

## **Experiences with a Paced Web-Taught Course in Numerical Methods in Engineering**

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### I. Introduction and Background

In the fall semester 2000 we instituted a paced completely Internet taught sophomore level numerical methods course for engineers. Prior to this, in the fall 1999 and spring 2000 semesters, the course was taught in a completely traditional manner. The transition to an Internet course was made in a controlled manner so that certain aspects of the course were preserved and these could be statistically compared.

The course is taught to 50 to 90 students each semester. One of the primary considerations for converting this course to an Internet based course was to provide prospective students in feeder institutions with a means of taking this course before they transfer to the main CSU campus.

In a paper presented at ASEE 2001 (Duff and Shunk), we discussed preparatory work leading up to instituting the course on the Internet, the process of actually putting the course on the Internet and experiences with the course during the two traditionally taught semesters and the subsequent Internet taught semester. Just one instructor has taught the course for all of the subject semesters. Much of the structure of the course as it was to be taught in the Internet version was incorporated into those two semesters of the traditionally taught course. The essential characteristics of learning elements such as quizzes, homework, exams and group projects, were then carried over into the Internet version. As a result, a number of specific comparisons could be credibly made between the traditionally taught course and the Internet taught course.

Some features incorporated into the Internet course are 1) that both quizzes and homework are now automatically graded so that immediate feedback is provided to the student, 2) some course material has been animated and student group projects are presented to the rest of the class on the Internet.

Analyses and statistics of student performance in quizzes, homework, presentations for these three semesters showed that the students had learned the course material as well as or better than when it was

traditionally taught. In spite of a demonstrated enhancement in the learning in the course, the student perception was the opposite. The primary criticism was the lack of direct interaction between the student and the instructor. This kind of adverse student reaction toward structuring the course too much toward Internet content was also evident in other ASEE 2001 Internet course content papers. As a result, the course has been further modified in the recent semesters to re-establish more traditional instructor-student classroom activities. Teaching assistant led computer laboratories and help sessions have been added. In the current semester live lecture and group participation activities have been reintroduced.

This paper builds on the previous paper by presenting additional statistical comparisons from the current more balanced approach course and by discussing some of the changed approaches to teaching the course.

## II. Group Presentations

The class was divided into groups of four to five students and each group was assigned two engineering application projects to be presented to the rest of the class. One application was presented mid-semester and the other toward the end of the semester. Each problem involved the use of the numerical techniques taught in the course. Since this was a sophomore level course, the groups received generous assistance from the instructor and teaching assistant.

In the traditionally taught semesters the groups presented live to the class. In the Internet taught semesters the groups uploaded PowerPoint, Word, HTML or MathCad presentations to WebCT so they could be viewed by the class. Students were asked to review the presentations and a portion of their examinations were devoted to assessing the presentations.

In recent semesters students view previous semester presentations, just one engineering application project is assigned to each group and a more emphasis is placed on careful project preparation and presentation.

## IV. Homework

The actual homework problems for the Internet taught course are practically identical to those given when the course was traditionally taught. However, the delivery is different. The weekly homework assignment is released after the close of the quiz. Ten or twenty variants of each problem have been generated and the homework is automatically graded, providing immediate feedback to the students. The emphasis for the Internet based course is shifted to obtaining the correct numerical answer. To

compensate and allow students to take advantage of the grading feedback, students are given three tries on the homework, with the highest score counting. Each try could take up to three hours and a five-day window was provided.

## V. Exams

The structure of the semester exams in the traditionally taught and the Internet taught semesters is essentially equivalent. Semester's exams have roughly thirty points worth of questions on the group projects, ten points worth of short answer questions and sixty points for utilizing the learned numerical techniques. The exams were also in-class and closed book. The grading philosophy and approach was also kept systematically consistent. This was all done deliberately to provide a controlled means of evaluating the Internet course relative to the traditionally taught course.

## III. Quizzes

When the course was traditionally taught, quizzes were used to help insure that the students were prepared before coming to lecture. A five to ten minute short answer, multiple choice, true-false and/or matching quiz on the assigned reading material was given at the beginning of each lecture period. The questions tested if the students had initially read through the material and if they had developed a broad understanding, as opposed to the in-depth understanding they would need for their projects and for the homework.

Quizzes for the Internet based course serve the same purpose. However, quizzes do not use class time, they are designed to test for a more thorough and in-depth understanding of the material and they provided feedback to the students to let them know if they have, in fact, comprehended and mastered the material.

Material that would have been presented in the traditionally taught course as lectures has been formatted into Internet presentations. These presentations are released to the students at the beginning of the week. Shortly afterwards, a short answer, multiple choice, true-false and/or matching quiz based on the Internet presentations and the text reading material is released. The quiz has a ten to twenty-minute time limit and a student can take the quiz up to three times during a six-hour window. The student receives the highest grade of the three tries. The question databases were sufficiently large and varied that the student would get a somewhat different quiz each time it was taken.

Though quizzes in the traditionally taught semesters are not as directly comparable to those in the Internet taught semesters as are the exams or homework, the increase in depth of learning tested is offset by allowing the students multiple attempts at the quizzes.

## VI. Changes: Spring 2001 to the Present

In order to address the student concern for more direct classroom interaction with the instructor, formal weekly hour long help sessions were instituted for the spring 2001 semester. Also, rather than having a midterm and final exam, only a final exam was given. The students had to pass the exam to pass the course.

As discussed below, results for the 2001 spring semester showed that learning remained statistically significantly better than for the traditionally taught version of the course and statistically equivalent to the previous semester. However, student course evaluations showed that their perceptions about the course had become decidedly more negative. The help sessions did not seem to accomplish much as they were poorly attended. A plausible reason for the more negative student evaluations was that the sophomore level students were put in an uncomfortable position at the end of the semester by the single exam that they had to pass to pass the course.

For the fall 2001 semester two midterm exams in addition to the final exam were instituted and a formal lecture hour was provided before the quiz was made available on the Internet. Because of the addition of the lecture hour, the number of times that the students could take the quiz was reduced from three to two. Also, the combined value of the quizzes plus homework was reduced from 30 percent of the course grade to 15 percent.

As discussed below, a statistically significant decline in student performance on the quizzes, homework and exams occurred. A plausible reason for this is that the reduced course grade value of the quizzes and homework caused students to put less effort into them and therefore they were less prepared for the exams than they had been in previous semesters. Indeed, the data show that, in contrast to previous semesters, many quizzes and homework assignment were simply not submitted.

In the current semester, live lecture and group participation activities have been reintroduced. A conscious effort has been made to address topics in these sessions that were not adequately learned in previous semesters and provide substance to the course that is not effectively delivered by the Internet based materials. The combined value of the quizzes plus homework was increased from 15 percent of the course grade to 20 percent. Submissions on quizzes and homework are back up to earlier levels.

## VII. Comparisons

Table 1 provides tests of hypothesis results for the Internet versus the traditionally taught course. For the quizzes and homework, where the means for the Internet semesters were greater than the traditionally taught semesters, the tests were  $H_0: \mu_I = \mu_T$  versus  $H_a: \mu_I > \mu_T$ . For the exams, where the means for

the Internet semesters were less than the traditionally taught semesters, the tests were  $H_0: \mu_I = \mu_T$  versus  $H_a: \mu_I < \mu_T$ . All tests were conducted at a confidence level of  $\alpha = 95$  percent.

Table 1. Tests of Hypotheses for the Internet versus Traditionally Taught Course

	Traditional		Internet			
	F 99	Sp 00	F 00	Statistically Significant?	Sp 01	Statistically Significant?
Quizzes	75.4	77.9	90.9	Yes	89.4	Yes
Homework	79.1	80.5	82.8	Yes	85.1	Yes
Exams	74.7	75.5	72.6	No	73.1	No

The results indicate that learning has been enhanced by switching from the traditionally taught course to the Internet based course.

Table 2 provides tests of hypothesis results between the fall 2000 and spring 2001 Internet taught courses and the fall 2001 Internet taught course. Here the means for the quizzes, homework and exams were less for the fall 2001 semester. Therefore, the tests were  $H_0: \mu_I = \mu_T$  versus  $H_a: \mu_I < \mu_T$  for all three. All tests were conducted for a confidence level of  $\alpha = 95$  percent.

Table 2. Tests of Hypotheses for the 2000 and 2001 Semesters

	F 00	Sp 01	F 01	Statistically Significant?
Quizzes	90.9	98.4	78.3	Yes
Homework	82.8	85.1	71.8	Yes
Exams	72.6	73.1	68.5	No

The results are inconclusive insofar as indicating that learning declined in the 2001 semester. Whereas the quizzes and homework mean scores are statistically significantly lower, the exam scores are not. Quizzes and homework means declined due to an assignable cause: substantially fewer submissions were made by students. At a 95 percent confidence level, lower student performance on the exams could have occurred by chance.

## VIII. Summary

A paced completely Internet taught sophomore level numerical methods course for engineers was instituted in the fall 2000 semester. Prior to this, in the fall 1999 and spring 2000 semesters, the course was taught in a completely traditional manner. The transition to an Internet course was made in a controlled manner so that certain aspects of the course were preserved and these could be statistically compared.

A statistical analysis of the fall 1999 through spring 2001 semesters indicate that learning has been enhanced by switching from the traditionally taught course to the Internet based course.

Lower quiz and homework scores in the fall 2001 semester suggested that learning may have declined in the Internet taught course. However, an assignable cause was identified: Reducing the worth of quizzes and homework from 30 to 15 percent of the course grade apparently caused a substantial increase in quizzes and homework that were not submitted, which consequently lowered the averages for the class. In the current semester the worth of quizzes and homework has been increased to 20 percent of the course grade. Quiz and homework non-submissions have decreased substantially.

Student perception of their learning experience with a heavy Internet emphasis has not been consistent with the statistical evidence of learning enhancement. In response to this, live lecture and group participation activities have been reintroduced and a conscious effort has been made to address topics that were not adequately learned in previous semesters and to provide substance to the course that is not effectively delivered by the Internet based materials.

## Bibliography

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Dr. William S. Duff is a Professor in the Department of Mechanical Engineering at Colorado State University in Fort Collins Colorado where he heads the Industrial Engineering and Operations Research Graduate Program.. He received his PhD in Industrial Engineering from Stanford University in 1971, his MS in Statistics from Stanford University in 1970, an MBA with Honors from the University of Pennsylvania Wharton School of Finance and Commerce in 1965, and a Bachelor of Mechanical Engineering from Cornell University in 1961. He was a Visiting Scholar at University of Chicago Department of Physics and Enrico Fermi Institute from 1991 to 1998 and a Visiting

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Dr. Duff teaches statistical process control, design of experiments, manufacturing simulation, capital budgeting, solar and renewable energies and mathematical optimization to Seniors, graduate students, and people from industry. He has been major professor to more than 20 Ph.D. students and over 100 M.S. students. He has published over a hundred papers in journals and conference proceedings. In 1991, The International Society for Optical Engineering selected Dr. Duff's paper "Focal Plane Flux Distribution Produced by Solar Concentrating Collectors," for a special collection as one of the decade's best papers in optics. His students have won the award for best paper at the Western Region Industrial Engineering Student Conference three different years.

Dr. Duff has been the principal investigator for over 20 funded projects including solar water pasteurization systems, photovoltaic cell development and the utilization of biomass from crop residues. He has been a leader in residential solar heating, cooling and DHW system development and evaluation over the past three decades. He managed an eight year 12 country international program on the applications of advanced solar collectors with funding levels totaling over \$15,000,000. He has been a consultant to numerous companies, universities, research institutes and a law firm. He has served on several companies' and professional societies' Board of Directors and was chairman for two of them. He is the co-inventor of the improved ICPC solar collector that was recently demonstrated in a double-effect absorption air-conditioning system on an office building in California.