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A New Look at Involving Undergraduate Students, Real Life Applications, and Active Learning Activities in the Industrial Engineering Undergraduate Course Delivery Process

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A New Look at Involving Undergraduate Students, Real Life Applications, and Active Learning Activities in the Industrial Engineering Undergraduate Course Delivery Process

Abstract

This paper discusses a new approach taken in industrial engineering course delivery that brings real life case studies and active learning activities into the industrial engineering classroom. The active role that senior undergraduate students with internship and co-op experience play in helping to deliver the real life, active learning components of the course is also discussed.

The paper first briefly summarizes the results of work that was completed on modeling student satisfaction and motivation in industrial engineering education. The results of this work led to this current effort of studying this new approach in industrial engineering course delivery. The paper goes on to explain the current and ongoing work being carried out in an engineering economy course to upgrade the curriculum, while also improving student satisfaction in the course by improving course delivery.

Motivation

When 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 Penn State University Park. Input from former students and an industrial professional advisory committee (IPAC) 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, financial accounting, and stock value. 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 this public university in the USA, industrial engineering students are only exposed to a semester of financial accounting and financial statements if they choose to complete a minor in business. Students would have limited exposure to these topics if they completed an engineering entrepreneurship minor.

Along with updating and changing the current engineering economy curriculum, the instructor also worked diligently to deliver the course in a manner that would address the findings of a study carried out during Spring 2013 on understanding the factors that drive student motivation and satisfaction for the industrial engineering students in this industrial engineering department. The goal is to deliver the most up to date and practical curriculum in a manner that seeks to maximize student motivation in an attempt to maximize satisfaction and student learning of the course material. The engineering economy course at Penn State University Park typically has enrollments each Fall and Spring semester of about 100 students. The instructor identified student motivation as being critical to setting the classroom tone and ultimately promoting student self-learning and satisfaction with their education. The positive feedback from incorporating senior level undergraduate students with internship or co-op experience in manufacturing into the delivery of a lab based manufacturing process solidification course for junior level students along with the interest of senior level undergraduate students assembling a student group that would bridge the gap between business and engineering spurred the idea of incorporating senior level undergraduate students into the delivery of a portion of the engineering economy course.

Background

Incorporating course delivery methods that adequately address the different learning styles in the classroom while developing practices to maximize student motivation is imperative to maximize student satisfaction and learning experiences. Previous work has shown that not just industrial engineering students but all STEM students are predominantly active, visual, and sensing learner types[1-4]. However, it is evident that most engineering undergraduate courses are generally taught toward reflective, verbal, and intuitive learner types. This is in fact the exact opposite of the suggestions made from multiple learning style studies[1-4]. Engineering teaching is more focused on theory and mathematical proofs over practical, "real world" applications and experimentation favored by sensing learners. Engineering instruction tends to be very verbal rather than visual, focusing on written explanations and mathematical formulas. In addition, the engineering classroom tends to rely heavily on lectures and reading assignments rather than utilizing hands on problem solving and active learning techniques preferred by active learners[3]. It is known that teachers often instinctively prefer to teach in the same way they prefer to learn or the way they were taught [5]. Previous work has shown that when an educator's teaching style and students' learning styles match, students gain a better understanding of the course material[3,5,6]. Students remember the course material for a longer amount of time and leave the course with a deeper understanding of the material. These students have a more positive course outlook than students whose learning styles do not align with the educator's teaching style[5].

For an instructor to achieve the highest motivation of a student, instructors must do more than to just use blended modes of teaching. For a student to be highly motivated, the student must value a goal, believe in their capabilities, and have a supportive environment around them. It is crucial to have positivity in all three areas to achieve motivated behavior. Motivated students strive to make the most of their education by acquiring new information and using it to further their knowledge[7]. Students that do not see the value in a goal will act in the rejecting or evading manner. To increase the value that students' place on a task, it is helpful to relate it to their interests[6,7]. If students are able to work on a topic that has meaning or relevance to them, they are more likely to see the value and become motivated[7]. Another tactic to increase motivation is to provide tasks that focus on real-world events. By focusing on real-world problems, students get to see the actual applications of the theories learned in class[6,7]. Felder and colleagues recommended presenting real-life examples of problems that theory will be used to solve before teaching students the actual theory[5,7]. Case studies, discussions on current events, and field trips are all strategies that help students see their classroom material come to life[7].

Research has also shown that students may find value in a class if they understand its future implications on their academic and industry endeavors. Stressing the importance of how course material will be relevant in the future will help to increase their motivation[6,7]. For instance, stressing the importance of communication in the workplace may help justify to engineering students the importance of proper writing in lab reports and collaboration as group members. Educators also should convey to students how they will be able to help them with challenging material, such as review sessions, supplementary materials, or additional office hours[7].

The study leading up to this implementation study found that student satisfaction with a course was directly tied to the course instructor[1,2]. From the previous study[1,2], when industrial engineering students were asked for ways to improve industrial engineering course delivery at this institution, the most commonly mentioned comments fell into the following eight categories: Approachability of Educators, Priorities of Educators, Enthusiasm of Educators, Assessment Practices, Grading Procedures, Use of "Real World" Examples, Modes of Teaching, and Active Learning Activities in Class[1,2]. The effort put forth by the instructor in delivering the course is of utmost importance to delivering positive learning experiences and overall student satisfaction with their industrial engineering education. In their work, Litzinger and colleagues discussed the importance of effective learning experiences. Effective learning experiences help students understand important concepts and contribute to a positive learning experience[8]. Deliberate practice, practice with the intent of developing a specific ability, contributes to effective learning experiences[7-8]. The medium from which students receive deliberate practice is in fact course design and instructor assistance[8].

In addition to the need for changes to be made in course delivery to help improve engineering student learning experiences, research has shown that more emphasis needs to be placed on effective learning activities that best prepare students to solve problems in the real world. Research performed by Sheppard, Macatangay, Colby, and Sullivan[9] at several United States engineering institutions found that current curricula are over-emphasizing analytic skills and not putting enough emphasis on professional skills, design, and experimentation[8,9,10]. The challenge for educators lies in implementing these activities into an already overloaded curriculum. Most engineering classes are required to cover large amounts of very important information, and many educators already feel overwhelmed with this responsibility.

A number of recent studies of engineering economics are published in the engineering education literature. In 2002 a futuristic look at engineering economics education[11] was provided making a number of observations about the future of the course given past trends and insight into topical coverage of the traditional versus modern textbooks. In 1999, there were two papers with suggestions and comments for undergraduate engineering economics education[12,13] and a follow-up discussion[14] in 2005. These papers discuss the move from decision making analysis towards financial mathematics, and also discuss spreadsheets and online educational tools (e.g., supplementary material in addition to the textbook material). Recent engineering economics textbooks, published in 2011, have reemphasized decision making analysis[15,16]. Since 2000, many articles have been published that provide either structure or experiences in teaching engineering economics at both the undergraduate and graduate levels[17-21], and the inclusion of risk and uncertainty in engineering economics[22,23].

There also includes an abundance of engineering education literature inclusive of engineering economics, but more broadly within the realm of industrial and systems engineering. Relevant to this paper, these studies have been completed on implementing lean and six sigma methods into a senior design capstone project course[24], and the usefulness of industry design projects for graduate students[25] and senior undergraduate students[26].

Taking into account the results of this current study[1,2] on motivation and satisfaction and also taking into account the prior work cited from the literature, changes were implemented to both the curriculum and the manner in which the engineering economy course was delivered. Incorporating senior level students with work experience and student group involvement into the delivery of a junior level course to improve student motivation and satisfaction was a new idea that has not been thoroughly studied in the literature.

Implementation

Engineering Economy Course

The engineering economy course is a 15 week long industrial engineering course at Penn State University Park. During the Fall 2013 semester at Penn State University Park, the course met twice per week for 75 minutes each period. The course enrollment was 92 junior and senior level industrial engineering students. The detailed breakdown of the course topics covered in this course is shown in the appendix in Table A.1.

Course Design

The primary mode of instruction in the course lecture was PowerPoint presentations given by the instructor using a tablet PC. The PowerPoint presentations were a mixture of type written notes and sample problems. The instructor manually wrote out and solved sample problems in the lectures with the help of student participation throughout the course. During each and every lecture, the instructor made connections to real life applications for the material being taught in the class. The engineering economy topics were not only taught in the context of making engineering investment decisions, but also in making every day personal financial decisions. Some of the personal topics discussed in the course were: auto loans and leasing, home buying and mortgages, student loans, apartment leasing, personal income taxes, retirement planning (Roth IRA, Traditional IRA, 401K), investing (stocks, bonds, precious metals), bank savings accounts and certificates of deposits, credit reports, and inflation. Additional in class problems were distributed to students throughout the semester to work on in groups followed by collective problem solving by the entire class. Attendance in all classes was mandatory; attendance was taken at the beginning of each class by roll call or by a sign in. Attendance was included as 10% of the final course grade. Out of class problem sessions were held before all (3) exams in the course. Students worked in groups to solve problems during the optional out of class problem sessions.

A case study worth 10% of the final grade on retirement planning (IRA, 401k), investment portfolio management (stocks, bonds, precious metals), and financial statements was assigned as a semester long active learning project with students working in case study groups of 4 to 5 students. An optional out of class talk titled “Engineering and Business: Getting up to Speed” was hosted by the Business in Engineering Group (B.E.G.) and was open to any student interested in learning more about various business and engineering topics including finance careers, business minor, future M.B.A., top financial employers, and the importance of business skills in engineering.

The course instructor or the teaching assistant for the course had regularly scheduled office hours every day of the work week (Monday-Friday). Students could also schedule times to meet with the instructor or teaching assistant outside of their regularly scheduled office hours. The grading policy in the class was a one class period policy for quizzes and case studies and a one week policy for all exams. All quizzes and case studies were graded and returned to the students one class period after they were given or were due. All exams were graded and returned to the students within one week of the exam date. Students wishing to have an assessment re-graded had the opportunity to submit a typed re grade memo to the course instructor within one class period of the assignment being returned in class. The instructor completed the re-grade and gave an explanation of the re grade back to the student within one class period after the submission of the re-grade memo.

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

After the Spring 2013 semester at Penn State University Park, a number of students with sincere interest in learning additional business topics outside of what is covered in the engineering economy course began talking with the engineering economy instructor about forming a student business group within industrial engineering. In the months following the end of the Spring 2013 semester, the senior undergraduate industrial students worked with the instructor of the industrial engineering economy course to form a new "Business and Engineering Group" (B.E.G.) within their industrial engineering department. The instructor of the engineering economy course is serving as the faculty adviser for B.E.G. Out of the four students that built the foundation for the new student group, three are male and one is a female student. The students helped to define the goals and initiatives for the group moving forward. Among others, one of the initiatives is for B.E.G. to be actively involved with the delivery of the junior level engineering economy course. The four students that have kick started B.E.G. all have sincere interests in business applications and they all have relevant industrial engineering internship and/or co-op experience.

Another part of the B.E.G. mission is to bring in guest speakers to discuss various business topics of interest to the industrial engineering students. The first B.E.G. talk occurred on Monday, November 18th, 2013 outside of the regularly scheduled engineering economy class time. The B.E.G. students hosted a member of the finance faculty from the school of Business at Penn State University Park. The talk covered various topics including completing a business minor, M.B.A. after graduation, careers in finance and accounting, corporate finance, financial statement analysis, stocks and business planning among other topics. The talk was optional and all undergraduate students from this department were invited to attend the talk. The students officially kicked off their student group (B.E.G.) at this talk. Approximately 45 undergraduate industrial engineering students attended the talk.

Engineering Economy Case Study and B.E.G. Involvement

All four of the founders of B.E.G. served as "financial advisers" to help deliver the case study component for the Fall 2013 engineering economy course. As mentioned, one of the key parts of the B.E.G. mission is to be actively involved in supporting the engineering economy course in industrial engineering. Each financial adviser had 5 case study teams to work with throughout the semester. Each case study team consisted of 4 to 5 students. The engineering economy students were responsible for assembling their own case study groups during the first week of the class. The case study was a real life assignment broken down into two parts as shown in Table 1 below.

Table 1: *Engineering Economy Case Study Topics*

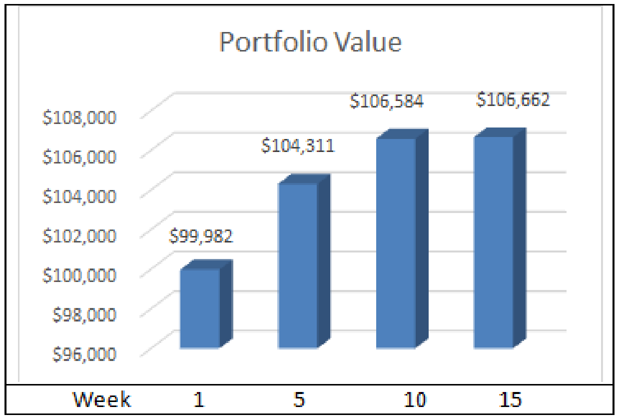
Engineering Economy Case Study Topics	
PART A (100 Points)	**PART B (100 Points)**
Roth IRA	Investment Portfolio (Stocks/ Metals)
Traditional IRA	Financial Statement Analysis (Apple Inc.)
401k	
Bonds	

In part A of the case study, the students worked on both qualitative and quantitative (calculation based) questions regarding retirement planning (i.e., traditional IRA, Roth IRA, and 401 (k)) and bond investing. In part B of the case study, the advisers helped the students to complete an in depth financial statement analysis on Apple, Inc. and also monitored stock and precious metal investment portfolios throughout the 15 week semester. In week 1 of the course, each group put together a $100,000 investment portfolio consisting of (10) stocks and precious metals. The groups were instructed to choose (2) stocks from each of the following five sectors: Manufacturing (Autos/ Machinery/ Aircraft), Energy, Retail, Internet/ Computer, Finance/Banking/ Credit. They were also asked to choose a precious metal to add to their portfolio. Portfolio allocation amounts were left up to each case study group. After each group made their selections and determined allocations, they submitted the portfolio allocations to their respective financial adviser. The financial advisers provided portfolio performance summaries every five weeks to the individual groups and they also provided the groups with an end of semester (week 15) investment portfolio summary that was included with the final written component of the semester long case study. Every five weeks, the course instructor provided in class updates on the top 5 performing groups and the top 10 and worst 10 performing stocks. At the end of the course, each group submitted a final portfolio summary as a portion of Part B of their case study. A sample portfolio summary is shown in Figure 1.

ENGINEERING ECONOMY FALL 2013

INVESTMENT PORTFOLIO SUMMARY (GROUP 1)

Investment Portfolio Bar Graph:



Investment Portfolio Stock & Metals Summary:

Sym	Name	Shares	Price/Share (8/30)	Price/Share (9/23)	Price/Share (10/28)	Price/Share (11/27)
TSLA	Tesla Motors	53	169.00	181.11	162.86	126.07
HMC	Honda Motor Company	252	35.94	38.92	39.76	42.03
CVX	Chevron Corp	75	120.43	125.52	120.91	122
XOM	Exxon Mobil Corp	120	87.16	87.75	88.23	93.69
MCD	Mcdonald's Corp	96	94.36	97.28	95.37	97.11
DLTR	Dollar Tree	172	52.70	57.88	59.23	55.92
GOOG	Google Inc	11	846.90	886.5	1015	1061.1
AAPL	Apple Inc	17	487.22	490.64	529.88	544.17
WFC	Wells Fargo & Company	221	41.08	42.31	42.83	44.25
AXP	American Express Company	126	71.91	76.44	82.76	85.5
	Palladium	12	718.00	716	739	715
		Portfolio Value	99982.27	104311.24	106584.18	106662.11

The above statement provides you with a 15 week summary of your investment portfolio performance. Please let me know if you have additional questions regarding your portfolio performance. Have a great winter break!

Sincerely,

John Smith

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

Financial Adviser

Figure 1: *Engineering Economy End of Semester Case Study Investment Portfolio Summary Supplied by Business and Engineering Group Financial Advisers.*

In addition to the summary above, each group also completed a financial statement (ratio) analysis of Apple, Inc. This activity allowed students to link financial statements and financial ratios with company stock performance. Ultimately, they were able to learn the importance of making sound engineering economic decisions that will help improve a company's financial statements.

As part of the curriculum and course delivery changes made to the engineering economy course, students voluntarily and anonymously completed a series of questions regarding the design and delivery of the new curriculum for the engineering economy course.

Survey Results

A student questionnaire regarding student satisfaction and the learning experience in the Fall 2013 engineering economy course was distributed to all engineering economy students present at the beginning of the final engineering economy class period of the Fall 2013 semester. All of the students surveyed were either juniors or seniors in the industrial engineering degree program, and all of the students had completed either microeconomics or macroeconomics at the undergraduate level (24 of the students had taken both microeconomics and macroeconomics). There were 92 students enrolled in the course. The survey was completely or partially completed by the 85 students (51 male, 30 female, and 4 unspecified) that were in attendance when the survey was distributed.

Undergraduate Student Involvement

The concept of having senior level undergraduate industrial engineering students (B.E.G. students) involved with the delivery of the engineering economics course was explored in one portion of the questionnaire at this public university in the USA. The questions asked to the engineering economics students regarding the involvement of the undergraduate industrial engineering students with the delivery of their course are shown in Table 2.

Table 2: *Student Survey Questions for Undergraduate Student Involvement in Course Delivery.*

Relevant Undergraduate Student Involvement Survey Questions
1. Did you like the idea of having industrial engineering undergraduate students with internship experience involved with the case study experience in your engineering economy class? Y OR N 2. Do you feel as though the undergraduate student involvement (i.e. financial advisers from B.E.G.) in your class has helped to: (a) Add Value to the Delivery of a Course (i.e. increases your satisfaction with course delivery)? Y OR N (b) Spark Your Interest in the Semester Long Stock and Investment Case Study? Y OR N (c) Motivate You to Want to Learn More about the engineering economy Topics (Namely Financial Statements, Stocks, Retirement)? Y OR N 3. Would you like to have industrial engineering undergraduate students with internship experience more involved with the delivery of your IE courses? Y OR N 4. Are you interested in being part of the Business and Engineering Group (B.E.G.) after taking the engineering economy course? YES OR NO

The results of the questionnaire showed the students taking the engineering economy course felt as though the involvement of the B.E.G. financial advisers in their course delivery was a positive experience that motivated them to want to learn more about the engineering economy course topics. 95.1% of the students (79 out of 83 responding) responded they did in fact like the idea of having industrial engineering undergraduate students with internship experience involved with the case study experience in their engineering economy course. 67% of the students (57 out of 85) responded they felt as though the undergraduate student involvement (i.e. financial advisers from B.E.G.) added value to the delivery of their engineering economy course (i.e. increased their satisfaction with course delivery). 74.1% of the students (63 out of 85) responded they felt as though the B.E.G. advisers helped to spark their interest in the semester long case study. 80% of the students (68 out of 85) felt as though the B.E.G. advisers motivated them to want to learn more about the engineering economy topics (namely financial statements, stocks, retirement). 85.3% of the students (64 out of 75 responding) felt as though they would like to have industrial engineering undergraduate students with internship experience more involved with the delivery of their industrial engineering courses. In fact, 69.4% (59 out of 85) of the students noted they were interested in being part of the new B.E.G. after they completed the engineering economy course.

Modes of Instruction

The student questionnaire asked the students how helpful they felt each mode of instruction used in the course was to their learning on a scale from 1 (not helpful at all) to 10 (extremely helpful). This portion of the questionnaire is found in Table 3. For questions E and F, since both were optional events, only a fraction of students present actually answered the questions.

Table 3: *Student Survey Questions for Modes of Instruction.*

Relevant Modes of Instruction Survey Questions											
1. Please rate how helpful you feel each mode of instruction was to your learning 1 (not helpful at all) - 10 (extremely helpful).											
A. PowerPoint Lectures	1	2	3	4	5	6	7	8	9	10	
B. Additional In Class Problem solving sessions	1	2	3	4	5	6	7	8	9	10	
C. Case Study (Active Learning, Group Work Module)	1	2	3	4	5	6	7	8	9	10	
D. Demonstrations/ Real Life Discussions	1	2	3	4	5	6	7	8	9	10	
E. Additional Out of Class Problem solving sessions	1	2	3	4	5	6	7	8	9	10	N/A
F. Optional B.E.G. Talk “Engineering and Business”	1	2	3	4	5	6	7	8	9	10	N/A

All 85 students completing the survey responded to questions A through D. The students overwhelmingly felt as though the interactive PowerPoint presentations, in class problem solving sessions, case study, and the in class demonstrations/ real life discussions were all helpful to their learning in the course. The average rating for the helpfulness of the PowerPoint lectures was 9.53 (all 85 responded 7 or higher). The average rating for the helpfulness of the in class problem solving sessions was 9.72 (all 85 responded 7 or higher). The average rating for the helpfulness of the case study was 7.91 (75 out of 85 responded 7 or higher). The average rating for the helpfulness of the demonstrations and real life discussions was 9.32 (83 out of 85 responded 7 or higher). 66 students responded to question E regarding the helpfulness of the additional out of class problem solving sessions. The average rating was 9.15 (62 out of 66 responded 7 or higher). 21 students responded to question F regarding the helpfulness of the

B.E.G. talk on Engineering Business. The average rating was 7.95 (16 out of 21 responded 7 or higher).

Effectiveness of Course Delivery

In addition to asking the students about their experience working with the financial advisers for the course and about the modes of instruction, the questionnaire also asked the students about the knowledge they gained from the engineering economy course. The questions surrounded the effectiveness of the topics that were recently added to the engineering economy curriculum in an attempt to measure the effectiveness of delivering the topics to the students. Table 4 below displays a list of five questions students were asked regarding the effectiveness of the engineering economy course in teaching them about the important link between industrial engineering decisions and financial statements, personal finances, and retirement planning.

Table 4: *Student Survey Questions for Effectiveness of Course Delivery.*

Relevant Effectiveness of Course Delivery Survey Questions
1. Before taking engineering economy, did you have any knowledge of financial statements, financial accounting, and finance? YES OR NO
2. After taking IE 302, do you feel as though it is important for you as an engineering student to understand financial statements, financial accounting, and finance? YES OR NO
3. Do you feel as though the engineering economy course did a good job of teaching you the importance of understanding how engineering decisions impact financial statements and the bottom line of the company? YES OR NO
4. Do you feel as though the engineering economy course did a good job of teaching you how to manage your own personal finances? YES OR NO
5. Do you feel as though the engineering economy course did a good job of teaching you how to plan for retirement? YES OR NO

Prior to taking the engineering economy course, only 22.4% of the students (19 out of 85) said they had any knowledge of financial statements, financial accounting, and finance. After taking the engineering economy course, 98.8% of the students (84 out of 85) said they felt as though it was important for them as an engineering student to understand financial statements, financial accounting, and finance. 100% of the students (85 out of 85) felt as though 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. Likewise, 100% of the students (85 out of 85) felt as though the engineering economy course did a good job of teaching them how to manage their own personal finances. Over 97% of the students (83 out of 85) felt as though the engineering economy course did a good job of teaching them to plan for retirement.

Student Rating of Teaching Effectiveness (SRTE) Engineering Economy Course Ratings Fall 2013

At this institution, all students are asked to complete an optional survey for teaching effectiveness for each of their courses. The courses are rated by students on a scale from 1 (Lowest Rating) to 7 (Highest Rating) with 4 being an Average rating. 63 out of 92 students (68.5%) completed the SRTE for this course during the final week of the semester. The mean for the overall quality of the course was rated as 6.81 out of a possible 7.00. The mean for the overall quality of the instructor was rated as 6.95 out of a possible 7.00. The mean for the organization of course material was rated as 6.84 out of a possible 7.00. The SRTE results showed that the industrial engineering students were overwhelmingly satisfied with their learning experience in the engineering economy course for Fall 2013.

Pilot Study: Manufacturing Processes (Solidification Processing Course) Spring 2013

The solidification processing course is a manufacturing process elective course in the industrial engineering curriculum at Penn State University Park. The course is a 15 week course that consists of two 50-minute lectures each week and a two hour hands on lab each week. During the Spring 2013 semester, two senior undergraduate industrial engineering students with metal casting industry internship or co-op work experience that were student officers of the Penn State the industrial engineering student chapter of the American Foundry Society (AFS) helped in delivering the manufacturing solidification processes course. Two students helped the instructor deliver the course through helping with hands on lab instruction, on site manufacturing plant visits, industry speakers and networking sessions, and a final course case study. There were 60 total students in the lecture portion of the class. There were three lab sections of 20 students per lab section. The feedback from the students on the delivery of the course, including the involvement of the senior level undergraduate students, was very positive. This initial positive feedback from the solidification processing course helped the design of the course delivery of the new engineering economy course during the Fall 2013 semester. The new approach being taken to deliver the course material in an active manner that includes current undergraduate students in the course delivery is ongoing. The solidification processing course will again be offered Spring 2014 and the student learning experience will be monitored and survey data will be collected.

Discussion and Conclusions

This work has provided valuable insight into designing curriculum and course delivery methods for industrial engineering courses in an attempt to increase student motivation and satisfaction with their learning experience. It is critical for educators to look at designing course delivery to address the needs of the different learning preferences in the classroom. Student motivation and satisfaction is driven by the manner in which the course curriculum is delivered and the effort put forth by the course instructor in trying to meet the learning needs of the students in the classroom.

In this study, the primary mode of instruction included PowerPoint lectures. The lectures were active learning dialogues between the instructor and the students in the classroom. Throughout the lectures, problems were solved to introduce new concepts while connecting the concepts with past knowledge of the students. Additional in class and out of class problem solving sessions were held for students throughout the course. During each and every lecture, the instructor made connections to real life applications for the material being taught in the class. The engineering economy topics were not only taught in the context of making engineering investment decisions, but also in making every day personal financial decisions. In addition, a semester long active, hands on group case study on contemporary retirement, investment, financial accounting was carried out with the help of students sincerely interested in the case study topics. The dominant learning styles in this population of industrial engineering students are known to be active, visual, and sensing[1,2]. For these students, there are more problem solving sessions, group activities, hands-on activities, and demonstrations in a satisfying class. These activities best meet the needs of active learners who prefer to take in information "actively" through physical activities. Experience helps these learners best understand new concepts, and they are energized by working with others[3,5,6]. Therefore, it is reasonable that students were overwhelmingly satisfied with the learning experience in this engineering economy course. Active learners are more satisfied with problem solving sessions, group activities, hands-on activities, and demonstrations. The modes of instruction discussed allow active learners the most hands-on interaction and collaboration, and this helps them to learn most effectively.

Adding additional activities to support deep learning may seem impossible to educators. The challenge for educators lies in implementing these activities into an already overloaded curriculum[8,9]. The bottom lines it that educators must be innovative in how they can work these activities into the existing engineering curriculum. This study has shown that by assigning group activities such as real world case studies and coupling these experiences with the opportunity to work with peers and educators with real world experience, it is possible to have students solve engineering problems while also working on the development and honing of professional, design, and experimentation skills.

The results of the survey show that students showed overwhelming support for the new topics and the new course delivery methods utilized in the junior level engineering economy course at Penn State University Park. A tremendous amount of effort went into the design of the new curriculum and also the design of the course delivery methods. The instructor, course teaching assistant and financial advisers for the course dedicated a large amount of time to the course delivery efforts. However, these are the types of efforts that are necessary to provide a positive learning experience[8]. The current work studying the effectiveness of having dedicated, experienced student groups to provide support for courses and topics that are of specific of interest to them is still being examined. The initial findings for the involvement of undergraduate students in course delivery in this study are truly encouraging. The potential academic and professional benefits gained by the students providing the classroom support (i.e. the financial advisers in this study) is yet another area of research that needs to be studied.

Industrial engineering educators can use this study as a model to build upon when designing course delivery in an attempt to improve student satisfaction and learning experiences with their industrial engineering courses.

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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
6	Continuous Compounding, Effect of inflation, Average Inflation Rate, Time Value of Money with Inflation, Actual Dollar Analysis or "Then Current Analysis, Constant Dollar Analysis
7	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
8	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
9	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
10	Make or Buy Decisions, Comparison of Mutually Exclusive Projects (Unequal and Equal Project Lives), Annual Equivalent Cost Comparisons
11	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
12	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
13	Business Planning, Financial Statements, Financial Accounting and Ratio Analysis, Activity Based Costing
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
16	Replacement Analysis, Cash-Flow Approach, Opportunity-Cost Approach
	Additional Case Study Topics: Retirement Planning, Traditional IRA, Roth IRA, 401K, Savings Accounts, Tax Implications, Stock and Bond Investments