A Comparison of Performance Between Distance-Learners and On-Campus Learners in a Graduate Level Quality Assurance Course for Engineers

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Abstract – **This paper describes the results of the study of two research questions: 1) is the performance (as measured by final grades) of distance-learning students the same as that for on-campus students in a particular graduate-level course offering in quality assurance?; and 2) is there a correlation between homework scores and exam scores of students in a particular graduate-level engineering class. In order to study these questions, 11 different semester offerings of the course (by the same professor with similar syllabi and course structure among the different semesters) are analyzed. The first research question is addressed by statistically comparing the grades of each group (on-campus vs. distance-learners) per semester over the 9 semesters in which there were both on-campus and distance-learning sections. In the second research question, data from all 11 semesters are used. Findings and results in the answer to both questions are based upon hypothesis testing results, probability plots, and scatter plots conducted in MINITAB and Microsoft Excel. Analyses indicate that, in answer to the first question, there are minor differences in the performance between the two groups; however, the differences are not statistically significant at α = 5% in the hypothesis testing. With regards to the second research question, medium, positive correlations are found between homework scores and exam scores.**

Index Terms – Distance Learning, Graduate Course, Hypothesis Testing, Correlation Analysis

INTRODUCTION

A core-course of the M.S. Industrial and Systems Engineering degree program at Binghamton University (a State University of New York (SUNY) school) has been taught by the same faculty member, with just a few exceptions, since 1995. The few exceptions related to a sabbatical leave and release-time based upon heavy research semesters. Since this course has been taught multiple times by the same faculty member, and having multiple semester offerings that had both in-class students and distance-learning students, it presents as a good candidate to compare the performance of these two types of students. The primary question under study in this work is the following: Is the performance (as measured by final grades) of distance-learning students the same as that for on-campus students for this course? A subsequent question is also studied: Is there a correlation between homework scores and exam scores in this course? The motivation for the first research question is merely intellectual curiosity on behalf of the primary author. He has been teaching (and will continue to teach) this core course for several years and, for the foreseeable future with both on-campus and distance-learning students. The second research question is studied due to recent budget cuts at the university. With the cuts, there will be fewer, if any, teaching assistants to assist with grading. If there is no strong correlation between assignments and exam scores, then restructuring the grading system – by putting more, if not all weighting on exam scores – will be considered.

HISTORY OF THIS COURSE OFFERING

This section will describe the course, in general terms. It will also describe the history of the EngiNet offering and recent changes to the delivery. EngiNet is the name of the distance-learning program at Binghamton University that supports graduate courses within the T.J. Watson School of Engineering and Applied Science. There are other courses at Binghamton University that offer distance-learning options; this paper is restricted to one particular course as delivered specifically through the EngiNet program.

SSIE 561 – Quality Assurance for Engineers

The course studied in this work is offered by the Systems Science and Industrial Engineering (SSIE) Department at Binghamton University. The rubric is "SSIE 561" and the course is titled "Quality Assurance for Engineers." Since 1995, the lead instructor of this course is the primary author of this paper. This course has been "on the books" prior to 1995, but this paper refers to this course as it has been offered since that time.

Due to the many offerings of this course by the same instructor and that this class has been offered several times with both on-campus students and distance-learning students, allows it to be useful to answer the questions studied in this work.

SSIE 561 is a fundamental, core-course for the MSISE degree at Binghamton University. Since 1995, the primary topics of this course have been the following:

- History of SPC/SQC techniques;
- 4 Quality Cost Categories
- 7 "Old" Tools for Quality Improvement and Control
- Measurement systems analysis (Gage R&R, P/T, etc.);
- Variables control charts (Xbar, R, s, etc.);
- Taguchi's Quadratic Loss Function
- Process capability indices (C_p, C_{pk}, etc.);
- Attributes control charts (p, np, c, u, and others);
- Inspection Sampling by Attributes (single, double, sequential, established plans such as ANSI/ASQ (Z1.4) MIL-STD (105E), Dodge-Romig, and others);
- Inspection Sampling by Variables;
- ISO 9000;
- MBNQA (Malcolm Baldridge National Quality Award);
- and others.

In addition to the above, other major topics that are now standard to the syllabus, but were not incorporated in the 1995 offering include, among others: the 7 "New" Tools for QI and QC, short-run SPC, and 6sigma concepts (e.g., the DMAIC process).

While the general topics have been rather consistent throughout the years, it would be inconsistent with quality concepts to say that the course has not been looked at as a candidate for improvement throughout the years. In fact, in this and other courses taught by the instructor (e.g., also see [5]), improvements to the curriculum are always made in each new semester. In the SSIE 561 course, for example, while the general topic list has been the same with some additions as described above, the main, but not the only, improvements to this course involve the instructor refreshing/updating examples. Why present manufacturing data on 5.25" floppy diskettes to demonstrate a p-chart when, instead, we can demonstrate the mechanics of that chart with "thumb-drives", iPods, or other devices that the students are more likely to be familiar with? Other improvements to the course involve the incorporation of these techniques that are used in the professor's research projects on "real-world" data. Utilizing non-manufacturing examples of these quality concepts is of particular interest to our students (e.g., many of them are interested in health-care systems and other applications in non-manufacturing arenas). Occasionally, new SPC topics are also incorporated into the curriculum, such as the new *defects per billion opportunities* "dpbo" attributes control chart [1].

In addition to the topics being fairly standardized across these different semester offerings since 1995, so has the assessment mechanism. In all offerings, the students' final grades are based upon homework assignments (typically 15-20%) and exam scores (typically, two exams, weighted about 25% each, and a final exam, weighted about 30-35%).

Except for rare exception, concerning examinations for the course and semester offerings studied in this work, the professor did not allow them to be graded by the Teaching Assistant (TA). On very few occasions, the instructor incorporated the use of TA grading of exams on easy-to-grade portions of the exam (e.g., Multiple Choice Questions (MCQs)) and grading happened in the presence of the instructor while he was assessing the other techniques/questions in order to provide feedback. Again, this is rare, as the majority of the questions is not of the MCQ type (nor are they fill-in-the-blank type) but require more detailed demonstration of the techniques and analysis by the student.

It is the case that in almost all semesters, TAs were used to grade the homework assignments. Occasionally the same TA was used in two semesters, but generally speaking the TAs were different from offering to offering. Of course, this can factor into overall grades. A way to minimize variability in this assessment is that, prior to each grading assignment, the instructor sits with the TA and describes the technique to perform the grading on each problem. Aside from question-specific techniques to monitor for, the TA is typically instructed to grade each question on a 10 point scale. The TA is instructed to monitor that the appropriate technique(s) is(are) used, first-and-foremost, and to subsequently concentrate on the final answer. If the technique looks correct and the final answer is correct (or in the "ballpark"), then they are to assign full points to the problem. If the technique looks correct and the final answer is incorrect due to, say, a minor calculation error, then the student should get most points. Major point loss is requested to be assigned in situations such as if the students have misapplied the techniques, have major miscalculations, and have not provided analysis of the solutions. Further, as this is a quality-related course, the submissions of the assignments should also appear to be professional and that is factored into the grading of homework.

EngiNet Program at Binghamton University

There are multiple options for students to be distance-learners at Binghamton University. This paper is restricted to a course offered via the EngiNet program. EngiNet caters specifically to graduate courses offered by the T.J. Watson School of Engineering and Applied Science. In the beginning of EngiNet in the early 1990s, the material (lectures (video/audio of the professor) and PowerPoint presentations/captures of the slides) was delivered to the students via VHS. The lectures (typically two per week)

were compiled and express-mailed at the end of the week. This forced a delay in the distance-learners by a period of about a week or more. Technology has progressed and been adopted to the point where the students now receive the same materials, not in real-time, but on the same day as the lecture presentation via streaming video after minor post-production in the EngiNet office. For more information about the EngiNet program, please visit their website [2].

By and large, the EngiNet program delivers graduate-level engineering and computer science courses from the Watson School. Many, but not all of the EngiNet distance-learners are full-time graduate students that are performing their research on their MS and PhD degrees in laboratories/facilities of external research sponsors. For example, there are many SSIE graduate students that are EngiNet students who have performed or are currently performing their research work in such locations as California, Texas, Massachusetts, Alabama, Florida, New Jersey, non-Binghamton area New York state sites, and other locations, including other countries.

RESEARCH QUESTION 1: Comparison of EngiNet vs. On-Campus Students

Now that a basic understanding of the course and overview of the EngiNet program has been provided, the first research question is now addressed. As measured by weighted grades (which determine their final letter grade), is the performance of distance-learners the same as that of on-campus students for SSIE 561?

This question is addressed by a combination of the following: scatter plots, probability plots, and hypothesis testing. MINITAB and MS Excel are utilized to conduct the analyses.

Since 1995, there have been 9 semesters in which the same faculty member taught SSIE 561 and had both an on-campus section and a distance-learning (EngiNet) section. An "EngiNet" student will be synonymous with a distance-learning student for purposes of this work. There were a few other occasions since 1995 in which a different faculty member has taught this course but those data are not included in this analysis.

Prior to conducting the hypothesis test, it is found that in 8 out of the 9 semesters, the average final grade of EngiNet students is higher than that of the on-campus students. The range of the difference is (0.61, 5.6) points. In the other semester, the on-campus students had an average final grade that is 0.51 points higher than the EngiNet students. Hypothesis testing is conducted to determine if there are any statistically significant differences.

Approach

For each of the 9 semesters, the following hypothesis was tested:

$$H_0 : \mu_O = \mu_D$$

vs. $$H_a : \mu_O \neq \mu_D$$

In the above, μ_O represents the mean final weighted grade of the on-campus students and μ_D represents the mean final weighted grade of the EngiNet students.

For each semester, a t-test is conducted at α = 5%, and a 95% CI on μ_O-μ_D is developed. If the CI contains zero (0), we concluded that the final grades are not statistically different, otherwise we concluded that they are different (at α = 5%).

After conducting the hypothesis test in each of the 9 semesters, the most important result is that in only one semester are the differences in the average grades considered to be statistically significant [3]. In Spring 2007, the 95% CI on μ_O-μ_D is (-7.61, -0.94). As a result, we conclude that the distance-learners performed better than the on-campus students in this one semester.

Generalizing, this provides some comfort in that, in all but one case, the on-campus and distance-learning students appear to perform similarly. Since the time at which this research question was asked and answered, a recent *Journal of Engineering Education* article studied distance learning in an international course (see Mackey and Freyberg [6]) and one result of their paper seems consistent with our conclusion on Research Question 1. In Mackey and Freyberg's study, the distance students learned as well as in-class students, albeit it was mentioned that they seemed to enjoy the class less (a question not studied in this current article) due to the decreased social presence of the instructor.

RESEARCH QUESTION 2: Correlation of Homework Scores and Exam Scores

The State of New York, as are many other states in the current economy, is experiencing budgetary difficulties and these difficulties are felt at Binghamton University and other schools in the SUNY system. Coupled with these difficulties and a simultaneous increase in enrollments, the instructor is looking at new ways to maintain the quality of the course offering while coping with reduction of TAs and other constraints. Without a TA, for example, the assessment of homework assignments would be extremely time-consuming for the faculty member. As a result, as students' final grades in this course are a weighted combination of homework grades and exam grades, the second research question studied is the following: Is there a correlation between Homework Scores and Exam Scores in this course?

Based upon the findings in Research Question 1, we have grouped all students (on-campus and distance-learners, alike) for this analysis. If it was discovered in the answer to the first research question that there was a significant difference in the performance between the two groups, then we would have stratified Research Question 2 into two groups for analysis. I.e., we would have done separate correlation analyses: one for on-campus students and one for EngiNet students. Since there was not a significant difference between the two groups, we collected them together to address Research Question 2.

In addition to the 9 semesters that had both on-campus and EngiNet students, there are 2 semesters wherein this course was offered by this faculty member that only had on-campus students. As such, 11 semesters and a total of 367 students create the data set utilized to address this question.

Approach

The steps we followed to address this question are the following:

1) For each semester, we used the average homework score and average exam score for each student;
2) For each semester, we made a scatter plot of average exam score and average homework score;
3) We added trend lines to each of the scatter plots;
4) We computed the Pearson Correlation Coefficient for each semester.

The Pearson Correlation Coefficient (PCC) reflects the degree to which these two variables (average homework score and average exam score) are related. A "+1" indicates a very strong positive relationship and a "-1" indicates a very strong negative relationship. Table 1 was used in our analysis; the table is from www.wikipedia.org and we added the color scheme utilized for a subsequent table.

Table 1. PCC Values and Categories

Correlation	Negative	Positive
Small	−0.3 to −0.1	0.1 to 0.3
Medium	−0.5 to −0.3	0.3 to 0.5
Large	−1.0 to −0.5	0.5 to 1.0

www.wikipedia.org

Summarized Results

All 11 semesters had PCC > 0. There was approximately a 50-50 split between Small and Large correlations (using the Table 1 categories). In one semester, a Medium correlation was found. Across all semesters, an obvious result is that there is a Medium correlation between the variables.

Table 2 provides the PCC values for each of the 11 semesters and across all semesters.

Table 2. Computed PCC Values [4]

Semester	Correlation	
All Semesters	.3217	
Fall 1996	.1936	
Fall 1998	.7058	
Spring 1998	.7276	
Fall 1999	.1647	
Fall 2000	.2609	
Fall 2001	.0862	Very Weak
Fall 2002	.4203	
Fall 2005	.6633	
Spring 2007	.5202	
Spring 2008	.2688	
Spring 2009	.1793	

CONCLUSIONS

We conclude from addressing Research Question 1, that the on-campus students and distance-learning students are not appreciably different in their performance in this class.

Based upon the findings of Research Question 2, it is likely that without the future use of a TA to assist in homework grading and assessment, one of the following or a combination may be utilized: homework scores will not be included in the final weighted scores to compute the students' letter grades (this is practice that is not uncommon); homework assignments may be revised such that grading is quicker (e.g., increased use of quicker-to-assess MCQs and other question types may be incorporated); and, as will be discussed by Rampelli et al. [5], the adoption of automated assessment systems such as those provided by Blackboard (V. 9) may occur.

FUTURE WORK

There are multiple avenues for future study. An obvious study would concern similar comparisons of other EngiNet courses wherein the same instructor has taught the same course to on-campus and distance-learners in multiple semesters. With regards to this particular study, there are the following research opportunities and questions, among others:

- In the hypothesis tests that have been conducted, results may be different with different alpha values.
- We could stratify the analysis of EngiNet students' performance based upon the type of material

delivery. E.g., compare those that received materials via mailed VHS tapes vs. those that received materials via streaming/web downloads.
- We could delve into certain semesters in more detail. For example, why, in Spring 2007, was there a statistically separable difference between on-campus versus distance-learners?
- We may study why there appears to be a 50-50 split between high values and low values.

ACKNOWLEDGMENTS

The authors would like to thank the following: the McNair Scholar's Program, the Louis Stokes Alliance for Minority Participation, and Binghamton University's Educational Opportunities Program (EOP) for funding the summer research experiences of Ms. Leandre and Mr. Ghebremical. Consequently, this paper is based in large part upon research work that was presented at the 2009 McNair Research Conference in Niagara Falls, NY and hosted by the University at Buffalo. Prof. Santos would particularly like to thank the EngiNet program and all of its staff at Binghamton University that allowed this and other engineering courses to be offered to distance learners. EngiNet supports not only these customers but is a vehicle that enables our off-campus research relationships with industrial partners to flourish.

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