An Integrated Approach to Developing Business Expertise in Industrial Engineering Students

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Abstract

Now more than ever companies are expecting students graduating from baccalaureate engineering degree programs to have both strong technical problem solving skills and a level of business expertise. With corporate investment and engineering project funding decisions becoming increasingly reliant upon company financial statement and stock price impact, it is crucial for engineers to have a working knowledge of financial accounting and finance. This paper discusses an integrated approach being taken in an industrial engineering program to increase student interest in engineering and business while teaching the important business concepts outlined above in a required engineering economy course for industrial engineering students. This paper discusses the evolution of a student group deemed the "Business and Engineering" group in industrial engineering at The Pennsylvania State University, University Park campus. The paper discusses the curriculum changes in the engineering economics course to incorporate important financial accounting and finance topics. The paper will discuss in detail a large U.S. retail company sponsored case study competition implemented into the course to complement the financial statement analysis curriculum added to the course. Student feedback regarding the updated curriculum, course delivery, and the company sponsored case study competition is also discussed.

Introduction

The motivation for making curriculum changes to the current engineering economy course came directly from suggestions made by corporate executives serving on multiple industrial engineering advisory boards for the industrial engineering department at this large U.S. public university. The discussions about changing the course curriculum of an engineering economy course began during the 2011-2012 school year. The course instructor embraced the inquiry for change and volunteered to help begin a curriculum overhaul of the current engineering economy course in industrial engineering at this large public university. Input from the industrial engineering advisory boards noted that industrial engineering graduates needed to graduate with a more thorough understanding of the link between engineering economic decisions and business planning, financial statements, and financial accounting. It is crucial for industrial engineering students to learn how to not only provide a definitive argument explaining the conclusion of their engineering decision (both from the subjective and quantitative perspectives) but also to take this one step further to be able to understand and explain how their decision will impact company financial statements (i.e., the bottom line of the company). At Penn State University Park, industrial engineering students are only exposed to a semester of financial accounting and financial statements if they choose to complete a minor in business/ liberal arts. Students would have limited exposure to these topics if they completed an engineering entrepreneurship minor. All of the industrial engineering students at Penn State must complete either macroeconomics or microeconomics as part of their general education course work in their freshman or sophomore year.

Simply adding additional lecture material in the engineering economy course to cover the link between engineering economic decisions and business planning, financial statements, financial accounting, and stock value was only one part of addressing the needs of the companies hiring industrial engineering students from this university. Bringing in a real life company problem for students to work on that would force the students to apply engineering economy tools learned in the course to justify their engineering decisions for the company problem would allow the students to gain real life training in this area. In attempt to make this as real life as possible, having the students provide a detailed report outlining an engineering problem solution and an economic cost benefit analysis to company engineers and business managers was discussed. Giving a final "sales pitch" presentation to a panel of company engineers and business managers where an economic justification and implementation plan were the main focus of the presentation was the goal to close the loop in this educational initiative for the students.

Feedback from Industrial Engineering Program Advisory Committees

The basis for the addition of the key business concepts to the engineering economy course within the industrial engineering curriculum at Penn State University Park resulted directly from input from corporate executives serving on two advisory boards. Company executives from the likes of Alcoa, ADT, and Armstrong among other companies serving on the Industrial & Professional Advisory Council (IPAC) and the Service Enterprise Engineering Advisory Board (SEE) expressed the pressing need for engineering students to have a more thorough understanding of the link between engineering economic decisions and business planning, financial statements, financial accounting, and stock value when briefing company leaders. The executives saw this as one of the biggest deficiencies in young engineers entering their companies. After collecting this feedback from the corporate executives it was evident that every industrial engineering student should be exposed to financial accounting topics including financial statements and financial ratio analysis with special emphasis on understanding how engineering project decisions impact company financial statements.

Business Skills for Engineering Students

After researching how the engineering students at Penn State University Park would typically gain knowledge of financial accounting and finance, it was found that the engineering students must typically minor in a Business/ Liberal Arts program that requires 25 to 26 credits to complete while the crucial topics in financial accounting and finance are only 7 of the 25 or 26 credits. It was found that less than 2% of the students in the industrial engineering program had actually declared the Business/ Liberal Arts minor as a minor they were completing. The minor degree program is administered through the College of the Liberal Arts, not the College of Business at Penn State University Park. Students would have limited exposure to these topics if they completed an engineering entrepreneurship minor.

Curriculum Changes

As a result of the feedback from the corporate executives and the statistics on the number of students in the industrial engineering program with declared minors in the Business/ Liberal Arts minor degree program, it was evident that curriculum changes within the required engineering

economy course in the industrial engineering program were necessary to give all industrial engineering students exposure to financial accounting and finance topics including financial statements and financial ratios. After the engineering economy basics were covered in the course (present value, future value, equal payment series, linear and geometric gradient series, and interest rate conversion), a course unit on business planning, financial statements and financial accounting with special emphasis on the balance sheet and income statement, and cost accounting was covered. In part A of the case study, the students (working in groups of 4) were assigned an in depth financial statement analysis on the large U.S. retailer that would sponsor the case study problem for part B of the case study. The students were required to complete an in depth analysis of three years of corporate financial statements by completing a series of ratio calculations. This would give the students real life practice working with corporate financial statements and also allow them to gain an understanding and background of the large U.S. retailer that would be sponsoring the real life case study competition in the course.

Background and Motivation for the Case Study

"The importance and relevance of engineering economic analyses is always emphasized when students discuss their projects with practicing engineers. Without this interaction students sometimes consider economics to be irrelevant to design – a subject for business students," an observation by Archibald, Reuber, and Allison[1]. Engineering education literature has continuously shown that projects with industry can be helpful for undergraduate and graduate students, even the processes of soliciting, administering, and managing industry projects that reinforce academic topics in engineering, technology, manufacturing, project management, lean, and six sigma[2-6]. Ancillary topics that are reinforced include professionalism (through interaction with industry), teamwork, and leadership[7]. Formally, these projects are also often assessed as student work with respect to meeting the established student learning outcomes[8].

Another benefit of incorporating industry projects within engineering economy courses is that academic materials (e.g., lecture notes, handouts, books) have excellent coverage of project economic analysis, but these academic materials lack the hands-on use of economic analysis within a design that a project with industry can provide[9]. In a broader context, within the K-16 realm, there has been a push to increase the mathematical competency of students, particularly financial literacy. Within the book, Mathematics and Democracy: The Case for Quantitative Literacy[10], the findings and suggestions are aligned with National Academy of Engineering recommendations[11]; that an individual will need to have a basic understanding of decision making to make competent financial decisions in order to survive in the 21st century society. Engineering economics takes this level of understanding to a higher ceiling by including competent financial decisions for a company or organization with respect to projects and designs.

The importance of economically quantifying projects has been shown in prior literature, as the economic and social well-being progress is a direct consequence of technical change and its application in the modern world. It was originally estimated that technological and engineering advances led to 80% of the economic growth and development of a society by Robert Solow[12]. Furthermore, incorporating the economic decision process within the design process is what sets engineers apart from other specialists with respect to financial decisions. Basically, understanding the economic characteristics of a technology or a design and its costs is what

distinguishes engineering economics from other branches of economics, accounting, and finance[13]. Also, engineers are equipped to analyze a project, technology, and design with respect to sustainability and environmental factors.

Brief Review of Prior Engineering Economy Education Literature

There are numerous studies of engineering economics education within the published literature. This includes work that looks at futuristic predictions of engineering economy education[14] and suggestions for improvement[15]. Recommendations for improving undergraduate engineering economics education discuss the importance of financial mathematics, decision making analysis, spreadsheet analysis, and the use of online educational tools[16,17]. Since 2000, many articles have been published that provide either structure or experiences in teaching engineering economics at both the undergraduate and graduate levels, the inclusion of risk and uncertainty in engineering economics, flipping the classroom, and teaching engineering economics online or in hybrid formats[18-28].

Prior Results With Respect to Projects for Industry

Prior analysis of projects with industry[3,4,6,9] were evaluated to determine which engineering economy concepts and metrics were significant to industry. The results were mixed and localized to the specific university. For example, in a paper published in 2014, the student projects with industry were all in the same region of North Carolina, which primarily included projects from the manufacturing, healthcare, and pharmaceutical industries[9]. The results from this paper indicate that first cost (initial cost) is the most significant metric, followed by annual worth, and payback (simple) within the students' analysis of their engineering design. Of these top three engineering economy metrics, the only metric that utilizes the time value of money concept is annual worth. However, the paper did note that over 40% of the teams used more than one analysis metric, which included methods such as net present value, rate of return, and benefit-cost ratio.

Large U.S. Retailer Sponsored Case Study

The literature did not provide details on previous engineering economy industry sponsored projects by U.S. retailers. A well-known, large U.S. retailer worked with the instructor of the engineering economy course at Penn State University Park to put together the case study problem and charter over a course of 3 months. This was the first large case study competition of its kind for this large U.S. retailer. This large U.S. retailer wanted junior level industrial engineering students to study and propose changes to their current regional distribution center recycling program.

The engineering economy course at Penn State University Park is 15 weeks in length. The course is 3 credits and it meets for 150 lecture minutes per week. During fall 2014, the class met twice per week for 75 minutes each class period. The detailed engineering economy course outline can be found in Appendix A.1. 116 students were enrolled in the course during the fall

2014 semester. 29 groups of 4 students each competed in the case study competition. A company kickoff event was held in class during week 8 of the course. An 8-page case study charter describing the U.S. retailers recycle program was distributed in class and posted on the class website on Tuesday October 14th. Attached to the case study was a series of appendices describing wooden pallets, the recycling flow of pallets, shrink wrap, and cardboard, and a layout of a regional distribution center for this large U.S. retailer. Some data regarding pallet numbers, pallet recycle pricing, deliveries to and from retail stores, numbers of pallets on recycle truckloads, among other items were unclear from the initial charter. A 2 hour question and answer (Q&A) session was held on the night of Tuesday October 28th. During this session, the instructor attempted to explain the charter in as much detail as he possibly could to the case study teams in attendance while also taking questions from the students. After the Q&A session, the course instructor worked with a senior engineer for the U.S. retailer to provide a list of answers to commonly asked questions that came out of the Q&A Session. The answers were both distributed in class and posted on the course webpage for all teams to have access to. The instructor wanted all teams to have the exact same set of given information to work on the case study. The instructor felt as though it was unfair for certain teams to have additional information or data from the retailer that other teams did not have access to. After the Q&A session answers were distributed to all teams, no additional technical questions were answered for the case study competition. The students were asked from this point on to work with the information they had in the charter and the Q&A session answers. The students were unable to physically visit a regional distribution center to see the recycling areas in question. They were provided two-dimensional layouts of the current recycling areas within the distribution center. As a result of not being able to visualize the distribution center recycling program from an on-site visit, students may have had to make assumptions to be able to explain and justify their proposed changes.

Case Study Deliverables

Teams had five weeks to work on the case study and submit a final report. They were asked to submit a maximum 10 page report. The final report consisted of four sections: an executive summary, which outlined the team's solution and cost justification; a results and discussion section, where the students explained their approach to the problem; proposed changes/proposed solution where the students explained their changes and the solution for the RDC recycling program; and a cost analysis and economic justification section, where the students had to sell their ideas to the U.S. retailer's engineering and management team. Of the 10 pages in the report, the first five pages were dedicated to the four sections explained. The final five pages provided space for supporting appendices.

Case Study Grading

Members of the student Business and Engineering Group (B.E.G.) executive board at Penn State University Park, the course instructor and the graduate student teaching assistant for the engineering economy course initially graded and judged the case studies based on the quality of writing/ presentation, the proposal/ explanation of the proposed solution, the cost analysis/

justification, and the overall effort of the team. The case study competition grade was worth 3.33% of the overall course grade in the engineering economy course. After the university team completed their assessment of the case studies, all 29 case studies and a top 10 team list (in no particular order) was passed on to the retailer's employees. The U.S. retailer's team graded all 29 case studies and after grading was complete they returned a top five to the course instructor. On Tuesday, Dec. 2, the top five teams in no particular order were announced in the engineering economy class by the executive board of B.E.G.

The top five teams were instructed to put together seven-minute sales pitch presentations to deliver to the U.S. retailer's team on Tuesday, Dec. 9th in class. Their presentations were limited to 8 total slides including proposed changes/solutions, cost analysis/ economic justification and an implementation plan. After each presentation, the teams were subject to a three-minute question and answer session. Eight representatives from the U.S. retailer's team judged the presentations. The panel of judges consisted of four women and four men. Four of the company representatives were engineers with three being industrial engineers and one being a mechanical engineer by training. One of the judges was an assistant general manager for a regional distribution center. A college/ military recruiter, human resources manager, and director of talent acquisition rounded out the field of judges.

The top three teams were announced and the top five teams were recognized at an awards reception sponsored by the U.S. retailer and hosted by the B.E.G. student group immediately following the final presentations. The top three teams received scholarships. The first place team was awarded $1,500. Second place received $1,000. The third place team was awarded $500.

Engineering Economic Approach Taken By Case Study Teams

The students completing the case study were open to use any engineering economic analysis covered in the engineering economy course to provide their cost/ economic justification. It was found that 23 of the 29 groups opted to calculate annual cost reductions or annual profits to justify their proposed solution. The remaining six teams assumed a MARR value with one team utilizing the present worth analysis, four teams calculating discounted payback in years, and one team calculating annual worth. The instructor of the course expected this breakdown of approaches given the manner in which data was presented to the students in the case study charter. The recycling data in the charter was presented in hourly, weekly, month and yearly amounts. The winning team proposed a new machine design to make wooden pallet sorting and recycling easier. The team also suggested design changes to pallet handling carts and proposed overall recycling process changes. The team assumed a company MARR value of 13% per year and carried out a discounted payback analysis for their proposed changes.

Surveys

Three separate surveys were carried out during fall 2014 as part of the ongoing curriculum and instructional changes being made in the engineering economy course. All three surveys were

administered during the final week of the course. The first survey was dedicated to the case study competition while the second survey was dedicated to the overall experience in the engineering economy course. Both surveys were answered by the engineering economy students and they were administered in different class periods. The final survey was completed by the eight U.S. retailer employees attending and judging the case competition final presentations.

Survey #1: Student Case Competition Survey Results and Discussion

After completing the case study competition, the students enrolled in the engineering economy course were asked to provide feedback on the student case study competition. The students provided feedback on the case study competition and on their knowledge of and interest in working for the case study sponsor.

Demographics

The student case competition survey was completed by 110 of the 116 students in the engineering economy course. 83 male students and 27 female students completed the survey. 108 of the 110 students responded as being junior standing while 2 of the students responded as seniors. All 110 students were industrial engineering majors. Out of the 110 students, 3 of the students were minoring in business/ liberal arts while 4 of the students were minoring in engineering entrepreneurship and 1 was minoring in engineering leadership. Only 20 of the 110 students said they had completed a company sponsored case study experience prior to completing the case study experience in the engineering economy course. Out of the 20 students having completing a company case study experience prior to the engineering economy course, 11 of the students noted the prior experience was part of their EDSGN 100 course (Freshman Engineering Design Course) while 5 of the students noted their prior experience came from their ENGR 310 course (Engineering Entrepreneurship and Leadership Course).

Satisfaction

Out of the 110 students polled, 105 students (95.45%) felt as though the case study experience added value to the engineering economy course. 98 out of 110 students (89.1%) felt as though the case study topic (U.S. retailer distribution center recycling) was a good fit for the engineering economy course. When compared to completing an assignment solely for a grade, 79.1% of the students felt as though the competition component of the study motivated them to try harder on the assignment. Over 91% (101 out of 110) of the students said they would like to see similar case study experiences in more of their industrial engineering courses. After completing this case study experience, 99.1% of the students (109 out of 110) felt as though they had a better understanding of how they would conduct an industrial engineering study and sell their work to upper level management using an engineering economic/ financial justification.

The students were asked to rate their overall case study learning experience on a scale from 1 to 5 with 1 being extremely unsatisfying, 2 being unsatisfying, 3 being neutral, 4 being satisfying and 5 being extremely satisfying. Table 1 below shows the results of the survey question.

Table 1: *Results of student overall case study learning experience responses.*

Experience	Extremely Unsatisfying - 1	Unsatisfying – 2	Neutral - 3	Satisfying - 4	Extremely Satisfying - 5
Number of Responses	0	1	12	73	24

The average student rating for the overall case study learning experience was 4.1 out of 5. With over 88% of the students rating the overall experience as being satisfying or extremely satisfying, the students were asked what they liked most about the case study experience and what they felt could be done to improve the case study experience. Not all students responded to the open ended questions. Tables 2 below shows a breakdown of the results of the feedback given:

Table 2: *Results of student pros and cons of case study learning experience responses.*

Like most about the case study experience?	What could be done to improve the case study experience?
(60) Real world problem solving	(21) More information given in the project problem statement
(7) Enjoyed the competition aspect	(16) More Q&A, communication, or more time with sponsor
(4) Freedom to be creative	(7) Less assumptions and more precise data given

Over 54% of the students noted they liked the real world problem solving experience while 6.4% noted they enjoyed the competition aspect and 3.6% liked the freedom to be creative on an assignment. 33.5% of the students did not respond to the question. Approximately 1 in every 5 students noted they would have liked more information given in the project problem statement. Approximately 15% of the students noted they would have liked additional Q&A sessions, communication, or more time asking questions to the sponsor. Over 6% of the students noted they would have liked to have less assumptions and more precise data. 66% of the students did not provide feedback on what they felt could be done to improve the case study experience.

Company Sponsor

Before completing the company case study experience, only 22.7% of the students (25 out of 110) said they had a good understanding of the work industrial engineers did for the U.S. retailer sponsoring the case study competition. After completing the case study experience, 92.7% of the students (102 out of 110) said they now have a good understanding of the work industrial engineers do for the case study sponsor.

Prior to completing the case study experience, 35.5% (39 out of 110) of the students responded 'Yes' they would have considered an internship or full time position with the U.S. retailer sponsoring the case study competition. 47.3% said 'Maybe' they would have considered an internship or full time position while only 17.3% responded 'No.' After completing the case study experience, 54.5% (60 out of 110) responded 'Yes' they would consider an internship or full time position with the sponsor. 40.9% said 'Maybe' they would consider an internship or full time position while only 4.5% responded 'No.'

The results showed that the case study competition helped to educate the industrial engineering students on the function of an industrial engineer within the sponsoring company. The case

study experience significantly increased the number of students considering the sponsoring company for an internship or full-time opportunity.

Survey #2: Company Sponsor Satisfaction Results and Discussion

After the final case study presentations were complete, the eight judges attending the final case study presentations responded to a series of questions regarding the case study competition experience from the company's perspective. Out of the eight judges present, five said they spend most of their time working at the company regional distribution centers while three spent most of their time at the corporate headquarters. When asked to state the main reasons (goals) for partnering with the Penn State University Park industrial engineering program to carry out the case study experience, the U.S. retailers responded with the following responses shown in Table 3:

Table 3: *U.S. retailer reasons for sponsoring the case competition*

Reasons for Sponsoring the Case Study Experience
(6) Branding of the U.S. retailer and talent acquisition/ future IE candidates
(2) Create a partnership with this large public U.S. University's IE program
(2) Present real world issues to students

The results show that the U.S. retailer was looking to attract future industrial engineering students to their company for employment. The results of the student survey showed they were successful in their mission to sell their brand to prospective students.

Table 4 below shows the results of the open ended questions regarding what the company representatives liked most about the case study experience and what they felt could be done to improve the case study experience.

Table 4: *Results of sponsor pros and cons of case study learning experience responses.*

Like most about the case study experience?	**What could be done to improve the case study experience?**
(5) Creativity	(2) Offer more information at presentation session
(3) Great Presentations	(2) Virtual Q&A/ Add another Q&A session with employees
(1) Great Results	(1) Have presentations at night for more presentation time
(1) Visibility to Students	(1) Judging/ Formal introduction of the judges
(1) Creating a challenging project for students	(1) Give more feedback to students
	(1) Invite students to tour a distribution center

The results showed that the judges overwhelmingly liked the creativity of the students. The case study judges also had responses similar to the student responses for improving the experience. Two of the judges felt as though additional Q&A sessions between the students and sponsor would be a way to improve the case study experience.

The eight judges were asked to rate their overall case study experience on a scale from 1 to 5 with 1 being extremely unsatisfying, 2 being unsatisfying, 3 being neutral, 4 being satisfying and 5 being extremely satisfying. Table 5 below shows the results of the survey question.

Table 5: *Results of student overall case study experience responses.*

Experience	Extremely Unsatisfying - 1	Unsatisfying – 2	Neutral - 3	Satisfying - 4	Extremely Satisfying - 5
Number of Responses	0	0	0	2	6

All eight of the judges said the case study experience was satisfying or extremely satisfying. The average company sponsor rating for the overall case study learning experience was 4.8 out of 5. All eight of the judges said they felt as though they would be interested in sponsoring a similar case study experience in the future with the industrial engineering faculty at Penn State University Park. In addition, all of the judges said they would be interested in making this an annual event in this engineering economy course at Penn State.

Survey #3: Student Business Skills and Interests Results and Discussion

The overall goal of the effort put into changing the engineering economy curriculum and adding this real life case study to the course was to graduate industrial engineering students with a more thorough understanding of how their engineering decisions impact company financial statements and to develop engineers that are able to sell their engineering proposals to company managers through the use of an engineering economic analysis and the use of key financial accounting terms and principles.

Demographics

Out of the 116 students enrolled in the engineering economy course, 105 completed the third survey regarding their business skills and interest. 79 male students and 26 female students completed the survey. 103 of the 105 students responded as being junior standing while 2 of the students responded as seniors. All 105 students were industrial engineering majors. Out of the 105 students, 3 of the students were minoring in business/ liberal arts while 4 of the students were minoring in engineering entrepreneurship and 1 was minoring in engineering leadership.

Financial Statements, Financial Accounting, Finance Knowledge, Economics

Prior to taking the engineering economy course, only 33.3% of the students (35 out of 105) said they had any knowledge of financial statements, financial accounting, and finance. After taking the engineering economy course, 99% of the students (104 out of 105) said they felt as though it was important for engineering students to understand financial statements, financial accounting, and finance. In addition, 99% of the students (104 out of 105) said the engineering economy course did a good job of teaching them the importance of understanding how engineering decisions impact financial statements and the bottom line of the company.

As for teaching students how to manage their own personal finances, 92.4% (97 out of 105) of the students said the course did a good job of teaching them how to manage their own finances. 95.2% (100 out of 105) of the students said they felt as though the engineering economy course did a good job of teaching them how to plan for retirement.

The breakdown of the economics courses taken by the 105 students responding was: 52 microeconomics, 31 macroeconomics, and 22 both micro and macroeconomics. All 105 students said that the engineering economy course was more valuable than the economics course(s) they previously completed. In fact, 93.3% of the students (98 out of 105) felt as though every student (non-engineering and engineering) should take a course like this engineering economy course. Over 87% of the students (92 out of 105) said they felt as though a course like the engineering economy course would be a good course to offer as a General Education (Social and Behavioral Sciences at Penn State) course available to all students.

Business Minor, MBA

Before taking the engineering economy course, 28.6% of the students said they were interested in completing a business minor. 58.1% of the students said they were interested in completing an M.B.A. prior to taking the engineering economy course. After taking the engineering economy course, 46.7% were now interested in completing a business minor while 70.5% were now interested in completing an M.B.A.

Business and Engineering Interest

The advanced engineering economy course in the industrial engineering program at Penn State is counted as an industrial engineering technical elective. After taking the engineering economy course, 92.4% of the students (97 out of 105) said they would like to take the advanced engineering economy course in the future. In fact, 94.3% of the students (99 out of 105) said they would be interested in completing a business and engineering specialization track or minor (4 or 5 courses) that was concentrated on business planning, engineering economy, project management, and financial accounting if one existed.

Business and Engineering Group (B.E.G.)

The instructor of the engineering economy course is the faculty adviser for the "Business and Engineering Group" (B.E.G.) at Penn State University Park. The first year in existence for this student group was the 2013-2014 school year. The group had 24 paid members. During the 2014-2015 school year, the group has grown to 70 paid members. As previously discussed[29], the executive board members of B.E.G. are the financial advisers for the stock portfolio case study in this engineering economy course. The B.E.G. executive board members were also actively involved with the company case study competition in this engineering economy course. All of the executive board members have taken the engineering economy course and have internship and/or co-op experience. 94.3 % of the students (99 out of 105) said they liked the idea of having industrial engineering undergraduate students with internship experience involved with the case study experience in the engineering economy class. 70% of the students said that the B.E.G. students added value to the delivery of the course. Likewise, 70% of the students said the B.E.G. student involvement helped to spark their interest in the semester long stock and investment case study. 69% of the students said they were motivated to want to learn more about the engineering economy topics (namely financial statements, stocks, retirement) as a result of

the B.E.G. student involvement in the course. In fact, 79% of the students would like to see industrial engineering undergraduate students with internship experience more involved with the delivery of the industrial engineering courses. Likewise, 79% of the students expressed interest in being part of B.E.G after taking the engineering economy course.

Conclusions and Future Work

The overall engineering education goals of this study were to determine if industrial engineering students can be taught the business principles of financial statements and financial accounting, apply those business principles for an industry-sponsored case study, and find value and appreciation for the business principles. The results from this study indicate that each of these goals was accomplished in overwhelming fashion. There were additional advantages shown in this study, including an appreciation by the company sponsor of the student groups' solutions, appreciation for the company sponsor by the students, and an interest in having members of the B.E.G. working with the engineering economy class.

From an engineering education standpoint within an engineering economics course, this study has shown that using an industry-sponsored case study can be used to reach educational objectives and expand the application of those objectives. Furthermore, this approach has additional advantages over a general case study because it gives students exposure to an actual company, an actual company project (or something very similar), and current company personnel (as both presenters and judges). This could also lead to expanding the students' network, and perhaps lead to employment (e.g., internship, full-time) at the sponsoring organization. Finally, 12 of the students were able to obtain scholarship funding from their work on the project.

This study does lead to questions of further inquiry:

- Does the competitive nature of the case study competition (i.e., for scholarship funding, beyond achieving a good grade) change the students' attitude and enthusiasm about the course and the case study assignment?
- Can the case study competition model be applied to other courses within industrial engineering and/or engineering?
- Can the case study competition model be repeated in this course and continue to produce the same level of student achievement, student appreciation, and sponsor appreciation?

Bibliography

1. Mark Archibald, Mark Reuber, Blair Allison, "Reconciling Well-defined Capstone Objectives and Criteria with Requirements for Industry Involvement," *Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition*.
2. J. Darrell Gibson, M. Patricia Brackin, "Techniques for the Implementation and Administration of Industrial Projects for Engineering Design Courses," *Proceedings of the 1999 American Society for Engineering Education Annual Conference & Exposition*.
3. James Noble, "An Approach for Engineering Curriculum Integration in Capstone Design Courses," *International Journal of Engineering Education*, 14(3), 197-203, 1998.

4. Ana Vila-Parrish, Dianne Raubenheimer, “Integrating Project Management & Lean-Six Sigma Methodologies in an Industrial Engineering Capstone Course,” *Proceedings of the 2012 American Society for Engineering Education Annual Conference & Exposition*.
5. John Lamancusa, Jens Jorgensen, Jose Zayas-Castro, Julie Ratner, “THE LEARNING FACTORY – A new approach to integrating design and manufacturing into engineering curricula,” *Proceedings of the 1995 American Society for Engineering Education Annual Conference & Exposition*.
6. R.S. Sawhney, S. Maleki, J.H. Wilck, P. Hashemian, "Center for Productivity Innovation's Student Project with Industry Program at the University of Tennessee, Department of Industrial and Systems Engineering," *INFORMS Transactions on Education*, 13(2), 83-92, 2013.
7. Alan Dutson, Robert Todd, Spencer Magleby, Carl Sorensen, “A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses,” *Journal of Engineering Education*, 86(1), 17-28, 1997.
8. Paul Kauffman, Gene Dixon, “Vetting Industry Based Capstone Projects Considering Outcome Assessment Goals,” *International Journal of Engineering Education*, 27(6), 1231-1237, 2011.
9. E. Dixon, J.H. Wilck, "Integrating Economic Analysis into Capstone Design," *ASEE Annual Conference & Exposition*, Indianapolis, Indiana, June 2014.
10. Mathematics and Democracy: The Case for Quantitative Literacy, The National Council on Education and the Disciplines, Executive Editor: Lynn Arthur Steen, 2001.
11. Greg Pearson and A. Thomas Young, Editors, Technically Speaking: Why All Americans Need to Know More About Technology, National Academy of Engineering (NAE), 2002.
12. Robert M. Solow, "Technical change and the aggregate production function," *Review of Economics and Statistics*, 39(3), 312-320, August 1957.
13. J.H. Wilck, P.C. Lynch, P.J. Kauffmann "Engineering Economics as a General Education Course to Expand Quantitative and Financial Literacy," *ASEE Annual Conference & Exposition*, Indianapolis, Indiana, June 2014.
14. Ted G. Eschenbach, "The Engineering Economy Course of 2020," *Proceedings of the 2002 American Society for Engineering Education Annual Conference*.
15. William R. Peterson, Rafael E. Landaeta, and Bryan Magary, "Is It Time For A New Paradigm?," *Proceedings of the 2005 American Society for Engineering Education Annual Conference*.
16. Ted G. Eschenbach, "Suggestions for Teaching Engineering Economy at the Undergraduate Level," *The Engineering Economist*, 44(1), 126-128, 1999.
17. Joseph C. Hartman, "Suggestions For Teaching Engineering Economy at the Undergraduate Level," *The Engineering Economist*, 44(1), 110-125, 1999.
18. P.-W. On, and L. Occena, "Instructor's Perspectives of Transforming a Traditional Engineering Economics Course into a Fully Online Delivery," *Proceedings of the 2012 ASEE Annual Conference*.
19. Scott E. Grasman, "Teaching Engineering Economics via Distance Education," *Proceedings of the 2002 American Society for Engineering Education Annual Conference*.
20. Joseph C. Hartman, and J. Smith, "Developing an Online Undergraduate Engineering Economy Course," *American Society for Engineering Education*, 2010.
21. Leslie Pagliari, Eugene Dixon, Paul Kauffmann, and M. Mehta, "A Distance Education Graduate Course in Engineering Economics: Results and Lessons Learned," *American Society for Engineering Education*, 2006.
22. Joseph C. Hartman, "Incorporating and Assessing Risk Analysis in Undergraduate Engineering Economy Courses," *American Society for Engineering Education*, 2012.
23. Ted G. Eschenbach and Jerome P. Lavelle, "How Risk and Uncertainty Are/Could/Should Be Presented in Engineering Economy," *IERC Proceedings*, Institute of Industrial Engineers, 2002.
24. J.H. Wilck, P.J. Kauffmann, "A Comparative Review of Two Engineering Economics Sections: One Traditional and One Online," *ASEE Annual Conference Proceedings*, Atlanta, Georgia, June 2013.
25. P.S. Peercy and S.M. Cramer, "Redefining Quality in Engineering Education Through Hybrid Instruction," *Journal of Engineering Education*, 100(4), 625-629, 2011.
26. K.R.M. Mackey and D.L. Freyberg, "The Effect of Social Presence on Affective and Cognitive Learning in an International Engineering Course Taught via Distance Learning," *Journal of Engineering Education*, 99(1), 23-34, 2010.
27. P.J. Kauffmann, J.H. Wilck, "Relationship of Final Grade and Use of Online Course Materials for an Engineering Economics Course," *ASEE Annual Conference Proceedings*, Indianapolis, Indiana, June 2014.

28. P.C. Lynch, C.A. Bober, J.L. Mines, "Designing Industrial Engineering Course Content and Delivery with an Understanding of the Learning Preferences and Factors Driving Satisfaction of Undergraduate Industrial Engineering Students," *ASEE Annual Conference Proceedings*, Indianapolis, Indiana, June 2014.
29. P.C. Lynch, J.H. Wilck, C.A. Bober, J.L. Mines, "A New Look at Involving Undergraduate Students, Real Life Applications, and Active Learning Activities in the Industrial Engineering Undergraduate Course Delivery Process," *ASEE Annual Conference Proceedings*, Indianapolis, Indiana, June 2014.

Appendix

Table A.1: *Detailed Engineering Economy Course Outline*

Unit	***Topics***
Intro.	Introduction to Time Value of Money
1	Applications of Engineering Economics, Interest and Time Value of Money, Simple and Compound Interest Rates
2	Economic Equivalence, Single Cash Flows (Present Value, Future Worth), Solving for (i) and (n), Unequal Lengths of Interest Period and Cash Flow Period
3	Equal Payment or Uniform Series, Sinking Fund Factor (A/F, i, n), Capital Recovery Factor (A/P, i, n)
4	Principal Amount and Interest Amount Included in Loan Payments, Present Value of Perpetuities, Linear Gradient Series, Present Worth Factor: Linear Gradient Series (P/G, i, n)
5	Gradient-to-Uniform Series Factor (A/G, i, n), Geometric Gradient Series, Geometric Present-Worth Factor (P/A_1, g, i, n), Composite Cash Flows, Continuous Compounding
6	Business Planning, Financial Statements, Financial Accounting and Ratio Analysis, Activity Based Costing
7	Continuous Compounding, Effect of inflation, Average Inflation Rate, Time Value of Money with Inflation, Actual Dollar Analysis or "Then Current Analysis, Constant Dollar Analysis
8	Comparison of Engineering Projects, Payback Analysis (Conventional and Discounted), PW Analysis (Net Present Worth and Net Present Value), Annual Cash Flow Analysis, Rate-of-Return Analysis, Selecting a MARR, Investment Pool Concept, Borrowed Funds Concept, Net Future Worth and Project Balance
9	Capitalized-Equivalent Method, Perpetual Service Life, Service vs. Revenue Projects, Evaluating Projects with Equal Analysis Periods and Lives, Evaluation Projects with Unequal Analysis Periods and Lives
10	Annual Equivalent Worth Criterion, Comparing a Set of Projects, Finding Annual Equivalent Worth by Conversion From NPW, Capital (Ownership) Costs versus Operating Costs, Calculating Capital Recovery Cost, Applying Annual-Worth Analysis, Unit-Profit or Unit-Cost Calculation
11	Make or Buy Decisions, Comparison of Mutually Exclusive Projects (Unequal and Equal Project Lives), Annual Equivalent Cost Comparisons
12	Rate of Return, Return on Investment, Return on Invested Capital, Internal Rate of Return, Simple vs. Non Simple Investments (Borrowing and Lending), Computational Methods (Direct-Solution, Trial-and-Error), Bonds, Yield to Maturity
13	Decision Rule for Simple Investments, Decision Rule for Non Simple Investments, Incremental Analysis for Comparing Mutually Exclusive Alternatives, Flaws in Project Ranking by IRR, Incremental-Investment Analysis, IRR on Incremental Investment Alternatives, Incremental Analysis for Cost-Only Projects
14	Mortgages, Fixed Rates, Adjustable Rates, Refinance Decision, Payback Analysis, Pay-Off Balance Calculations, Interest and Principal Calculations, Credit Scores
15	Accounting for Depreciation and Income Taxes, Depreciation and Cost Basis, Useful Life and Salvage Value, Depreciation Methods: Book and Tax Depreciation, Straight Line Method, Declining Balance Method, Depreciation Rates, Switching Policy, Units-of –Production Method, Tax Depreciation Methods, MACRS Recovery Periods, Switching from DB to the SL Method, MACRS Depreciation of Real Property
	Additional Case Study Topics: Retirement Planning, Traditional IRA, Roth IRA, 401K, Savings Accounts, Tax Implications, Stock and Bond Investments