ENGINEERING ECONOMY: A SURVEY OF CURRENT TEACHING PRACTICES

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INTRODUCTION

This paper describes the results of a survey conducted during the fall semester of 1995. The intent was to gather data regarding the ways and means in which engineering economy is being taught at our universities. The hope was that such data would prove enlightening and perhaps lead to a better understanding of how engineering economy could/should fit into curricula in the future. Also, the hope was to-uncover data that would lead others to understand the pedagogy being used and perhaps increase the efficacy of their own teaching of the subject.

In the following sections the results of the various questions of the survey are given as well as some commentary and conclusions regarding potential implications of that data at the end.

THE SURVEY

The survey was distributed via conventional mail and e-mail to all members of the industrial engineering and engineering economy communities (via CAIEDH and ASEE-EED mail lists). A note contained in the distribution asked all who received it to forward copies to other departments that teach engineering economy within their respective colleges/universities. The surveys, containing some dozen questions, were completed and returned to the author during the fall semester of 1995 — the names of those who participated in the survey are given in Appendix A. The results of the individual questions from the survey are given below:

QUESTION: Which department(s) Teaches Engineering Economy at Your School?

Entity That Teaches	No. of Responses	Answer Frequency	Entity That Teaches	No. of Responses	Answer Freque
Industrial Engineering	26	54.2%	Industrial Technology	1	2.1%
Engineering Management	6	12.5%	College of Engineering	1	2.1%
Civil Engineering	5	10.4%	School of Management	1	2.1%
Chemical Engineering	5	10.4%	Engineering Technology	1	2.1%
Engineering & Mngt Sciences	1	2.1%	Manufacturing	1	2.1%

QUESTION: Do Graduate Students Teach Your Engineering Economy Course?

NO: 31 (73.8%)YES: 11 (26.2%)

	Average (if YES)
If YES, What % of Time: 50,40,40,33,30,20,20, 20,20, 10,10	26.6 %

QUESTION: How many Times a year is it taught? How many students Per Offering?

Number of Times Taught Per-Year	No. of Responses	Frequency of Answer	Students Per Offering	Average No. Students Per Offering
1	3	07.0 %	500,30,25	185.0
2	11	25.6%	250, 150, 100, 105, 70, 55, 50, 50, 35, 30, 25	083.6
3	14	32.6%	400,225, 100, 100, 90,80,65,60, 50, 50,45,32,30,30	096.9
4“	6	14.0%	200, 140, 140, 50, 50,30	101.7
5	3	07.0%	40, 30,20	030.0
7	3	07.0%	60,45, 25	043.3
8	1	02.3%	45	045.0
10	1	02.3%	40	040.0
11	1	02.3%	30	030.0
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QUESTION: What Percentage of Each type Students is in Your Course?

Type of Student	Percentage Type of Student in Your Class (Ordered)	Average (n=42]
IE	100,95,70,70, 70,60, 50,35,30,30,25,20,20, 20, 20, 15, 15, 13, 10, 10, 10, 10, 12, 5, 5, 5, 5 (rest O)	19.8%
ME	70,65,60,42,40,40,40, 35,35,30,30,30, 30,30,30, 26,25,25,25, 20,20, 20,20,20,20,10, 8, 7, 5,5,5, (rest O)	20.7%
CE	100, 100,60, 55, 55, 50,45, 30,30, 30,26, ,26,25 >25,23, 20, 20, 20, ,20, 15, 15, 10, 10, 10, 10, 5, 5, (rest O)	20.7%

E	100, 50, 40, 30, 30, 30, 30, 30, 30, 30, 25, 25, 20, 20, 20, 17, 15, 15, 10, 10, 10, 10, 7, 5, 5, 5,4,2, 1, (rest O)	14.9 %
Engr.	159, 100,41,40,30,20,25, 15, 15, 10,10, 10, 7,7, 7, 5,4, 3,3,2, 1, (rest O)	12.2 %
ChemE	100,40, 37, 25,20,20,20, 15, 10, 10, 5, 5, 5, 5, 5, 5, 3,2, 2, (rest O)	08.0 %
Other	60, 19, 15, 14, 5, 5, 1, 1, 1, (rest O)	02.9 %
Egr.Mgt.	80.10, 8, 5, (rest O)	02.5 %
Business	10, 1, (rest O)	00.3 %

QUESTION: In Terms of a "Student Grading Policy" What Percentage Does each of the Following Count in the Final Student grade in Your Class?

Grade Device	Percentage that it Counts For the Final Grade	Percentage Ave (n=41)
Exams	100,90,90,90,90,85,85, 80, 80, 80,80, 80, 80, 75,75, 75,75,75,75, 74,73,72,70,70,70,70, 67,65,65,60, 60,60,60,60, 55, 50, 50, 40,40,33, 25	71.9 %
Homework	**33, 30, 30,25,25,25, 25, 20, 17, 16, 15, 15, 15, 14, 14, 14, 10,10, 10, 10,10,10, 10, 10, 10, 8, 5, 5, (rest O)**	**10.1 %**
Projects	33,30,25,25,25,20,20, 20,16, 15, 15, 10, 10,10, 10, 10, 10, 10, 10, 10, 8, 5,5, (rest O)	08.6 %
Pop Quizzes	**25,20, 17, 15,14, 13,10, 10, 10,10, 10, 10, 10, 8,7,5, 5, 5,5, (rest O)**	**05.1 %**
Cases	25, 20, 16, 15, 10, 11, 10, 5, 5 (rest O)	02.9 %
Attendance	**5, 5, (rest O)**	**00.2 %**
Class Participation	**10, (rest O)**	**00.2 %**
Bus. Game	**10, (rest O)**	**00.2 %**

QUESTION: Are You Currently Re-Working or Addressing Re-Design Issues Regarding How Engineering Economy is Taught in Your Department or College?

NO: 22 (50.0%) YES: 22 (50.0%)

If YES, Explain:

• Considering expanding cost estimating and cost accounting portion, may require move to **4** hour course. • Incorporating design issues based on NSF project • Looking at several sources of material to incorporate management accounting as a supplement • Considering increasing spreadsheet formulation in course as well as expanding the coverage of basic cost accounting • Working with new dean to integrate into design sequence • Trying to increase design content through examples from various engineering disciplines • Attempting to include more real-world projects • We are considering general restructuring in spring 1996 semester • Trying to find out how we can help in a general case ● Reworking with materials developed from NSF grant • Would like to make class more active, less lecture oriented. Will be trying group exercises and other ideas this semester • Combining with classical economics • Exploring the development of an interactive software. Converting from quarter to semester system • More accounting and "green" design issues

QUESTION: Do You Use "Groups" (Formal or Informal) As Part of Your Classes?

NO: 18 (42.9 %) **YES: 24 (57.1 %)**

If YES, Explain:

• Use groups in Lab • As part of business game ● Only in term project • **3** or **4** person term project groups are used • Group work on spreadsheets and selected problems • Teamwork on homework • Pkm to + Students work in groups on homework in recitations and outside of class. No formal group assignment is given • For case studies • Group projects/presentations used • Informal, they work on a problem together • A team is required to complete the financial section of a design project + Three person teams work on a spreadsheet project

QUESTION: Do You Use "Projects" For Your Course? NO: 14 (35.0 %) YES: 26 (65.0 %)

If YES, Explain:

• Adapted from textbook problems • Use both real world and made up projects + We do a real-estate investment over a period of years • Students devise imaginary business • Project is actual problem from local industry ● Use bonus projects • Students use real-world problems from their co-ops • Students find their own real-world problems • Sometimes if a real-world problem is available + Made up projects of software design or financial investment analysis • All students must do a design project, graded in three phases, approved by the instructor and real-world • Real-world, student defined, approved by instructor • One individual project — they work on a "real world" problem of their choice

QUESTION: Do You Use a Single Text? **NO: 04 (09.5%)** **YES: 38 (90.5%)**

"Do you supplement with anything?

• Class notes • Notes on capital recovery, time independent economy, data gathering, home mortgages, lotus 1-2-3 • Notes on cost accounting, cost estimating and analytical materials on relationship between PW and I for various types of cash flows (for understanding IRR) • Handouts based on transparency presentation in class + Have used spreadsheet functions and templates to help illustrate modeling and analysis • I discourage use of built-in functions until I am convinced that the students understand what they are doing and who to model economic analysis situations • Add notes on accounting • Add engineers journal, scheduling and planning, activity based accounting concepts • Supplement with note and articles from TEE • Use case book • Use case studies from my casebook • Supplement with a finance text and a Managerial economics text in two quarters • Supplement notes on cost estimating and cost accounting • Use notes developed from NSF project • Each lecture supplement with examples from other texts, will use cases later in semester ● A workbook in conjunction with a text has been used • Augment with personal notes

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QUESTION: Do You Use "Spreadsheets" in Your Course? **NO: 10 (24.4 %)** **YES: 31 (75.6%)**

If YES, Explain:

• **Use Lotus from scratch, build** up spreadsheets to handle various engr. econ. problems ● Req' d to solve after-tax HW by spreadsheets, students build there own after in-class "how to" lecture • For sensitivity analyses • To solve homework and project • Don't teach spreadsheet stuff, students develop own spreadsheet design • Use for four tables: factors, BT analysis, loan amortization, AT analysis • They are used for homework problems • Students build spreadsheets for various example problems — three are handed in during the semester • We show students how to check all of the problems this way • Students build their own • Software projects can be done in BASIC or with spreadsheets • Have used in the past, now I use EZ CASH by Chan Park • Students are expected to know how to use (or learn) spreadsheets. Homework is assigned to use spreadsheets. Some help is provided in recitation • Utilize CASH software included with text • Text has software that the students use • EXCEL spreadsheets that they build themselves • EXCEL project provided by the instructor

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QUESTION: What is Your Assessment of the State-of-The-State of Engineering Economy as a Body of Knowledge?

• Becoming more important • Mature but not widely used in industry except for basic ideas • Good but could be better • Info is basic logic and state-of-the-art, except for computer software, is consistent • Undergrad materials well developed in terms of tools, theory, etc. but not well integrated with the rest of the engineering curriculum • Fundamental principles are well known — current application of these is not as well known. • Field is growing but needs more dissemination to the classroom + Most textbooks focus too narrowly and in too much detail on interest factors and manipulation — too little focus on cost concepts cost accounting, decision analysis under risk, etc. • Mature and applications oriented • Fairly mature and well understood as a body of knowledge with notable gaps in understanding risky decisions (esp. new technologies) where the future is most difficult to model and in a coherent approach to benefit the cost analysis that is in concert with the approaches of the pure economists • Basic techniques are straightforward — problem is getting reliable data to make comparisons! • Essential knowledge — can't separate time and money • Lagging • On the move

(upward)! New energy is developing in relevant areas of teaching and research • Important to all engineering disciplines. In the past too much emphasis on TVM and interest factor manipulation made the course uninteresting. Should be taught from engineering-decision-making point-of-view by pooling examples from various real-world disciplines cases ● O.K. on mechanical aspects, behind times on spreadsheets — should be used in all courses and is not. Weak on fundamental question of finding the value of i% • Adequate but developing • Needs updatingh-evising • The standard EE textbook is inadequate. We teach basic EE topics of plant and equipment investment, facility location, equipment replacement, cost analysis from the point of view of macroeconomics and finance ● Very useful and practical for engineers • Good • The math is extremely easier now, although important — people using "cost" accounting should evaluate the strategy and effect ● In good shape • Needs expanding • Remains very important — however, no text seems to really be modernized + Getting the students to understand the economic consequences of their designs is an important issue which is not addressed by many instructors • Lots of books available • Functions in spreadsheets plus change in tax laws have pretty well wiped out engineering economics • If real-world applications are applied to theory the student accepts the material well. We apply the Engineering Econ theory to real world situations found in current newspapers — this produces and maintains student interest • Mature • As taught in an introductory course, the body of knowledge is relatively stable • Mature and stable (calculations are getting much easier) • It is an integral part of engineering education. We require it of all majors due to employee feedback • Basic tool in project evaluation. Not a fertile research area

CONCLUSIONS and IMPLICATIONS

Tome the survey offers several interesting aspects of engineering economy education as it exists today. Given below are some of the highlights of the survey.

➡ In the survey, 54% of the respondents indicated that the IE department teaches engineering economy at their university — with just over 10°/0 each for engineering management, civil engineering and chemical engineering respectively. It seems then that IE still is the predominate supplier of this subject at our universities. This result may be somewhat biased because of the method of distributing the survey, but all-in-all this is probably a pseudo-valid fact. The implications are that we need to be proactive in creating student knowledge in those engineering economy topics and techniques that our customers need and are requesting.

➡ Over 58% of the respondents indicated that they offer engineering economy courses 2 or 3 times per year with an average class size of about 90 students. On the other hand just over 20% offer the course 5 to 11 times per year with smaller class sizes of around 35 students. This implies that large sections taught infrequently are favored over smaller sections taught more often. To me this structure promotes a teaching style that emphasizes the "roteness" of the topic of engineering economy. Because of the prohibitive nature of teaching to large sections the focus becomes measuring the students' ability in solving homework problems and taking tests. More and more in higher education, we are being exposed to the notions of active and co-operative learning models, and the focus is tending toward small group interaction and group learning. A class structure with large sections certainly does not facilitate this mode of instruction.

➡ There was a relatively even distribution of the types of students in engineering economy classes. This was a bit surprising to me because I had developed a belief that EE's, ME's, ChemE's and CE'S were, in these days of "squeezed" credit hours, tending to de-emphasize engineering economy in their curricula (or eliminate it) in lieu of other discipline specific courses. I was happy to see that based on the responses to the survey that perhaps this is not a general trend and indeed is still viewed as a core competency for engineers.

➡ In the survey, on the average, 72% of the students' final grade was placed on their scores on examinations — with another 10°/0 placed on homework proficiency. A very small percentage, on the average, was placed on group work and case studies. Here again we can see that the reward system (grades) promote individual problem solving (and competition) and work. Little has been built into our classes, and the way that we grade students, with respect to the concepts of team problem solving, answer consensus dynamics, and group design skills.

➡ It was interesting to me to see that about 50% of the respondents were actively addressing re-design of their engineering economy courses. This tells me that although an old paradigm still is somewhat pervasive in the way that we teach engineering economy, that indeed many are active in addressing issues surrounding the pedagogy of the course. Some of the concerns include: incorporating design costs, adding more real world examples and the effects of "green" issues, classical economics and cost accounting. To me, this is encouraging!

➡ In the survey, 57'% of the respondents indicated that they use groups in some form in their courses. Most were used for term projects — with a few used for case studies and homework. So it seems that although most instructors require some group assignments, little relative weight (on the average) is placed on those assignments in terms of calculating student grades. One interesting exception to this that I have become aware of recently is with the engineering economy courses taught by Professor Bob Martinazzi at the University of Pittsburgh — Johnstown. In his course he has experimented with team teaching (small student groups teach each other) and team testing (an exam might have one individual question and then three questions that the small group must solve). Grading too is centered around the team concept. I'm trying to get him active in ASEE-EED and we may hear from him at next year's conference.

➡ In the survey, 65% of the respondents indicated that they assign some form of a project in association with their course. From other statistics it appears that some projects are individual in nature versus group projects. Instructors use both real-world and made-up type projects. There seems to be a desire to move toward more of the real-world variety. Again the observation can be made that even though a majority of instructors are using projects to emphasize aspects of engineering economy or to pool together collective knowledge from the course, the degree to which those project constitute a final grade (incentive) seems disproportionately small.

➡ Over 90% of the survey respondents are using a single text with their courses. However, a majority also supplement the text with other material. Common items that serve as supplements include: personal notes (to add clarification), costs accounting and accounting principles, spreadsheet-use notes, case studies, and notes on data gathering and decision making. These items may point to topics that textbook authors may want to investigate.

➡ *Some* 75% of those surveyed are currently using spreadsheets in some capacity in their courses — this is enlightening and encouraging. Spreadsheets are a basic generic problem solution tool that our students need to be proficient with. Instructors are using both "canned program" and build-your-own-template assignments.

➡ Lastly, on the survey was a question intended to get a feel for the perceptions of engineering economy as a body-of-knowledge from those of us who teach the subject. The complete list of comments is given in the paper, but a few general themes seemed surface. These themes included: engineering economy is a stable and mature body of knowledge, it is applications based with little research component, it is behind the times and inadequate to address contemporary needs, it is very useful and necessary, too much focus is placed on principles of time-value-of-money at the expense of others, the mathematics has become trivial, it is developing/changing/transitioning, and it needs to develop/change/transition. I'm not too sure what all of these comments mean, but my sense is that there is a lot more skepticism and negativeness concerning out field as opposed to positiveness and optimism.

This has been an--interesting and enlightening endeavor for me. I enjoyed all of the wonderful comments and " contributions from those who participated. Thanks again for caring!

AUTHOR BIOGRAPHY

JEROME P. LAVELLE is an assistant professor in the Department of Industrial and Manufacturing Systems Engineering at Kansas State University. He received his BS and MS degrees in Industrial and Systems Engineering at Ohio University and worked at AT&T Bell Labs before obtaining his Ph.D. in Industrial Engineering at North Carolina State University. Dr. Lavelle's teaching and research interests are in the areas of engineering management, economic analysis, production and operations costing and effectiveness issues in advanced quality initiatives. He is an officer with ASEE in the Engineering Economy and Engineering Management divisions, and is a member of IIE and ASEM. Dr. Lavelle received a 1996 ASEE NASA Summer Faculty Fellowship and will be spending this summer at the Kennedy Space Center in Cape Canaveral, Florida.

APPENDIX A : List of Participants of the Survey

NAME	UNIVERSITY	NAME	UNIVERSITY
B. Hazeltine	Brown University	R. Williams	Ohio University
W. Vorizka	University of Nevada - Las Vegas	D. Merino	Stevens Institute of Technology
S. Sarin	North Carolina A&T University	J. Borowick	Cal State Polytechnic University
H . Ligggett	Northern Illinois University	J. Luxhoj	Rutgers University
V. Hillsman	Purdue University	R. Bernhard	North Carolina State University
P. McCright	University of South Florida	M. Duffey	George Washington University
W. Moor	Arizona State University	R. Creese	West Virginia University
D. Fisher	University of New Mexico	R. Lutz	University of Texas - Dallas
W. Sullivan	Virginia Tech University	C. Park	Auburn University
T. Eschenbach	University of Alaska Anchorage	A. Henderson	North Dakota State University
D. Hendricks	Iowa State University	T. Chang	Univ. of Wisconsin - Milwaukee
A. Hunter	Northwestern University	R. Waters	George Washington University
A. Badiru	University of Oklahoma	H. Meeks	Iowa State University
J. Buck	University of Iowa	C. Heising	Iowa State University
M. Bowman	Purdue University - Indianapolis	V. Zaloom	Lamar University
H. Parsaei	University of Louisville	K. Bursic	University of Pittsburgh
M. Riley	University of Nebraska - Lincoln	A. Grum	Mercer University
G. Bier	University of Missouri - Rolls	W. Kennedy	Clemson University
J. Smith	Texas Tech University	A. Kendall	University of Minnesota
J. Erjavec	University of North Dakota	J. Noble	University of Missouri - Columbia
G. Sedrick	Univ. of Tennessee - Chattanooga	W. Thompson	University of Central Florida