

Transforming Engineering Economy into a Two-Credit Course

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Transforming Engineering Economy into a Two-Credit Course: A Work in Process

Abstract

Engineering Economy has been part of many American engineering university core curriculums for decades. It is considered vital to the Professional Engineer and has remained about 3 to 8% of the Fundamentals of Engineering Exam for decades. However, engineering curriculums are getting packed with new topics and over the decades there have been changes to what faculty consider important. As such, Stevens Institute of Technology recently modified its curriculum from a 4 credit engineering economics course to a 2 credit engineering economics course, which must also instruct Project Management. This new 2 credit course will be taught for the first time in the 23-24 academic year. This article discusses the modifications undertaken to make this new course a reality.

Background – Engineering Economics

Engineering Economics has been part of the Fundamentals of Engineering Exam, the precursor to the Professional Engineers Exam, for decades and currently comprises between 3 to 12 questions on the exam (NCEES for current information and Lavelle for historical information). Engineering Economics provides engineers with valuable mathematical tools for implementing cost analysis in their technical design process. Businesses must respond to increased competition through the selection of lower cost solutions and engineering economics provides the tools for this project selection. Engineering Economics accomplishes this by allowing companies to allocate financial resources in the most efficient manner while maximizing financial payback to the company. As Eugene Grant said engineering “involves a realization that quite as definite a body of principles governs the economic aspects of an engineering decision as governs its physical aspects”. Thus, engineering economics deals with the kinds of economic decisions engineers need to make when choosing which alternative design their company should pursue. “Logic” would then dictate that “the engineering economy course would be highly valued” by employers and thus educators. (Burns, et. al.)

For over four decades, the Engineering Economics course at Stevens Institute of Technology has been part of the “core” engineering curriculum; meaning all engineers regardless of discipline take the course. As such it has a high enrollment: approximately 130 in the fall, 400 in the spring. The Engineering Economics course has been a four-credit course comprised of three credits of “course” and one credit of “lab”. The lab portion could be imagined as mandated excel for engineering economics use in the classroom.

Background – Course Design

It has often been the bane of many employers that traditionally trained engineers lack understanding in the skills necessary to succeed in business. Often the engineer understands the technology, but not how that technology can benefit the business. It is skills like teamwork, communication, project management and financial implications of design, etc. that are missing from the traditional engineering education (Felder, Vest, etc). Authors like Sheppard et. al. says the classroom should be modified to allow ways these skills can be taught.

Around 2010, a movement was started at Stevens to infuse Senior Capstone Design experience with necessary skills outside of the major discipline. However, the discipline specific Senior Capstone Design Advisors did not have time, nor often the skill, to teach these topics. A series of one and two credit courses was created to run alongside both senior semesters of Senior Capstone Design to provide knowledge in these areas. The goal was to provide just-in-time learning over both semesters of senior capstone design. This allowed the needs of the senior design advisors from the various disciplines to be married to courses necessary for capstone design, but outside the major discipline, improving functionality of capstone design teams as well as the team's project outcomes. However, Engineering Economics remained its own course, and Project Management as a specific course was not part of the courses that ran alongside the Capstone courses.

Impetus for Change

Around 2020, Stevens revamped its entire engineering core curriculum. “Core” courses at Stevens are taken by all engineers regardless of discipline. During this revamping, Stevens merged classes together and removed others altogether. Prior to the modification process, Engineering Economics was a pre-existing 4 credit course and project management was not a course in the core curriculum at all.

The Senior Capstone Instructors were aware that many of their students did not have good project management skills. They were also aware that their students lacked preparedness in meetings with clients and sponsors. Additionally, faculty were also aware that Engineering Economics is a portion of the Fundamentals of Engineering Exam, and thus a necessary skill that could not be entirely removed from the new curriculum.

As part of the curriculum modification process, it was decided by the faculty as a whole that Engineering Economics was to be merged with Project Management and allocated 2 credits to teach both subjects. Partially due to history of Engineering Economics being a junior level course, and partially due to the desire for students to enter Capstone Design with both skill sets, the course was allocated to term 6 in the junior year. There were two overarching goals for the new 2 credit course:

- to provide the basic Engineering Economics instruction to enable students to pass the Engineering Economics portion of the Fundamentals of Engineering Exam, as well as

- provide generalized instruction on the activities involved in, and the benefits of, project management in order to increase functionality within Capstone Design Teams.

Population

The current study takes place at Stevens Institute of Technology, a small, private, urban campus across the Hudson River from Manhattan in New Jersey. Approximately 4000 undergraduate students are enrolled, of whom over 2000 are engineering students. The Engineering Management Program housed in the School of Systems and Enterprises at Stevens has been ABET accredited since the early 1990's and has been responsible for teaching the junior level Engineering Economics course at Stevens for decades.

Course Re-Design and Instruction

As could be discerned, there needed to be major differences between the old and the new course due to multiple factors; format, credit hours and topics. Originally, 150 minutes of engineering economics class time per week, plus an additional engineering economics lab, with now an additional topic of project management needed to be fit into 100 minutes a week. Additionally, originally 4 engineering economics credit, plus 3 credits of Project Management course work now needed to be reflective of the new 2 credit course weight. This required re-thinking and reimagining the teaching environment just as Sheppard had said needed to happen.

A group of prior Engineering Economics instructors and prior Project Management instructors joined together to form a committee to study and create the new 2 credit combined course. This committee was formed in the spring of 2022. A few virtual meetings occurred in the spring of 2022 during which time the members were advised and discussed the upcoming overarching tasks and goals.

Over the summer of 2022, each committee member was individually tasked with providing a 1-2 page write up of what topics they felt should be covered in the new course and the justification for each topic, keeping in mind the new constraints of time per week and credit hours. Each committee member did this individually without contribution from other members in order to not bias anyone. Prior to the fall semester, the committee chair combined the contributions of each committee member into one document. Although no comments were disregarded in the initial compilation, additional weight was provided to committee members' contributions who taught the topic under discussion (i.e. comments about Project Management by a Project Management instructor were weighted more heavily than Project Management comments by an Engineering Economics instructor, and vice versa).

Over the Fall of 2022, the committee met multiple times to discuss the compiled collection of proposed topics. As could be imagined the original list of topics was long. However, the list also demonstrated general agreement among the faculty on topics. Coming together as a group in the Fall and by recalling and adhering to the two overarching goals of the new course, topics in Engineering Economics were streamlined to align with those on the FE, and Project Management topics were streamlined by committee agreement. This led to a reduced list of topics that each committee member was satisfied with.

In specific, each prior deliverable was reviewed against the two overarching goals of the course. Firstly, Engineering Economics topics were compared to those covered in the FE. As long as the topic was on the FE, it remained in the new course. Those additional topics that were not part of the FE would no longer be taught in the new course. Second, project management topics were reviewed for their contribution to team development and functionality. Those project management topics that were deemed by the committee to contribute to new team cohesivity, functionality and overall production quality were deemed relevant to the new course and remained.

The next task of the committee was to take these potentially disparate topics and connect them together into a cohesive course, instructed not just on the topic, but also by demonstrating how the topic benefits the design and the team to create a design that fits the needs and the costs of the producer and user, not just the desires of the engineer.

Lastly, course instruction was reviewed. Given the course would now be only two credits, a normal load of home works, projects and finals was not considered fair to the students. The committee debated how to cover the multiple topics and adequately assess student learning under the 2 credit requirement. To do so, it was decided to use flipped learning and mostly team assignments; 2 based on Project Management and 5 based on Engineering Economics. There would additionally be a quiz on each topic which would provide individual assessments of student learning.

The Final Syllabus is found below. Class time each week is 100 minutes. When there is no homework listed, lecture will be the only event and will comprise most of the 100 minutes. The weeks where homework is listed, lecture would be reduced to 50 -70 minutes. The remaining 30-50 minutes would be dedicated to completing team-based assignments while the instructor moves around from team to team guiding the students toward the correct approach for the problem sets.

	Lecture Topic Title (50 to 100 mins)	Topic Details	Team Based HW Assignments
Week 1	PM - Project Initiation, fundamental management steps	Integration and Change Management – Understanding and incorporating Stakeholder needs analysis, etc	
Week 2	PM - Managing Systems and IT Projects	Trends and Benefits in Project Management – Less rework and Improved productivity through defined roles and responsibilities and resource management	HW -1 PM
Week 3	PM – Strategic Planning, Project Selection and Project Integration Planning	Project Life Cycles – Improved Project Cost and Scheduling duration Resource Management – Better allocation of resources	HW 2 - PM
Week 4	EE – Topic Introduction & Understanding Cash Flow Diagrams		Quiz - PM

Week 5	Time Value of Money and Interest Rates	Cash flow Diagrams, Interest Rates and Time Value of Money	HW 1 - EE
Week 6	EE - Understanding the 3 Worth's and Capitalized Cost	Introduce the 3 worth's and the evaluation of alternatives and Capitalized Cost	HW 2 - EE
Week 7	EE – Internal Rate of Return	IRR and simple understanding that Incremental is the change from old to new	HW 3 - EE
Week 8	EE - Benefit-Cost Analysis	Include: BCR and simple understanding that Incremental is the change from old to new	HW 4 - EE
Week 9	EE - Depreciation + Break Even Analysis	Include: Depreciation, Break-even analysis	
Week 10	EE - Inflation	Include: Simplified understanding of inflation stressing how to convert between inflation rates. Inflation has immediate real-world relevance and should still be taught but not assessed	HW 5 - EE
Week 11	Project Risk Analysis	Sources of Risk, Quality Assurance and Risk Management– Better Project Monitoring and Control, Change Management	HW 6 – EE
Week 12	Quiz - EE		
Week 13	-What engineers need to know to pass the EE portion of the FE -What seniors should remember as they begin their Capstone Design	Discuss benefits of taking the FE Communications Management and Conflict Resolution – Improved Work instruction	

Conclusion

The new 2 credit combined Engineering Economics and Project Management course will be taught for the first time as a pilot in the fall of 2023 to approximately 40 engineering students. It will then be taught in Spring 2024 to the remaining ~400 engineering juniors. Feedback will be gathered after the pilot and again after the full-scale instruction in order to tweak any issues that may remain. In addition to the two goals set out by the faculty at large of having the seniors pass the Engineering Economics portion of their FE and having more cohesive project management within their Capstone teams, it is also the goal of the instructors of the course to have students appreciate the lessons of both and see the value in understanding that finances and team cohesivity are critical factors in the success of engineering projects in their future careers.