The Engineering Economy Course of 2020

Dr. Ted G. Eschenbach, P.E.
TGE Consulting

Abstract

Historical and current trends in engineering economy texts, self-directed and assisted instruction, classroom and distance delivery, and spreadsheet use are analyzed to project the engineering economy course of 2020. This presentation contrasts descriptions of what has and is likely to happen with prescriptions of what could and should happen.

Introduction

At one level the question of what the future engineering economy course will be like can be answered by examining what has changed in typical course content in the 27 years that I've been teaching this course. At this level there are only two changes or trends. One trend is the addition of spreadsheets. A second trend is a degree of "dumbing or slimming down" the course and the texts. The course topics included in most books have not changed over this interval. Chapters get added, dropped, split, combined, and rearranged; but there is virtually no fundamental development other than that linked to spreadsheets.

This is neither a radical assertion, nor a new one. It is well documented [9] that this field has a history of examining its slow development. Texts and presumably courses have focused more on financial mathematics and removed material linked to design and decision making. The question is whether this trend will continue or be reversed.

At another level the future engineering economy course can be described by trends in the methodology of course delivery. In contrast to the course content, this is an area where innovation is very active. In fact, the engineering economy course has been in the forefront of development at several universities.

At yet another level there are discouraging trends in the role of engineering economy in engineering curricula and the licensing exams for professional engineering. This paper examines these sets of trends to speculate about the future nature of the engineering economy course, students, and faculty.

Historical Analysis of Course Content

One approach to predicting the future is to compare the past with the present and project. The most accessible basis for this type of analysis is introductory texts. These texts have been analyzed in more detail in previous papers on the field's development [9] and on specific topics [1, 2]. Instead of a detailed analysis of nearly a century's set of texts, this paper relies on an evaluation of three texts. These texts include the first [6] from 1915 and two editions of the current text with the longest history[7, 8]. While this is a very limited set, as an active text author who closely reviews competitor's texts, I would assert that in terms of topical coverage the most recent text [8] is representative of the field. In addition I assume that this audience is familiar with most of the current texts, and thus well qualified to conduct their own evaluation. The macro-view of the topics covered in these 3 texts is summarized in Table 1.

An analysis of this table is discouraging as one of the main conclusions is that the field is not developing rapidly. Even though we have far more powerful tools, the more recent texts do not cover substantially more than the text of 1938. We have moved beyond it in financial mathematics, but fallen behind in cost estimation from 1915.

Table 1. Contents of historical and representative texts.

<table>
<tr><td>Fish [6]</td><td>Grant [7]</td><td>Grant [8], Ireson, & Leavenworth 8th</td></tr>
<tr><td>Estimating first cost, salvage value, yearly cost of service, & errors</td><td>Capacity & load factors, immediate vs. deferred investment, engineering reports & budgets</td><td>Other measures, inflation, probability, regulated businesses</td></tr>
<tr><td></td><td colspan="2">Internal rate of return, depreciation, taxes, replacement, increment & sunk costs, sensitivity analysis, public works</td></tr>
<tr><td colspan="3">Principles of economic choice, interest, equivalence, PW, EAC</td></tr>
</table>

In addition to the topical comparison, it is worthwhile to consider the methodologies that are used in the 3 texts. In 1915 there are already tables of engineering economy factors (basic six). In 1938, the same six factors are tabulated. In 1990, there are two additional factors added for arithmetic gradients. Even though many texts and instructors cover spreadsheets, these factors are still the basis for most engineering economy courses. One current text [24] has dropped the tables of engineering economy factors.

Slide rules were available as a computational aid in 1915. As these are matched nicely with the accuracy and variety of numbers in engineering economy calculations, I expect that slide rules were not supplanted by mechanical calculators for many engineering economic uses. Undoubtedly there were significant industrial applications, but at least in one educational setting the transition was from slide rules to computers and electronic calculators.

The next methodological revolution was the development of spreadsheets. This software (VisiCalc) was specifically developed in 1979 for financial analysis [21], thus it is not surprising that it has been very important to engineering economy classes. Many presentations were made at ASEE and IIE conferences [3, 5, 21, 22] and in *The Engineering Economist* [12] on including spreadsheets in the teaching of engineering economy. Revised editions of popular texts slowly added spreadsheets, so a noteworthy milestone is a text that was specifically written to support spreadsheets [10]. Today almost all introductory texts include spreadsheets to some varying extent. A 1997 survey of instructors indicated that 75% include spreadsheets in their engineering economy course [17, 18].

Observations on Current Trends in Teaching Methodologies

It would be easy (and wrong) to conclude that spreadsheets will replace engineering economy factors. At some point the tables may fall into disuse, but the annuity functions that are very powerful spreadsheet tools require exactly the same conceptual understanding as the tabulated factors that they generalize.

Professional meetings have included numerous presentations on better teaching of engineering economy by innovative uses of computer power. Recent presentations range from relying on spreadsheets [15] to asynchronous delivery over the web with computer mediated problem sets and testing. Noteworthy among these are approaches that provide 1-on-1 instruction. For example, written sets of multiple choice problems on the web can link wrong answers with explanations of the error [19]. Similarly sets of spreadsheet problem generators can be designed to support step-by-step problem solution and error correction [11].

At last year's ASEE meeting there was a workshop on using the web to support delivery of a normal lecture based engineering economy course [20]. However, there are at least five universities that have delivered engineering economy instruction asynchronously. Bradley U., Drexel U. [16], Georgia Tech [13, 14], and U. Wisconsin Colleges have used the web. Some of these are for distance learning, but some are directed at on-campus students, that would traditionally have attended lectures. Old Dominion University has used CDs sent out on submarines and surface vessels.

Similarly, the leading texts are adding web pages and CDs to the support that is provided to instructors. While most of this material is designed to support normal lectures, some of the material is focused on more student-driven learning. As observed at last year's ASEE meeting [15], there are students in normal classes practicing asynchronous learning – they never come to class.

Engineering economy is commonly included in graduate engineering management programs which have a long history of distance delivery through TV and videotape. As these programs move into web based and other asynchronous approaches, the engineering economy course seems to be a common test bed [15]. Other programs are doing the same with their undergraduate engineering economy course [13, 14].

However, as noted by a referee for this paper, there are many topics that can only be properly covered by relying on current computing tools. These include "decision trees, simulation, capital budgeting, debt management, principles of investment, utility analysis, and portfolio analysis." In some cases spreadsheets can provide the power, in other cases add-in or stand-alone software is required. The question is whether the integration of these more powerful computational tools into basic spreadsheets will occur. And then, will engineering economy courses take advantage of them.

Trends in Engineering Curricula and Practice

Georgia Tech is one of the universities that have redesigned their engineering curricula to meet a standard of 120 semester hours to graduate. In this kind of redesign there is pressure to drop requirements for engineering economy or to reduce the number of credit hours [13, 14]. Many faculty outside of IE, view engineering economy as more peripheral than structures, highway design, reservoir modeling, and fracture mechanics. It is the peripheral courses that are sacrificed to make way for workload reductions and new courses.

Several faculty here have worked on integrating engineering economy into the teaching of the design process in all engineering disciplines. This may have worked on individual campuses, but it has not become a major national trend. As a recent MCE graduate, I have evidence [4] that there is little to no engineering economy in the lectures, texts, or question answering repertoire of even CE faculty.

In the professional arena, there are other reductions in the role of engineering economy. For example, several years ago NCEES dropped engineering economy as a topic area for a question "group" on the PE exam for civil engineering. The rationale is that a question on fluids or structures can include engineering economy within it. However, realistically engineering economy has been dropped from that exam.

These educational and professional trends imply that graduates and PEs are likely to be less qualified in engineering economy and consider it less important. In the long run, this will reinforce the trend to cover less engineering economy.

On the other hand, surveys of engineering employers have often focused on the need to improve the training of engineers in communication, teamwork, and business. Most engineers spend more time on these areas than on design [23]. The current focus of ABET on continuous improvement, customer involvement, and measurement of achievement means that there may be a force to include more engineering economy, accounting, and cost estimation.

Predicted Future

Obviously, the engineering economy course is carried along on the currents that are driving engineering education. Prominent here is the increasing emphasis on distance and asynchronous delivery as the universities reach out to non-traditional students. There is also the often unfilled promise of lower cost delivery through economies of scale.

It seems reasonable to conclude that the financial mathematics that is a major part of what is in many engineering economy courses can and should be replaced with asynchronous computer mediated instruction interspersed with problem generation, solution, and correction with links as needed to explanatory material. This is particularly true for the material that is tested on the FE and PE exams.

This would clearly improve upon and replace "recitation" sections with teaching assistants or at home reworking of text examples. It will support both on campus lecture classes and asynchronous delivery off campus.

This development is underway, it may be fairly rapid, and it is principally a straightforward development of intellectual capital that may be melded into CD based texts or web support of paper texts. However, I suggest that it will take considerable time to diffuse throughout academia. Many instructors of this course do so as adjuncts or as a "service" course. Some departments want to keep bodies in traditional classrooms for FTE generation.

The more interesting question is what will be left to be done in the classroom or through computer mediated modes that we do not currently envision. I believe many of the conceptual foundations and skills that underlie the effective practice of engineering economy are best developed through interactive classroom presentations and discussions. Analyzing cases, developing data, including uncertainty, and balancing multiple objectives seem to require the richer face-to-face communication process. While this currently requires in-person interaction, video and computer conferencing seems likely to stretch what we do.

This focus on the design and decision-making use of engineering economy is facilitated by the pervasiveness of spreadsheets. Students are coming to the class better prepared to use spreadsheets and the field is developing pedagogically sound teaching of spreadsheet modeling. Both design and decision making are iterative processes that virtually mandate the use of spreadsheets.

Future spreadsheets are likely to include at least some software developments to support simulation, decision trees, sensitivity analysis, and uncertainty. However, it is unclear whether the classroom time and interaction will be there. Virtual teams might permeate the classroom, but first we must learn how to effectively develop student teaming skills.

If this future occurs, the future student will be more internally directed (fewer MWF 8 am lectures to attend) and far more independent. Thus the demands on faculty will continue to increase. There will be more teaching of higher order skills, and more time working with new technology.

Conclusions

The predicted future is perhaps best classed as what I believe should happen. That value judgment is based on the belief that engineering economy is of enduring importance to the practice of engineering. Thus the question is how to best prepare a wide variety of students for the future. It is suggested that computer mediated instruction in financial mathematics is one part. The second part is the professor and teams of students in communication rich process focused on more difficult conceptual and skill development.

While I believe this *should* happen by 2020, I am less than certain it will. There are very substantial impediments to change. Professors, educational institutions, book publishers, and even students have a substantial stake in the current system. Their business and personal interests may be a very large constraint on change. Teaching decision-making and design is a difficult, expensive, and resource intensive process. It is far easier to continue to focus on financial mathematics, and many students like knowing what they need to learn for the test.

Bibliography

1. Eschenbach, Ted G., and Stephen L. Allen, "Selecting *i* — Engineering Economy Needs A Consensus," *The Engineering Economist*, forthcoming.
2. Eschenbach, Ted G., and Jerome P. Lavelle, "How Risk and Uncertainty Are/Could/Should Be Presented in Engineering Economy," *IERC Proceedings*, Institute for Industrial Engineers, May 2002, CD.
3. Eschenbach, Ted G., and Robert White, "Using Spreadsheets to Teach Engineering Economy," American Society for Engineering Education, June 1992, Toledo Ohio, full 1.5 hr session delivered by Ted.

4. Eschenbach, Ted G., “The View from Both Sides of the Podium,” *2000 Annual Conference Proceedings*, American Society for Engineering Education, St. Louis, June 2000, CD.
5. Eschenbach, Ted, Henry Wiebe, and Hulya Yazici, "Spreadsheets vs. Formulas for Engineering Economy Instruction, *ASEE Proceedings*, June 1991, pp. 530-534.
6. Fish, John Charles Lounsbury, *Engineering Economics: First Principles*, McGraw Hill, 1915.
7. Grant, Eugene L., *Engineering Economy* ^{revised}, Ronald Press, 1938.
8. Grant, Eugene L., W. Grant Ireson, and Richard S. Leavenworth, *Engineering Economy* 8^{th}, John Wiley, 1990.
9. Hartman, Joseph C., ASuggestions for Teaching Engineering Economy at the Undergraduate Level,@ *The Engineering Economist*, Vol. 44 No. 1, 1999, pp. 110-125. “Response” by Ted G. Eschenbach, pp. 126-128.
10. Kahl, Alfred, and William Rentz, *Spreadsheet Applications in Engineering Economics*, West, 1992.
11. Lacksonen, Thomas, “Automated Problem Generator for Asynchronous Learning,” *2001 Annual Conference Proceedings*, American Society for Engineering Education, Albuquerque, June 2001, CD.
12. Lavelle, Jerome P., “Enhancing Engineering Economy Concepts with Computer Spreadsheets,” *The Engineering Economist*, Vol. 41 No. 4, Summer 1996, pp. 381-386.
13. Lohmann, Jack R., and Gunter P. Sharp, “Video-Stream Lecture Series for Remote Learning by On-Campus Students: Results after Two Years,” International Conference on Engineering Education, Oslo, August, 2001.
14. Lohmann, Jack R., and Gunter P. Sharp, “The Electronic Delivery of Engineering Economy,” *2001 Annual Conference Proceedings*, American Society for Engineering Education, Albuquerque, June 2001, CD.
15. Mandeville, David E., “Innovative Teaching Methods in Engineering Economy: Web Delivery, Excel Calculation, Teamwork Support,” *2001 Annual Conference Proceedings*, American Society for Engineering Education, Albuquerque, June 2001, CD.
16. Morris, John M., Steven V. Smith, Carole Mablekos, and John Fekete, “Teaching Engineering Management via the Web,” *Engineering Management Journal*, Vol. 10 No. 2, June 1998, pp. 5-10.
17. Nachtmann, Heather, Kim LaScola Needy, Jerome P. Lavelle,, and Eschenbach, AEngineering Economy: Current Teaching Practices,@ *1999 Annual Conference Proceedings*, American Society for Engineering Education, Charlotte, June 1999, CD.
18. Needy, Kim LaScola, Heather Nachtmann, Jerome P. Lavelle, and Ted G. Eschenbach, AAn Empirical Analysis of Engineering Economy Pedagogy,@ *The Engineering Economist*, Vol. 45 No. 1, 2000, pp. 74-92.
19. Smyer, William, “Integration of the Web into an Engineering Economy Course,” *2000 Annual Conference Proceedings*, American Society for Engineering Education, St. Louis, June 2001, CD.
20. Sullivan, William, and Janis Terpenny, "A Virtual Classroom Experiment for Teaching the Economic Principles of Engineering Design," NSF Workshop at 2001 Annual Conference of ASEE, June 2001.
21. Ward, Thomas L., “Spreadsheet Software: Puissance in Practice,” *1987 Annual Conference Proceedings*, American Society for Engineering Education, June 1987, pp. 104-106.
22. White, Bob E., “Computers and the Future of Engineering Economy Education,” *1988 Annual Conference Proceedings*, American Society for Engineering Education, June 1988, pp. 1085-1091.
23. Whittaker, John D., and Eschenbach, AConnecting What Engineers Do with How & What They Are Taught,@ *1998 Annual Conference Proceedings*, American Society for Engineering Education, Seattle, June 1998, CD.
24. Young, Donovan, *Modern Engineering Economy*, Wiley, 1993.

Biographical Information

DR. TED G. ESCHENBACH, P.E.
Consultant. Emeritus professor at the University of Alaska Anchorage. Ph.D. in industrial engineering from Stanford University (1975) and M.C.E. degree from UAA (1999). Founding editor of the *Engineering Management Journal*. Author or co-author of 5 engineering economy texts. Serves on national board of directors for ASEM, board of directors for PMI's Alaska chapter, and editorial board of *The Engineering Economist*.