AC 2007-540: TEACHING ENGINEERING ECONOMY AS A HYBRID ONLINE COURSE: TOOLS, METHODS, ASSESSMENT, AND CONTINUOUS IMPROVEMENT

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Teaching Engineering Economy as a Hybrid On-Line Course: Tools, Methods, Assessment, and Continuous Improvement

Abstract

A traditional engineering economy course was converted to a hybrid (partially) on-line course in 2003. Sixty percent of the course is now on-line. WebCT is used as a course management system and content is delivered asynchronously using streamed, narrated PowerPoint presentations. Forty percent of the course is face-to-face in a classroom with computer workstations and projection system for instructor demonstrations, class presentations, and in-class WebCT quizzes. Active learning strategies were used in the redesign of the course to integrate constructivist approaches for on-line learning environments. Instructional and outcomes assessment data, as well as demographic and tools usage survey data (including the results of a learning styles survey) was collected for each class. This paper will: (1) Compare the before and after instructional assessment and outcomes assessment data for the course; and (2) Analyze the patterns of learning tool usage based on demographic variables. Innovative uses of instructional technology discovered along the way will also be presented.

The paper is organized into the following parts:

1. Introduction
2. On-line teaching options, strategies, and considerations
3. Teaching strategies and learning activities for Engineering Economy
4. Analysis of Instructional and Outcomes Assessment Data
5. Analysis of Learning Tools Usage Data
6. Summary

A major objective of this paper was to show other instructors that engineering economy can be successfully taught as a hybrid course. Along with that was the desire to provide useful detail that would aid in course development.

Part 1 - Introduction

The author has been using web-related technologies to assist with teaching since 1997. From 1997 through Spring 2002 the primary on-line technologies used were internet search engines, course web pages, and email. In Fall 2002 and Winter 2003, WebCT was also incorporated at varying levels of usage for teaching engineering economy (EGR 403 Asset Allocation in Technical Decision Making). For the 2002-2003 academic year the author was involved with a campus research program call the "Collaborative On-line Learning and Teaching" (COLT) Program. Twelve faculty members who submitted acceptable proposals were part of a campus research project to work collaboratively and explore how on-line teaching and learning could be used and whether there could be measurable benefit to the campus community. Results were documented and presented to the campus community and to ASEE in 2003. Since 2003 the course has been taught several times each year with efforts to incorporate student recommendations and improve course management and student outcomes. Also of interest was the degree to which various learning tools are used and their relative use based on learning

styles. The ultimate goal was continuous improvement with plans to share findings of interest to the engineering economy and hybrid on-line class communities. Another desire was to be able to recommend learning tool strategies based on actual student experience.

An initial study was conducted using data collected Spring 2002, Fall 2002, and Winter 2003. Spring 2002 was taught using the traditional face-to-face format. Fall 2002 was a transition quarter, and Winter 2003 was taught in a hybrid on-line format. Throughout the paper this is referred to as the 2003 study period[8]. Subsequently, data was collected for nine additional quarters during the *continuous improvement* period. The same survey was used for all periods when surveys were given.

The data collected for this paper comes from four sources:

Instructional Assessment Survey – Consists of ten traditionally-used course management questions rated features as: 5 = Very Good, 4 = Good, 3 = Satisfactory, 2 = Poor, 1 = Very Poor

Program Outcomes Assessment Survey – Consists of seven questions related to the department version of selected ABET a-k outcomes. Questions measured student assessment of improvement in skills, knowledge or ability rated: 5 = Very Good, 4 = Good, 3 = Satisfactory, 2 = Poor, 1 = Very Poor

Course Tools Assessment Survey – Student rating of perceived value of twenty different learning tools provided as part of the hybrid course. Responses rated value as: 5 = Very High, 4 = High, 3 = Medium, 2 = Low, 1 = Very Low. Five demographic questions relating to learning style questionnaire results and GPA. One open-ended question solicits suggestions for improving tools.

Quiz Scores – Average scores for the first 5 quizzes were compared for the quarter before and after the hybrid course began (Fall 2002 and Winter 2003). The same WebCT quizzes were used for both quarters.

Data was collected and used as shown in the following table:

Table 1 – Data Collection and Study Period Information

	2003 Study	2007 Study	Instructional Assessment Data Included	Course Assessment Data Included	Tools Assessment Survey Data Included	Quiz Scores	Level of Web Usage*	n**
Spr 02	X		X	X			2	65
Fall 02	X		X	X		X	3	54
Win 03	X		X	X		X	8	27
Fall 03		X	X	X			8	57
Win 04		X	X	X			8	25
Spr 04		X	X	X	X		8	36
Su 04		X	X	X	X		8	42
Fall 04		X	X	X	X		8	32
Win 05		X	X	X		X	8	32
Su05		X	X	X	X	X	8	36
Fall 05		X	X	X	X		8	27
Fall 06		X			X		8	21

* See Part 2 and Table 2 for explanation of Level of Web Usage
** Number of students in class who took instructional assessment survey. Sample size varies from question to question due to N/A and omitted responses

The motivation behind this study is several-fold. The obvious motivation is an attempt for rigorous outcomes assessment tied to an interest in technology. In addition, however, is a desire to conduct a study comparing the effectiveness of on-line teaching to a traditional face-to-face course. Over the years colleagues have made comments that face-to-face teaching is superior to all other teaching formats. In many cases it was a foregone conclusion that on-line teaching was inferior. These conclusions were not based on any recent evidence or an understanding of new synchronous and asynchronous tools available. This paper is an attempt to provide credible evidence that on-line technologies can produce learning outcomes that are at least equivalent to face-to-face classes.

Part 2 - On-line Teaching Options, Strategies, and Considerations

There are many books and articles that talk about on-line teaching and learning in higher education. To provide context for the rest of the paper, it is helpful to reference a very excellent article that presents the usage of web technology as a ten-level continuum [1]. Note: An email response from one of the developers of the ten-level continuum indicated that there is really a 12 level continuum. The Twelve Level Continuum is reflected in Table 2.

Table 2 - Twelve Level Web Integration Continuum

Levels 1 - 5: Informational use of the web		
Level	Web usage	Remarks and/or examples
1	Marketing/Syllabi via the Web	Instructors use the Web to promote Course and teaching ideas via electronic flier and syllabi.
2	Student Exploration of Web Resources	Students use the Web to explore pre-existing resources, both inside and outside of class.
3	Student Generated Resources Published on the Web	Students use the Web to generate resources and exemplary products of the class. (e.g., students can post reviews or papers. PowerPoint presentations can be uploaded to the Web.)
4	Course Resources on the Web	PowerPoint presentations, study guides, lecture notes, homework solutions, prior work, and other materials can be made available via the Web.
5	Re-purpose Web Resources	The best student and other work from previous classes is adjusted and used as a resource for future classes. A very powerful concept.
Levels 6 -10: Required Web Activity		
6	Substantive and Graded Web Activities	Students participate with classmates in Web-based activities such as weekly article reactions or debates as a graded part of their course requirements
7	Course Activities Extended Beyond Class	Students are required to work or communicate with peers, practitioners, teachers, and/or experts outside of their course, typically via computer conferencing.
8	Web as an Alternative Delivery System	Local students with scheduling or other conflicts use the Web as a primary means of course participation, with the possibility of a few live course meetings. (Courses that include live or face-to-face sessions are called *hybrid* courses).
9	Entire Course on the Web for Students Located Anywhere	Students from any location around the world may participate in a course offered entirely on the Web.
Levels 11-12: Course is Part of a Larger Program		
10	Course Fits Within Larger Programmatic Web Initiative	Instructors embed Web-based course development within larger on-line program.
11	Course is part of a Fully-On-line University	Instructors and administrators embed Web-based course development within larger initiatives of their institution.
12	Course is Part of a Consortia of Universities	Instructors and administrators embed Web-based course development within larger programmatic initiatives of their consortium. Course materials are shared with other institutions within the consortium.

Levels 1-5 of the continuum refer to usage that supplements or streamlines traditional teaching and learning activities. These levels do not substantially change the pedagogy of the course or teaching style of the instructor. They are attempts to implement technological improvements to the way material is distributed and how communications and research are conducted.

In levels 6-12 of the continuum, the learning strategies and activities are significant changes to the traditional pedagogy of higher education. At many universities they require major changes in the way educators view the educational process and assessment processes. The author has done substantial work at all levels of the continuum, including levels 11 and 12 mentioned (albeit at different institutions).

Level 6-7 activity most likely includes the use of threaded discussions to bring students into active participation with course materials. The literature strongly suggests that threaded discussions be used to engage students.[5] Participation is required. Students are asked to post discussion questions of their own and respond to discussion questions from the instructor and others in the class or on their team. As a learning community develops, students become engaged in the course material.

Levels 8-12 require that some or all of the course material be delivered electronically. This can be done over the web or with CD-ROM. The advantage of CD-ROM is that connectivity requirements are minimized.

Part 3 - Teaching Strategies and Learning Activities for EGR 403

The EGR 403 course was divided into four curriculum components for purposes of designing teaching strategies and learning activities:

1. Basic concepts (e.g., compound interest, cash flow diagrams, etc.)
2. Terminology (e.g., interest, compounding period, inflation, nominal interest, APR, etc.)
3. Analysis Methods (e.g., Present Worth Analysis, Annual Worth Analysis, etc.)
4. Applications (e.g, case study, project, problem solving, company visit, etc.)

After discussion of alternatives with a collaborative team, department colleagues, and experts from instructional technology, the following methodology was chosen for delivery of course content in the hybrid course format:

1. The first three components would be taught in a linear fashion using content modules (or vignettes) delivered electronically (asynchronous). Lecture materials were developed into sixteen PowerPoint presentations. This took some time as tables, graphs, and other illustrations had to be made as necessary. Adobe Photoshop, scanned images, EXCEL, and MS Paint were used to create the graphical images. PowerPoint slides were based on the PowerPoint slides provided with the text: Newnan, LaVelle, Eschenbach. Essentials of Engineering Economic Analysis.(2nd Edition) 2001. Engineering Press. Austin, TX These presentations can be viewed on-line at: (http://www.csupomona.edu/~rosenkrantz/egr403presentations.htm)
2. Narratives of the PowerPoint presentations were recorded in a sound studio on campus to make streaming audio files. Hyperlinks were put on the first slide of each presentation of the narratives. Clicking on the links connected the presentation to the streaming audio on the campus server providing sound for the presentation.

3. Students could go through the presentation the first time with the streaming audio narrative, and then only as desired during subsequent viewing. These options serve both auditory and visual learners well.
4. Students were asked to complete an on-line "Learning Styles" questionnaire and analyze their own learning style relative to the options they would have for learning the material. They were asked to submit their analysis as the first homework assignment (survey URL: http://www.engr.ncsu.edu/learningstyles/ilsweb.html)

After exploration and discussion with COLT Team colleagues during a summer on-line course, two on-line learning strategies and subsequent learning activities were planned for the course to deliver curriculum component 4.

Learning Strategy #1: Personalize and engage the student in the subject matter and communicate with them often [2].

Learning Activity #1: This activity is an individual project. To generate engagement students are asked to create their personal retirement plan to illustrate the course concepts, terminology and methods in a way that should interest them. The normal lecture approach was supplemented with a narrated four-part PowerPoint presentation on retirement planning that included information about retirement plans and investing options. A basic EXCEL template was provided as a starting point for each student to develop their own retirement plan and sensitivity analysis. In the end they had some idea about how much they will need to save over their working career in order to retire with the lifestyle they desire [3]. Students upload to WebCT their EXCEL template and a brief paper about their findings and retirement plan.

Results of Learning Activity #1: Students learned how to apply course concepts and use an EXCEL spreadsheet to make financial calculations. They also learned how to perform sensitivity analysis using the spreadsheet. They learned how to summarize their results in the form of an executive summary. No negative comments were received during assessment about the use of the retirement plan as a learning activity. Many students responded in the optional comment section of the survey that they really liked the activity and found it valuable on a personal level. Several students said they would have liked more in-depth instruction regarding the use of EXCEL spreadsheets. Comments from students also indicated they thought the project due date should be earlier in the quarter to separate it from the team project and other end-of-quarter obligations.

Learning Strategy #2: Collaborative learning and building a learning community. Collaborative learning is a proven strategy for engaging students in learning and keeping them accountable. It also embodies constructivist theory through experiential learning using real-world contexts [4].

Learning Activity #2: From an on-line survey assignment completed during the first week, each student identified an "area of practical application covered" that was important to them (e.g., lease vs. purchase a car). From those responses, students were grouped into small teams of 3-6 students each to complete a project related to their objective that requires the knowledge learned from the first three components of the class. Activities of the team included: [3,5]

1. Getting organized and assigning roles (personality and team role assessment). [6]

2. Creating a scenario for their project (e.g., purchase or lease a new Toyota Camry).

3. Gathering relevant data (costs, trade values, interest rates, resale values, gasoline mileage, maintenance costs, extended warranty, inflation rate, etc.)

4. Creating an analysis model using EXCEL (e.g., determine equivalent uniform annual cost)

5. Analyzing alternatives and performing sensitivity analysis

6. Searching the Web for sites that provide analysis tools for the situation being analyzed (e.g., LendingTree.com). [7]

7. Comparing the group's analysis to those of websites found. Creating a "webliography" that can be uploaded to a course web site that recommends sites for students to access and use after they graduate.

8. Creating and delivering a PowerPoint presentation for the class that summarizes their project scenario and results.

Team Dynamics: Each team member had a secondary role as an organizer (or "facilitator"), technician, or summarizer. These roles were intended to prevent the team from getting bogged down. Organizers keep people on schedule and follow-up to make sure the team stays on schedule. The summarizers communicate with the instructor on a regular basis and make sure that the results are understandable. The technicians are the experts with technology (e.g., PowerPoint, WebCT, HTML, etc.) being used and make sure that obstacles are overcome that may be slowing the team down. [6] A team web page was created with team pictures and role assignments. This was very useful to both students and the instructor for matching names with faces.

Results of Learning Activity 2 from the 2003 study period: Student teams performed well although about half of the teams had one or two members who were non-contributors. A team member assessment survey was given that identified those individuals. This process should be done at the beginning or middle of the project as well as at the end to prevent some team members from slacking and give the instructor time to intervene if appropriate. Another idea is to have each team do a very brief project after they first get organized to help assess strengths and weaknesses and who the non-participants might be. The project could be putting together a PowerPoint presentation introducing their team and their project proposal.

Testing: Testing consisted of six on-line quizzes in WebCT given in-class in the presence of the instructor. Quizzes generally consisted of 15 multiple choice/true-false questions. For most questions a bank of 2-5 questions was created from which WebCT would randomly choose one for the quiz. This produced unique quizzes for each student. Each quiz covered approximately two chapters of material from the book. Students were allowed to drop their lowest quiz.

Each quiz was preceded with a "practice" quiz option. The practice quizzes are important because the students need to get familiar with the quiz tool in WebCT and prepare for the types of calculations that will be thrown at them on the quiz. Prior to WebCT, the quizzes were almost always the same format as the homework problems. For on-line courses this similarity is usually not the case.

Practice quizzes consisted of 5 or 6 multiple choice/true false questions taken from or equivalent to some of the quiz questions and were available for two days before the real quiz. Students could see comments to each question they missed on the practice quiz and could retake it up to three times.

Part 4: Analysis of Instructional and Outcomes Assessment Data

Spring 2002 was the base period as a face-to-face course. Fall 2002 was a transition quarter as a face-to-face class with a team project and Quizzes given using WebCT. Finally, Winter 2003 was the first hybrid course with content delivered on-line. The initial study period covered these three quarters. Data was gathered and continuous improvement ensued from Fall 2003 through Fall 2006. The initial study period showed that most instructional assessment measures dropped significantly. This was alarming, but not unusual when a course is converted to on-line technology. Student outcomes, however, did not experience statistically significant drops. Again, this is not unusual with proper use of on-line technology.

Subsequently, efforts were made to improve both student satisfaction with instruction as well as well as outcomes. Below are some of the enhancements that were made to try and improve the course along with assessment of the results of those changes.

Tables 3a and 3b below is a summary of the results of most of the instructional and outcomes assessment survey data. The table reports the survey average for each question. The Chi Square Test for Homogeneity was conducted using the categorical survey data for each question compared to Spring 2002 (Ho: Results are homogeneous). See the table footnotes to clarify table notation related to the Chi-Square test results. The shaded columns represent the 2003 study period. The unshaded columns represent the continuous improvement period. For example, question 1 shows a statistically significant drop in average score for Fall 02 and Winter 03. Subsequent quarters the responses were not significantly different at the $\alpha = 0.05$ and $\alpha = 0.01$ levels.

Table 3a - Results of Program Assessment for Instructional Factors

	Instructional Assessment	S 02 n=65	F 02 n=54	W 03 n=27	F 03 n=57	W 04 n=25	S 04 n=36	Su 04 n=42	F 04 n=32	W 05 n=32	Su 05 n=36	F 05 n=27
1	How effectively does the instructor organize and structure the course?	4.67	4.31	4.42	4.65	4.44	4.53	**4.75**	4.63	**4.75**	**4.69**	4.56
2	How well does the instructor define and meet objectives of the course?	4.68	4.30	4.24	4.62	4.48	4.56	4.52	4.53	4.59	4.57	4.59
3	How well does the instructor arouse interest and transmit knowledge of the subject?	4.45	4.11	3.96	4.37	4.00	4.37	4.19	4.41	4.41	4.29	4.22
4	How well does the instructor demonstrate knowledge of the subject?	4.74	4.41	4.42	4.68	4.72	4.64	**4.84**	4.69	4.66	4.54	**4.78**
5	How well does the instructor answer student questions?	4.66	4.43	4.29	4.48	4.16	4.47	**4.71**	**4.81**	**4.69**	4.40	4.59
6	How effectively are the board and other visual aids used?	4.42	4.13	4.32	**4.51**	4.17	4.40	**4.61**	4.44	**4.56**	**4.42**	**4.56**
7	How available is the instructor to students for consultation?	4.37	4.32	**4.39**	**4.48**	4.26	4.31	4.15	**4.39**	**4.71**	4.00	**4.50**
8	How well was the course material paced?	4.46	4.17	3.84	**4.55**	4.28	4.22	4.33	4.25	4.34	4.22	4.26
9	How accurately does the instructor's grading reflect what the student has learned?	4.31	4.06	3.88	**4.45**	4.00	**4.33**	**4.29**	**4.35**	**4.39**	4.14	4.15
10	How would you rate this instructor compared to other instructors?	4.60	4.42	4.12	4.51	4.32	4.57	4.41	4.50	4.58	4.39	**4.70**

Note: underscore = Chi-Square test significant at 0.05 level, double underscore = Chi-Square test significant at 0.01 level. **Bold** = average is higher than base period (Fall02).

Table 3b - Results of Program Assessment for Outcomes

	Outcomes Assessment Skill, Knowledge, Ability or Attitude Area	S 02 n=65	F 02 n=54	W 03 n=27	F 03 n=57	W 04 n=25	S 04 n=36	Su 04 n=42	F 04 n=32	W 05 n=32	Su 05 n=36	F 05 n=27
11	How would you rate your ability to apply what you learned from this course?	4.25 n=60	4.19 n=52	3.92 n=25	**4.33**	4.24	4.00	**4.34**	4.19	**4.37**	**4.25**	4.15
12	How would you rate the improvement in your ability to identify and solve problems based on your experience in this course?	4.18 n=61	4.08 n=51	4.12 n=26	**4.20**	**4.32**	4.03	4.10	**4.28**	**4.30**	**4.26**	4.12
13	How would you assess the value of what you learned from this course when seeking a job?	4.10 n=61	4.10 n=49	3.92 n=24	**4.28**	3.83	3.94	**4.33**	4.06	**4.37**	**4.26**	**4.36**
14	How would you assess your improvement in engineering skills (e.g., CAD, programming, data analysis, CNC, use of software, use of scientific equipment, finding technical information, etc.)?	3.92 n=36	3.70 n=37	**3.92** n=13	3.87	3.80	3.76	**4.04**	**3.93**	**3.95**	3.78	3.74
15	How would you assess the coverage of issues related to professional behavior and ethics in this course?	4.09 n=47	3.87 n=38	4.07 n=15	**4.12**	3.80	**4.16**	**4.11**	4.06	**4.20**	**4.11**	3.95
16	How would you assess your improvement in communications skills (either written or oral) from your experience in this course?	3.85 n=40	**4.02** n=45	**4.00** n=20	**3.85**	3.76	**4.00**	**4.09**	**3.97**	**4.03**	**3.89**	**3.92**
17	How would you assess your improvement in teamwork skills from your experience in this course?	4.05 n=19	4.02 n=50	3.83 n=24	**4.10**	4.00	**4.11**	**4.21**	4.13	**4.23**	**4.09**	3.96

Note: underscore = Chi-Square test significant at 0.05 level, double underscore = Chi-Square test significant at 0.01 level. **Bold** = average is higher than base period (Fall02).

Quiz Score Comparisons – Since the same WebCT quizzes were used for before and after going hybrid, the average quiz scores were used as an objective measure of outcomes. Five mandatory quizzes administered during the quarter yielded the following results for the base study quarters and two randomly selected quarters from the continuous improvement period:

Table 4 – Quiz Score Average Comparisons

	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5
Fall 02	86.8	86.8	79.4	79.1	82.2
Winter 03	86.7	74.8	76.4	84.4	80.0
Winter 05	90.3	83.3	80.9	73.7	85.1
Summer 05	91.1	83.5	79.7	82.1	90.5

There were no significant differences between quiz averages from Fall 02 (shaded), although quiz #2 was somewhat lower in Winter 2003 than Fall 2002. In most cases, the average scores

were very similar or higher. Note that while the quizzes were the same for all quarters, students were allowed to take quizzes at home or on their own during Fall 2002. During Winter 2003 and after, all quizzes were proctored by the instructor.

Changes and improvements since first hybrid course offering:

1. Organization and Structure – Students expressed the desire for a regular schedule and structure. Consequently, a fixed weekly schedule of activities is now followed starting in the third week. In addition, the WebCT calendar is used and maintained. As a result, scores for questions 1, 2, and 8 seemed to improve.
2. The Project 1 (individual retirement plan) template has been enhanced numerous times to include retirement plan options, comment boxes to explain inputs, color coding to show input cells, geometric gradient of savings required, and additional user-provided parameters. Supplemental video clips to explain EXCEL and demonstrate sensitivity analysis have been provided.
3. Students must develop a retirement plans for scenarios for both with and without a company enhanced retirement plan
4. Project 2 (team project) Proposal Presentation - Added requirement for each team to create a PowerPoint presentation of their proposal and present to the class. This requirement forces students to get organized and produce something tangible highlighting team member contributions.
5. Added Team Member Mid-Project Evaluation – Students rate team members for their level of contribution to the team. Results are used to identify slackers and other potential problems so corrections can be made early.
6. Clarified grading and expectations by adding rubrics and detail to the project web pages.
7. Team size – Starting Summer 2004, team sizes were reduced from 5-6 to 3-4, with an occasional 5. Team sizes of 5-6 were too cumbersome for the type of students and their lifestyles.
8. Examples of previous projects have been made available to show students both good and bad samples of projects.
9. Final project spreadsheets and PowerPoint presentations are due two days prior to the class presentation so the instructor can preview and alert the team to major deficiencies. There is no penalty if deficiencies are corrected.
10. Practice quizzes were opened up for four days prior to the regular quiz, instead of only two days.
11. Supplemental video clips were created and uploaded to WebCT to explain key textbook examples and supplement textbook weaknesses.
12. Concerted effort was made to answer all email the same day received.
13. Added homework input quizzes where students could input their homework answer for instant feedback prior to the deadline. Homework can be corrected and resubmitted as many times as necessary up to the deadline. This allowed students to correct their own work.
14. Homework solutions were made available automatically the morning after homework was due to be uploaded to WebCT.
15. Homework templates were provided for each homework assignment. Templates provided a structure for submitting answers to assigned problems.

16. Handout copies of PowerPoint presentations were made available in the university copy-N-mail store. Students can purchase all 108 pages of handouts, (3 slides per page, 3-hole punched) for under $9.00.
17. Audio files and downloads were made available for download from WebCT. This was by student request, but downloading that many files was not convenient for most students.
18. Supplemental video clips were created using "Camtasia" screen capture software. Clips for explaining WebCT usage, textbook examples, homework solutions, Excel functions and data manipulation, and other course topics were created and made available as downloads from WebCT.
19. Approximately Fall 2004, PowerPoint presentations, audio files, and supplemental video clips were put on CD-ROM and made available for sale in the university bookstore for $10. Sales were minimal.
20. For Fall 2006, CD-ROMs were loaned to all class members for personal use and copying to their hard drive.

As a result, most instructional assessment scores improved to same level as the face-to-face base period scores. The exceptions were items 2 (How well does the instructor define and meet objectives of the course?), 3 (How well does the instructor arouse interest and transmit knowledge of the subject?), and 10 (How would you rate this instructor compared to other instructors?). It is challenging to compete with face-to-face interaction for some things such as transmitting enthusiasm and showing genuine concern for the objectives of the course. However, now that this weakness is apparent, work can begin on improvement. All that being said, during the continuous improvement period, 63% of students rated the instructor "Very High" for Question 10 and 90% of students rated "Very High" or "High".

Continuous improvement efforts seemed to have a positive effect in all seven outcomes areas. All outcomes seem to be hovering at the same levels as the base study period. While this may not seem like much, it does present evidence that hybrid courses can be comparable to face-to-face courses. It should also be considered that during the continuous improvement period 32% of all outcomes were rated very high with a combined total for "Very High" and "High" of 81%.

Quiz averages during the continuous improvement period were at generally the same or better than the base study quarter (Fall 2002).

Part 5: Analysis of Course Tools Usage Survey

A mid-course survey was given to find out which learning tools students were using and solicit feedback regarding the tools.

Survey questions 1-20 referred to the usefulness of specific tools with a rating scale of: 5 = Very High, 4 = High, 3 = Medium, 2 = Low, 1 = Very Low:

1 PowerPoint Presentations
2 Audio narration to accompany PowerPoint Presentations (streaming or CD ROM)
3 Textbook
4 Homework templates (EXCEL) provided

5 Homework solutions provided after homework submitted
6 WebCT alerts showing updates that are visible in left column when you log in
7 Assignments Web Page (intranet)
8 WebCT Email Messages to the class or individual students
9 Sample EXCEL calculations/solutions
10 Learning Style Assessment Survey and Analysis
11 Practice Quizzes available 2-4 days before regular quiz
12 Chapter Quizzes
13 Grade book screen with updates after each quiz/assignment is graded
14 Schedule Web Page (intranet)
15 Project Web Page (intranet) for instructions for Project #1 (retirement project)
16 Threaded discussion with other class members
17 Video Clip demonstrations of detailed procedures
18 Month-at-a-glance and other calendar pages in WebCT
19 Project Web Page (intranet) instructions for Project #2 (team project)
20 Team Project tools: work area, discussion board, and chat rooms on WebCT

Questions 21-26 Demographics and Comments
21 Active vs. Reflective score range from Learning Styles Survey
22 Sensing vs. Intuitive score range from Learning Styles Survey
23 Visual vs. Verbal score range from Learning Styles Survey
24 Sequential vs. Global score range from Learning Styles Survey
25 University GPA range
26 Comments

Survey Results – Over 200 completed surveys were analyzed. Average usefulness was computed and a Pareto chart was constructed. See Figure 1 below.

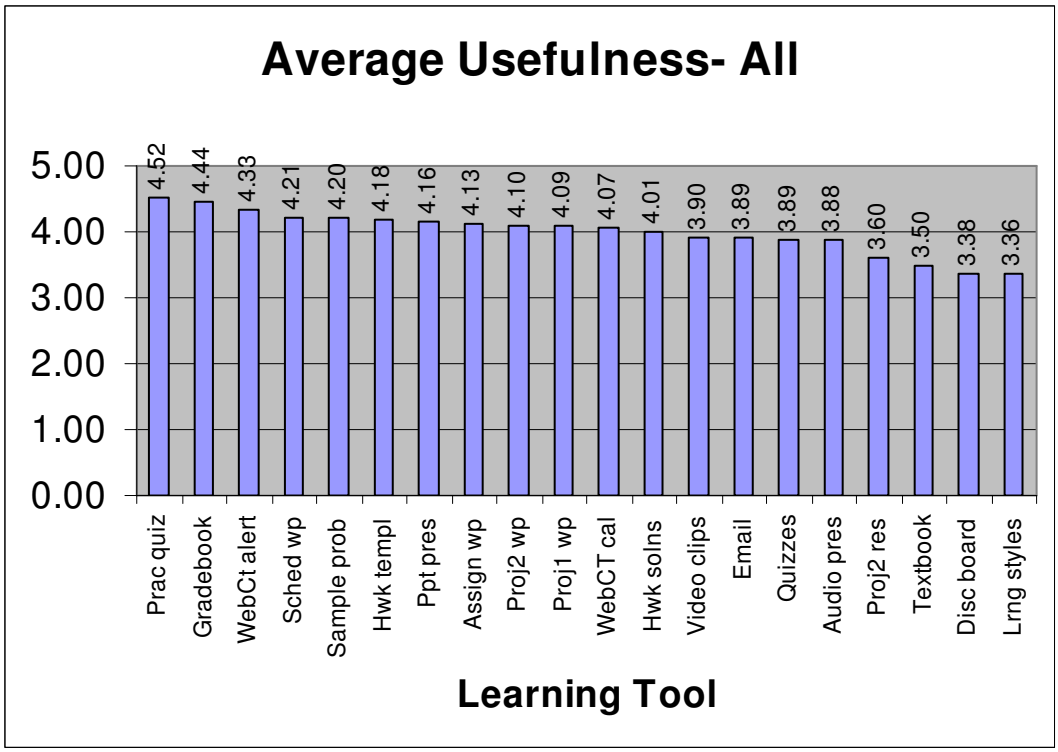

Figure 1 – Pareto chart of average scores from learning tools survey

Practice quizzes were the highest valued learning tool, followed by informational tools such as the on-line grade book screen, WebCT alerts, and Schedule webpage. Next in value was a group of four homework related study tools. It appears that students highly value practice they feel is effective and efficient, as well as solid current information about the course or their progress. These findings agree with the literature on on-line learning.

Project 2 resources, the textbook, discussion board, and the learning styles questionnaire were not considered as valuable as the other tools, but did still average in the medium value category.

Table 5 is an analysis of the learning tools data by GPA range. The purpose of this analysis was to see if there was useful information by comparing the learning tool values by varying levels of student academic success. In general, the higher GPA students valued information, instructions, and detailed information far more than other students. They appear to do a lot more reading about their assignments and course material.

Table 5 – Average Value of Learning Tools and Rank by GPA Range

Variables	Wt. Avg	3.6+ GPA	3.2-3.6 GPA	2.8-3.2 GPA	2.4-2.8 GPA	<2.4 GPA
Practice quiz	4.52	1	1	1	2	1
Grade book	4.44	2	3	2	1	6
WebCt alerts	4.33	9	2	3	3	5
Sched webpage	4.21	14	5	4	10	2
Sample problems	4.20	5	8	5	8	4
Hwk templates	4.18	10	12	6	4	7

Ppt presentations	4.16	8	13	7	6	3
Assign webpages	4.13	7	4	8	13	8
Proj2 webpage	4.10	4	7	12	7	13
Proj1 webpage	4.09	3	6	11	11	11
WebCT calendar	4.07	17	11	10	5	9
Hwk solutions	4.01	15	10	9	16	15
Video clips	3.90	16	15	13	9	16
Email	3.89	12	9	16	14	10
Quizzes	3.89	6	16	15	12	14
Audio pres	3.88	13	14	14	15	12
Proj2 resources	3.60	18	17	17	17	17
Textbook	3.50	11	18	18	19	20
Discussion board	3.38	20	19	20	18	18
Learning styles	3.36	19	20	19	20	19

The data in Table 5 lead to another analysis. A gap analysis was made to see where the largest differences were between students with GPAs > 3.6 and all other students. Table 6 shows, for example, that high GPA students value the textbook, quizzes, and detailed assignment related information much more than other students. Since a lot of reading is required in on-line classes to supplement the instructor not being around, these findings are not too surprising.

Table 6 – Difference in Value of Learning Tools between High GPA students and Others

Variables	3.6+ GPA	<3.6 GPA	difference
Textbook	4.16	3.44	0.72
Quizzes	4.42	3.89	0.52
Proj1 webpage	4.58	4.08	0.50
Proj2 webpage	4.53	4.10	0.42
Grade book	4.74	4.42	0.32
Practice quizzes	4.84	4.53	0.31
Assign webpage	4.37	4.16	0.21
Sample problems	4.42	4.21	0.21
Audio presentations	4.05	3.92	0.13
Ppt presentations	4.32	4.20	0.11
Email	4.06	3.98	0.08
Hwk solutions	4.00	4.01	-0.01
Hwk templates	4.16	4.21	-0.05
Video clips	3.84	3.95	-0.10
WebCt alert	4.26	4.38	-0.12
Learning styles	3.21	3.40	-0.19
Proj2 resources	3.47	3.71	-0.24
Sched webpage	4.00	4.27	-0.26
WebCT calendar	3.84	4.14	-0.30
Discussion board	3.16	3.48	-0.32

Learning styles data was analyzed, but initial results were not deemed helpful enough to include in the paper.

Part 6: Summary

On-line teaching and engineering economy - Engineering economy is the kind of course that can be successfully taught on-line if sufficient learning options are available and students become engaged in the course through projects of interest and team activities. Web resources abound and teaching materials are not hard to prepare if the instructor is willing to put in the time. It is the author's opinion that a hybrid course lends itself very nicely to teaching engineering economics with the recommendation that 25% to 50% of classes be face-to-face.

Analysis of instructional and outcomes assessment results - The literature talks about the role of the instructor changing from the "sage on the stage" to the "guide on the side". As the focus is taken away from the instructor and placed on the technology, the instructor's importance and comparative value is diminished in the eyes of the students. A comparison of the instructional assessment results (questions 1-10) between the traditional course (Spring 2002) and the hybrid WebCT course (Winter 2003) initially showed a decrease in 9 of the 10 questions. Questions 1, 2, 3, 4, 5, and 9 showed decreases significant at the 0.05 level. Questions 8 and 10 showed decreases significant at the 0.01 level. With continuous improvement instructional assessment scores returned to the traditional course levels.

The outcome assessment results (questions 11-17) between the traditional course (Spring 2002) and the hybrid WebCT course (Winter 2003) showed no significantly different results using the

Chi-Square test, although most average scores went slightly down. After continuous improvement, scores bounced back and were basically the same. Objective assessment of learning based on quiz scores showed no significant difference before and after switching to the hybrid class format.

Structure - As literature about on-line teaching warns[5], students need to have structure and clarity in order to stay on track and remain accountable. The analysis of the learning tools survey data seems to bear this out and the author's experience only confirms that. When some students are not forced to go to class several times a week, they forget about the course and/or procrastinate. These students need to be held accountable from the very beginning to deadlines and team commitments to make sure they do not get too far out of line with their coursework. Likewise, it is the instructor's responsibility to prepare materials for on-line use that are clear, easy-to-use, and sensitive to varying learning styles. Not only do students need to understand the course material, but they also need to understand the on-line technology environment they using. I should be noted somewhere, that the hybrid versions of the EGR 403 course were the only ones where students completed a team project in addition to an individual project. This was a benefit of the flexibility gained in the hybrid format.

This paper provides credible evidence that engineering economy can effectively be taught in a hybrid on-line format. Student comments gleaned from surveys indicated a high level of satisfaction with the course and the format followed.

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