Engineering Economy - A Follow-up Analysis of Current Teaching Practices

Jerome P. Lavelle/ Kim LaScola Needy, Heather Nachtmann Umphred
Kansas State University/University of Pittsburgh

Abstract

Results of a survey conducted to gather data regarding the ways and means in which engineering economy is taught in U.S. universities is described. This represents an extension of the work previously reported by Lavelle at the 1996 ASEE Annual Conference in the following ways: (1) additional surveys are included; (2) a more rigorous statistical analysis is performed; (3) responses to open-ended questions have been tallied, coded, grouped, and analyzed; and (4) the foundation is laid for a follow-up survey to probe more deeply into the significant findings from the first survey. The intent of this research is to identify potential pedagogical implications of the findings as they relate to increasing the efficacy of teaching engineering economy.

Background

At the 1996 ASEE Annual Conference, Lavelle (1996) reported findings from a survey which was distributed to all members of the industrial engineering and engineering economy communities in the Fall of 1995 via CIEADH (Council of Industrial Engineering Academic Department Heads) and ASEE - Engineering Economy Division mailing lists. The purpose of this survey was to gather data regarding engineering economy and the ways and means in which it was taught in U.S. universities. The initial report presented by Lavelle included responses from 43 respondents. Since this reporting, two additional surveys were collected. Results reported in this paper represent on average a total of 165 sessions of engineering economy being taught in the U.S. each year, to a total of 10,411 students. Class sizes varied from 20 to 500 students on average.

This paper will re-examine the findings from the initial survey (with the inclusion of the two additional surveys), including a more rigorous statistical analysis of the data. Responses to open-ended questions will also be examined more thoroughly. Finally, the survey instrument to be used in a follow-up survey will be described.

Survey Findings

Breakdown by Discipline and Class Size

Industrial Engineering (IE) faculty are not the only ones teaching engineering economy. This subject matter is being taught by a wide variety of engineering disciplines. Of the 45 surveys, 64% of the engineering economy courses are taught by Industrial Engineering (IE) faculty. The remaining 36% are taught by “other” (Non-IE) faculty, for example Engineering Management, Civil Engineering, and Chemical Engineering. The average number of students per course offering (class size) varied significantly amongst those surveyed. For purposes of this analysis, data has been broken down into small (0 - 30 students per class), medium (31 - 75 students per class), and large (76 or more students per class). Of the 43 surveys that reported class size, the breakdown is 36%, 38%, and 26% for the small, medium, and large categories respectively. This analysis will examine survey results by the discipline teaching the course (IE versus Non-IE) and by the average number of students per course offering (0 - 30, 31 - 75, and 76+).

Number of Times per Year Course is Taught

Respondents were asked to state the number of times per year that the engineering economy course is taught. Results show that IE faculty teach on average more sessions of engineering economy per year than Non-IE faculty. Table 1 shows the average number of times per year that the course is taught by an IE faculty member is 4.3 as compared to 2.5 by a Non-IE faculty member. This difference is statistically significant at a 95% confidence level. The number of times per year that the engineering economy course is taught is not statistically different for small, medium, and large class sizes.

	Discipline		**Class Size**		
	IE	**Non-IE**	**0-30**	**31-75**	**76+**
Average	4.3	2.5	4.1	4.1	2.8
95% Confidence Interval	3.4 -5.2	1.9 -3.2	2.4 - 5.8	3.1 - 5.1	2.1 - 3.5

Table 1. Number of Times per Year Taught

Number of Students per Course Offering

Although the average number of students per course offering is higher in courses taught by IE faculty as compared to Non-IE faculty, it is not statistically different at a 95% confidence level (see Table 2). As would be expected, there is a statistical significance of the average number of students per course offering by class size.

	Discipline		**Class Size**		
	IE	**Non-IE**	**0-30**	**31-75**	**76+**
Average	81.3	72.9	27.2	46.8	184.4
95% Confidence Interval	50.6 - 112.0	7.7 - 138.1	25.4 - 29.0	41.9 - 51.7	100.3 - 268.6

Table 2. Number of Students per Course Offering

Type of Student Taking Engineering Economics

Figure 1 shows a breakdown of students taking engineering economics by discipline. Mechanical engineers, civil engineers, industrial engineers, and electrical engineers represent the largest groups of students taking this course.

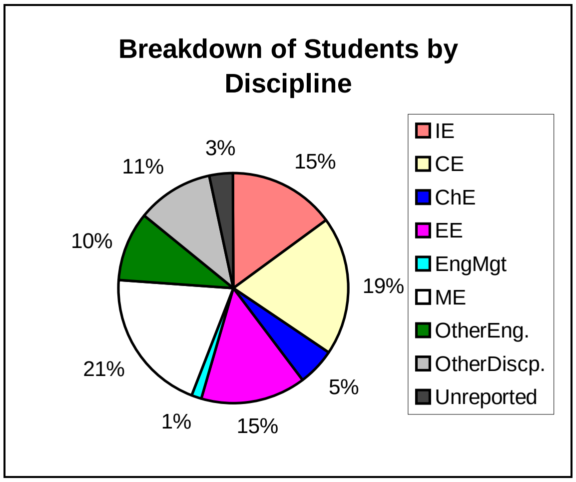

Figure 1. Breakdown of Students by Discipline

Student Grading Policy

Respondents were asked to list the percentage of weight placed on various assessment tools on determining the students' final grade. Overall, the non-normalized breakdown by weight for each item is as follows: exams - 68.8%, homework - 16.6%, projects - 15.1%, case studies - 13.4%, and pop quizzes - 10.8% on average. Tables 3 - 7 summarize this information by discipline and class size. Overall results show that exams are by far the primary factor used in grade determination. Table 3 shows that there is no significant difference in the weight of exams by discipline or class size. Homework and projects are used similarly regardless of discipline and class size (see Tables 4 and 5). Case studies are statistically weighted differently for IE and Non-IE disciplines as depicted in Table 6. Non-IE faculty weight (on average) case studies 18.2% as compared to 7.0% by IE faculty. This is an interesting discovery that deserves more in-depth analysis. Results of the weight placed on case studies also vary by class size. Small class sizes place significantly more weight on case studies 22.5% on average as compared to medium sized classes (on average 10.5%) and as compared to large sized classes (9.2% on average). Weights are not significantly different for case studies between medium and large sized classes. Considering the time required to grade case studies, it is not surprising to learn that case studies are not being used as much in medium and large sized classes. The average weight placed on pop quizzes, Table 7, has no significant difference by discipline, but does vary between small and large classes sizes. On average, large class sizes place more weight on pop quizzes (12.9%) than the small class sizes (7.5%). Perhaps large sized classes weight quizzes more heavily because they can be graded more quickly and objectively than case studies.

	Discipline		Class Size		
	IE	Non-IE	0-30	31-75	76+
Average	71.6	64.0	64.5	72.9	64.1
95% Confidence Interval	64.1 - 79.1	54.5 - 73.4	52.2 - 76.8	66.9 - 78.9	50.3 - 77.8

Table 3. Percent of Exam Weight on Final Grade

	Discipline		Class Size		
	IE	Non-IE	0-30	31-75	76+
Average	16.3	16.9	18.5	12.2	20.4
95% Confidence Interval	12.1 - 20.6	12.8 - 21.1	11.5 - 25.6	8.9 - 15.4	14.8 - 26.0

Table 4. Percent of Homework Weight on Final Grade

	Discipline		Class Size		
	IE	Non-IE	0-30	31-75	76+
Average	12.9	17.4	14.5	15.8	14.9
95% Confidence Interval	10.1 - 15.8	13.1 - 21.8	11.4 - 17.6	11.8 - 19.8	7.6 - 22.2

Table 5. Percent of Project Weight on Final Grade

	Discipline		Class Size		
	IE	Non-IE	0-30	31-75	76+
Average	7.0	18.2	22.5	10.5	9.2
95% Confidence Interval	6.0 - 8.0	15.1 - 21.3	20.6 - 24.4	10.1 - 10.9	5.2 - 13.3

Table 6. Percent of Case Study Weight on Final Grade

	Discipline		Class Size		
	IE	Non-IE	0-30	31-75	76+
Average	10.3	11.9	7.5	11.5	12.9
95% Confidence Interval	8.5 - 12.2	8.8 - 15.0	6.0 - 9.0	8.8 - 14.3	9.3 - 16.5

Table 7. Percent of Pop Quiz Weight on Final Grade

Additional Questions

Table 8 summarizes the results for the remaining questions asked on the survey. These questions also allowed the respondent to reply in an open-ended form. Responses were tallied, coded, and grouped into similar categories. Figures 2 - 8 (which will each be discussed separately) depict these results.

		Discipline		Class Size		
	Total	**IE**	**Non-IE**	**0-30**	**31-75**	**76+**
Answered YES to Graduate Students to Teach	29%	35%	19%	27%	19%	42%
Answered YES to Reworking or Redesigning	47%	48%	44%	47%	38%	50%
Answered YES to Using Groups	44%	35%	63%	53%	38%	50%
Answered YES to Using Projects	58%	48%	75%	67%	56%	50%
Answered YES to Using a Single Text	89%	100%	69%	80%	94%	92%
Answered YES to Using Supplements	44%	48%	38%	40%	38%	50%
Answered YES to Using Spreadsheets	76%	76%	75%	80%	69%	75%
Positive Comment on the State-of Engineering Economics	67%	66%	69%	53%	63%	92%
Negative Comment on the State-of Engineering Economics	38%	45%	25%	53%	31%	25%

Table 8. Additional Questions

In total, 29% of the respondents indicated that they use graduate students to teach the engineering economy course. With respect to discipline, IE's are more likely to use graduate students to teach this course. Perhaps this is because IE's teach on average 0.8 more engineering economy courses per year as compared to Non-IE's (refer to Table 1). Large class sizes are more likely to use a graduate student to teach the engineering economy course as compared to small and medium sized classes.

Nearly half (47%) of those surveyed indicated that they are reworking or addressing redesign issues regarding how engineering economy is taught in their department or institution. Figure 2 explains how this is being done. The most frequently mentioned response is that they are in some way expanding the course to include cost estimating and accounting or simply undertaking general restructuring.

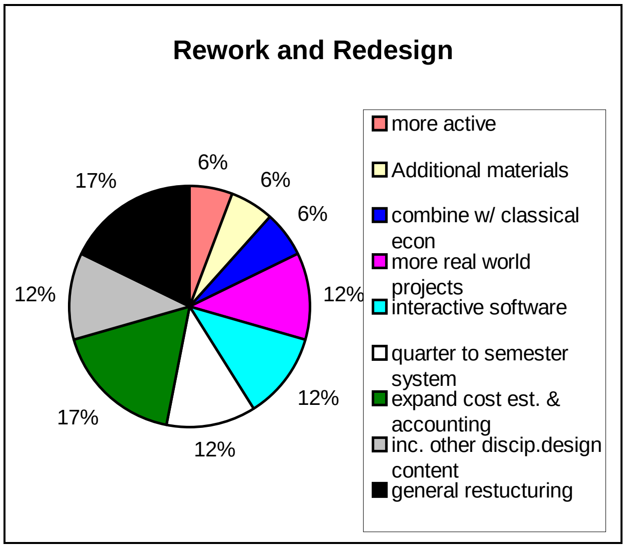

Figure 2. Response to Open-Ended Question on Rework and Redesign

When asked if groups (formal or informal) were being used as part of their class, respondents indicated "yes" 44% of the time. Non-IE faculty use groups nearly twice as often as IE faculty. Further probing into this finding is planned for future work. As depicted in Figure 3, groups are being used most frequently in the form of term projects and presentations.

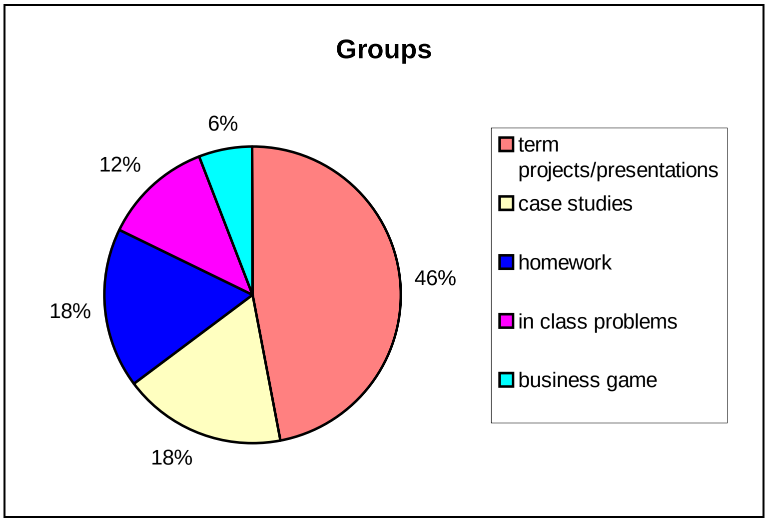

Figure 3. Response to Open-Ended Question on Groups

Projects are being used 58% of the time when teaching engineering economy courses. Non-IE faculty use projects more than one-and-one-half times as much as IE faculty. The authors plan to look into this finding more closely in future work. Use of both real world and made-up projects are the most common types of projects used as shown in Figure 4.

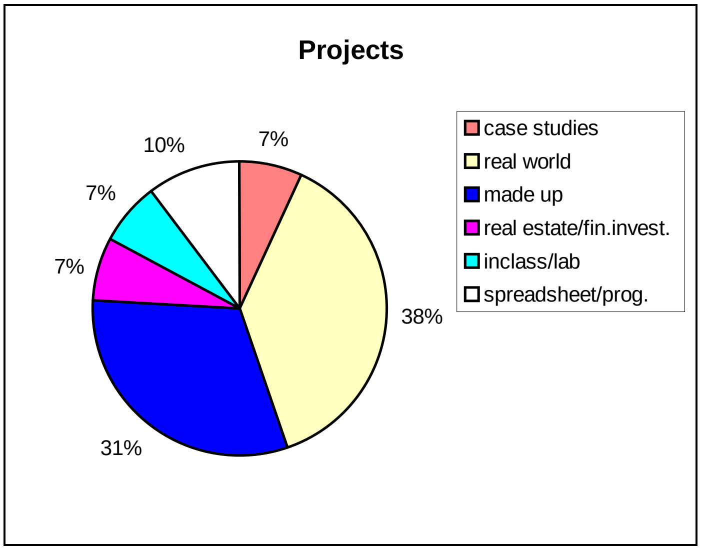

Figure 4. Response to Open-Ended Question on Projects

A single textbook is used 89% of the time by those teaching engineering economy. We surmise that this is an attempt to keep the cost low for students. In addition, there are a plethora of engineering economic textbooks on the market. Many of these texts are quite comprehensive. Several of the best texts are revised every few years to reflect new developments and future trends in the body of knowledge. Faculty do, however, supplement the single textbook with other material 44% of the time. Figure 5 reflects that class notes are most regularly used as a supplement. From a pedagogical perspective, it would seem beneficial to build a "bank" of class notes used by faculty to be shared and improved upon by all.

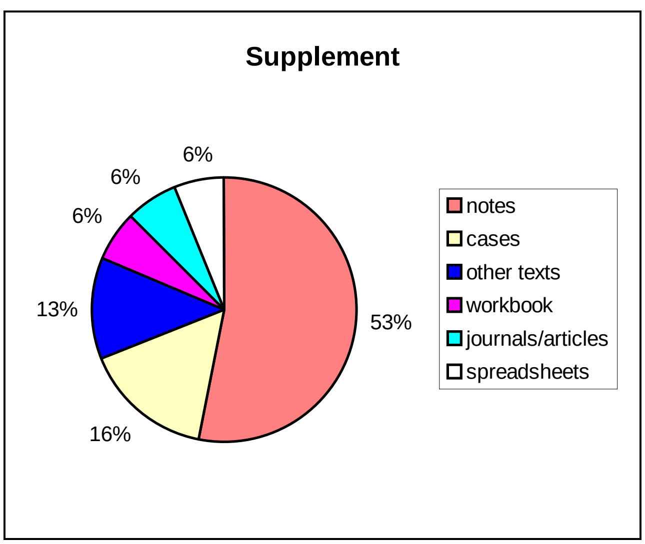

Figure 5. Response to Open-Ended Question on Supplement

Increasingly, spreadsheets are becoming a standard tool in teaching engineering economics. Software and/or spreadsheet templates are included with many of the recently published textbooks (for example refer to DeGarmo, et. al., 1997, and Park, 1997). Respondents mentioned most frequently that spreadsheets built by students are used most frequently as shown in Figure 6.

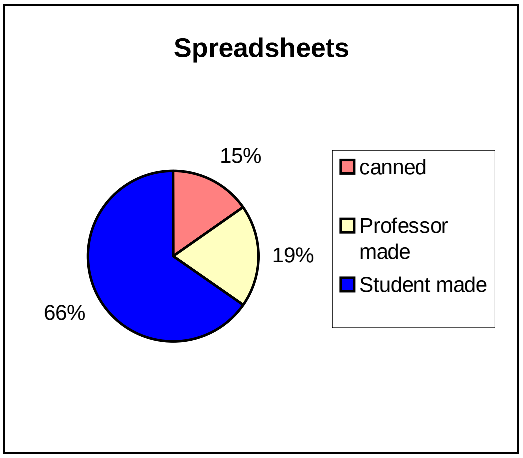

Figure 6. Response to Open-Ended Question on Spreadsheets

The final question asked the respondents to assess the state-of engineering economics as a body of knowledge. Overall, positive statements are made 67% of the time and negative comments were made 38% of the time. Note, if a respondent cited one or more positive items, we counted this as a single positive response. A similar approach was used to tally negative responses. Furthermore, a respondent could have both positive and negative responses. Thus, nearly twice as many positive statements as compared to negative statements are made with respect to the state-of engineering economics as a body of knowledge. These results are favorable when one considers that people are generally more likely to mention problems (negative comments) as opposed to successes (positive comments). On the positive side, respondents most frequently cited that engineering economy has an important/essential place in the engineering curriculum. In addition, respondents feel satisfied that the body of knowledge has reached a state of maturity and stability. In contrast, the most frequently cited negative comment is that the body of knowledge needs expanding and updating. Clearly, this inconsistency needs to be examined in greater detail. Respondents also feel that available materials are inadequate. In future work, the authors would like to examine this concern more closely. Although there are a large number of text books on engineering economics, perhaps the problems lies within the lack of integration of materials.

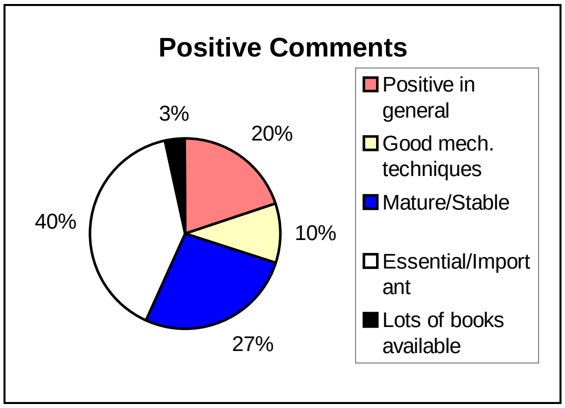

Figure 7. Response to Open-Ended Question on Positive Comments

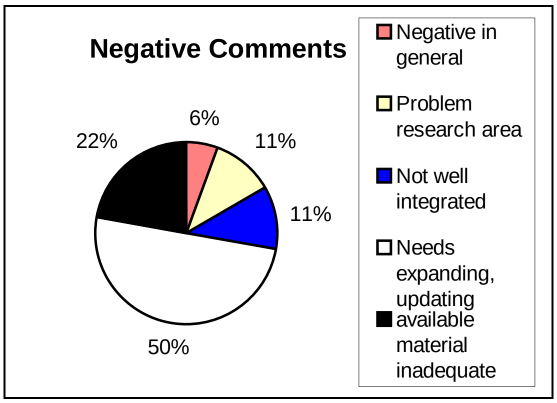

Figure 8. Response to Open-Ended Question on Negative Comments

Summary of Findings

Following is a summary of the major findings from the survey conducted to gather data regarding the ways and means in which engineering economy is taught in U.S. universities:

- Approximately 64% of the sessions of engineering economy have 30 or more students on average.
- IE faculty teach on average more sessions of engineering economy per year than Non-IE faculty.
- With respect to grade determination, exams are weighted most heavily. In addition, Non-IE faculty weight case studies more heavily as compared to IE faculty. Results on the weight placed on case studies also varied by class size. Small class sizes placed significantly more weight on case studies as compared to medium and large sized classes. And large class sizes placed more weight on pop quizzes than did small class sizes.
- IE faculty are more likely to use a graduate student to teach an engineering economy course than Non-IE faculty.
- Nearly half (47%) of those surveyed are reworking or redesigning their curriculum.

- Non-IE faculty use groups nearly twice as frequently as IE faculty as part of their class.
- Non-IE faculty use projects more than one-and-one half times as much as IE faculty.
- Only 44% of respondents indicated that they supplement the single textbook with other material.
- Respondents cited more positive than negative comments regarding the assessment of the state-of engineering economics as a body of knowledge.

Follow-up Survey and Conclusions

A more thorough understanding of the significant findings noted above needs to be obtained. For example, the authors were surprised to find that IE faculty do not incorporate some of the more popular active learning techniques (see Smith, 1989) such as groups and case studies into their engineering economy course as frequently as compared to Non-IE faculty. This needs to be investigated further. A follow-up survey with the initial survey participants will be conducted in the Spring Term of 1997 to probe into these issues as well as others. Some of the additional questions that will be asked include:

- What is your age?
- How many years have you been an educator at the college level?
- How many years have you been teaching engineering economy?
- Do you conduct research in the area of engineering economics? If so, what is your research field, and do you incorporate results from your research into your engineering economy course?
- For each discipline taking engineering economics at your institution, state whether it is a required or elective course.
- Are there other courses available to your students in the engineering economy body of knowledge?
- In general do your students report that the engineering economy course was an important class at the time the course is taken, one or more years later?
- What types of tests do you give, i.e., multiple choice, essay, quantitative?
- What textbook are you currently using and which chapters do you generally cover in this book?
- What are your biggest complaints with the currently available engineering economy textbooks?
- Is a separate/different engineering economics course taught for IE's and Non-IE's? If yes, how do these courses differ, e.g., class size, course material, grading policy, method of instruction, credit hours, etc.?
- Which, if any, of the following "new" teaching methods do you use in your engineering economics course: student advisory groups; 5-minute quizzes; turn-to-your-neighbor exercises; turning questions back to class; group problem solving; group test taking; others (list)?

The intent of this research is to identify potential pedagogical implications of the findings from the initial and follow-up surveys as they relate to increasing the efficacy of teaching engineering economy. Although these results were not available at the writing of this paper, they will be presented at the 1997 ASEE Annual Conference.

References

DeGarmo, E. P., Sullivan, W. G., Bontadelli, J. A., and Wicks, E. M. (1997). *Engineering Economy, 10th Edition*. Upper Saddle River, NJ: Prentice Hall.

Lavelle, J. P. (1996). Engineering economy: A survey of current teaching practices. *1996 American Society for Engineering Education Annual Conference Proceedings*. Washington, D.C.

Park, C. S. (1997). Contemporary Engineering Economics, 2nd Edition. Menlo Park, CA: Addison-Wesley.

Smith, K. A. (1989). "The craft of teaching cooperative learning: An active learning strategy." *1989 Frontiers in Education conference Proceedings*, pp. 188-192.

Biographical Sketches

JEROME P. LAVELLE

Jerome P. Lavelle is an Assistant Professor in the Department of Industrial & Manufacturing Systems Engineering at Kansas State University. He is currently the director of the engineering economy division and program chair for the engineering management division of ASEE. Dr. Lavelle received his Ph.D. in Industrial Engineering at North Carolina State University and previously worked at AT&T Bell Labs. His teaching/research interests are in the areas of Engineering Economy, Cost Analysis, Engineering Management and Total Quality Control.

KIM LaSCOLA NEEDY

Kim LaScola Needy is an Assistant Professor of Industrial Engineering at the University of Pittsburgh. She received her B.S. and M.S. degrees in Industrial Engineering from the University of Pittsburgh, and her Ph.D. in Industrial Engineering from Wichita State University. She has obtained nine years of industrial experience at PPG Industries and The Boeing Company. Her research interests include Activity Based Costing, TQM, Engineering Management, and Integrated Resource Management. Dr. Needy is a member of ASEE, ASEM, APICS, IEEE, IIE, SME and SWE. She is a licensed P.E. in Kansas.

HEATHER NACHTMANN UMPHRED

Heather Nachtmann Umphred is currently a graduate student in the Industrial Engineering Department at the University of Pittsburgh where she also received her B.S. in Industrial Engineering. Her research interests include Engineering Valuation and Cost Analysis and Engineering Education. She is a student member of IIE.