The Impact of Testing Frequency and Final Exams on Student Performance

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Abstract – The purpose of this paper is to discuss how the frequency of testing i.e., the number of tests given during a given semester and the inclusion of a final exam will impact a student's final grade. A study was conducted on ten course offerings of EVE 406 Design and Analysis of Water Treatment Systems, a required course in the environmental engineering curriculum at Mercer University. Pearson correlation coefficients indicated low correlation between testing frequency and test average and no correlation between testing frequency and final grade at a 0.05 level of significance. A marked, substantial degree of correlation was observed at the 0.05 level of significance between a student's test average and final grade and between a student's final exam score and final grade. Paired comparison analysis at α=0.05 indicate there is a statistically significant difference in final grades when a mandatory final examination is included as part of the grade. For the 10 course offerings consisting of a total of 83 students, 8 students earned lower grades because of lower performance on the final; whereas, 20 students earned higher grades because of better performance on the final.

Keywords: Correlations, paired comparisons, final exam, final grades, frequency of testing.

INTRODUCTION

Engineering professors maintain currency in their area of expertise and apply various teaching strategies in the classroom and on-line to be effective educators. Many engineers became academicians to help students learn and perform well in class so they will become successful in the engineering profession. Throughout the author's teaching career, numerous strategies have been applied to enhance student learning, such as capitalizing on different learning styles by using a variety of assignments. For example, the author has successfully used design projects, field trips, laboratory assignments, digital storytelling assignments, on-line reading quizzes, on-line homework assignments, and technical papers. Inevitably, some methods seem to have worked better than others depending on the composition of a particular class. The application of these teaching strategies has empowered students to both perform at higher levels of thinking and retain their knowledge for future applications. The purpose of this paper was to explain how both testing frequency and a mandatory final examination impacts final student grades.

BACKGROUND

Mehta and Danielson [1] discussed twelve principles for enhancing student learning and they are presented in Table 1. The author has used several of these principles in his courses and has devoted much time and effort into using fair testing and grading procedures.

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Table 1. Next Generation Principles

1. Be learner-centered
2. Show applications and relevance of course material
3. Focus on student outcomes and critical content
4. Explain subject matter clearly
5. Use fair testing and grading procedures
6. Incorporate active cooperative learning into the classroom
7. Incorporate classroom assessment
8. Incorporate service learning
9. Incorporate use of appropriate technology
10. Incorporate writing assignments
11. Set high standards
12. Provide great learning support

Several researchers have studied the frequency of testing on student performance, relationships between various assignments and test performance, and whether or not to conduct a final examination in a course. Professors [2] at the United States Military Academy at West Point reported on the benefits of conducting daily quizzes in undergraduate engineering mechanics courses. They concluded that conducting daily quizzes did not erode student morale; however, statistically, there was no evidence indicating that daily quizzes enhanced student performance on exams.

According to Reisel [3] the literature shows several examples of using frequent quizzes or tests in a course to keep students more involved and prepared for class. Some advantages promoted by this approach include less material covered between quizzes, leads to less procrastination, better class preparation, and the ability to provide students with fast feedback. The down side to frequent testing includes less class time for covering other topics, potential damage to student morale by increasing student anxiety, more time required for making up and grading quizzes, less effort given to studying by students since frequent quizzes are typically weighted lower in the final grade determination, and no correlation between students' grades and testing frequency. Reisel [3] compared the results of teaching a Basic Thermodynamics course at the University of Wisconsin, Milwaukee using different testing frequency. The first technique consisted of 30-45 minute quizzes every 2 or 3 weeks with a final exam; whereas, the second technique involved 2 exams during the semester followed by a final exam. He concluded that there was no immediate student-knowledge benefit for using either technique.

Mays et al. [4] concluded that weekly or biweekly testing frequency in engineering courses not only improves student grades, but also student morale.

Fernandez et al. [5] investigated the correlation between individual student scores on homework, quizzes, tests, and final examination. The authors found weak correlations between homework and quiz, test or final examination scores. They suggested that homework may potentially not be an effective means of enhancing student performance on tests and that mandatory graded homework should be replaced with more frequent in-class quizzes.

Jenkins and Schultz [6] analyzed student grades from 10 sections of Statics and 8 sections of Engineering Economy to determine the impact of the final examination score on students' overall grades. They found that the effect of the final exam on the average numeric course grade was less than 3%. They suggest that a one hour exam at the end of the course may suffice adequately for motivating and assessing student performance rather than a final examination.

COURSE OFFERINGS AND METHODS

The objective of this research was to determine if there is a relationship between frequency of testing and final grade and between final exam and final grade. Data that were evaluated came from ten course offerings of EVE 406 Design and Analysis of Water Treatment Systems consisting of a total of 83 students. For each course offering, a comprehensive final examination was given. It is an upper-level design course required by all students enrolled in the environmental engineering specialty at the Mercer University School of Engineering (MUSE). Various statistical analyses were performed in MINITAB and a α and *p*-value of 0.05 were used for establishing the level of significance. Pearson correlation coefficients, paired comparison analyses, and analyses of variance were performed on the data.

To determine if there was a significant difference in students' grades including and excluding a final exam score, paired comparison analyses were performed. For each course offering, final grades with a mandatory final exam had previously been determined. It was necessary to re-calculate final student grades by not including the final exam score in the calculation. Typically, students' final grades are based on homework assignments, tests, design project or technical paper, and final exam or some variation thereof. As an example, for the fall 2012 semester, final grades were based on the following allocation: tests at 40%, on-line quizzes at 10%, on-line homework sets at 20%, and final exam at 30%. Equation (10 was used for calculating the final grades (including the final exam).

$$\text{FG} = 0.40\ \text{Test average} + 0.10\ \text{Quiz average} + 0.20\ \text{HW Set average} + 0.30\ \text{Final Exam} \quad (1)$$

Where: FG is the final student grade based on a 100 point scale,

Test average = average of all tests based on a 100 point scale,

HW Set average = average of all homework sets based on a 100 point scale, and

Final Exam = score on final exam based on a 100 point scale.

Final grades excluding the final examination score were based on the remaining course items such as homework, quizzes, tests, and design project or technical paper depending on the specific course offering. Equation (2) was used for calculating the final grades (excluding the final exam grade) for the fall 2012 semester.

$$\text{FG} = \frac{\left[0.40\ \text{Test average} + 0.10\ \text{Quiz average} + 0.20\ \text{HW Set average}\right]}{0.70} \quad (2)$$

Students' scores on tests, final exam, and final course grades were entered into an Excel spreadsheet before being transferred into MINITAB for performing the statistical analyses. The results and discussion of the statistical analyses are presented in the next section.

The objective of this research was to determine if there is a relationship between frequency of testing and final grade

RESULTS AND DISCUSSION

Correlation between # of Tests and Test Average or Final Grade Average

Table 2 presents the number of tests administered, test average, and final grade average for each of the ten course offerings. The highest test average occurred during the fall 2012 semester when six tests were given throughout the semester while the highest final grade average was observed for the fall 2002 semester.

Table 2. Frequency of Testing, Test Average, and Final Grade Average by Semester.

Semester	Number of Tests	Test Average	Final Grade Average
F2003	2	64.1	72.1
F2010	3	76.3	83.4
F2008	3	78.8	84.7
F2002	3	80.3	85.7
F2001	3	83.2	80.0

F2005	3	84.6	84.5
F2007	5	80.7	80.8
F2006	6	75.5	77.0
S2010	6	78.4	84.2
F2012	6	89.1	84.3

Pearson correlation coefficients between the number of tests administered and test average or between tests administered and final grade average are shown in Table 3. Fernandez et al. [4] referencing Franzlau [7] state that a correlation coefficient in the range of [0, 0.20) indicate no correlation between variables, values in the range of [0.20, 0.40] indicate a low degree of correlation, values of [0.40, 0.60] indicate a moderate degree of correlation, and values of [0.60, 0.80] indicate a marked, substantial degree of correlation. The results from the Pearson correlation coefficient determinations indicate a low correlation between number of tests and test average and no correlation between number of tests and final grade average. In both instances, the results are not statistically significant since the calculated *p*-values are much greater than the *p*-value of 0.05 which was established as the level of significance. Therefore, testing frequency appears to have little effect on a student's test average or final grade.

Table 3. Pearson Correlation Coefficient between # of Tests and Test Average or Final Grade Average.

	n	***r***	***p*-value**
Between # of Tests and Test Average	10	0.378	0.282
Between # of Tests and Final Grade Average	10	0.154	0.672

A two-tail, single analysis of variance (ANOVA) performed at α=0.05 on final course grade averages for the ten course offerings indicated a significant difference (F= 2.411 > F_{crit} = 2.010). This difference may be partly attributed to testing frequency; however, as noted in Table 2 and Table 3, there was no significant correlation between either the number of tests administered and test average or final grade so there must be other variables that cause the difference. Further research on should be conducted to determine which parameters may be contributing to the difference, i.e., homework grades, technical paper grade, or design project grade, etc.

Correlation between Test Average and Final Grade and between Final Exam and Final Grade

Correlations between Test Average and Final Grade and between Final Exam and Final Grade were also determined. Table 4 presents the Pearson Correlation Coefficients for each. Based on the previous correlation classification that was used by Fernandez et al. [4], a marked, substantial degree of correlation was observed between students' test average and final grade and a moderate degree of correlation was observed between students' final exam score and final grade. The results are statistically significant since the calculated *p*-values are less than the *p*-value of 0.05 which had been established as the level of significance. Therefore, a student's test average or final exam score correlates substantially with a student's final grade in the course. These results may not have been statistically significant if the final exam "weight" was 10 or 20% of the final grade.

Table 4. Correlation Coefficient between Student Test Average and Final Grade and Final Exam and Final Grade.

	n	***r***	***p*-value**
Student Test Average and Student Final Grade	85	0.678	0.000
Student Final Exam Score and Student Final Grade	85	0.599	0.000

Paired Comparison Analyses on Final Grades with and without Final Exams

Tables 5 through 8 show students' final grades for each course offering based on including and excluding the final exam score.

Table 5. Students' Final Grades with and without Final Exam Grades Included Fall 2001 to Fall 2003.

F2001 Final Grade without Exam n = 7	F2001 Final Grade with Exam n = 7	F2002 Final Grade without Exam n = 7	F2002 Final Grade with Exam n = 7	F2003 Final Grade without Exam n = 2	F2003 Final Grade with Exam n = 2
84.9	85.2	80.0	88.7	69.9	69.2
82.7	82.0	86.9	86.7	78.3	75.1
88.2	90.3	81.6	82.0		
75.1	75.8	83.2	91.0		
69.4	67.4	90.1	92.9		
77.0	72.6	81.5	81.4		
83.9	86.4	80.2	83.2		

Table 6. Students' Final Grades with and without Final Exam Grades Included Fall 2005 to Fall 2007.

F2005 Final Grade without Exam n = 5	F2005 Final Grade with Exam n = 5	F2006 Final Grade without Exam n = 10	F2006 Final Grade with Exam n = 10	F2007 Final Grade without Exam n = 8	F2007 Final Grade with Exam n = 8
84.4	86.5	79.5	81.3	73.3	78.3
86.2	84.6	73.8	79.0	88.2	88.8
75.8	78.2	75.8	80.9	61.1	69.7
83.6	84.1	58.8	63.6	70.9	75.0
88.5	89.0	80.5	79.7	78.1	83.8
		84.5	85.1	79.3	83.9
		91.0	90.3	88.9	88.3
		63.9	68.1	78.6	84.8
		70.5	77.3		
		53.2	64.4		

Table 7. Students' Final Grades with and without Final Exam Grades Included Fall 2008 to Fall 2010.

F2008 Final Grade without Exam n = 5	F2008 Final Grade with Exam n = 5	S2010 Final Grade without Exam n = 18	S2010 Final Grade with Exam n = 18	F2010 Final Grade without Exam n = 7	F2010 Final Grade with Exam n = 7
76.3	75.5	92.0	92.6	89.2	88.7
78.2	79.9	78.0	81.7	76.9	76.0
88.9	90.1	83.6	85.9	83.7	80.8
88.7	89.1	80.8	84.1	84.8	81.7
88.0	88.8	82.1	84.6	79.6	79.3
		88.9	88.0	92.2	91.5
		85.6	86.1	84.2	85.8
		89.1	86.0		
		80.5	83.0		
		91.4	91.5		
		79.2	77.5		
		80.7	79.3		
		71.8	68.4		
		86.2	87.7		
		79.9	82.1		
		84.3	85.0		

		87.8	83.9		
		87.9	88.7		

Table 8. Students' Final Grades with and without Final Exam Grades Included Fall 2012.

F2012 Final Grade without Exam n = 14	F2012 Final Grade with Exam n = 14
88.8	89.0
91.3	87.8
95.1	93.6
88.1	83.1
79.0	77.6
83.3	81.3
92.5	88.8
84.1	84.2
88.5	87.6
82.9	83.1
75.1	76.6
84.6	82.6
86.0	85.3
78.9	79.0

A paired comparison, student's *t*-test was performed on the final grades (including and excluding final exam scores) for each student in each course offering using the values presented in Tables 5 through 8. The result of the paired comparison analysis is presented in Table 9. As seen in Table 9, there is a statistical significant difference in final grades when the final examination is included in the final grade determination at a α value of 0.05. This means that that the score on the final examination can have a significant impact on a student's final grade in EVE 406 for any given semester.

Table 9. Paired Comparison Analysis Between Final Grades with and without Final Examination.

Course Offering	n	df	α	t	$t_{0.025}$	Significant Difference Yes or No
10	83	82	0.05	-2.718	1.989	Yes

Table 10 shows the impact of including or excluding the final exam score in a different fashion. For all course offerings listed with exception to F2003 and F2005, most students profited from taking the final exam which resulted in an improvement of one-half letter grade i.e., going from a C+ to a B or from a B to a B+. Evaluating the entire data set indicates that 8 students representing 10% of students would have received a higher final grade in the course if the final grade was independent of the final exam; however, 20 students which represent 24% of the students had their grades increase by counting the final exam. It would appear that students benefit from taking a final exam.

Table 10. Impact of Final Exam on Final Grade in Course

Course Offering	Number of students with higher and lower grades	Impact on Letter Grade
F2001	1 had higher grade without exam 1 had higher grade with exam	1 had half-letter grade lower 1 had half-letter grade higher
F2002	2 had higher grade with exam	1 had half-letter grade higher 1 had full-letter grade higher
F2003	No difference	No difference
F2005	No difference	No difference
F2006	1 had higher grade without exam 6 had higher grade with exam	1 had half-letter grade lower 4 had half-letter grade higher 2 had full-letter grade higher
F2007	5 had higher grade with exam	5 had half-letter grade higher
F2008	1 had higher grade with exam	1 had half-letter grade higher
S2010	3 had higher grade without exam 4 had higher grade with exam	2 had half-letter grade lower 1 had full-letter grade lower 4 had half-letter grade higher
F2010	1 had higher grade with exam	1 had half-letter grade higher
F2012	3 had higher grade without exam	3 had half-letter grade lower
Overall	8 had higher grade without exam 20 had higher grade with exam	7 had half-letter grade lower 1 had full-letter grade lower 17 had half-letter grade higher 3 had full-letter grade higher

SUMMARY AND CONCLUSIONS

In this study, the impact of testing frequency and inclusion or exclusion of the final exam score on students' final grades was examined. Pearson correlation coefficients were estimated between testing frequency and test average and between testing frequency and final grade average. A two-tail, single analysis of variance was performed on final course grade averages. Pearson correlation coefficients were determined to ascertain the degree of correlation between average student test scores and final grades. A paired comparison analysis performed on students' final grades calculated by including and excluding final exam scores indicated the final exam score has a statistical significant impact on a student's final grade. The major conclusions that can be drawn from the data are listed below.

- Pearson correlation coefficients indicated a low correlation between the testing frequency and test average (r = 0.378) and no correlation between testing frequency and final grade average (r = 0.154). Testing frequency appears to have little effect on a student's test average or final grade.
- Although a single analysis of variance shows a statistical significant difference between final course grade averages, variables other than testing frequency such as homework average, technical report grade, or design project grade must have contributed to the difference. These and other variables should be investigated to determine their impact and correlation with a student's final grade.
- A paired comparison analysis at α= 0.05 indicates there is a statistical significant difference in final grades in the course when a mandatory final examination is included as part of the grading, i.e., the final exam has a significant impact on a student's final grade in EVE 406.
- For the 10 course offerings consisting of a total of 83 students, 8 students earned lower grades because of poorer performance on the final exam; whereas, 20 students earned higher grades in the course because of better performance on the final. In other words, 24% of the students benefited from taking the final exam in EVE 406.

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