Impact of ABET 2000 on Teaching Engineering Economics: What Subjects Define Economic Literacy for Engineers?

Donald N. Merino, Ph.D., P.E.
Stevens Institute of Technology

Abstract

This paper addresses a major assessment issue for those who teach engineering economics and related courses. That is, what subjects do we teach, how important are they and do they impact the ABET EC 2000 criteria. To determine these subjects, a list was developed that utilized previous ASEE/EE papers and a review of engineering economics texts. A survey was conducted of engineering graduates who work for companies that hire engineers, who started their careers as engineers and who have supervised engineers. The survey asked the respondents to rank the selected economics topics using a 1 - strongly disagree to 5 - strongly agree Likert scale.

Even though a broad set of subjects was chosen, all subjects had above average scores of more than 3.0/5.0, indicating that none of the major subjects were clearly eliminated. This result indicates that engineers need to know a broad set of subjects to achieve economic literacy.

Risk Analysis Fundamentals and Simulation Models were rated high, 4.0 and 3.7 respectively, although they are usually taught in more advanced engineering economics courses. The survey averages for more traditional topics such as Cost Estimation and Cost Accounting Fundamentals, 4.0 and 3.8, and Engineering Economics - Basic and Advanced - 3.9 and 3.5 were high, as expected. So, too, were the rankings for Fundamentals of Basic and Financial Accounting, 3.6 and 3.5.

I. Introduction

Meeting ABET EC 2000 requires a system of outcome assessments that meet a program and school's educational goals and overall objectives and can be used to continuously improve the outcomes. One element of this interrelated system is the need to develop outcome assessments for all courses in the engineering curriculum. As a number of recent papers given at the ASEE/Engineering Economy Division have shown, Engineering Economics is taught with varying credits and with differing course subjects (Needy, 1999). Implementing outcome assessments requires identifying subjects in engineering economics as well as measures to ensure that all students have achieved competency in these subject areas.

It is hoped that this research will start a process that will result in a consensus of what constitutes economic literacy for engineers. A major thrust of this paper is to better define the body of knowledge for engineering economics and related topics. The survey topics and subtopics are included in Appendix A with the hope that other schools will add to the survey results.

II. Impact of ABET 2000 on Teaching Engineering Economics

As any professor of engineering can attest, ABET 2000 has been a major topic of concern at ASEE conferences, in articles and in their engineering schools. Stevens Institute of Technology is no exception and Stevens has developed a comprehensive assessment approach to ABET 2000.

III. Stevens' Approach to ABET 2000

The Stevens curriculum has traditionally been based on a broad core that provides breadth in the sciences, engineering and the humanities while at the same time, allowing for meaningful specialization in various engineering disciplines. Thus, Stevens' educational objectives are expressed at the Engineering Curriculum Level to emphasize this unified approach to engineering education and to satisfy ABET 2000 Criterion 3. The individual discipline objectives at the Program Level, required in ABET 2000 Criteria 2 and 8, were expressed as matters of emphasis and application within this general structure. The implied learning objectives are expressed at the Course Level.

Stevens has developed a system of outcome-based assessments. These included:

1. *quantitative* evaluation based on *distributed grading* of *individual* student achievements related to detailed educational objectives,
2. *quantitative* measurement of student and faculty attitudes about the learning process,
3. the comprehensive construction, management and mining of a school-wide Web-based *educational databas*e, and
4. the implementation of a continuous feedback process at *three levels* to insure the integrity and effectiveness of the engineering curricula on a *continuous* basis.

Distributed grading is a direct quantitative linkage between typical assessment methods (exams, projects, etc.) and the educational objectives. Stevens believes that in conducting assessments it is crucial for improvements to begin with full utilization of current examinations, projects and other activities. *Distributed grading* distributes current aggregate grades as well as the Grade Point Average over the curricular objectives and allows for a quantitative expression of the emphasis given to the objectives across the curriculum (DeLancey, 1998, 1999).

To make this work at the course level requires a series of problems, exams, projects, etc. that measures a student's ability in a particular competency that can be expressed as a specific course related Assessment Performance Criteria (APC). These APCs need to be reviewed as to how they meet the Curriculum Performance Criteria established for the curriculum.

While each engineering program needs to establish its own educational goals and specific curriculum, every engineering program still needs to implement these concepts through specific courses which are defined by specific topics.

Thus, for Engineering Economics and related courses we need to develop a list of major topics and related competencies. As others have indicated there is a wide variety of subjects taught in Engineering Economics courses (Needy, 1999). The first step, therefore, is to develop a list of these subjects.

IV. Survey of Stakeholders to Define Economic Competencies and Literacy for Engineers

A review of ABET criteria and articles of various engineering school ABET EC 2000 efforts (Lohmann, 1999, Awoniyi, 1999, etc.) reveals that a common thread among the efforts is an inter-related system that includes input from various stakeholders. Stevens shares this approach.

As part of this process, a survey of industry stakeholders was conducted asking them to rank the major topics that are generally taught in engineering economics and related courses. The survey included a broad number of subjects that could contribute to making an engineer economically literate. Table 1 lists the major topics chosen.

The survey was constructed so that the respondents first had to weight (on a Likert 1 to 5 scale) the major components of the topic. See Appendix A for these sub-categories.

The survey was given to students enrolled in the executive level Master of Technology Management (MTM) program at Stevens. Almost all of these students are graduate engineers, scientists or computer scientists with 14 years average work experience, an average age of 39 and with about 3 / 4 having advanced degrees. Most importantly these students work for the hi-technology companies in the New Jersey area who hire Stevens engineers. Thus, this group is a sample that represents the employer stakeholder.

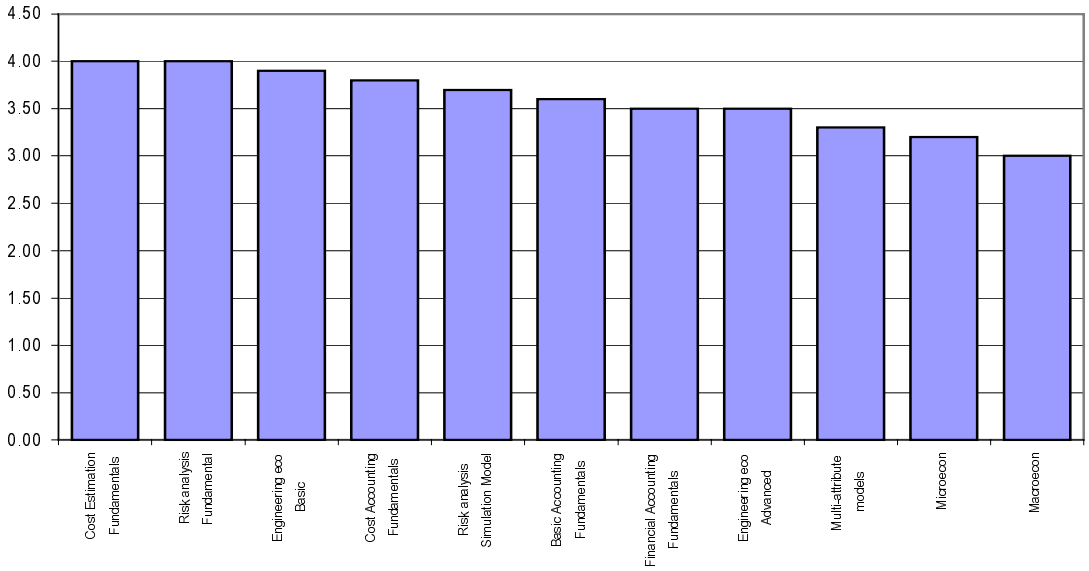
To further stratify this sample, only respondents that were (1) graduate engineers, (2) started their careers as engineers and (3) supervised engineers were chosen. This stratified sample had 48 respondents, about half of the total sample. For this sample, the average years of work experience was 13.8 yrs. and the average number of engineers supervised was 15.2. The other half of the original sample was almost all computer scientists or physical scientists and a few with other undergraduate degrees.

Table 1: List of Subjects/Topics that Define Economic Literacy for Engineers: Ranking (1= strongly disagree; 5 = strongly agree)

		1	2	3	4	5	No.	Tot	Avg	SD
A	Basic Accounting – Fundamentals	2	4	11	27	4	48	171	3.6	0.9
B	Financial Accounting – Fundamentals	1	3	18	22	4	48	169	3.5	0.8
C.	Cost Accounting – Fundamentals	1	2	13	23	9	48	181	3.8	0.9
D	Cost Estimation – Fundamentals	0	1	9	25	13	48	194	4.0	0.7
E	Engineering Economics – Basic	0	2	11	25	10	48	187	3.9	0.8
F	Engineering Economics – Advanced	2	4	18	17	7	48	167	3.5	1.0
G	Risk Analysis – Fundamental	0	3	6	27	11	47	187	4.0	0.8
H	Risk Analysis - Simulation Model	1	4	11	21	10	47	176	3.7	1.0
I	Multi-attribute models	1	6	23	13	4	47	154	3.3	0.9
J	Macroeconomics	3	12	17	12	3	47	141	3.0	1.0
K	Microeconomics	3	7	17	15	4	46	148	3.2	1.0

The numbers in the table are; 1-5:the number of respondents who chose that rank, No.: the total number responding, Tot: the total raw score, Avg.: the average response and SD: standard deviation. The total raw score is the weighted response (e.g. 0x1 + 0x2 + 0x3 + 2x4 + 6x5 = 38), etc.

Figure. 1 – Average Scores on Survey – In order of Importance



IV. Results of Survey

The most surprising result was that none of the major topics were clearly eliminated in this survey. The lowest two, Micro and macroeconomics, were 3.2/5.0 and 3.0/5.0 respectively, which are average or slightly above average in a 1 - 5 Likert scale.

Another surprising result was the relatively high ranking for Risk Analysis – Fundamentals (4.0 /5.0) and Risk Analysis –Simulation Model (3.7/5.0)

An expected result was the relatively high ranking for Cost Estimation – Fundamentals (4.0/5.0) and Cost Accounting – Fundamentals (3.8/5.0), for Engineering Economics – Basic (3.9/5.0) and Engineering Economics – advanced (3.5/5.0), for Basic Accounting – Fundamentals (3.6/5.0) and Financial Accounting – Fundamentals (3.6/5.0)

V. Conclusions and Observations

The fact that there were no topics clearly eliminated suggests that engineers need to know a broad set of topics to achieve economic literacy. This result is reinforced by a survey done on the criteria most important to supervisors of new engineering undergraduates (Koen, 1997, 1998), that indicated a large gap in these areas. The Engineers Workforce Project (Parker, 1997) showed that engineers in industry spend a very significant amount of time in management/administration and accounting, finance and contracts which also indicates that engineers need a broad set of competencies.

The relatively high ranking for Risk Analysis and Simulation may reflect the fact that many of the engineers in this survey work in the telecommunications and chemical process industries where

simulation models are used extensively for engineering design and economics. Since statistics is the basis for Risk Analysis and there is low statistics literacy among many engineers, this may be the cause for a large "gap" in this area.

Based on this survey, Engineering Economics and Cost Estimation are still important topics for engineers to know yet a basic knowledge of accounting fundamentals is also necessary. Thus, these topics still need to be included in engineering economics or other related courses for all engineers.

VI. Future Work

ABET 2000 criteria assumes each engineering school determines its own curriculum and its own system of assessing outcomes. However, an engineer's economic literacy is a requirement that is set by the companies and government organizations that hire our engineering graduates. As such there is a need to establish a set of competencies that define economic literacy for all engineers.

This study is the first step in determining these competencies. It would be very helpful for other schools to undertake similar surveys and to compare results. Another approach is to make this type of assessment part of the studies of engineering curriculums.

The results of these studies could be used to help guide Fundamentals of Engineering (FE) and Professional Engineering (PE) tests. They could also be used to evaluate the courses in an engineering curriculum.

Note that this paper was concerned with the general or core requirements for all engineers in all majors. It would be expected that the economic literacy requirements for industrial engineering and engineering management majors would rank higher. This will be the subject of another survey.

Appendix A – Break down of Major Categories

A. Basic Accounting – Fundamentals
* Debits and Credits: Assets, Liabilities; * Income; Expenses; Equity Definitions;
* Income Statement; Balance sheet; Cash Flow Statement; and how these are integrated;
* Asset & Inventory; LIFO; FIFO

B. Financial Accounting - Fundamentals -
* Financial Ratios; * Capital Structure of firm; * Stocks, Bonds and Financial Instruments.

C. Cost Accounting - Fundamentals
* Fixed & variable costs; Break–even Analysis; * Job, process and standard costs; Direct and Indirect costs; * Cost of goods sold; overhead costs, profit and loss calculations;
* Activity Based Costing (ABC); * Flexible & master budgets; performance assessment.

D. Cost Estimation
* Statistical Cost Estimation; * Use of cost indices and cost factor;
* Survey: Expert Panel, Delphi; * Design for Cost / Affordability.

E. Engineering Economics - Basic
* Time Value of Money; Interest rates; * Figures of Merit – 3 worths: PresW; AnnW; FutW IRR, B/C; CapCost; CapRev; MARR; * Loans and Amortization

F. Engineering Economics - Advanced
* After Tax Analysis & Depreciation; * Sensitivity Analysis; * Retirement and Replacement, Sunk and Opportunity Costs; * Inflation Analysis

G. Risk Analysis – Fundamentals
* Basic probability – decision trees; * Statistics: Expected value & variation

H. Risk Analysis – Simulation Models
* Distributions:Continuous & Discrete; * MonteCarlo Simulation Models; * Risk Profile
I. Multi-Attribute Analysis
* Scaling, Weighing, Democratic Voting; * Utility Analysis /SMART; *
* Analytical Hierarchy Process (AHP)
J. Macroeconomics
* Laws of Supply /Demand; * GDP and National Accounting: * Monetary and Fiscal Policies;
* Money, Banking, & interest Rates; * International Trade and Finance.
K. Microeconomics
* Demand Analysis; * Industry Competition Models; * Cost Analysis;
* Labor Markets. & Employment

Bibliography:

1. Awoniyi, S. A.
   A Template for Organizing Efforts to Satisfy ABET EC 2000 Requirements
   Journal of Engineering Education, ASEE, October 1999, Pg. 449-453
2. DeLancey, G. P.; Urken, A. B.
   C. V. Schaefer School of Engineering Assessment Plan
   Stevens Institute of Technology, September 1998
3. DeLancey, G. P.; Urken, A. B.
   Engineering Curriculum Assessment: A Model in Process
   Stevens Institute of Technology, March 1999
4. Koen, Peter A.; Kohli, Pankaj
   ABET 2000: What are the most important criteria to the supervisors of new engineering undergraduates?
   1998 American Society of Engineering Educators (ASEE), Conference Proceedings
5. Koen, Peter A.
   Using an Industry Survey to Obtain Faculty Support for ABET 2000 Criteria
   1997 American Society of Engineering Education (ASEE) Conference Proceedings
6. Lohmann, Jack R.
   EC 2000: The Georgia Tech Experience
   Journal of Engineering Education, ASEE, July 1999, Pg. 305-310
7. Parker, Linda; Byron, Lawrence
   Engineers Workforce Project
   National Science Foundation (NSF)
   1997 American Society of Engineering Educators (ASEE) Conference Proceedings
8. Needy, Kim; Lavelle, Jerome; Nachtman, Heather
   An Empirical Analysis of Engineering Economics
   1999 American Society of Engineering Educators (ASEE) Conference Proceedings

Authors Profile:

Dr. Donald Merino is a tenured full professor of Engineering Management and Management at Stevens Institute of Technology. He has developed undergraduate and graduate courses and teaches Engineering Economics, Decision Analysis, Total Quality Management, Strategic Business Planning and Concurrent Engineering.
He is the Program Director for the Master in Technology Management (MTM) Program. He was founder of the undergraduate program in Engineering Management at Stevens. He won the Morton Distinguished Teaching Award for full professors at Stevens. He was PI to develop a concurrent engineering graduate program. His book, "The Selection for Capital Projects", was published by John Wiley in their Engineering and Technology Management series.
Dr. Merino received two Centennial certificates from the ASEE in Engineering Economics and Engineering Management. He is past chair of the Engineering management Division and Engineering Economy Division of ASEE.
Dr. Merino was awarded the B. Sarchet Award from the American Society of Engineering Management (ASEM). He is a Fellow and past president of ASEM.
Dr. Merino has 25 years of industrial experience in positions of increasing managerial responsibilities. Since joining academe 10 years ago, he has published 20 refereed journal articles and conference papers and over 50 research reports in Design for Cost/Concurrent Engineering; Environmental Economics and Medical device development/Economics.