Improving Statics Instruction in Four-year Technology Programs

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ABSTRACT - Four-year engineering technology students often find their first course in Statics to be most challenging. This paper discusses a study of students' performance in algebra and trigonometry-based Statics courses over a three semester period of time. The purpose of the study was to determine if students in a mini-semester, 12 day long course performed as well as students in a traditional, 16 week long semester.

The discussion includes a short literature review and an examination of the steps taken to monitor the performance of Statics classes provided to technology and construction management students. Student Scholastic Aptitude Test scores were found to be statistically equal for all three classes. Students' performance on a standard, multiple choice final exam in all three classes was also statistically equivalent. It appears that a shortened, intense period of study did not have any detrimental effects upon student performance when the class size was kept small.

Keywords: Statics, beam design, column design, student retention, strength of materials

INTRODUCTION

According to the Fairleigh Dickinson University School of Engineering and Engineering Technology [4],

> "Engineering technology programs are characterized by their focus on application and practice, and by their approximately 50/50 mix of theory and laboratory experience. Technologists are employed across the technological spectrum, but are better suited to areas that deal with hardware application, implementation, and production, as opposed to the conceptual design and research functions. Engineering technology is the profession in which knowledge gained through higher education, experience and practice is devoted primarily to the implementation and extension of existing technology in such areas as product improvement, manufacturing, and engineering operations"

This description of engineering technology provides the reader a concise description of the scope of work applicable to an engineering technologist and a construction manager. Statics is a course commonly taught in engineering technology and construction management educational programs. The Accreditation Board for Engineering and Technology (ABET) requires students have "an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology" before they complete their program of study [1, p2]. The American Council for Construction Education (ACCE) requires design theory in construction management curriculum, specifically naming Statics in their accreditation standard [2,p7]

What are the characteristics of a successfully delivered Statics course? At Western Carolina University in Cullowhee, North Carolina, success may be measured by final grades and student course satisfaction. Students must

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have an appreciation of the processes used to solve problems in Statics and have the ability to adapt this knowledge to other areas of study and practice.

The discussion which follows includes a short literature review of Statics teaching methods and an examination of the steps taken to monitor the performance of Statics classes provided to technology and construction management students. Student Scholastic Aptitude Test scores were examined for three Statics classes at Western Carolina University. Students' performance on a standard, multiple choice final exams in the three classes was also reviewed. The objective of this study was to determine if a shortened, intense period of study will have any detrimental effects upon students' performance when the class size was kept small during the intense period of study.

LITERATURE REVIEW

There are many articles which discuss supplementary materials, computer programs and innovative methods to improve students' grasp of the concepts necessary to master Statics problems, but very few articles which specifically address learning objectives for Statics students or the differences in learning styles of technology and engineering students. Literature on the teaching of Statics with the use of web-based, on-line materials to supplement in-class instruction and those articles on the mechanics of learning Statics will prove helpful to this discussion.

Dollar and Steif [3, p1] wrote "in sum, all is not well with Statics". They indicate that the biggest issues related to students' learning in Statics is in application of principles. Students tend to focus on obtaining a mathematical solution to problems presented by the instructor. To improve students' understanding of Statics, they suggest collaboration, active engagement of students in the classroom, and integration of assessment into the learning process. Holzer and Andruet [8] also recommended cooperative/collaborative learning and assessment. Steif [10] provides specific classes of student errors related to solving Statics problems such as "leaving a force off the free body diagram" (p.4).

There are several articles related to online Statics teaching methods. Gramoll [6] recommended a supplementary software/CD based multimedia for Statics students. Oglesby, Carney, Prissovsky and Crites [9] discuss on-line supplementary materials for Statics students in the form of audio/graphic lectures, automatically submitted homework with instant feedback, and online grade reports and syllabi. Flori, Olglesby, Philpot, Hubing, Hall and Yellamraju [5] suggested animated theory models, conceptual quizzes, web-based homework and video mini-lectures online to improve Statics students' performance. Gramoll, Hines and Kocak [7] found similar student performance in Statics when comparing online and in-class methods of delivery. They discussed teaching Statics entirely online. All lectures, homework and tests were provided online.

DISCUSSION

Student performance on final exams and homework, and student satisfaction surveys were used to evaluate the effectiveness of instruction provided to technology and construction management students in Statics courses at Western Carolina University in Cullowhee, North Carolina over a three semester period of time from the fall semester of 2007 through the summer semester of 2008. The primary course instructor, assigned classroom, and all student assignments were kept consistent through-out the period of study. The semesters included in this case study included a fall, 16 week traditional semester, a spring, 16 week traditional semester and a summer mini-semester. The mini-semester at Western Carolina University is a twelve day, intensive course offering. These classes meet everyday for four hours during the mini-semester. The class sizes are generally smaller in the mini-semester—14 in this case study, versus the 29 and 32 students respectively during the Fall 2007 and Spring 2008 offerings.

Overall student satisfaction determined by course surveys was found to be highest during a twelve day, summer mini-semester course when compared to traditional 16 week duration spring and fall courses. The overall satisfaction score for both 16 week semesters was 4.1 out of 5 while the score for the mini-semester was 5.0 out of 5. The sample size for the mini-semester was extremely small and prohibits any meaningful conclusions based on statistical significance. Generally, the qualitative, opinioned conclusion of the instructor of the studied Statics classes was that the summer, mini-semester students were much happier with the course instruction and their performances than either of the other classes included in this study based upon course evaluations.

A standard, multiple choice final exam was provided for all three classes. An analysis of variance (ANOVA) was performed on the exam grades for all three classes. The fall and spring final exam grades were found to be statistically equal to the mini-semester class exam grades, See Table 1. Combined math and verbal scholastic aptitude test (SAT) scores were obtained for the students in all three class groups to determine if student academic ability was equivalent. The average SAT scores were 1037, 999, and 944 for the Fall 2007, Spring 2008, and Summer 2008 classes, respectively. An ANOVA was performed on the SAT scores and found that all three groups had statistically similar SAT scores, see Table 2. An examination of the relationship between exam grades and SAT scores found very little correlation (R^2<0.25). The shorter, more intense period of study seemed to have no negative effects on student performance. The ANOVA results for the final exam scores and the SAT scores are shown below.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Fall 2007	38.000	2916.000	76.737	606.361
Spring 2008	33.000	2466.000	74.727	293.955
Summer 2008	16.000	1271.000	79.438	76.529

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	243.827	2.000	121.913	0.310	0.734	3.105
Within Groups	32989.851	84.000	392.736			
Total	33233.678	86.000				

Table 1: Average Final Exam Grades: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Fall 2007	29.000	30070.000	1036.897	11365.025
Spring 2008	32.000	31980.000	999.375	15102.823
Summer 2008	14.000	13210.000	943.571	17824.725

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	83169.048	2.000	41584.524	2.941	0.059	3.124
Within Groups	1018129.618	72.000	14140.689			
Total	1101298.667	74.000				

Table 2: SAT Scores ANOVA: Single Factor

There are some issues which also may have accounted for the statistically equal final exam grades among the summer students. The paper exam copies were collected by the instructor after each exam, but some regular semester students may have recorded the content of the exam afterwards for fraternity files or personal records, as is often done, and provided this information about the exam to the summer students. The final exam was consistent throughout this period of study, but grammatical errors were corrected after the first semester of this study which may have affected students' understanding of the exam.

Homework grades were found to be higher for the mini-semester when compared to the fall and spring course offerings. Homework during the mini-semester was weighted 40% in the summer, versus 10% in the fall and spring semesters, which appears to have resulted in higher homework grades for the summer students.

In conclusion, this study found that student performance in a technology Statics course in a mini-semester format did not negatively affect student performance. Even though the mini-semester is a much shorter period of time than the traditional semester, the reasons for the equivalent statistical performance of all three classes may have been due to increased student focus and class preparation, better implied student course satisfaction, and better instructor/student interaction due to the smaller classes. A summary table of satisfaction, exam grades and homework grades is provided below.

Semester	**Overall satisfaction**	**Exam average grade**	**Homework average grade**
Fall 2007	4.1 out of 5	77/100	85/100
Spring 2008	4.1 out of 5	75/100	88/100
Summer 2008	5.0 out of 5	79/100	99/100

Table 7: Summary of performance metrics

CONCLUSION

The findings of this study indicate that short, intense periods of instruction may be as effective in the Statics classroom as traditional semester-long offerings. Smaller class sizes also may have influenced the results of this study, but the specific effects of the smaller mini-semester class were not quantitatively recorded. The emphasis on student completion of homework assignments appears to be another significant factor affecting student performance. More, formal study is needed.

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