outcome. Conversely, Perlmann and McCann (2002) found that hours studied was the most important factor contributing to exam grade improvement or decline in undergraduate psychology courses. The studies by Eikeland and Manger (1992), Okpala et al. (2000), and Perlmann and McCann (2002) used linear or multiple regression analyses relating exam performance to hours studied. Nonlinear regression equations may offer an opportunity to better model exam achievement related to hours studied.

Many college instructors suggest to students how much outside-of-class study time they will need to achieve an A or B grade. For studying Physics, Chapman (1949) recommended 2 h of outside study time per week for each course credit (where a course credit is equivalent to 1 h of lecture). Simanek (2002) refers to this ratio as the *Carnegie Rule*.

Is the Carnegie Rule encouraged in college courses today? Perusal of various college-course Internet postings of course syllabi and study suggestions for college students attest that the rule is widely communicated. Oliver (1994) indicated that the Carnegie Rule was reasonable if students wanted to succeed in a Mathematics for Elementary Education course at Humboldt State University. In the second semester of Physics for Scientists and Engineers (four credits) at the University of Central Oklahoma, Wilson (2000) stated that students should anticipate investing a minimum of 2 h outside of class and about 4 h on homework problems per week. Seward (2002) encouraged the Carnegie Rule in the Rogers State University Earth Science course. In the three-credit General Microbiology class at University of Texas, Saxena (2002) conveyed that students should study at least 4 to 6 h per week. Elzinga (2001) specifically stated that an average student in a three-credit Economics course at the University of Virginia should plan on investing 12 h per week if they wish to earn an A or B. Utilizing end-of-the-semester questionnaires, de la Harpe et al. (1997) found that students studied an average of 2.27 h per week for a one-credit Educational Psychology core unit. When providing hints on succeeding in college classes, Bennett (2000) specified 2 to 3 h per week of outside-of-class study for each course credit. Dutch (2001) supported the notion of the Carnegie Rule on his web page entitled "Top Ten No Sympathy Lines," stipulating that a college credit is 1 h in class and 2 h outside.

We chose to evaluate the relationship between hours studied and exam performance and if students followed the Carnegie Rule. Information from four semesters of Introductory Soil Science (SC240) at Colorado State University (CSU) and two semesters of Soils and Fertilizers (URH125) at Front Range Community College, Larimer Campus in Fort Collins, CO, comprised our data set. Our hypotheses were:

1. The hours studied should significantly ($P < 0.05$) affect exam scores as determined by regression models.
2. The ratio of hours studied to lecture hours to achieve a 90% exam score (45 points) will be 2.0 (e.g., the ratio will follow the Carnegie Rule).

MATERIALS AND METHODS

The data set for this study was the fall 2000, spring 2001, fall 2001, and spring 2002 semesters of SC240 at CSU and the

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Abbreviations: CSU, Colorado State University; *P*, probability level; r^2, coefficient of determination; SC240, Introductory Soil Science at Colorado State University; SE, standard error of the estimate; URH125, Soils and Fertilizers at Front Range Community College, Larimer Campus, Fort Collins, CO.

fall 2000 and fall 2001 semesters of URH125 at Front Range Community College, Larimer Campus in Fort Collins, CO.

The SC240 course consisted of three 50-min lectures per week at 0800 h (8:00 a.m.) on Monday, Wednesday, and Friday and a 100-min laboratory session per week (Barbarick, 1998). A course in freshman chemistry was an enforced prerequisite. Between 140 and 200 students enrolled in SC240 each of the four semesters. We gave 10, 50-point exams plus an optional 100-point final (e.g., the final could replace the two lowest 50-point exams), and we generally allowed the students 25 min to complete each exam (Barbarick, 1998). For 1 point on each 50-point exam, we asked the students to answer the question "How many hours did you study for this exam?"

The URH125 course consisted of two 90-min lecture–laboratory–demonstration combinations at 1500 h (3:00 p.m.) on Monday and Wednesday. Chemistry was not required for URH125. The URH125 enrollment was 21 students in fall 2000 and 25 in fall 2001. The same exam scenario was used, including the 1-point question mentioned above.

For each exam plus the overall averages for each semester, we determined the average number of hours students studied compared with exam scores. We then conducted regression analyses of the exam scores vs. the hours studied using the following three models:

Linear

$$\text{Score} = a_1 + a_2 \text{ (hours studied)} \qquad [1]$$

where a_1 = y axis intercept, and a_2 = slope of the curve.

Quadratic

$$\text{Score} = b_1 + b_2 \text{ (hours studied)} + b_3 \text{ (hours studied)}^2 \qquad [2]$$

where b_1 = y axis intercept, b_2 = slope constant, and b_3 = curvature constant.

Exponential Rise to a Maximum

$$\text{Score} = c_1 + c_2\{1 - \exp[-c_3 \text{ (hours studied)}]\} \qquad [3]$$

where c_1 = y axis intercept, c_2 = exam score increment above the y axis intercept, and c_3 = rate constant for change in exam score for a given change in hours studied.

For the exponential rise to a maximum equation, the regression-model curve will approach the maximum ($c_1 + c_2$) asymptotically. We also conducted nonlinear regression analyses for Eq. [3] with a 50-point maximum (e.g., setting $c_1 + c_2 = 50$, the highest possible exam score), since we felt intuitively that this model would more accurately portray the actual exam data. We will designate the two models as either *no limit* or *50-point maximum* in the Results and Discussion section. Because of the small sample size for URH125 each semester, we also conducted analyses on the combination of data from the two semesters. We judged the best regression models as those that produced the highest r^2 values and the lowest standard error of the estimate (SE). For predicted exam scores for 0, 1, 2, 3, 4, 5, and 6 h studied, we compared the four-semester SC240 and two-semester–combined URH125 data using oneway analysis of variance ($P < 0.05$).

Using the overall average exponential rise to a 50-point maximum models for each set of data, we calculated the number of study hours required to earn the overall exam average and to earn 90% (45 points). We then calculated the ratio of these *predicted hours studied to earn 90%* to the *average number of lecture hours covered for an exam* to see how our ratio compared with the Carnegie Rule.

Table 1. Range of average exam scores and coefficients of determination (r^2) for exponential rise to a maximum models for each semester.

Course	Semester	No. of students	Range of avg. exam scores	Range of r^2 values: No limit	Range of r^2 values: 50-point max.
SC240 †	F2000	192	35–40	0.25–0.53	0.20–0.60
SC240	S2001	152	34–41	0.23–0.53	0.17–0.52
SC240	F2001	162	32–44	0.34–0.57	0.12–0.49
SC240	S2002	144	29–40	0.28–0.61	0.17–0.60
URH125 ‡	Combined	46	39–41	0.39–0.57	0.21–0.56

† SC240 = Introductory Soil Science at Colorado State University.
‡ URH125 = Soils and Fertilizers at Front Range Community College, Larimer Campus, Fort Collins, CO.

RESULTS AND DISCUSSION

The linear model (Eq. [1]) produced the lowest r^2 values and highest SE for individual exam and overall average regression (data not shown). Most r^2 values and SE for the quadratic (Eq. [2]) and exponential rise equations (Eq. [3]) were similar. We chose to focus our discussion, however, on the exponential rise models with either a no-limit or a 50-point maximum ($c_1 + c_2 = 50$). The quadratic models implied that a student's exam score could eventually decrease as they spent more hours studying, which is a highly unlikely possibility. The better fit of the data to the nonlinear equation suggests that hours studied may have been a bigger factor in determining exam performance than Eikeland and Manger (1992) and Okpala et al. (2000) found with their linear and multiple regression models.

The overall range of average exam scores for the four semesters of SC240 and two semesters of URH125 was 29 to 44 out of 50 possible points (Table 1). The r^2 range for individual exams was 0.23 to 0.61 and 0.12 to 0.60 for the no-limit and 50-point maximum models (Eq. [3]), respectively. Most of the individual exam r^2 values were between 0.30 and 0.50 (data not shown). Using a 50-point maximum invariably led to smaller r^2 values and larger SE values compared with the no-limit exponential rise to a maximum models; however, we feel the 50-point maximum model is a more realistic model than the no-limit model since every no-limit model found exam maximums less than the 50 points possible on each test.

Overall average exponential rise to a 50-point maximum for the four SC240 semesters and the URH125 combined data are shown in Fig. 1. Our overall average regression models were significant ($P < 0.05$) with r^2 values ranging from 0.31 to 0.49 and SE ranging from 9 to 12; therefore, we accept our first hypothesis. The URH125 model predicted larger exam scores than the four SC240 models for up to 6 h studied. With oneway analysis of variance of the predicted exam scores for 0, 1, 2, 3, 4, 5, and 6 h studied, we found, however, that no significant differences existed between the SC240 and URH125 models (data not shown). Probably, many other factors (Baker and Lombardi, 1985; De Meuse, 1985; Okpala et al., 2000; Perlmann and McCann, 2002) that we could not quantify also affected exam performances. Predicting about 40% of the

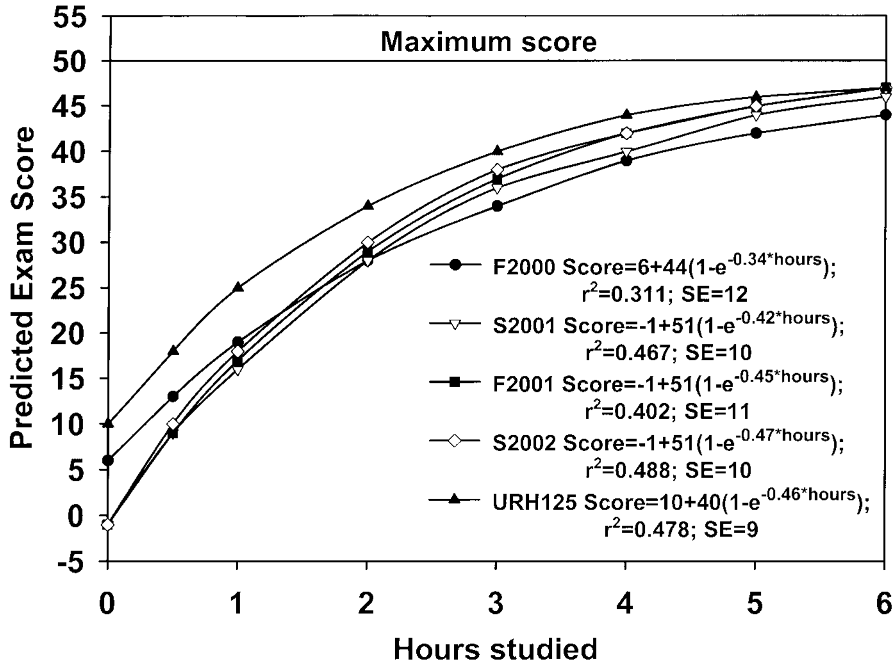

Fig. 1. Exponential rise to a maximum of 50 points regression models of predicted exam scores vs. hours studied for SC240 (Introductory Soil Science) at Colorado State University and URH125 (Soils and Fertilizers) at Front Range Community College, Larimer Campus for 2000 through 2002.

variability in exam scores with just the single factor of hours studied, however, encouraged us to use the models to generally predict exam scores if students study for a certain number of hours. While a model with only an r^2 of 0.40 does not allow for highly accurate predictions, we wanted to communicate this general information to students regarding possible exam-score expectations for the hours they studied. Next, we examined if these calculations complied with the Carnegie Rule.

Using the overall exam averages (ranged from 38 to 40; Table 2) and the regression equations shown on Fig. 1, we calculated that students needed to invest from 3.0 to 4.4 h to earn an average score. A frequently asked student question is "How much do I need to work to earn an A?" According to our models, the students would need to study from 4.5 to 6.4 h to earn 90% (45 points) on average. We found that the ratio of hours studied to earn 90% to the lecture hours covered ranged from 1.5 to 2.1 with a mean of 1.7 ± 0.2 (Table 2). Therefore, our results indicate that our students did not consistently match the Carnegie Rule of 2 h studied outside for every hour in class, and we must reject our second hypothesis. Our ratio is also lower than the 2.27 h per week de la Harpe et al. (1997) found for students completing a one-credit Educational Psychology core unit. We do not have an explanation for why our ratio is less than the Carnegie Rule. Again, we believe that this information is very useful and should be communicated to students so that they will know general, average expectations.

For four semesters of SC240 and two semesters of URH125, we discovered that exponential rise to a 50-point maximum regression models of exam scores vs. hours studied could predict about 40% of the exam-score variability. We also learned that the ratio of predicted hours studied to earn 90% to the hours spent in lecture were less than the Carnegie Rule ratio of 2.0. Indicating to students how many hours that previous SC240 and URH125 students needed to study to earn average or 90% exam scores should effectively communicate study expectations.

Table 2. Overall exam averages and predicted parameters from the 50-point maximum exponential rise to a maximum models.

Course	Semester	No. of students	Overall exam avg.	Hours to earn exam avg.	Hours to earn 90% (45 points)	Hours studied to lecture hour ratio to earn 90%†
SC240‡	F2000	192	40	4.4	6.4	2.1
SC240	S2001	152	38	3.4	5.5	1.8
SC240	F2001	162	40	3.6	5.2	1.7
SC240	S2002	144	38	3	4.9	1.6
URH125 §	Combined	46	40	3	4.5	1.5
Mean ± SD			39 ± 1	3.5 ± 0.5	5.3 ± 4.6	1.7 ± 0.2

† The average number of lecture hours per exam was 3.1.

‡ SC240 = Introductory Soil Science at Colorado State University.

§ URH125 = Soils and Fertilizers at Front Range Community College, Larimer Campus, Fort Collins.

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