

AC 2010-1469: A LOOK INTO THE ENGINEERING ECONOMY EDUCATION LITERATURE

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A Look into the Engineering Economy Education Literature

Abstract

Approximately ten years ago a two-part survey of how engineering economy was taught in U.S. universities was conducted. This survey, conducted in 1995 and 1997, collected data from engineering economy instructors and investigated: 1) the faculty that teach it, 2) the course content and mechanics itself, and 3) the students that take the course. We are currently embarking on a follow-up data collection effort to conduct a longitudinal analysis of this prior study. This survey paper presents a review of the most relevant literature published since this survey. The pedagogy highlighted in this paper includes problems with current teaching methods, modern technological advances in the engineering economy classroom, and new approaches to enhance the classroom experience. These findings support our long term goal of improving engineering economy pedagogy by increasing visibility, enhancing instructor knowledge, and influencing external stakeholders such as textbooks writers and funding agencies.

Introduction

The literature review presented in this paper serves two purposes. One purpose is to present engineering economy education research that has been published in the last ten years and discuss the synergies between these efforts. As a number of papers have stated, there has been some consensus about the problems with the current teaching of engineering economy. This paper looks to shed some light on the evolution of engineering economics pedagogy including the areas that have undergone change and those that have remained the same. We also examine how the engineering economy curriculum is being taught in progressive classrooms, those which use new methods for teaching and new technologies as a medium for conveying knowledge and materials. Research on suggestions for how the course should be taught including new technologies and suggestions for new teaching methods are also presented.

The second purpose of this paper is to support follow-on work of a study conducted approximately ten years ago about how engineering economy is being taught in undergraduate engineering classrooms at various universities⁶. Needy, et al.⁶ presented an empirical analysis of engineering economy pedagogy via a two phase survey that collected data from engineering economy instructors regarding how engineering economy was taught in engineering programs throughout the United States. The primary findings of their survey are:

- The majority of the engineering economy courses average more than 30 students,
- Respondents provide a positive assessment of the state-of engineering economics as a body of knowledge,
- On average, industrial engineering (IE) faculty teach more engineering economy sessions per year than non-IE faculty,
- In calculating final grades, exams are weighted most heavily (non-IE faculty weight homework, projects and case studies more heavily),
- Non-IE faculty use groups and projects almost twice as much as IE faculty, and

- The vast majority of faculty is incorporating “new” teaching methods into their engineering economy classes.

We are motivated to conduct this follow-up study as we have observed that there have been significant changes during the last decade that warrant changes in engineering education in general and in engineering economy education specifically such as globalization and the movement of the U.S. economy from a manufacturing sector to a service sector. The objectives of our follow-up study will be to conduct a properly designed longitudinal analysis a decade later and to further investigate the findings of the Needy, et al.⁶ study.

Problems with Current Teaching Practices

Multiple sources have the same view of the state of engineering economics, in that they find that the curriculum of the class has failed to move forward with the times and has in fact “become stagnant”³. Hartman³ states that the curriculum being taught now is almost identical to that taught many decades ago. In general, it is believed that engineering economy instruction puts more emphasis on routine and trivial calculations and less emphasis on the analysis and decision making processes^{2,3}.

According to the literature, while the teaching materials of engineering economy has changed very little over the years, the actual implementation of the topic in the work force has changed dramatically. Smith⁹ comments on how risk and risk management is vital to the engineering environment, and yet the curriculum in undergraduate classes only skims the surface of these topics. Most textbooks acknowledge the presence and an overview of methods for measuring risk, but many do not provide up-to-date methods for managing risk. Smith⁹ suggests that the engineering economy course curriculum should incorporate current tools and instruction that will prepare students to solve real world problems and analyze realistic decisions.

There have been vast economic and technological advances in the past century. This fact would lead one to assume that the associated curriculum would have made vast advances as well. However, when comparing engineering economy textbooks, Hartman³ found that the material being taught now is virtually the same material that was taught “early in this century.” Hartman³ suggests a “revitaliz[ation in] the curriculum” and gives an alternative approach to teaching engineering economy. He suggests putting less weight on the trivial calculations and putting more emphasis on decision analysis and the incorporation of engineering economy research into the classroom.

The question of whether or not we “should drastically change the way we teach undergraduate engineering economics” has been asked⁸. Peterson, et al.⁸ reference the change from slide rules, to calculators, to the now wide spread use of personal computers by students. Though this change has occurred slowly, there is always a need to be looking to the future to see what new innovations can be used. In addition, they ask if the “goal of the engineering economy course” still the same as it was many years ago. Since the application of the course has changed over time, then so should the goals of the class.

While researching opportunities for improvement in engineering economy education, many other teaching suggestions were found. Elizandro and Matson² also see a need to “reduce rote

calculations” and suggest approaching engineering economic problems using moments from statics and mechanics. The suggested teaching methods seek to enhance the learning process for students. Many of the instructors wish to see their students improve their knowledge on the subject of engineering economy, but most observe students spending the majority of their time “master[ing] calculations”². This supports the claim that engineering economy should be a more engaging class that includes more realistic decision analysis and risk analysis instruction.

New Technology Available

Over the many years that engineering economy has been taught, there have been numerous technological advances. Changes in the way educational materials are presented and the way problems are being solved can be attributed to these new advances. Most of the papers discussing technological advancement in the instruction of engineering economics mention the use of spreadsheets in the classroom and the need to move away from the “traditional methods” of calculation⁴. Review of these articles shows that incorporating new technology into the engineering economic curriculum can support traditional concepts, encourage higher learning, and move students toward more current methods of practice.

Spreadsheets are an “available and affordable” way to incorporate new technology into the classroom. The completion of a spreadsheet requires the student to have a certain understanding about the concepts they are dealing with. As with any new method, there comes with it rewards and challenges. According to Lavelle⁴, use of spreadsheets in the classroom is no exception. One of the many rewards associated with the use of spreadsheets is the need for students to create and implement methods used to solve the problem at hand. This results in students having a better understanding of the problem and solution process and requires the student to present their results in a neat and logical way. Spreadsheets also offer students alternative ways of solving engineering economic problems. Each problem can be solved using traditional methods as well as in a spreadsheet. This helps the student learn both methods and have a better understanding of the material¹. Some challenges that Lavelle⁴ mentions are making sure that the students’ work is their own and that their assignments are turned in on time. Each of these challenges is avoidable if the correct precautions are taken. It is believed that the challenges are outweighed by the rewards and should not sway a teacher from using spreadsheets.

Other technological advances have been made in addition to spreadsheet usage. Bafna and Aller¹ mention a number of changes and enhancements that have been useful to the engineering economy curriculum. Some have added convenience while others have been environmentally friendly. Bafna and Aller’s¹ paper focuses on a semester class of engineering economy. In this semester class, the teacher made presentation slides available online to all his students. By doing this, the students are able to absorb the teacher’s “words of wisdom,” instead of racing to copy notes. Furthermore, Ryan’s¹¹ paper discusses a new innovation that was tested in a large engineering economy class. The classroom was centered on an information technology-based learning portal. The goal of this learning portal is to eventually interconnect all industrial engineering classes, but this test was done on a smaller scale. The curriculum was put into place to “promote collaborative and active learning”¹¹. This computer-based learning environment is designed to help students relate to real-life engineering problems, to clarify the relationship between all parts of the curriculum, and to improve student’s thinking skills by challenging them

in ways they have never been before. The results of the experiment proved successful. Ryan¹¹ found that the learning portal did in fact “promot[e] deeper learning and higher order thinking.”

Teaching Suggestions

Upon researching how engineering economy is being taught in today’s classrooms, three papers that specifically focus on suggestions for teaching engineering economy were found. The proposed teaching suggestions include what subjects should be taught, an improved method to assist the students in gaining a better understanding of the lecture material, and a spreadsheet-based learning portal.

Merino⁵ discusses the findings of a survey about what knowledge an “economically literate” engineer needs to possess. He surveyed people who use engineering in their everyday life, be it teaching, supervising, or applying skills as engineers. He asked the respondents to rank a list of topics that were taught in courses similar to engineering economy. The goal of his survey was to compile a “body of knowledge” that would serve as the basis for all engineering economy students⁵. The subjects were ranked on a scale that measured the importance of each topic. The findings from the survey revealed that no single subject was completely unnecessary in the curriculum. This supports the notion that engineers must be educated in a broad range of economic subjects to be considered “economically literate”⁵. As stated previously, no subject was completely eliminated, but there were subjects that stood out as highly important. These subjects include Cost Estimation Fundamentals, Risk Analysis Fundamentals, Basic Engineering Economics, and Cost Accounting Fundamentals⁵. Merino’s⁵ findings encourage engineering economy educators to put emphasis on these four topics.

Olson⁷ conducted an experiment in his engineering economy course to investigate how the timing of quizzes affect the way students understand lecture material. He encouraged all of his students to read the chapter before coming to class and then split his class into two groups. One group was assigned an online quiz via WebCT over the reading material before lecture, and the other was assigned the same quiz after lecture. Because the quiz was over the reading material, the post-lecture quiz group would seemingly have an advantage over the other because they would have both read the chapter and attended lecture prior to taking their quiz. After each lecture, all students notified the instructor how well he or she understood the material discussed in class that day. After the results of Olson’s⁷ experiment were analyzed, it was determined that the pre-lecture quiz group believed they understood the lecture material better. In addition, the pre-lecture group also averaged a higher quiz score than the post-lecture group. This is surprising because the post-lecture quiz group was able to read the material and hear the lecture before taking the quiz. A statistical comparison of grades in the course displayed a significant difference in the final grades of each group where the pre-lecture quiz group scored significantly higher in the class than the post-lecture quiz group⁷. The success of the pre-lecture quiz group could be attributed to the students having learned more of the course material on their own. This experiment was successful in the investigation of when to quiz students on the lecture material. When quizzing prior to lecture, it encourages the students to read and have a basic understanding of the material prior to the lecture delivery.

Ristroph¹⁰ introduces a new way for teachers to convey engineering economics material to students. In this spreadsheet-based learning portal, teachers are given the reigns to create interactive examples that teach students how to master the material in the class. The program is easy for professors to create assuming they are “reasonably familiar with Excel and can use [the Excel] graphics program”. From the student’s point of view, the program is almost like a game. They are shown a problem and then must answer sequential questions in order to move on to the next part of the problem. The program is able to provide drop down boxes for student responses and indicates to the student of the validity of their answer. According to Ristroph¹⁰, “once the novelty wears off, students will realize that they’ve been tricked into learning.”

Each of the previous teaching suggestions, which topics to teach, when to administer quizzes, and the learning portal, are likely just a few examples of ideas that instructors have about how best to teach engineering economy. These suggestions show that there are instructors that are being progressive in finding which curriculum and teaching methods work best for their students. In our follow-up study, we will collect information on other suggestions for improving the teaching of engineering economy.

Conclusions and Future Work

While this paper reveals what some authors state to be the current problems with engineering economy education, it also includes ways in which the curriculum could be improved upon. Suggestions for implementing technologies and teaching methods are presented to help revitalize the classroom experience and practice of teaching engineering economy. This paper seeks to encourage engineering economy instructors to incorporate innovative ideas inside the classroom by increasing awareness of current pedagogical approaches.

During our presentation at the 2010 American Society for Engineering Education conference, we will engage engineering economy educators in an interactive discussion with the purpose of increasing the value of our follow-on data collection efforts and providing more valuable insights to the engineering economy community. Not only will the input obtained from this forum be important in formulating our data collection tool, but it will also be valuable to engage the engineering economy community in this discussion so that we can gain their commitment and challenge them to ensure that engineering economy pedagogy continuously improves and remains relevant as we embark on the 21st century. An important aspect of this will be the connection of specific teaching practices to educational outcomes. As stated earlier, the goal of the follow-up study is to have a better understanding of how engineering economy is being taught in undergraduate engineering classrooms and to uncover new and innovative methods for improving how the curriculum is conducted.

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