

Engineering Economics on the Web

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Abstract

In Fall 1996, an NSF workshop on Engineering Economics and Design¹ was presented in conjunction with the Salt Lake City FIE Meeting. At that workshop, multimedia instructional material was used and given to the participants. In this paper, we present an outgrowth of that multimedia material - the development of a web site for engineering economics. The site is located at www.sie.arizona.edu/sie265. The site was first designed to supplement a one semester (45 hour) course and was then expanded to enable use as a stand-alone course. Materials included in the site include a set of lecture notes and alternate explanations, homework assignments and solutions, example exams and solutions, class organization, spreadsheet downloads for experimentation, learning tools for special topics, and links to sites with engineering economics data and topics.

During the first semester of use with an accompanying lecture, students extensively evaluated the site and textual materials and the navigation interface were changed to be more effective. The site was used as a stand alone course during the summer 1998 term (5 weeks) and results on student outcomes from a final exam given to three student groups - no web usage, lecture-web usage, and web only usage is included. Usage statistics for various portions of the site from both groups and estimates of time on the system are also included.

I. Introduction and Organization

SIE 265 – Engineering Economics – is a required sophomore level course in systems and industrial engineering. In the summer of 1996, development was started to use web based technology as a primary teaching method for this course. The initial ideas for this material came from two sources. First, the author had a significant experience in the use of Web based teaching while on sabbatical and working in the Systems Engineering Department at the United States Military Academy at West Point. Second, the author learned of the possibilities for using engineering economics as an experimental vehicle at the 1996 NSF Workshop on Integrating Economics in Design, presented before the Salt Lake City FIE Meeting (W. Sullivan et. al. Principal investigators).

In this paper, the course topics and why this material has high potential for a successful web implementation are discussed. Next, the design and evolution of the site are detailed. Three evaluations were developed and are discussed along with results. A final exam and a major case

study have been given three times; once to a “no web” section, once to a “partial web” section, and once to an “all web” section. Also, students completed a survey on site usage and impact on learning. The paper concludes with recent developments in the site and future directions.

II. Course Topics and Motivation for Web Based Instruction

This course prepares the student to consider the economic dimensions in the evaluation of engineering alternatives. Hence it is particularly useful in the analysis and decision stages of the engineering design process. Emphasis is on the analytical consideration of money and its impact on the areas of system operations and acquisition.

The course is taught in 4 related lesson blocks. Block 1, The Time Value of Money, provides students with the quantitative methods for economic analysis of engineering alternatives. Block 2, Analysis Methods, covers the methods and decision criteria used to make economic decisions. Block 3, After Tax Cash Flow, covers the effects of taxes, inflation, and depreciation into the decision process. Block 4, Special Topics, completes the course and covers topics such as project financing, capital budgeting, and probabilistic outcomes. By the end of the course, the student is prepared to analyze complex decision problems and has sufficient background to perform well on the engineering economics section of the Fundamentals of Engineering (FE) Exam. A set of outcomes were developed for the course and these are detailed on the Department’s ABET web site at <http://www.sie.arizona.edu/ABET>.

The text used is, *Contemporary Engineering Economics*, 2nd Edition, Addison Wesley by Chan S. Park². The course includes 2 mid semester exams (15% or grade each), 10 weekly assignments (20% total), 1 case study (25%), and one final exam (25%). Since there is significant group work on the case and the homework, to pass the course, a student must average at least 60% on the exams. This criteria has been used for one student during the experiment, however that student also had poor homework scores.

Many reasons justify the use of this material as a web based course. The students perceive the course material as highly relevant and relatively easy, hence they might be enthused to use the site and would not have excessive difficulty. This is not a desirable faculty assignment since the course material is considered mundane and there can be a large class size. Excellent text material is available and there are other web sites available.^{3, 4, 5} It is easy to develop interactive work in spreadsheets and this had been done successfully while the author was on sabbatical at USMA. Finally, there is a need for reference material in this area as a study aid for the FE exam.

III. Web Implementation

The current web site for the course was developed over a 2 year period. During the first year, the directory structure, key sections, and basic course material were design, compiled, and formatted for the web. During the final year, the navigation and human interface and the interactive spreadsheets were improved and implemented. The site now contains over 200 pages of material and can be accessed using the URL

<http://www.sie.arizona.edu/sie265>

The course material starts with a course homepage that has links to the major sections in the site:

- latest news and announcements
- syllabus and class topics
- learning tools
- downloads
- class email listing
- links to related sites

News and announcements - The students use the site as a means of communication and as a course calendar. This section contains a history of all announcements made in class or broadcast to the class through e-mail. The section is particularly useful for students that miss class and students that don't have printed versions of the course syllabus handy. Due dates are posted along with tips for the homework and case problems. Exam study tips are also listed here.

Syllabus and Class Topics - This section is the heart of the site and contains a mapping of all of the topics in the course to the class notes material and the learning tools. The students can use this page to easily access class notes, current and past exams, and interesting material related to class topics (but not covered in the notes). The class notes section contains material for each class including learning goals, vocabulary, basic theory, applications, and examples. Many of the examples have an associated spreadsheet that enables experimentation. Also, there is often a section on the class page describing how the class relates to past and future material in the class.

Learning tools - This section contains many odds and ends that can be used to help students learn the material. For example, interesting applications problems are described and solved (for example, the economics of leasing versus buying a car, the economics of choosing a job, and the economics of going to an expensive private university). Also, the page links to helpful hints in using spreadsheets and in programming graphing calculators. Homework assignments and solutions (including the case problems) and previous years exams can be accessed through the learning tools page (most popular pages in the site). Finally, a glossary of terms and links to where those are defined was added after students requested such information.

Downloads - The Downloads section contains all of the spreadsheets that are available for downloading. The spreadsheets are all in MS Excel 6.0 for Windows 95 format and these are updated periodically as the software versions change. The page also has space for audio and video downloads, however these have not been created at this time and are left to future work.

Class Email Listing - This page contains a complete email listing of all students in the class, the instructor, the teaching assistant, and the class newsgroup. This information comes in handy when the students are working in groups on the case study or homework, or when a student wants to communicate to the entire class simultaneously. The students requested that we enable a threaded news discussion section to archive questions and answers about the homework and class

material (and it saves instructor time in that there is no need to send every message response to every student).

Links to Related Sites - The final section contains links to related topics in engineering economics. These include links to data sources (such as the Internal Revenue Service, the Consumer Price Index, the Kelly Blue Book Used Car Guide), links to additional worked problems (various sites for engineering economics courses and the text book author's site), links to systems and industrial engineering departments (students locating graduate school opportunities), and links to systems and industrial engineering professional organizations.

IV. Experiment and Results

There are many purposes for designing and implementing the web site including:

- to give students more material that they can use to learn and explore course content,
- to give students with different learning styles an alternative method,
- to give students more time flexibility so that they can schedule around jobs and other activities,
- to expand the use of electronic communication between the students and between the students and the instructor,
- to show students the power of the web for finding relevant information and to help solve problems.

The goal was to develop a site and to test it under a variety of situations. The experiment ran over three semesters. In fall 1996 (39 students), the students did not use any web material and simply experienced a standard course that used techniques such as lecture, collaborative learning in class, and group projects. In fall 1997 (25 students), the students went through the standard course and had the baseline implementation of the site. The class lecture material was similar in the 1996 and 1997 offerings. All the site material was present except the glossary and the class newsgroup (however, this was simulated using the instructor as a focal point for storing and distributing messages). After this offering, the above two items were added and along with an improved site navigation structure based on student comments. In summer 1998 (9 students), the students went through an all-web experience with periodic review sessions as needed.

Three types of evaluations were used. One evaluation concerned the student usage characteristics of the site and tried to measure the five issues listed above. The second evaluation was a final examination that tried to measure student learning of the course topics. All three sections took the same final exam (security was maintained since the final exams were not returned) and the same scoring rubric was used. The exam questions covered a variety of topics and skills including routine 1-step numerical problems and multi-step induction problems. The third evaluation tool was a 1-month case study project where the students worked in groups of 2 or 3 students to develop a cash flow analysis to help make recommendations on the purchase of hotel facilities. In the interest of saving space, all three evaluation tools can be obtained from the author.

The final exam consisted of five questions of varying degrees of difficulty. The average scores on all questions as well as overall results are listed in Table 1.

Table 1 - Final Exam Scores (Section Averages)

Semester	Question 1 Modeling	Question 2 Repeat	Question 3 Probability	Question 4 Open Ended	Question 5 Case Based	Total
fall 96	14.2	22.9	9.2	18.8	15.4	80.4
fall 97	15.0	21.8	8.7	18.8	17.6	82.0
summer 98	15.2	20.6	7.7	16.4	14.7	74.6
maximum	20.0	25.0	10.0	25.0	20.0	100

Question 1 was a modeling problem where the students construct an equation to model cost and then solve for a breakeven value. The summer 98 group scored a bit higher on average and this is encouraging since this problem requires independent thinking.

Question 2 was a question on constructing cash flow tables and this was basically a repeat question from the second exam. The summer 1998 group scored significantly less on this question and there were clear misconceptions in the group. This skill is taught on the case problem and by way of using the spreadsheets. From the evaluations using the case and from the site evaluation, it was clear that summer 1998 students were not as strong in constructing these diagrams.

Question 3 was a simple problem in probabilistic outcomes. This material is not intuitive for most students and in general probability is a hard topic for students to learn on their own (evidence in our other courses in probability and statistics). Again, the summer 98 students scored worse on average.

Question 4 was an open ended equipment replacement problem. Little guidance was given on the exam itself and many students flounder on this question. Again, there is a decrease in performance on the summer 1998 students. This decrease is similar to the problems encountered on the case assignments where the students were again asked to deal with open ended problems.

Question 5 was a question based on the case itself and in particular, the financing of a project. Again, as the problems become more open ended, the summer 1998 student performances declined relative to the other two groups.

On average, the summer 1998 group performed at about 1 grade less than the 1997 group. There can be many reasons for this other than just “the web material did not help.” First, the summer semester is shorter and hence there is simply less time to learn the material. Second, none of the 1998 students had taken a web-based course (they were apprised of the experiment before they signed into the course). Third, the issues in the case study and the design portion of the course are not as well covered in the site as in the classroom. In the classroom, the instructor can adapt easily to problems and difficulties, where this is harder with an all-web version. We do note

however that the site helped the 1997 section and this was especially evident in the case study results.

Besides the exam, the following observations were gleaned from the other two evaluations and anecdotal comments. We do not include the raw data to save space.

- **the web-only learning was inefficient for the summer 1998 group.** Even though the students did not come to an organized class, they reported far more time on the class than the 1996 and 1997 groups, even if we include class time. Given that this was a summer class and time is more compressed, the extra time required became critical and clearly affected student learning. Help sessions were started about 1/3 of the way through the class to help the students focus their time better
- **the summer 1998 group had significantly less ability in problem interpretation and economic intuition at the end of the course.** This observation comes from results on the case study and exam problems 4 and 5. It is clear that instructor adds in insight and interpretation in the classroom setting, and this material was not translated as effectively with the web material.
- **the summer 1998 group was adequate in solving routine problems and simple modeling problems.** (1-step problems where you must select a technique implement to find a solution) This observation comes from results on the homework assignments and exam problem 1.
- **no group used the spreadsheets extensively.** This was a bit surprising since the spreadsheets provided a baseline structure for the case study analysis and homework assignments and this was the most “engaging” material in the site. Since this is not covered extensively in the exams, it was not considered as important when the students were allocating time to the course.
- **no group used the linked sites extensively.** Again, this was a bit surprising since the site provided by the text author had numerous worked problems and practice exams. The summer 1998 group used the text site more than the 1997 group.
- **the 1998 group had few complaints about site design and navigation.** After a revision following 1997, the problems encountered by the 1997 group were fixed and there were no complaints on the format of the materials.
- **the 1998 group did not use email and the newsgroup significantly.** Even though the 1998 group had no class time, there were significantly fewer email questions during the semester (even accounting for the smaller class populations). It was difficult for the students and the instructor to form a learning bond until the review sessions were implemented after the first exam. The newsgroup was not used and this was probably a result of the small class size.
- **The course seemed more difficult for the 1998 group.** The short time frame, the newness of the process, and the amount of material made the class more difficult for the web-only students. The summer 1998 students reported that they spent more time on course and that the material was more difficult than their predecessors had reported.

V. Future Work

The site is primarily a “flat” site and the major interactive portions are the spreadsheet models. It is clear from the evaluations that we need to improve the students’ insights and ability to use the material outside of simple textbook type problems. Our plan is to augment the site with dynamic demonstrations as well as online evaluation and testing of students. We are using funding from a GE Foundation Grant to finance augmentation of the site and we are developing dynamic learning tools developed in Authorware and Shockwave, audio and video material to help explain concepts, and new material on cost estimation. Also, we are constructing a 15 hour shortened version of the course to use as a stand-alone aid for FE exam preparation and student that need only a portion of the 45-hour course.

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