



Work in Progress: Do Engineering Students Gain Financial Literacy Skills by Taking an Engineering Economy Course?

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Premise

The global economic crisis, rising tuition costs, and the shaky job market are making financial literacy one of the most critically needed student skills, regardless of major. However, this capability is not being fulfilled in K-12 education, higher ed., or through family coaching. With this gap, the financial outcomes of Americans show the following alarming impacts:

- Americans owe over \$1.48 trillion in student loan debt which has increased 511% in the last 10 years. This debt impacts 44 million borrowers and totals \$620 billion more than the U.S. national credit card debt [1].
- The average Class of 2016 graduate has \$37,172 in student loan debt, up six percent from the previous year [2].
- Eighty-eight percent of Americans are concerned about their retirement, with only 48% of households 55 and older having any personal retirement savings. The average retirement savings of all households, considering those that do and don't have personal retirement savings, is only \$2500 [3].
- Knowledge of financial literacy among Americans is poor. According to the results of a six-question financial literacy quiz, Americans on average can only answer 3.2 of them correctly [4].

Engineering Economy courses traditionally teach students how to evaluate the financial viability of capital investments from a business perspective, but the foundational concepts of time value of money may have a broader applicability in their personal lives. Students who have taken an engineering economy course should be able to calculate their student loan payments using the same method they would to calculate the annual equivalent worth of a business investment. To determine their future retirement assets, they can use the concepts taught under future worth analysis which are instilled in this course.

To support the broad impact of this research, Engineering Economy is taught in almost every engineering degree-granting university in the United States as a core subject related to the ABET Criteria and the Fundamentals of Engineering (FE) exam [5, 6]. The researchers wanted to know if the students in the class were gaining skills that could enhance their financial literacy since the core concepts in the course are applicable to personal financial literacy.

The questions being studied in this research paper are:

- 1) How financially astute are students before taking Engineering Economy compared with other widely studied populations?
- 2) Does taking an Engineering Economy course improve their financial literacy?
- 3) How well prepared do engineering students perceive they are in facing their financial futures?

Background

According to Annamaria Lusardi [7], a renowned financial literacy researcher, “Governments and employers have increasingly transferred the responsibility to save and invest to individuals.” As of 2014, only 2% of American employers had a defined benefit (pension) plan, down from 28% in 1979. Today, employees are expected to save for themselves; in the same study, 34% of employers offer only a defined contribution (401K/403B) plan, which is up significantly from 7% with plans in 1979 [8]. With these underlying social changes, students graduating from engineering programs today will need to be more financially savvy and recognize their need to save for their own retirement, but are they prepared to do this?

Fortunately, large volumes of baseline data on different populations and their financial literacy skills exist. Through her research at George Washington University’s Global Financial Literacy Excellence Center, Lusardi has spent decades studying the financial literacy of different populations across the globe. Thousands of people in diverse countries have answered her three-question basic survey to gauge their understanding of financial principles. Further, the Financial Industry Regulatory Authority (FINRA) [9], the non-profit regulatory body that facilitates the enforcement of financial management practices in the US, has expanded Lusardi’s three-question survey to a six-question survey to evaluate an individual’s knowledge of finance and investing concepts.

Using this as a backdrop, the population for this research is based on more than 400 students taking Engineering Economy at a large Midwestern university for one semester. The course is a half-semester, 2 credit hour 7-week session course taken by most engineering majors in the engineering college. Many examples used in class and homework problems relate to personal finance as a way of helping students understand and internalize the concepts related of the time value of money. Some of the examples include personal investment methods as simple as the spread of interest rate banks pay and the dollar value of savings accumulating for retirement. Students use Microsoft Excel to calculate payments on student loans with different interest rates and payment periods. However, it is not known whether these examples help them internalize the skills they need.

Research methodology and results

To determine financial literacy skills, engineering economy students were offered the opportunity to take an anonymous, short online pre-course and post-course financial literacy survey for 0.5% extra credit for each survey, without regard to how many questions they answered correctly. The six financial literacy questions [10] came from the FINRA/George Washington Financial Literacy standard block of questions as follows:

1. Suppose you have \$100 in a savings account earning 2 percent interest a year. After five years, how much would you have?
 - A. More than \$102
 - B. Exactly \$102
 - C. Less than \$102
 - D. Don’t Know

2. Imagine that the interest rate on your savings account is 1 percent a year and inflation is 2 percent a year. After one year, would the money in the account buy more than it does today, exactly the same or less than today?
 - A. Don't Know
 - B. Same
 - C. Less
 - D. More

3. If interest rates rise, what will typically happen to bond prices? Rise, fall, stay the same, or is there no relationship?
 - A. No Relationship
 - B. Don't Know
 - C. Rise
 - D. Fall
 - E. Stay the same

4. A 15-year mortgage typically requires higher monthly payments than a 30-year mortgage but the total interest over the life of the loan will be:
 - A. Same for 30 years and 15 years
 - B. Less for 15 years than 30 years
 - C. More for 15 years than 30 years
 - D. Don't Know

5. Buying a single company stock usually provides a safer return than a stock mutual fund:
 - A. False
 - B. True
 - C. Don't Know

6. Suppose you owe \$1,000 on a loan and the interest rate you are charged is 20% per year compounded annually. If you didn't pay anything off, at the interest rate, how many years would it take for the amount you owe to double?
 - A. Less than 2 years
 - B. 2-4 years
 - C. 5-9 years
 - D. More than 10 years
 - E. Don't know

In addition to the FINRA questions, the students were given 2 Likert scale questions in the post-course survey only as follows:

7. How well prepared do you feel you are to handle your financial future?
1 – Very Well Prepared to 5 Very Unprepared

8. How important to you feel financial literacy skills are?
1 – Very Important to 5 Very Unimportant

The research was conducted comparing the engineering economic students to a large database of the US population. The students' survey responses were collected over four course sections of the course with approximately 100 students per section. Students completed 421 pre-course surveys and 385 post-course surveys. For comparison, the 2015 National Financial Capability Study Data Tables have 27,564 data points of people ages 18-65+ across the United States that asks the same six questions. The US survey was conducted by 3 firms, Survey Sampling International, EMI Online Research Solutions, and Research Now. The findings from the FINRA survey are weighted to be representative of Census distributions, based on data from the American Community Survey. It is important to note that there is nothing in the FINRA survey [11] that incentivizes the participants to try to get the correct answer, nor is there for the college students. In order to receive research board approval for the student survey, the data had to be anonymous and ungraded, so students would only receive credit (0.5%) for completing the task.

Some notable background from the 2015 FINRA data [12] include: 71% of participants had completed some college but only 27% had fully completed a bachelor's degree or more. Two interesting FINRA survey questions asked the participants about their math and financial literacy skills; 79% responded they were fairly good at math; 76% indicated they would assess their overall financial knowledge as high.

The FINRA study data and the class pre-and post-course data are compared in the tables below:

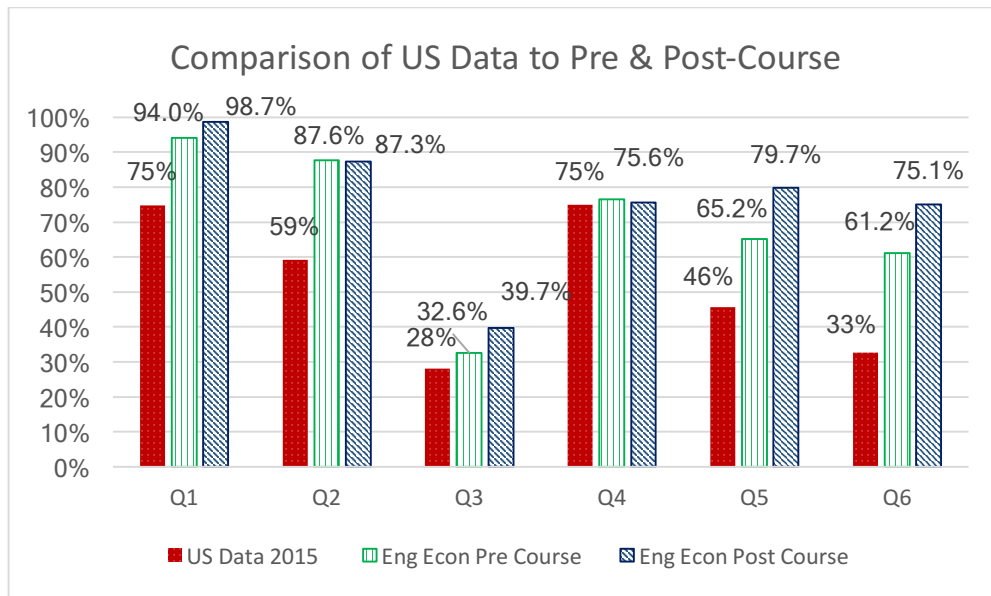


Figure 1: Frequency (%) of correct answers to FINRA questions 1-6 comparing the US population sample (n=27564) to the pre-course (n=421) and post-course (n=385) Engineering Economy student data.

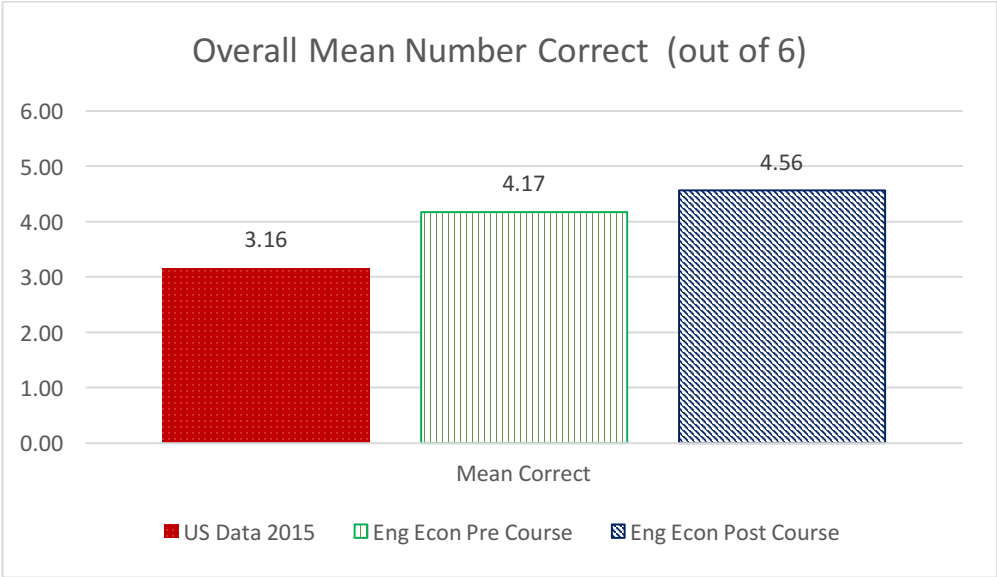


Figure 2: Comparison of overall mean number correct between the US population sample (n=27564) to pre-course Engineering Economy (n=421), and post-course (n=385)

After we visually compared the 2015 FINRA US data with the Engineering Economy pre- and post-course survey results, we conducted a statistical analysis to answer the first two questions being studied.

First, we perform hypothesis testing to determine if the financial knowledge of the students entering the Engineering Economy course is the same as the US population. We used one sample z-test with unknown variance since we could derive only the mean of the US data as our population mean. We are not assuming any distribution for the population nor our sample. We are using central limit theorem since our sample number is large enough, namely 421. Our hypothesis follows:

$$\begin{cases} H_0: \mu = \bar{x} \\ H_1: \mu \neq \bar{x} \end{cases}$$

Table 1: One-sample z-test results between the Pre-course sample and the US Population

Population Mean of US (μ)	Sample Mean of Pre-Course Students (\bar{x})	Number of Pre-Course Students (n)	Standard Deviation of Pre-Course Students (s)	Z-Test Statistic	P-value
3.16	4.17	421	1.2602	16.44	<0.00001

With a p-value <0.00001, we reject the null hypothesis in favor of the alternative hypothesis with 99% confidence. This analysis demonstrates that the financial knowledge of the students before taking an engineering economics course was significantly different than the financial knowledge of the population. Therefore, to answer the first research question, we have determined at a 1% significance level that the students taking Engineering Economy at this institution are more financially astute before taking the course than FINRA’s US population was in 2015.

To compare the central tendency of students who took the survey before and after Engineering Economic course, we performed a Mann-Whitney test. The null hypothesis is that the median of the both groups are equal.

$$\begin{cases} H_0: \eta_{pre} = \eta_{post} \\ H_1: \eta_{pre} \neq \eta_{post} \end{cases}$$

Table 2: Two-sample Mann-Whitney test

Pre-course Median (η_{pre})	Number of Students (n_{pre})	Post-course Median (η_{post})	Number of Students (n_{post})	99% Confidence interval	Statistical significance
4	421	5	385	(-0.9999, 0)	<0.0001

As table 2 shows, the median of the score of who took the survey before taking Engineering Economics course was 4 while the median of the ones who took the survey after taking Engineering Economics was 5. Since the P-value of the test is smaller than 1%, it can be concluded that the medians of the two groups are statistically different. This could answer the second question of this study since the students who took the course had scores higher post course median scores and this was due to an external cause which could be taking this course.

In order to address the third research question, data was gathered on the students' perception of how prepared they are to handle their future financial requirements and how important it is to them to be financially savvy. The next two graphs display those results:

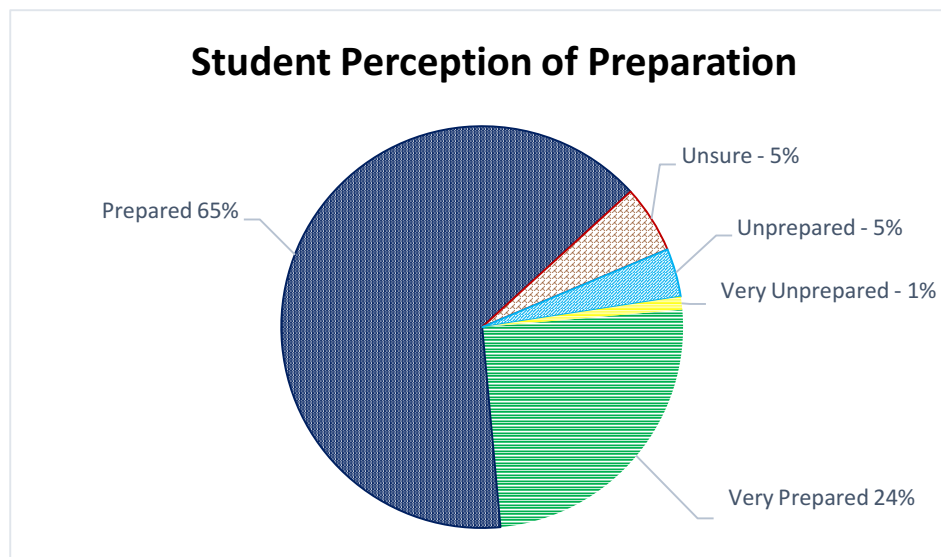


Figure 3: Frequency of responses (%) from students' post-course survey regarding their opinion of their preparedness for handling their financial future

This data shows that 90% of the students believe they are prepared to handle their financial future, but at least 10% are feeling less confident.

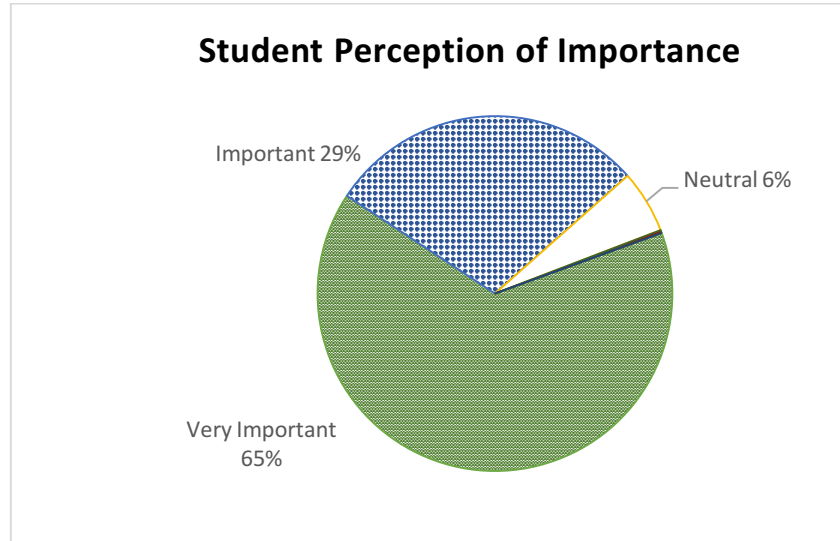


Figure 4: Frequency of responses (%) from students' post-course survey regarding their perception of the importance of financial literacy skills

This data shows that 94% of students believe that having good financial literacy skills is important and no students said it was unimportant. Overall, this has to be seen as one of the most positive outcomes of this survey.

Conclusion

The results of the data are conclusive from this research and provide definitive conclusions to the research goals.

1. Engineering Economy students, typically second and third year engineering students at this large university are more financially literate than the US population before taking Engineering Economy.
2. Engineering Economy students do gain *some* financial literacy skills from this course.
3. Engineering students believe they are well prepared to handle their financial future. Further, they believe these are important skills to possess even at this young age.

To provide some additional context, a question is why do these students have significantly higher pre-course financial literacy skills as measured by the FINRA survey. This result could possibly be explained by the general higher numeracy skills of engineering student because these students usually excel in math as a precursor to even consider a career in engineering. "Numeracy is having the confidence and competence to use numbers and data in everyday life to make good decisions, including financial ones [13]." In a 3461-person study, *Financial capability in the UK 2015* [14], a clear link between numeracy skills and financial capability was demonstrated. In her 2011 paper, Lusardi [15] stated that "numeracy has been found to be linked to financial decision-making." Overall, the data is encouraging that engineering students are already more financially

literate due to their strong numeracy skills and that taking Engineering Economy courses helped improve their financial literacy. These findings may further reinforce the premise that Engineering Economy courses should be considered as a general elective as proposed in a 2014 ASEE conference paper by Joe Wilck and others [16].

Unfortunately, the students didn't gain as much personal financial capability as would have been desired and it is clear upon completion of this study that just participating in the course wasn't enough to bridge the gap. This could be for the following reasons:

- Some topics in this course don't align well enough with the survey objectives/questions. Most striking in this category is Question 3 which asks about bond prices in an increasing interest rate environment. This course doesn't cover bond valuation, and only mentions bonds as a source of capital funds for companies.
- Some course topics use a similar idea, but in a different context that does not translate. Question 2 asks about the impact of inflation on the spending power of money earning low interest. The results here show no impact for taking this course even though inflation is discussed and the geometric gradient, (little g) is used in the calculation methods for present worth. It is clear that this is not translating to how this would impact the students' future spending power.
- Some topics show that students just aren't internalizing the concepts. Question 4 attempts to ascertain if students understand that the shorter the loan period, the lower the interest will be paid under the question scenario. For this question, there was no impact of taking this course and knowing that there is a class example problem on principal and interest as well as a homework problem, this definitely calls out that more attention needs to be put on this subject in the course.

After completing the research on this course, it can be said that engineering economy does improve financial literacy to a small degree, but business applications of capital spending isn't sufficient to bring students to where they need to be.

Finally, we believe that mindset has an impact on financial capability and discovered the students overwhelming indicated that financial literacy was important or very important to them (94%). A large number (80%) agreed that they were well prepared or very well prepared to handle these issues which indicated another promising touchpoint, as long as they are not over confident. In the 2015 FINRA study [17] (25,674 participants) many believed their financial literacy skills were better than they actually were. This therefore provides an avenue for further research. Are the students overconfident? Are they competent today in calculating payments and future worth, but will those skills be lost if they are not practiced? Understanding financial literacy, having strong numeracy skills, and possessing the confidence to make good decisions are all important skills; however, having the ability to apply these concepts to diverse lifelong financial challenges maybe be harder than understanding how to calculate the impact. However, giving them some foundational skills and having them recognize the importance is a good start.

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