

Personal Finance Coverage in Engineering Economy Courses

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Abstract

This paper addresses several questions about using personal finance topics in teaching engineering economics. Should personal finance materials be intentionally designed into an engineering economy course? What topics have been and are included in texts? What could be included? What do students think about including these topics—with new survey results? What do we believe should be included and why.

Introduction

What personal finance topics are covered in engineering economy courses and texts? At one level almost every text and course includes some personal finance in the savings and borrowing examples and problems that are part of teaching basic time value of money relationships. Our focus is on *published* material that goes beyond this level. Published material can be examined, referenced, and re-examined by others. Thus it is the basis for our assessment of what has been and is being included. From conversations at conferences we do know that personal finance topics are mentioned most frequently as what instructors add to their courses.

Why are we asking what should be included? Far too often, engineering economy is the only engineering course that covers money. Far too often students have already made bad or questionable economic decisions. We also know that future success or failure is linked between personal and professional realms. Thus, we suggest that in some cases there might even be a moral obligation to include more personal finance coverage in engineering economy courses and texts.

This paper is organized as follows.

- The literature review focuses on articles, papers, and texts as the best available way to gauge the level of current practice.
- Because we believe that one reason to include personal finance topics is student interest and motivation, the next section describes results from a student survey and after-class evaluations.
- We describe why personal finance is important. For example, we believe that shifts in how retirement is funded and the seemingly ever increasing level of student debt have created the need to better educate future engineers about personal finance.
- Examples of how personal finance could be integrated with current topics in engineering economy courses are presented next.
- There are also potential links between the technology that is used to teach engineering economy and covering personal finance.
- Our conclusion is that more coverage of personal finance is possible, desirable, and perhaps necessary.

Literature Review

We have examined the last decade of *The Engineering Economist* and proceedings from the engineering economy divisions of ASEE and ISERC and found no papers on personal finance as a topical area. We searched more deeply within the ASEE proceedings, because those papers focus on education and because presentation-only talks are rare. From 1996 to 2016 there were 33 papers on peer.asee.org searched under a “personal finance” search, but only 6 are identified with the engineering economy division—none focus on personal finance. Mutter (2011) is on pen-based tablet technology. Wick, Lynch, and Kauffmann (2014) is on using engineering economy as a general education course. Ghanat et al. (2015) is on active learning. Lynch, Bober, and Wilck (2015) is on business expertise. Yamayee, Takallou, and Albright (2015) is on using engineering economy as a benchmark course for continuous improvement. Lynch, Wilck, and Ashour (2016) is on engineering economy as the crossroads for business, engineering, and entrepreneurship.

We have identified papers about specific personal finance topics. These include Reifschneider (2011) on residential renewable energy, Creese (2013) on traditional loans, two on social security by Eschenbach, Lewis, and Zhang (2012) and Lewis and Eschenbach (2013), and Eschenbach and Lewis (2015) on investing for retirement.

Engineering Economy Historical Perspective: From an historical perspective, many contributors have added to the content, perspectives, and methods which make up engineering economy’s *Body of Knowledge*. Nearly a century after the first text was written, realistically only books can be used for early references. All of the following books are focused on business applications.

Engineering economy as a discipline often maps its roots to Wellington (1887). Fish (1923) was the first text. Interestingly one of his observations is close to modern engineering teaching outside of the engineering economy course. In the forward of his first edition he notes on the education of an engineer, “...he may have seen hundreds of books on principles of design and his time is largely employed in studying these principles and their application, [however] he has not seen one book devoted to the principles which underlie economic judgement...” Grant (1930) had 23 chapters ranged from the basics of tabulated factors through load factors, replacement analysis, and capacity planning to the type of enterprise, financing, forecasting, extreme conditions, and social implications. Its coverage of the human element is business focused.

Another important text was Woods and DeGarmo (1942) which has evolved into today’s text by William Sullivan et al. The text’s topical coverage was more limited than Grant’s but with more explanation—and still with more advanced topics than most of today’s texts. H.G. Thuesen (1950) added a functional system for interest factors along with the “given x find y ” language that is still used today. Early editions of both texts were focused on topics and examples for businesses and the public sector—not toward individual engineers and *certainly not students*. Note that J.G. Thuesen and Sullivan (1999) is an interesting review of engineering economy’s history by the lead authors of later editions of these two titles.

Personal finance topics in more recent textbooks: Our assessment of the inclusion of personal finance topics in engineering economy textbooks in the 1970s through the mid-1990s is summarized in Table 1. That time period was chosen because it seems to have the largest numbers of titles with a broader variety of chosen coverage. Most currently available texts are later editions of these titles.

From Table 1 it is clear that as a group, undergraduate textbooks in engineering economics have not made the inclusion of personal finance topics a priority. In most texts, problems and examples on personal finance were limited to basic time-value-of-money concepts with loans, savings accounts, etc. One exception was Newnan (1976) which had many examples and problems framed for you, a student, or a young engineer. It also included personal income taxes, which were included by nearly 40% of the texts in Table 1. Note that coverage of personal income taxes in some cases was limited to one-year calculations with no time value of money.

Personal finance was covered in the most detail by Collier and Ledbetter (1982), which had chapters devoted to personal finance topics. For example, its Chapter 18 was on home ownership, mortgage financing, and comparisons with renting.

Because the focus of this paper is on engineering economy courses rather than the smaller number of current texts, we have chosen not to develop a table with details of today's texts. We will note however that White, Case, and Pratt (2012)'s third chapter is on borrowing, lending, and investing. The personal finance material in the 12th edition of Newnan's text is similar to the 1st edition. The only significant content additions were brief sections on student loans and retirement accounts. However, the 13th edition by Newnan, Eschenbach, Lavelle, and Lewis (2017) has been heavily influenced by our work on this topic. Other current texts are similar to most texts in Table 1—personal finance focuses on the time value of money for saving, loan payments, and retirement funds.

Student Survey on Personal Finance in Engineering Economy Courses

To gain an initial understanding of students' assessment of personal finance in engineering economy courses an anonymous voluntary Qualtric survey was conducted. The results reported in Table 2 are from undergraduate students who are or were in one of the co-author's undergraduate engineering economy sections over the past two years.

These results are from classes where there was *no formal discussion of personal finance as an organized set of materials*. Table 2 provides the detailed results and Table 3 summarizes them.

Table 1. Personal finance topics in selected engineering economy textbooks, 1970's-90's

Author	Title	Publisher	Year	Personal Finance in the Text				
				Exp. Topics	HW Probs	Bonds	Personal Taxes	Personal Finance Content Beyond Basic TVM
Canada	<i>Intermediate Economic Analysis for Management and Engineering</i>	McGraw-Hill	1971	few	few	valuation & mechanics	no	none
Smith	<i>Engineering Economy: Analysis of Capital Expenditures, 2nd</i>	Iowa State University Press	1973	no	limited	no	yes	none
Tarquin and Blank	<i>Engineering Economy: A Behavior Approach</i>	McGraw-Hill	1976	Some limited	few	yes	no	Ch. 13: bonds—classifications, terminology, interest, PW calc., ROR, solved examples
Newnan	<i>Engineering Economic Analysis</i>	Engineering Press	1976	many	many	valuation	yes	Many problems & examples framed as a personal situation.
Collier and Ledbetter	<i>Engineering Cost Analysis</i>	Harper & Row	1982	few	few	ratings, mechanics, buying/selling	yes	Ch. 17: bonds (mechanics); Ch. 18: Home Ownership and Mortgage Fin., Owning Vs Renting Ch. 19 Investment Prop (land and real estate, taxes, rental rates, return)
DeGarmo, Sullivan, & Canada	<i>Engineering Economy, 7th</i>	McMillan	1984	few	few	valuation & mechanics	no	none
Fleischer	<i>Engineering Economy</i>	PWS	1984	no	few	mechanics	no	none
Riggs and West	<i>Essentials of Engineering Economy, 2nd</i>	McGraw-Hill	1986	few	few	valuation & mechanics	no	none
Cassimatis	<i>A Concise Introduction to Engineering Economics</i>	Unwin-Hyman	1988	no	very few	no	no	none
Thuesen and Fabrycky	<i>Engineering Economy, 7th</i>	Prentice-Hall	1989	few	few	type, mechanics	yes	none
White, Agee, & Case	<i>Principles of Engineering Economic Analysis, 3rd</i>	Wiley	1989	limited	some	valuation	no	Sec. 3.11: bonds
Grant, Ireson, Leavenworth	<i>Principles of Engineering Economy, 8th</i>	Wiley	1990	limited	moderate	yield, valuation	yes	none
Steiner	<i>Engineering Economic Principles</i>	McGraw-Hill	1992	few	some		no	Ch. 13: Loans—criteria, unequal terms, tax effects, inflation, collateral
Lang and Merino	<i>The Selection Process for Capital Projects</i>	Wiley	1993	few	few	no	no	none
Eschenbach	<i>Engineering Economy: Applying Theory to Prac.</i>	Irwin	1995	few	some	example, IRR	yes	none
Park	<i>Contemporary Engineering Economics, 2</i>	Addison Wesley	1997	some	some	valuation, finance, & mechanics	no	none

Table 2. Student survey results (n = 116 all students answered every question)

<p>This anonymous survey is designed to assess your opinion of your learning in the Engineering Economy course that you took, and the use of personal finance examples, assignments and content. Personal finance refers to the financial decisions that students face as persons, versus as working engineers. As an example, below are two equivalent questions both of which teach/test finding the future worth of a present investment:</p>		
<p><u>Personal Finance Orientation:</u> An engineer inherits \$10,000 on graduation day, and invests it in an account that earns 2% per year. How much will they have in this account to help with a down payment on a house in 6 years?</p>		
<p><u>Engineer/firm Orientation:</u> ABC Inc. invests \$10,000 for an equipment purchase in 6 quarters. What is the maximum amount they can pay for the equipment if their investment interest is 2% per quarter?</p>		
<p>Questions 1 and 2 used the following five-point Likert scale: 1 = Strongly disagree; 2= Disagree, 3= Neither agree nor disagree, 4= Agree, 5= Strongly agree</p>		
Question 1: If personal finance were intentionally designed into my engineering economy class, I would...	Mean	SD
...be more excited about the course and material than if not included	3.91	0.97
...be more engaged in the learning process than if not included	3.86	0.92
...retain the material longer than if not included	3.82	1.01
...enjoy this class and material more than if not included	3.79	1.02
Question 2: I would be interested in having my instructor include the following in this course....		
...how personal loans/mortgages work	4.41	0.67
...student loans and grants, options and paying them off	4.21	0.90
...buying versus leasing a car	4.22	0.95
...renting an apartment versus purchasing a home	4.29	0.81
...saving for retirement	4.41	0.72
...how insurance works	4.49	0.65
...basics of personal budgeting	4.31	0.79
Question 3: How familiar are you with investing?		
	n	%
Never studied	33	28.4
Some study	47	40.5
Some real world	10	8.6
Some of both	23	19.8
Experienced investor	3	2.6
Question 4: How familiar are you with demonstrating the value of diversifying your investments?		
	n	%
Diversification is a new concept to me	30	25.9
I knew diversification is good; less clear about why	43	37.1
This was covered in a previous classes	12	10.3
I learned this in the real world	23	19.8
I learned this in other classes and the real world	8	6.9
Question 5: Investing should be part of an engineering economy course?		
	n	%
Definitely yes	64	55.2
Probably yes	45	38.8
Doesn't matter to me	5	4.3
Probably not	2	1.7
Definitely no	0	0.0

Table 3. Personal finance (PF) survey summary

Question	Assessment goal of question	Summary of results
1	Measure elements of student behavior and attitude	Students would be mildly more excited about, engaged in, and overall enjoy the course more if PF topics are included in a structured way. They also report that they would retain the material longer.
2	Determine relative desire to include specific PF topics	Average responses above 4.00 show a strong desire by students to include the topics. Understanding insurance had the highest average rating.
3	Measure experience with investing	Less than 25% of the students were experienced or had both study and some real world knowledge.
4	Measure understanding of diversification	To a quarter of the students diversification was a foreign concept, another 37.1% had little understanding.
5	Measure direct desire to include PF in course	94% of students supported including PF in teaching engineering economy—55.2% answered definitely yes and 38.8% probably yes

Why is Personal Finance Important in Engineering Economy?

One might argue that the teaching of engineering economics should include content, exams, problems and contexts exclusive to the domain of the working engineer. Are we not educating engineers to “hit the ground running” with specific skills necessary to solve the types of problems that they will face in the working world? In this paper we propose that the teaching and *learning* of engineering economics can be amplified when personal finance topics are included structurally in the syllabus.

Student interest in the material they are studying, their motivation toward the subject, and learning are linked in important ways (Schiefele, 1991). In addition, students learn materials by generating self-explanations (Chi et al., 1989). We propose that including personal finance topics in the teaching of engineering economy can improve learning. For example, a student using time value of money concepts and calculations for saving and borrowing scenarios with a bank would be more interested, more motivated, and generate an alternate learning model for these concepts than had the material been framed to them solely in an engineering context.

More than ever before, students need to understand personal finance. The student loan crisis has increased the debt load on many new engineers. Changing retirement plans have forced even young engineers to take on the risk of investing for their own retirement, usually without any coursework on investment terms and methods. Questionable practices by many companies mean many engineers must understand loans, savings, mortgages, and other financial dealings. We have seen many instances where advertised costs do not translate to final costs, or where loan amounts are manipulated to include hidden fees or added interest. Mortgage lenders have been known to unlawfully demand high escrow balances in order to reap additional interest. The only

course where most engineering students get any information related to personal finance is engineering economy. We as instructors need to be mindful of that fact.

Engineers tend to have a lower percentage of their college costs paid with borrowing than people with other majors, and they are better positioned to pay off their loans. Even so, many engineering students and recent graduates can be described by the following statistics. Student loan debt is now over \$1 trillion, and is the second largest form of consumer debt (after home mortgages) (Kaplan-Leiserson, 2013). Nearly 40% of borrowers are in default or late on student loan payments (Hiltonsmith, 2017). Managing student debt starts with understanding loans and the time value of money as applied to personal finances. Understanding federal tax deductions and credits for college expenses, as well as student loan interest deductions, can help a person manage the loan burden.

Since 1980, there has been a strong trend away from both private and public employers offering defined benefit pensions, moving instead toward defined contribution programs (Eschenbach and Lewis, 2015). The shift in defined benefit and defined contribution plans among the Fortune 500 companies is shown in Figure 1 (McFarland, 2016). New employees must manage their own retirement plans, and many new engineers will need to make important investment decisions when (or shortly after) starting full time employment. Employers usually do not offer the background needed to make informed investment decisions.

While topics such as personal taxes, managing loans, and making long term investment decisions may not be core topics of engineering economy, most students will have exposure to the underlying principles (such as time value of money) only in this course. We believe we have a duty to our students to provide the information and help them translate those skills to the personal finance realm. While engineering economy courses are usually very full of important topics, personal finance can be used as examples, and additional reference material can be provided in our courses.

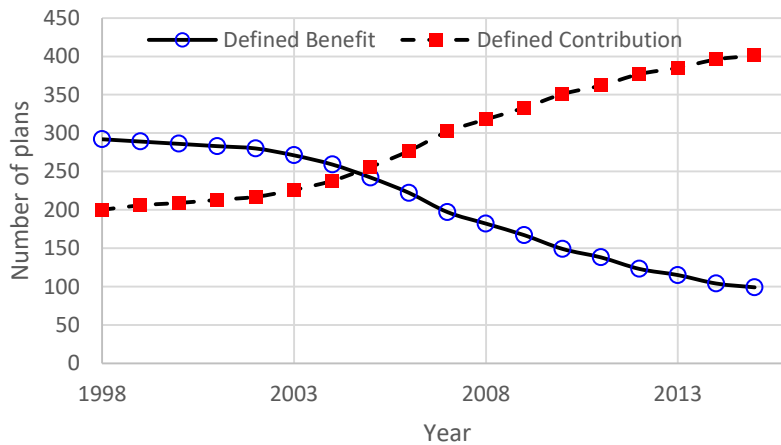


Figure 1. Defined Benefit and Defined Contribution Trends, Fortune 500 Companies

Personal Finance Topics That Could be Included

A Mapping of Topics Textbook and Personal Finance Topics: In an effort to provide guidance on the potential inclusion of personal finance topics in the teaching of engineering economics a mapping was created as in Table 4. This table shows that personal finance topics are applicable and plentiful across the span of the engineering economy *Body of Knowledge*. Instructors are only limited by their imagination as it relates to choosing meaningful examples across the syllabus.

Table 4. Mapping standard engineering economy and potential personal finance topics

Engineering Economy Topics	Personal Finance Example
Cash flow diagrams	Student loan
Cash flow equivalencies -Present worth -Future equivalent -Annual equivalent	Lottery Long-term cost of current spending & lifestyle choices Affordability of a car
Decision models -Equivalent worth (PW, FW, AW) -Rate of return (IRR, ERR, MIRR) -Payback period (Simple, Discounted)	Comparing purchase vs. leasing a car True interest on a loan with points, add-on interest, or an available cash discount Installing solar panels on your house
Income taxes	Student loan interest; education credits
Estimating cash flows	Choosing car insurance deductible
Risk and uncertainty	Choosing a retirement plan/mutual fund
Accounting and engineering economy	Monthly budget, quarterly financial status
Replacement analysis	How long to keep a vehicle and replacement choices
Selecting an interest rate	Based on credit card, loan, or investment rate vs. opportunity cost

Finance Topics That We Believe Should be Included

Whereas in Table 4 we illustrated the type of personal finance examples that *could* be included across the engineering economy syllabus, here we propose what *should* be included. In teaching engineering economy it is easy to recognize that various forms of debt, including simple loans, savings accounts, and mortgages are essential examples of time value of money principles. And nearly all textbooks cover these, as is appropriate. Taking these principles one step further leads to topics such as investments, including bonds, treasury bills, and equities. Bonds are well described in our textbooks, but the treatment of equities is almost non-existent. While class testing various material, we were surprised at the strong level of student interest in investments and portfolios; they quickly understood the need, and were hungry for information. We believe that these topics need to be covered in all engineering economy courses.

Most engineering economy courses cover corporate taxes, but based on current texts most do not include individual income taxes. Of particular value to students and recent graduates are education credits, deductible expenses (including student loan interest), and the after-tax cost of

a college education. Progressive income tax tables provide a mid-course reminder of how and when to use marginal and average rates.

There are a number of topics that could be considered optional for a standard course. Budgeting may seem simple, but it is a new concept for many students. Of interest to some will be subsidized loans (such as the Stafford and Perkins loans), how insurance works, and the difference between term and whole life insurance. While time may not permit in-depth discussion of these topics, it is useful reading and supplemental material.

Additional Considerations: Technology and Personal Finance

Technology and its adoption in the pedagogy of engineering economy provide some unique examples and spaces to explore personal finance. Included here are technologies that the authors have extensive experience with in teaching engineering economy—spreadsheets and audience response clickers.

Spreadsheets: The role of spreadsheets in the teaching of engineering economy has been the subject of innumerable talks, papers, articles, and presentations. The many viewpoints ensure that any consensus must be stated in somewhat general terms. Nevertheless, we suggest that most faculty teaching engineering economy would accept that spreadsheets:

- Make it easier to get correct answers.
- Make it more difficult to give tests that match the methods used in class and homework while controlling academic dishonesty.
- Will be how students do engineering economy in the real world.
- Have some level of impact on student motivation, because the course seems to be more relevant to their futures.

The presentation of personal finance topics can be strengthened by choosing problems where students must build models that they can readily link to their current lives or choices they will be making in their early years as a professional. For classroom use one can define a set of variables, allow students to build a model with the *right* relationships (or wrong until you go over), and then finish the course with a set of models they can use wherever they go. Good candidates for this approach include:

- Buying multiple 1-term parking permits or one for the school year.
- Calculating the amortization table for a vehicle and spreadsheets that show the impact of shorter terms or extra payments.
- Calculating the annual cost of ownership for a vehicle and linking that to initial cost and ownership period.
- Saving for retirement with an annual salary with a jump for becoming an EIT or a PE and that increases at an $x\%$ rate that is likely to decrease over 40 years. How much is needed to fund your retirement goal?

- Planning how to manage those retirement savings in concert with spending goals and how long to remain in the workforce.
- Learning how to choose between collecting a pension like Social Security at an early, normal, or delayed age.

Clickers: Because personal finance can be *deeply* personal, the anonymity of student responses can be a factor. For example, starting with the question, “Have you or anyone in your family declared bankruptcy?” will get more accurate answers through clickers than a show of hands. Sometimes, just seeing that other students share an experience opens students up.

We suggest that, if students are building spreadsheet models in class that they be allowed to complete one or several steps or to discuss what those steps should be. Then, the prof can ask what he should do with those steps of his displayed model. At each stage clickers can get more accurate feedback on what students think or did.

Clickers can also be used for trivial things whose only purpose is to engage students and wake them up. For example, a class vote on whether the vehicle for the equivalent annual cost is a pickup or a sports car; new or used; or even purchased or leased?

Conclusion

As detailed in earlier material, we believe that engineering economy courses should include more coverage of personal finance than is suggested by the content of most current engineering economy texts. Our survey data shows that students would place a high value on including the material in their engineering economy course.

Specific examples show that it can be possible to include personal finance and show the direct linkage to engineering practice. For example, does it matter whether a replacement analysis focuses on a personal vehicle or an industrial forklift? In other cases, personal finance will require extensions of current coverage. Projects may be financed by bonds, but these bonds are also investments available to individuals and retirement funds.

We suggest that the shift in types of retirement funding and the seemingly ever increasing level of student debt create an obligation for faculty teaching engineering economy to increase the financial literacy of their students. Students who cannot do more than “scrape by” when they receive their degrees or afford continuing education throughout their career are unlikely to excel as engineers. Students who cannot save for retirement or next month’s loan or mortgage payment are more vulnerable to ethical compromises. We hope and believe that these consequences would be rare without more coverage of personal finance. However, we are sure that including personal finance will make the consequences even more rare.

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