TEACHING & TECHNOLOGY INNOVATIONS IMPROVE LEARNING IN PROBLEMS & TEAM-BASED COURSE

David W. Gore
Middle Tennessee State University

INTRODUCTION

The undergraduate and graduate course in Engineering Economy was re-designed in the fall semester 2001 based on the Georgia Institute of Technology nationally-ranked course by Lohmann (2001). Due to high student dropout rates and poor student performance, this course was changed to a problems-based course in summer 2005 based on the model described at the Middle Tennessee State University (MTSU) Information Technology Division (ITD) Faculty Institute by Notre Dame University (2004). Further course enhancements using technology-based learning exercises were included in the course in summer 2006 as the result of a roundtable discussion at MTSU hosted by the Learning, Teaching & Innovative Technologies Center (LT&ITC) and presented by Montemayor (2006). To solidify the course for all learning styles a more traditional classroom overview was suggested at this roundtable by Hayes (2006) and was also added to this course in the summer 2006.

BACKGROUND

Course Description

The traditional course in Engineering Economy consists of methods of economic analysis in engineering, including time value of money, equivalence, economic measures of worth, selection rules for alternatives, corporate income taxes & equipment depreciation, inflation and uncertainty. (The textbook currently used is, *Contemporary Engineering Economics, 3rd edition,* by Park). Objectives are set based on what students will use in actual business and industrial applications as well as personal finances in order for them to make sound economic decisions. For example, students must be able to do simple calculations to determine payments on loans or investments knowing the affects of pre-paid interest, annual percentage rate, compounding period, and time as well as more complex calculations involving comparison of engineering project alternatives using after-tax cash flows in calculation of internal rate-of-return, benefit-cost-ratio and payback period.

Teaching Methods

This course began in spring 2001 as a calculator and table-based lecture course with manual table entries for cash flow analyses. After being taught in this manner for several semesters it became apparent that the course material was very difficult for students to learn. The use of PC spreadsheets was introduced which aided students by providing

financial functions in Microsoft Excel® and made the course more compatible with the tools students would be using after graduation.

However, student learning of basic economic principles and problem-solving was not substantially improved using spreadsheets and traditional homework problems. Students followed lecture materials very easily but could not effectively solve homework assignments on their own. Class lecture time for new topics became encumbered with previous session homework problems where the instructor hurriedly showed the students the problem solutions. In an effort to improve this situation, student teams were organized for after-class meetings to work on homework problems. Only a few teams were successful in meeting together. Even then, a student who grasped the concepts more easily led a team but feedback was that each one ended up working the problems while other students simply copied results without participating in the problem-solving process. Significant change in course design was needed.

COURSE ENHANCEMENTS

Problem-Based Learning

Notre Dame University physics professors presented the advantages of problem-based learning at an MTSU Faculty Institute on October 7th, 2004. Problem-based learning is a student-centered active learning technique that develops critical-thinking and problem-solving skills by requiring "homework" assignments be done in the classroom with instructor facilitation of team problem solving. It is used by teachers of all disciplines, but works exceptionally well in the sciences (Montemayor, 2006) and engineering.

As a result, in the summer semester of 2005, the classroom lectures were made available on-line using Impatica® software to efficiently combine the voice with the PowerPoint® presentation slides (see "Appendix"). For each class preparation students have been required to review the "lecture" and do simple problems embedded in the on-line presentation. Students bring these problem solutions into class to demonstrate their readiness to participate in more complex problem solving with their team members. (To provide added motivation, students earn "points" by completing these problems outside of class and providing them to the instructor prior to start of class). At this point, learning appeared to improve for more students but not for everyone.

Over the next two semesters two "new" concerns were obvious:
1. The dominant student still controlled the pace of the team in the classroom, hindering the learning process of those requiring a slower pace.
2. A few students could not seem to learn "the basics" from the on-line lectures – primarily because they were not verbal learners and had trouble disciplining themselves to complete the self-paced lecture.

Again, more course enhancements would be necessary to address both types of students.

Interactive Class Exercises

In a roundtable discussion hosted by MTSU's Learning, Teaching & Innovative Technologies Center (LT&ITC) on April 11th, 2006, it was learned that an MTSU physics professor (Montemayor, 2006) gives an interactive short-answer quiz consisting of five multiple-choice questions (not problems), and then student group work begins with teams of three to four students working on interactive Excel spreadsheets that lead them through a series of nontrivial problem-solving exercises that apply concepts and definitions from the online lectures. By use of this technique, the dominant student is no longer dominant when his/her answer comes back incorrect several times. The quiet, or less confident, members of the group will then feel that maybe their approach is correct and will finally speak up and offer suggestions that lead to the problem solution. This type of feedback encourages these students and also helps the dominant student to become a team player.

In order to apply this technique to the Engineering Economy course by summer 2006, Captivate® software provided a quick and easy capability to design interactive spreadsheets and quizzes (see "Appendix"). (Six Excel interactive exercises and four interactive quizzes were completed with more planned for future classes). Experience during that semester addressed the dominant-student issue and engaged the less-involved students using the quiz function of Captivate which was setup to "hide" the answers and to not reveal which questions were answered incorrectly. The team would work until all responses were correct. This iterative process brings out the quiet or less confident students.

Traditional "Overview"

To address the concern of the non-aural online learner, an LT&ITC Faculty Fellow (Hayes, 2006), suggested that a brief overview of the online material be done by the instructor prior to beginning the interactive classroom exercises and the problem-based team learning. This overview should involve a typical problem that is solved by the class as the instructor guides the exercise on the whiteboard using the Socratic method while letting class members make the typical mistakes and recover with correct approaches (since there is more than one way to work the problems). This approach was combined with the technique of "Interactive Class Exercises" mentioned previously and was also introduced in the summer semester 2006.

ASSESSING PERFORMANCE

Study Description

The course enhancements improved class participation by addressing the issues mentioned previously; however, there had been no formal assessment of learning improvements over the last thirteen (13) semesters. A study has been done using XmR (X and moving range) graphical analysis and ANOVA hypothesis testing to determine what, if any, improvements were significant over this period. The data used consisted of "low grades" (D's and F's) and student course "drops" (from spring semester 2001 to summer 2006). The data (see Table 1) were grouped into three (3) chronological four-semester groups to determine statistically if there were any differences in "treatments" between groups 1 & 2 (minor course improvement periods) and group 3 (the last 4 semesters in which major course enhancements were made as described previously).

Table 1
Percent Low Grades & Percent Drops

|		Group 1				Group 2				*Group 3			
Item	**Sp 01**	**F 01**	**Sp 02**	**F 02**	**Sp 03**	**F 03**	**Sp 04**	**F 04**	**Sp 05**	**SU 05**	**F 05**	**Sp 06**	**SU 06**
n	10	19	38	20	39	20	22	28	23	18	32	26	10
D's	0	0	1	3	2	0	1	4	2	2	4	3	0
F's	0	1	0	1	3	4	1	5	2	0	2	4	0
Drops	2	6	10	1	4	2	5	2	1	0	0	0	0
Sum D's/F's	0	1	1	4	5	4	2	9	4	2	6	7	0
% Low Grades	0	5	3	20	13	20	9	32	17	11	19	27	0
% Drops	20	32	26	5	10	10	23	7	4	0	0	0	0

*Note: Groups 1 & 2 are periods of minor course improvements.
Group 3 is the period of major course enhancements.

Graphical Analysis

The "Low Grades" actually appear to on the increase while the student "Drops" are observed to be decreasing. The graphs are shown in Figure 1 and Figure 2.
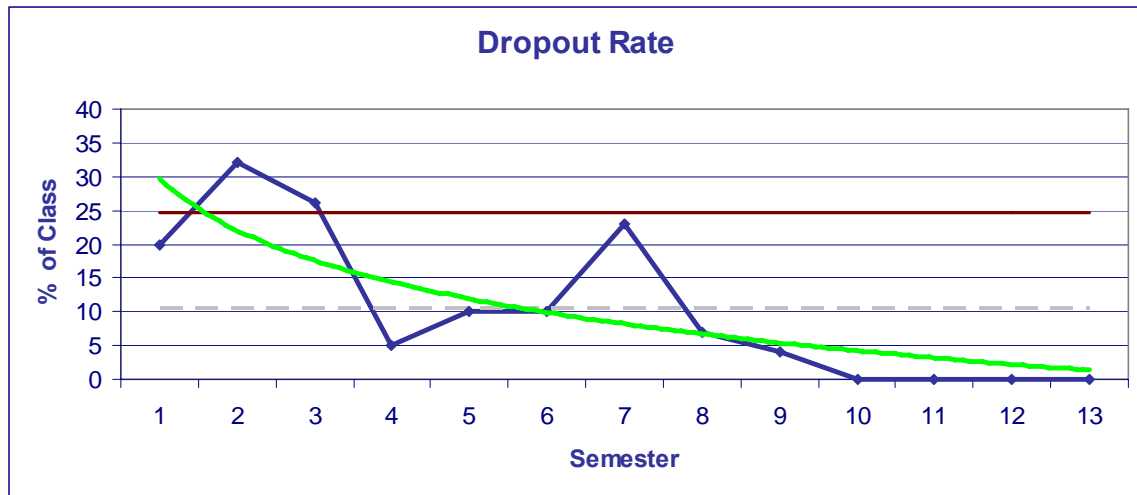
Figure 1
Percent Low Grades *X*mr Chart

Low Grades - D's or F's
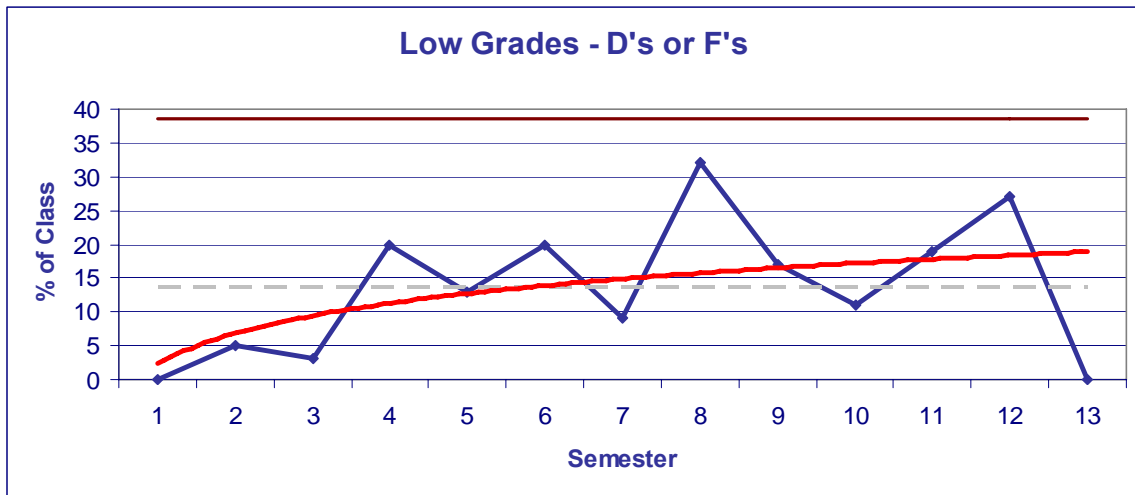
A logarithmic best-fit line shows an increase in low grades with a sharp decline in the last semester to "0" when the "interactive exercises" and "overview" were added.
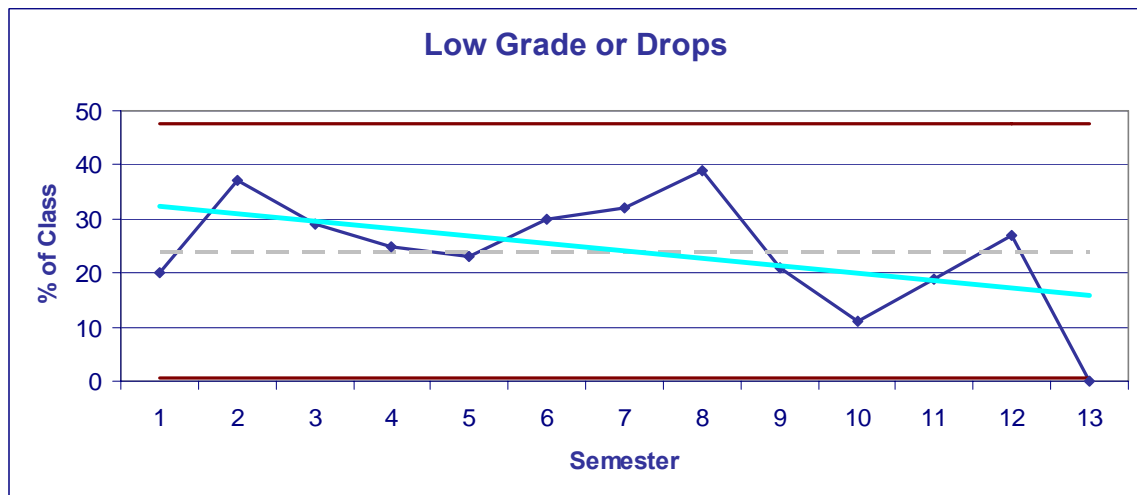
Figure 2

Percent Drops *X*mR Chart

Over the corresponding period, the dropout rate declined with the rate dropping to zero during the period of major course enhancements (the last four semesters 10 – 13). The combined chart of "Low Grades" and "Dropout Rate" is shown in Figure 3.
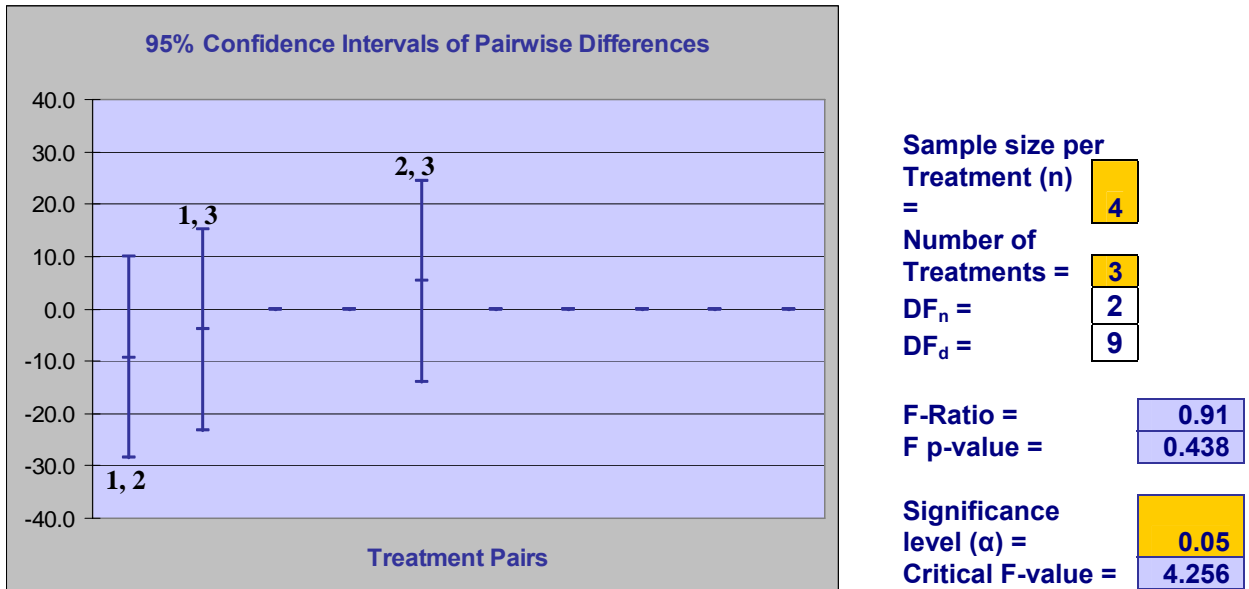
Figure 3 Percent Low Grades & Percent Drops *X*mR Chart

Even though the drop rate causes the trend towards improvement, it then became necessary to test the significance of changes in both low grades and dropouts using ANOVA analysis.
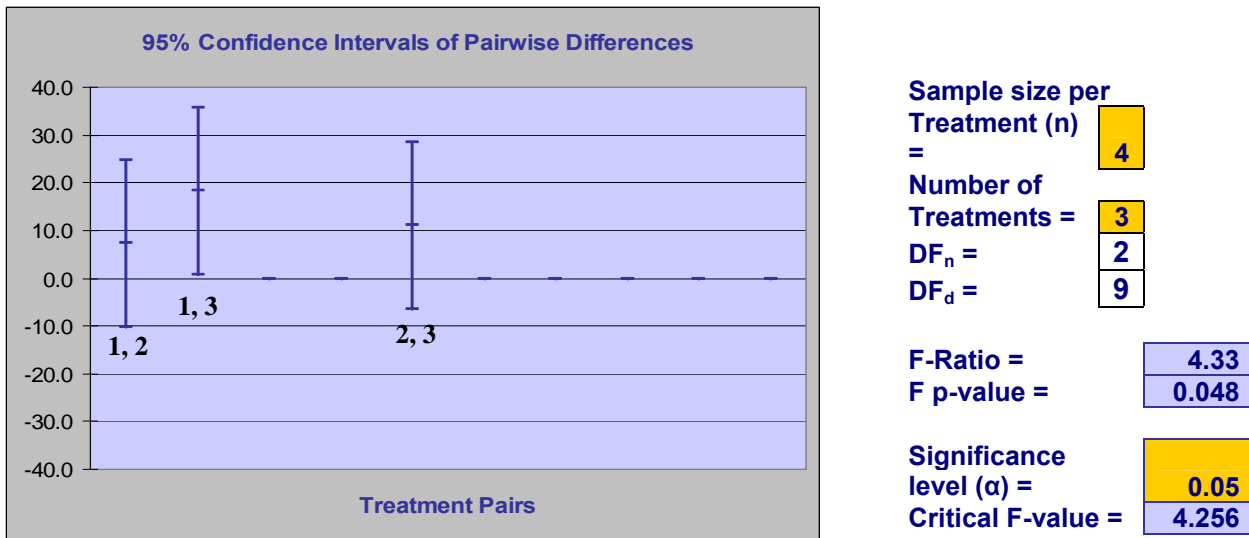
ANOVA Analyses

Figure 4 Percent Low Grades ANOVA Analysis

The graph shows each pair comparison passing through "0" (no difference in the means) and the F-Ratio of 0.91 compared to the critical F-value of 4.256 indicate **no significant differences in low grades** exist among the three groups of four semesters.

Figure 5 Percent Dropouts ANOVA Analysis

The F-Ratio of 4.33 compared to the critical F-value of 4.256 indicates there **is a significant difference** dropout rate among the three semester groups. It is notable that the dropout rate for the last four semesters (group 3) is "0."

CONCLUSIONS AND RECOMMENDATIONS

There has been no significant change in the rate of low grades (D's or F's) over the last twelve semesters; however, there has been a significant decrease in the student dropout rate during the last four semesters with the advent of student-team problems-based learning.

For the last semester of this study (summer 2006), there were no low grades in the class. This learning improvement may be due to the addition of interactive PC-based exercises to engage students at all learning levels and an instructor-led group problem-solving overview at the beginning of each class to supplement online learning. There is cautious optimism that the rate of poor grades will continue to be significantly lower as a result of these course enhancements.

The use of the problems-based team learning and classroom interactive PC-based exercises as well as interactive instructor-led problem solving is highly recommended for those courses where problem solving is critical.

Other non-problem's based courses should likewise benefit from interactive learning. The use of PC-based software, such as Captivate®, is recommended since it is "user friendly" and customizable for any discipline. (See "Appendix" for further information about the software).

REFERENCES

Hayes, Janice (2006), Faculty Fellow, Middle Tennessee State University Learning, Teaching & Innovative Technologies Center.

Lohmann, Jack (2001), Professor, Engineering Economy, Georgia Institute of Technology.

Montemayor, Victor (2006), Physics Professor, Middle Tennessee State University, Roundtable Discussion at Learning, Teaching & Innovative Technologies Center, April 11, 2006.

Notre Dame University (2004), Faculty Teaching and Learning Institute at Middle Tennessee State University, October 7, 2004.

APPENDIX

What is Impatica for PowerPoint?

Impatica for PowerPoint is a software tool that allows Microsoft PowerPoint presentations to be played over the Internet or corporate intranets without plug-ins, at modem speeds as low as 28.8 kbps.

More specifically, Impatica for PowerPoint is a standalone program, which runs on Windows 98/NT/2000/Me/XP and on Mac OS X*. Impatica for PowerPoint reads and interprets the PowerPoint file and produces a compressed file that can be streamed over the Internet, preserving the various multimedia elements, such as: text, graphic, audio, video, animation and interactivity. The new "impaticized" file can then be read by Impatica's Java player applet ("ImPlayer") and played in real time while the file is streaming over the Internet. Once you have created the impaticized version of your presentation, it can be played from any HTML web page or from within an e-mail message. No special server side software is required.

You may optionally choose to impaticize your presentation for delivery to BlackBerry handhelds. Once it has been converted to the BlackBerry file format, your presentation can be loaded directly onto a BlackBerry via USB or Bluetooth. It can also be uploaded to a web server so that the presentation can be loaded over-the-air from a link in a WML page or e-mail message.

Middle Tennessee State University has a site license that is available to all faculty members. It is very user friendly and very easy to learn how to use.

For detailed information go to the URL: http://www.impatica.com/

What is Captivate?

Adobe or Macromedia Captivate ® software can be used to develop quizzes or PC demonstrations.

For demonstrations, Captivate simply "records" your PC screen activity and then lets you add your comments and explanations in text and/or voice for instructions on how to use Excel or any other PC software. It then provides the web-compatible files for use on your web-based courses. This package is very easy to learn and use.

Quizzes are setup like "slides" that are controlled by you as the author. It is easy to learn and provides excellent web-based files for publishing to your website.

For detailed information go to the URL: http://www.adobe.com/products/captivate/