What Engineering Economy Offers that Can Improve the Teaching of Introductory Corporate Finance

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ABSTRACT

Both finance and engineering economy focus their introductory courses on the time value of money. Yet, in spite of this shared foundation, those courses are very different. This presentation discusses what these differences are, why they occur, and what the disciplines can offer each other. The goal is to help textbook authors and classroom teachers in each field to do a better job of learning from each other. This presentation is from the perspective of an engineering economist with over 30 years of teaching and textbook writing experience, who has recently had his world-view shifted by multiple forays into finance classrooms.

INTRODUCTION

The time value of money is the foundation of two fields—engineering economy and finance. Yet how those two fields are presented in their introductory course have a surprisingly small intersection. The basic reason is that engineering economy focuses at the project level, while introductory corporate finance focuses at the firm level. But both courses include the firm and project levels and both include applications of the time value of money to the personal lives of students. This creates the opportunity for an exchange of content, emphases, and approaches that can enrich the classrooms of both fields.

Vertical paragraph bars are used for those who want to scan the paper for the specific points where finance teaching and texts could learn from the engineering economy literature.

This paper analyzes the similarities and differences of typical finance and engineering economy (1) texts, (2) students, and (3) faculty. For example, the typical project in an introductory finance text has a five year life and uniform cash flows. In contrast, most engineering economy texts will have chapters of detailed project analysis with 20-year projects that may have different cash flows in every year. The engineering students are on average better with mathematics, tables of factors, and spreadsheets, but the finance students analyze problems more quickly by using financial calculators.

The textbook authors and classroom teachers in each field have honed their presentations to match their students, their colleagues, and their course goals. Yet they have not done a good job of learning from each other. This paper suggests some mutual lessons. It is written from the perspective of an engineering economist with over 30 years of teaching and textbook writing experience, who has recently had his world-view shifted by multiple forays into finance classrooms.

This paper is the flip side of Eschenbach [2010], which won a best paper award for describing what engineering economy professors can learn from teaching finance. Those lessons will be briefly summarized, while the lessons for finance from engineering economy are the focus of the paper.

The paper's organization starts with an overall comparison, which includes the comparison of exemplar textbooks. The next focus is the similarities between the two fields, which is followed by sections offering lessons first briefly from finance for engineering economy and then vice versa in detail. Appropriate references are included but there is no literature review, because other comparisons of the fields could not be found. The paper closes with a summary that suggests which lessons might offer the most opportunity for improvement in student understanding and capabilities.

More so than most papers, this one comes with a caveat that some conclusions are based on personal observations and anecdotal evidence. To emphasize this, the observations that seem most open to debate are presented using "I" rather than the author. The author would also like to apologize to the authors of any finance or engineering economy text that has either been omitted or inadvertently mischaracterized. While specific references are few, I have tried to include representative finance texts by the leading author teams (too many to include all) and all of the larger players in the market of engineering economy texts in comparing the approaches of the two fields.

OVERALL COMPARISON OF FIELDS

Table 1 summarizes some of the important differences in the fields, but a comparison of typical introductory texts is left for Table 2 and the next section. One of the most important differences highlighted in Table 1 is the central role of finance for the careers of both business students and faculty. While engineering economy is often cited as one of the most important courses taken by engineering students who have transitioned to industry, it is not generally the focus of a career except for a very limited number of faculty.

One consequence of the difference in scale between the two fields is that engineering economy is led by a single journal, *The Engineering Economist*, which includes pedagogy but focuses on research. There are many research journals in finance, and the Financial Education Association has *JFE* and *AFE* devoted to finance education.

In terms of importance to the content of classes, a key difference is computational tools. All engineering economy texts focus on using tabulated engineering economy factors, while most introductory finance texts seem to give a larger role to financial calculators than to tables and formulas. The finance approach is clearly defensible, as significant amounts of business valuation of bonds, stocks, and simply described projects can be analyzed with financial calculators. The focus of engineering economy on the use of tabulated factors is less defensible. As Bill Peterson [2009] observed, use of the tables rather than a spreadsheet by a practicing engineer is arguably evidence of incompetence that should cause counseling for a first offense and potentially job separation for repeat offenders.

Using calculators is faster, so students can do more examples. They allow solving real-world problems, such as how long to payoff a credit card with an APR of 14.5%. And fewer mistakes will be made. As described in Eschenbach [2010], Paul Componation of the University of Alabama in Huntsville has been tracking student errors on exams for many years. He has found a consistent level of 30% of the student errors represent transposed digits or table lookup errors of wrong row, column, or page. These arithmetic errors are related to the number of items

Table 1. Summary of differences between engineering economy and finance

	Engineering Economy	Finance
Course focus	Project	Firm
Students		
Degree of emphasis	One course or less	Ranging from 1 course to major & focus of future job
Average mathematical ability	High	Low to moderate
Principal computational tool	Tables & spreadsheets	Financial calculator
Faculty		
Academic background in field	1 or 2 graduate courses	Major for 1 or 2 degrees
Research background	46% of faculty teaching engr. econ. report doing research in engr. econ. (56% for IE & 30% for non-IE) [Needy, et al]	Focus on finance is a given

that must be entered in the calculator, so use of TVM calculators should reduce the number of errors. Students will still sometimes enter incorrect values, but if doing more problems has improved their understanding, we can hope that they'll be more likely to catch some of the errors.

As a direct consequence of the author's experiences in teaching finance, the new edition of Eschenbach [2011] and the forthcoming edition of Newnan, Eschenbach, and Lavelle [2012] are the first two engineering economy texts to include TVM (time value of money) calculators (done as the appendix preceding the tabulated factors). My goal is to eliminate the tables in some future edition.

This comparison leads to the first suggestion for improving the teaching of finance. If it is time for the more mathematically sophisticated engineering students to shift to TVM calculators, then perhaps it is time for the finance texts to drop the tables and all formulas except the basic compounding of a present amount.

COMPARING EXEMPLAR TEXTS

Selecting Newnan, Lavelle, and Eschenbach [2009] as the engineering economy text for Table 2 was relatively easy, as the Newnan text has been the market leader for nearly 20 years. Because Hamilton and Saunders [2009] noted that 39% of the finance faculty used some form of a Brigham textbook and 33% used some form of Ross, Westerfield, and Jordan, texts by those authors were used as exemplars for the comparison. The Besley and Brigham [2008] text in Table 2 was chosen because of the leading role Brigham plays in financial textbooks, because of this text's stature as a 14^{th} edition, and because I wanted the familiarity that comes from teaching out of a text. For comparison of the tabulated factors, Ross, Westerfield, and Jordan [2008] is also included. These observations are consistent with my experiences with the two editions of Megginson and Smart [2006 & 2008] that I have taught out of and others that I have examined.

The exemplar finance text is topically more comprehensive than the exemplar engineering economy text; however, the engineering economy text has much more detailed models of what are the economics of a project. The larger number of problems for the

Table 2. Comparison of example texts

	Engineering Economy Newnan, et al. 2009	Finance Besley & Brigham 2008
Text length, revision cycle, # colors, list price	636 pages, 3 years, 2-color, $110	857 pages, 3 years, 4-color, $214
Average number per chapter of End-of-chapter problems Figures Tables	 57.5 5.5 1.5	 22.4 (also 11.4 questions) 4.2 3.2
Chapters on interest rate	Ch. 15 Selecting MARR	Ch. 5 Interest rates Ch. 8 Risk & rates of return Ch. 11 Cost of capital
Chapters on project analysis	Ch. 5 – 8, 10, 12, 13, 16	Ch. 10 Project cash flows
Text chapters often skipped	Ch. 10 Uncertainty	Ch. 14 Working capital Ch. 15 Short-term assets Ch. 16 Short-term liabilities Ch. 17 Planning & control Ch. 18 Corp. restructuring
Pages of interest rate tables	32	0 8 (Ross, Westerfield, & Jordan 2008)

engineering economy text suggests that more problems are likely to be assigned, which matches the conventional wisdom on engineering and business courses.

While only anecdotal, comparing my past course assignment lists for engineering economy and finance show an average of 10.5 problems per week in engineering economy vs. 5.4 problems in finance. In general, I assign and collect slightly more homework than the average professor in engineering at my university. However, I assign and collect MUCH more homework than the average professor in business at my university.

The topic of depreciation is an interesting example of the dichotomy between finance and engineering economy. All engineering economy texts cover both MACRS and historical methods of depreciation, and surveys indicate that most faculty cover both in detail. Much to my surprise, MACRS was appendix material in my finance text. And to my further surprise, 63% of the students in my finance course had not been exposed to MACRS in either of the two prerequisite accounting courses. Obviously for accurate models of after-tax project cash flows, MACRS is required material.

A broader comparison of each field's texts and summaries of their pedagogy suggests the following points.

- Comparing texts within each field shows a high degree of commonality of topics [Cooley & Heck, 1996]. The differences are principally sequencing and depth of coverage for particular topics. This similarity extends to "conventional wisdom" on particular topics, such as IRR within finance texts and EAW within engineering economy texts.
- While not consistent across all texts, each field seems to exhibit a slight tendency to slim texts down. This could be focused on reducing costs, better matching text coverage to average course coverage, or perhaps even conjectured declines in average levels of student preparation and capabilities.

- While most engineering economy texts clearly include spreadsheets as an integral part, they also clearly focus on tabulated factors over spreadsheets. Spreadsheets are part of most engineering economy courses [Nachtmann et. al., 2008], (about 75% by 1998) [Needy et. al., 2000]. Similarly, the finance texts include spreadsheets, but financial calculators are the principally used tool. However 53% of the faculty also use spreadsheets in the undergraduate course [Hamilton & Saunders, 2009]. While spreadsheets are part of teaching in both fields, they are not generally the dominant approach in the introductory course.
- Both courses are typically delivered as lectures and grading relies heavily on in-class exams [Cooley & Heck, 1996] and [Needy et. al., 2000].

LESSONS FROM FINANCE

These are detailed in Eschenbach [2010], but only summarized here, since I expect these to be relatively obvious to an audience of finance faculty.

- A common structure for valuing bonds, stocks, projects, and firms helps students develop understanding.
- The use of calculators is matched to many of the simplified problems for which engineers use tables. Using such calculators allows students to solve many more problems.
- The valuing of bonds and stocks is also the foundation for personal investing by students.
- At a macro level risk is fundamental, cannot be avoided, and must be included for decision making.
- The capital asset pricing model (CAPM) and the security market line (even with problems in statistical validation) are central to the business community's view of the link between risk and reward.
- A clear view that equivalent annual worth (if mentioned at all) is fundamentally for mutually exclusive alternatives, which receive much less attention than independent projects.
- Financial options may be omitted, placed as a late chapter, or placed on a CD only chapter. Real options are included in about half of the texts checked (5 of 11), generally in longer texts not Essentials. In contrast many engineering economy texts seem to be seeing some pressure to add financial and real option material.
- The finance text's reliance on simple projects with uniform cash flows and 5 year horizons contains an implicit message that projects that require longer lives to be economically justified are likely to face challenges in garnering executive support. This may suggest that the many engineering economy examples that require a 20 year life may not be realistic for much of industry, although clearly more justified in a public agency context.

Even after authoring several engineering economy texts and taking at least one capital budgeting and finance course, I'll confess that I did not understand until I taught introductory finance the central role of systematic versus non-systematic risk. In theory the non-systematic risk of a project should play at most a small role for firms and no role for diversified investors, versus the fraction that is systematic risk potentially linked with a firm's β. However that said, the author confesses to befuddlement as to how to in general separate a project's total risk into systematic and non-systematic pieces.

Of course, for the many engineering economy courses that skip their text's single chapter on uncertainty, the question of risk is much more likely to be handled qualitatively. Given the greater mathematical ability of the average engineering student, this would seem be an opportunity for improvement in at least some engineering economy courses.

If personal investing and TVM functions for financial or scientific calculators are part of an engineering economy course, then modeling of bonds, stocks, and simple project models are mutually reinforcing topics where students can solve large numbers of problems in class and on their own. This is clearly supportive of an intuitive and complete understanding by students, which can be developed further through more realistic spreadsheet models for the greater detail associated with engineering projects.

LESSONS FROM ENGINEERING ECONOMY

Like the last section, let us organize with a simple bullet list of the lessons. However, these will be discussed in more detail

- Real project evaluations often require a long-term view (not 5 years) and estimation of non-uniform cash flows, such as arithmetic and more often geometric gradients. For these problems detailed cash flow tables are best built and analyzed with spreadsheets. Examples like these are not often found in introductory finance texts.

  Given the expectation that practicing managers will be using spreadsheets, shouldn't the only finance course that many students take use spreadsheets extensively—at least for modeling non-uniform project cash flows.
- One important set of non-uniform cash flows that is given cursory treatment in the reviewed texts is the tax impact of MACRS. Analyzing projects with MACRS should be done with spreadsheets, which would reinforce the first point.

  Using MACRS rather than straight-line depreciation for taxes matches the law and normal corporate practice. It can also increase the PW of the write-off by more than 50% [Eschenbach, 2011, p. 337]. Including other realistic possibilities like Section 179 and 50% bonus first year depreciation can double the PW of the write-off. Examples and topics like these are common in engineering economy texts—even though the students have typically never studied depreciation or corporate taxes before the course.
- PW and IRR have the same reinvestment assumptions, unlike the conclusion suggested by the title of a presentation at this conference [Walker, Check, & Randall, 2010].
- Challenger/defender incremental analysis is the correct response to the "Fisher intersection" problem for IRR or benefit/cost ratio evaluation of mutually exclusive alternatives, rather than saying IRR and benefit/cost are fundamentally flawed and incorrect measures. This is properly done in every engineering economy text that I know of; it is also improperly described in most introductory finance texts that I've reviewed as one of the reasons to prefer PW to IRR. Note that this reasoning is also applied to the comparison of independent projects that are not mutually exclusive, where the Fisher intersection problem doesn't even arise.

  If the Fisher's intersection material is covered, then the correct conclusion is that, "this is why incremental analysis is required to use IRR for mutually exclusive alternatives." Certainly PW is easier, but for mutually exclusive alternatives, PW's common challenge is that the lives don't match and then equivalent annual measures are easier. No finance text that I've reviewed has more than cursory coverage of this issue.
- Engineering economy texts typically treat the double-root problem for IRR as an advanced topic that many intro courses omit (appendix not in main flow of text). This is clearly preferable to the silly examples included within some finance texts. No real mine is opened

with a $150M investment at time 0, shows a profit of $300M in year 1, and is cleaned up for $160M in year 2.

Research by Eschenbach, Whittaker, and Baker [2008] has analyzed more realistic environmental remediation problems modeled with an initial cost, a series of uniform net receipts, and a final cleanup cost. Results show that a double positive root for the IRR only exists when the final remediation cost is a significant multiple of the first cost, that small changes in the data result in no interest rate having a PW>0, and that the problem is in the cash flows not in the IRR measure.

- I believe that the typical emphasis on the Fisher intersection problem and the double root possibilities with IRR is part of finance texts as arguments for using PW over IRR, rather than to really develop student understanding of the topics. I suggest that it would be more productive to simply relax and acknowledge that both PW and IRR are typically used in industry. There are good reasons for the popularity of the IRR measure in practice. If nothing else, it allows characterization of a project's value with a single number. Where the PW typically takes three numbers—the PW, the interest rate, and the initial investment. Is that PW of $48,000 at 15% for an initial investment of $100,000 or a $100 million.
- Engineering economy texts typically include a chapter on public sector applications. While corporate finance is intrinsically private sector, I know that a significant number of business students in my finance classes will end up working in government agencies, non-profit hospitals, etc. Others will work in private sector firms that focus on clients in the public and non-profit sectors. I wish that the finance texts that I'm choosing from offered a chapter focused on the differences in financial analysis for these sectors.

  Note: my engineering economy lecture title is "Public Sector Engineering Economy is for Heroes," and it focuses on the multiple objectives, longer time frames, difficulties in benefit estimation, and conflicts in stakeholder perspectives that are common in public sector applications.
- Engineering economy and finance texts seem to typically make different assumptions about what the interest rate is. In engineering economy texts the interest rate is almost always a real rate of return (except for the chapter on inflation), while in finance texts the interest rate is almost always a market rate of return.

  Both texts also typically describe cash flows as a uniform series. Such a uniform series is believable as a constant-$ estimate of energy costs, savings in operating costs, or revenue. If inflation is included in the costs or benefit estimation, then there will typically be a geometric gradient due to inflation—not uniform cash flows.

  The combined assumptions in engineering economy are congruent (real interest rates & uniform constant-$ cash flows). However, the combined assumptions in finance conflict. Market interest rates must be used with cash flows that are inflated—and those cash flow estimates will not be uniform.

Of these items. two are conceptual errors in many texts: Fisher's intersection and inconsistent inflation assumptions for cash flows and interest rates. Academically these are serious flaws. However, the focus on uniform cash flows is more troubling when the future use of the material by students is considered.

I believe that relying on calculators and spreadsheets even more would permit the inclusion of this material to a course that is already very full. I'm currently using a custom publishing edition that includes 14 of 18 chapters from an abridged edition, as that represents how much I can fit into my course and it reduces the text cost to my students.

Dropping double roots rather than covering it badly, and even possibly dropping Fisher's intersection since it only applies to mutually exclusive alternatives would also open up possibilities for other coverage.

SUMMARY AND CONCLUSIONS

As the title of this paper suggests, I believe experienced professors of finance and the authors of finance texts could improve their offerings by considering how some topics are taught in engineering economy. While the lessons for engineering economy from finance are larger, the sheer number of finance students ensures that any improvements in finance instruction will have more impact on the world. I believe both groups of instructors have the opportunity to improve their courses by teaching the time value of money from another perspective. I hope that this paper can help those who won't have the opportunity to do so, and perhaps provide a head start for those that can.

If you teach at a university that has both business and engineering perhaps you can convince the instructor of engineering economy to switch classrooms with you. I suggest that both of you will return to your home classrooms with a broader perspective on the time value of money, and that both groups of students will benefit in the long-term.

Unfortunately, this requires time taken away from research, because you will need new knowledge and you will have to adjust your teaching.

I know that the next time I teach engineering economy, I'll be

- Having students use financial calculators or equivalent TVM capabilities on their engineering calculators,
- Covering risk differently,
- Skipping or minimizing my coverage of arithmetic gradients,
- Using bonds, stocks, and projects for a unified conceptual approach to evaluation that students can link to their future lives, and
- Relying on spreadsheets even more.

This semester as I teach introductory corporate finance, I'll be

- Emphasizing that students should use their calculators, and not the formulas or tabulated factors. Note: because my classes emphasize the use of student response units (clickers), students solve many more problems in class than before I switched to clickers from examples.
- Correcting my text's coverage of double roots, Fisher's intersection, and combined assumptions for inflation.
- Talking about IRR and the opportunity cost of capital in the context of capital budgeting.
- Including spreadsheets for both simple and complex problems.
- Wishing that I had an introductory chapter on financial decision-making in government agencies and non-profits.

REFERENCES

Besley, S., and E. F. Brigham, *Essentials of Managerial Finance 14th*, South-Western, (2008).

Componation, P., University of Alabama in Huntsville, personal communication, (March 2010).

Cooley, P. L., and J. L. Heck, "Establishing Benchmarks for Teaching the Undergraduate Introductory Course in Financial Management," *Journal of Financial Education*, Vol. 22, (Fall 1996), . 1–10.

Eschenbach, T. G. “Why Engineering Economy Professors Should Teach Introductory Corporate Finance,” *Proceedings of 2010 ASEE Conference*, Louisville, CD (Best Paper Award for Engineering Economy Division) (June 2010).

Eschenbach, T. G., *Engineering Economy: Applying Theory to Practice 3rd*, Oxford University Press, (2011) (printed August 2010).

Hamilton, J., and K. T. Saunders, “An Update of Teaching Methods and Evaluation in the Introductory Finance Classroom,” *Advances in Financial Education*, Vol. 7, (Summer & Winter 2009), pp. 86–100.

Megginson, W. L., and S. B. Smart, *Introduction to Corporate Finance*, Thomson South-Western, 2006.

Megginson, W. L., and S. B. Smart, *Introduction to Corporate Finance 2nd Abridged Ed*, Thomson South-Western, 2008.

Nachtmann, H., K. LaScola Needy, J. P. Lavelle, and T. G. Eschenbach, “How Do Engineering Managers Teach Engineering Economy?” *Proceedings of the 2008 ASEM National Conference*, West Point, (November 2008), CD.

Needy, K. LaScola, H. Nachtmann, J. P. Lavelle, and T. G. Eschenbach, “An Empirical Analysis of Engineering Economy Pedagogy,” *The Engineering Economist*, Vol. 45 No. 1, (2000), 74–92.

Newnan, D. G., J. P. Lavelle, and T. G. Eschenbach, *Engineering Economic Analysis 10th*, Oxford University Press, (2009).

Newnan, D. G., T. G. Eschenbach, and J. P. Lavelle, *Engineering Economic Analysis 11th*, Oxford University Press, (2012 in press).

Peterson, W. R., “Spreadsheets as the Primary Means of Engineering Economy Education,” *Proceedings of the 2009 IERC National Conference*, Miami, (June 2009), abstract on CD.

Ross, S. A., R. W. Westerfield, and B. D. Jordan, *Essentials of Corporate Finance 6th*, McGraw-Hill, 2008.

Saunders, K. T., “Teaching Methods and Assessment Techniques for the Undergraduate Introductory Finance Course: A National Survey,” *Journal of Applied Finance*, Vol. 11, No. 1, (Fall 2001), 110–112, (unabridged version accessed at http://facultyweb.anderson.edu as saundersfpe.doc March 1, 2001)

Walker, J. S., H. F. Check, Jr., and K. L. Randall, "Does the Internal Rate of Return Calculation Require a Reinvestment Rate Assumption? There is Still No Consensus," ABE/FEA 11th Annual Conference, San Antonio, (Sept. 2010).