Modification of Engineering Economics Class at Villanova University

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***Abstract*—There are several aspects of engineering economics that depend on cutting-edge technology because it is an area that integrates fundamental economic knowledge and several industry features that are continually advancing. This paper presents modification of the current engineering economics core course that is offered to junior-level civil and environmental engineering students and its corresponding impact on students' performance.**

I. Introduction

ENGINEERING economics represents a branch of economics applied by engineers to achieve the optimal project design and ultimately the optimal decision making through various alternative analyses. At the same time, there are several aspects of engineering economics that depend on cutting-edge technology because it is an area that integrates fundamental economic knowledge and various industry features that are continually advancing. Thus, the onus is on educators to develop a pedagogic approach to not only delivering the basic economy contents but also to exposing the real-life professional scenarios/problems solving process. This paper introduces efforts in enhancing engineering economics core course to better fulfill the above need, especially in civil and environmental engineering (CEE) department at Villanova University. A total of three modules are proposed to transform existing engineering economics class setting.

II. Background

This section describes the inter-relation between engineering economics class (*CEE 3705 Engineering Economics*) and other core courses of CEE curriculum at Villanova University. In addition, survey results that reinforce the importance of engineering economics course are also presented.

A. CEE Curriculum (Junior & Senior Levels)

CEE 3705 Engineering Economics is a junior-level required core course with traditionally total of 48-52 students enrollment divided into two sessions (average of 25 students per session). Main course concepts and knowledge obtained in *CEE 3705* is significantly applied in many senior-level courses and notably in *CEE 4606 Senior Capstone Design* and *CEE 4602 Professional Practices*, both senior core courses. Figure 1 depicts this relationship.

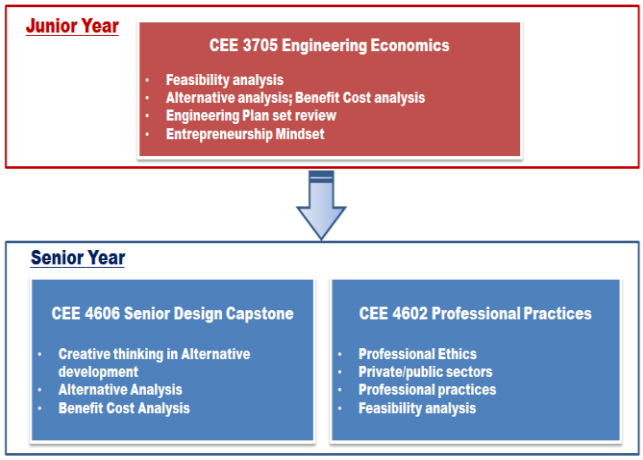

Fig. 1. CEE Core Courses

As it is clear from Figure 1, the *CEE 3705* course modification is expected to not only enhances the corresponding engineering economics course but also other core CEE courses. Furthermore, by exposing students various professional elements at early stage of junior year, one of the three proposed modules for course reformatting, we expect students will make a smooth transition toward senior year where expectation of professionalism is high.

B. Survey results

To fully capture needs and importance of engineering economics course contents, a survey was further conducted and distributed to various stakeholders' including academia, public and private sectors. Survey results confirmed the importance of the economic analysis, software applications, and design standards and plan sets.

Furthermore, annual senior (student) exit survey results also showed that it is essential that they are learning the types of skills that will make them competitive upon graduation and that they have an opportunity to be creative while learning.

To meet these identified needs, *CEE 3705 Engineering Economics* is newly designed by following three modules presented in Section III.

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III. Modules Setting

The proposed course redesign is intended to 1) implement inverted classroom that will allow more interactions between instructor-students during actual classroom setting, 2) to expose civil engineering students to real-life professional scenarios through the preparation of project cost/benefit estimate by reviewing various engineering construction plan sets and in finding and effectively utilizing resources, and 3) to introduce entrepreneur mindset context to help better understand risk management as well as widen students' view associated with engineering economics. In addition, this approach will also foster our students to meet the global needs of multi-discipline engineers. Efforts in this proposed work are consistent with various ABET and ASCE designations such as "*an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability*". It should be noted that this work is still under process and therefore assessment of the proposed work is limited to Modules I and II.

A. Module I: Inverted Classroom

Concept of inverted classroom is a key element in this proposed work. Research has shown that active learning breeds the best retention rates [1]. However, in order to do the type of active learning proposed, the instructors must engage the principles of inverted classroom by recording lectures which students can watch outside of classroom time [2].

In Module I, the inverted classroom (pre-recorded) lectures for several topics are developed. Fundamental topics (e.g., cash flow diagram, various interest rates and present worth etc.) that are consistent over the time were the main areas covered through inverted classroom. Video recording length ranged 15-30 minutes to retain student's full attention. One advantage of having inverted classroom is that students will be able to retrieve help as needed. Villanova University has shown a success in distance learning where the required technology for such classroom setting is significantly similar to the inverted classroom. By applying this recognized technology into Module I, this process is also expected to help student build rigorous knowledge in fundamental economy components. This setting will allow students to fully maximize interaction with the instructor.

B. Module II

Module II focuses on the further application of each topic's knowledge acquired via Module I with the in-class session. Some examples of how to apply concepts taught during Module I include:

- Real-world practices such as
    - Reviewing engineering project plan sets from various state Departments of Transportation (DOTs) to estimate project Life Cycle Cost (LCC).
    - Learn the impacts of regional infrastructure project on regional economy through participating and discussing the public agencies initiatives (i.e., Delaware Valley Regional Planning Commission [DVRPC] Choices and Voices (http://www.dvrpc.org/ChoicesAndVoices) etc.)
- Effectively utilizing library resources to further analyze current economy situation (i.e., homework assignment that covers inflation time-series analysis and correlation analysis between socio and economic element etc.)
- Application of various computer software packages in problem solving (e.g., ATHENA, STEAM etc.), a practice that has been shown to have instructive benefits [3].
- Introducing professional guest speakers to foster real-world scenario and case-study learning

It is expected that upon completion of Module II, students will gain in-depth knowledge of current engineering practices by exposing themselves to real-world professional environments and help broaden the theoretical application.

C. Module III: Entrepreneurship Mindset Cultivation

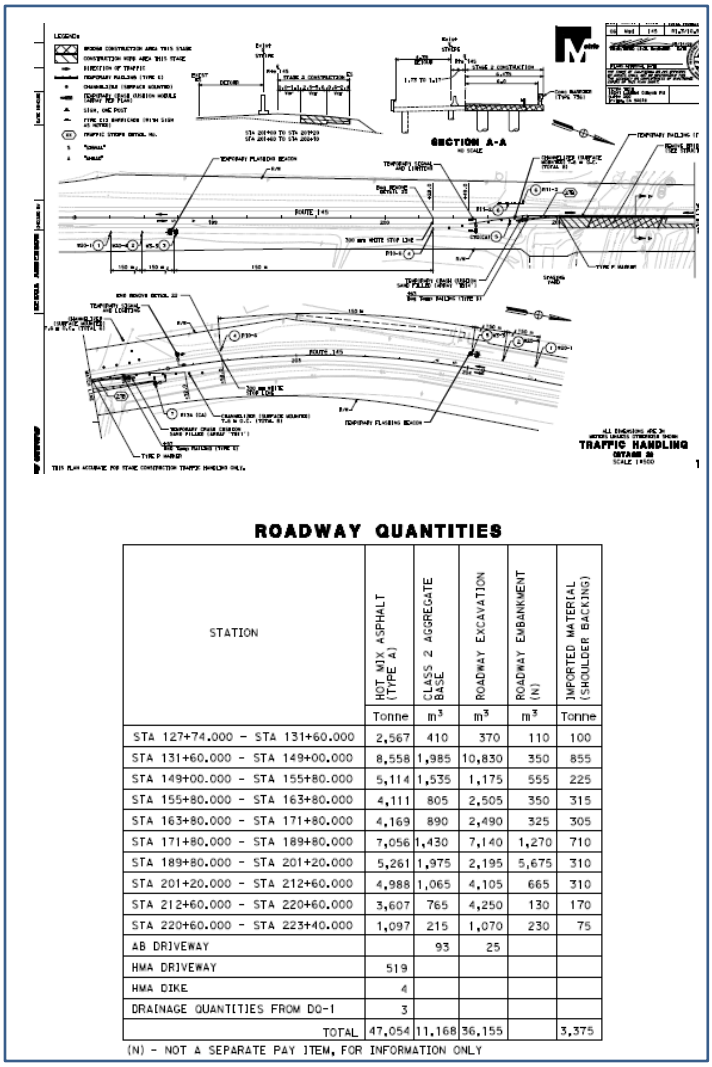
Module III aims to develop an entrepreneur view in the overall engineering economics curriculum. Specific plans include:

- Link Risk Management topic with the Entrepreneurship.
- Semester-long group project assignment focusing on a new product invention. Tasks will include but not limited to:
    - Market survey, feasibility analysis (includes cost-benefit analysis), and LCC.
    - Designation of a student as "project lead" during group project will hone skills related to project management and leadership.
- Collaborate with Villanova's Center for Innovation, Creativity, & Entrepreneurship (www.villanovaice.com/) for various class activities related to Entrepreneurship (e.g., coordination of guest speaker, student competition etc.)

While Module III is not considered as a key core element in traditional engineering economics courses, the value of this module is crucial in that students will be asked to be a creative engineer in a professional manner after mastering Modules I & II.

IV. Assessment Results

Year 2013 Fall semester was the first time to introduce active learning setting (Module I) with the integration of the real-world problem sets (Module II, Figure 2.). As a preparatory step toward future inverted-classroom, active learning method was practiced throughout the semester. Mid-course evaluation, which was conducted right before the fall break, shows that students appreciated real-world problem sets exercise through active learning.



ROADWAY QUANTITIES

STATION	HOT MIX ASPHALT (TYPE A)	CLASS 2 AGGREGATE BASE	ROADWAY EXCAVATION	ROADWAY EMBANKMENT (N)	IMPORTED MATERIAL (SHOULDER BACKING)
	Tonne	m^3	m^3	m^3	Tonne
STA 127+74.000 - STA 131+60.000	2,567	410	370	110	100
STA 131+60.000 - STA 149+00.000	8,558	1,985	10,830	350	855
STA 149+00.000 - STA 155+80.000	5,114	1,535	1,175	555	225
STA 155+80.000 - STA 163+80.000	4,111	805	2,505	350	315
STA 163+80.000 - STA 171+80.000	4,169	890	2,490	325	305
STA 171+80.000 - STA 189+80.000	7,056	1,430	7,140	1,270	710
STA 189+80.000 - STA 201+20.000	5,261	1,975	2,195	5,675	310
STA 201+20.000 - STA 212+60.000	4,988	1,065	4,105	665	310
STA 212+60.000 - STA 220+60.000	3,607	765	4,250	130	170
STA 220+60.000 - STA 223+40.000	1,097	215	1,070	230	75
AB DRIVEWAY		93	25		
HMA DRIVEWAY	519				
HMA DIKE	4				
DRAINAGE QUANTITIES FROM DO-1	3				
TOTAL	47,054	11,168	36,155		3,375

(N) - NOT A SEPARATE PAY ITEM, FOR INFORMATION ONLY

Fig. 2. Example of In-class Exercise Plan Set

In order to assess the effectiveness of the inverted classroom teaching, unique pre-and-post quizzes was developed and completed by students along with their unique anonymous ID (e.g., last four digits of cell phone) to track detailed individual achievement in anonymous way. Analysis of pre-post self-evaluation of the course knowledge level and interest level (Figure 3) shows that not only students perceived that they learned but also gained interest in the corresponding course.

Before

		None	Limited	Fair	Good	Excellent
Knowledge Level	Interest/interest rate concept	3	22	12	7	1
	Alternative analysis	17	15	8	5	0
	Congestion Pricing	30	13	0	2	0
	Excel	0	2	10	30	3
Interest Level	Interest/interest rate concept	12	10	16	4	3
	Alternative analysis	15	14	7	8	1
	Congestion Pricing	20	13	10	2	0
	Excel	1	5	13	21	5

After

		None	Limited	Fair	Good	Excellent
Knowledge Level	Interest/interest rate concept	0	1	6	20	18
	Alternative analysis	0	1	7	25	12
	Congestion Pricing	0	2	16	24	3
	Excel	0	1	5	26	13
Interest Level	Interest/interest rate concept	1	7	16	19	2
	Alternative analysis	1	8	15	19	2
	Congestion Pricing	1	9	21	13	1
	Excel	0	1	13	22	9

Fig. 3. Example of Pre-Post Student Self evaluation

Details of the mid-course evaluation are presented in Figure 4. More than half of the class indicated the in-class examples are main strength of the redesigned course. Approximately 56% of the class were positive when asked class format transition toward inverted-classroom. These results clearly demonstrate the supports and needs of the proposed course redesign.

Things students like about the class	# Students	% Students
In class examples	26	59.1
Relevance of topics & real-world problem	10	22.7
Classes are easy to follow	9	20.5

How the course can improve	# Students	% Students
More examples	15	34.1
Shorter homework	13	29.5

Student 1	Different materials than other courses
Student 2	I enjoy the "Real-World" plan set!
Student 3	More relevant real world examples

Do you think having core topic recorded in video and having more examples during in-class session (as oppose to go over the core topic in-class) will help understand better the corresponding course?	YES 56 %	NO

Fig. 4. CEE 3705 Mid-course Evaluation

V. FUTURE RECOMMENDATIONS

Based on the students' course evaluation and instructor's assessments of students' assignments, the following key items were observed and will be considered for further course enhancement and implementation.

- Effectiveness of inverted- classroom is heavily dependent on the class size and course contents. Fundamental concept which does not vary over time is a good content for inverted-classroom.
- Length of recorded lectures should be limited to 15-20 minutes considering student's attention span as well as potential content correction.
- Students' earlier exposure to various project plan sets was proved to be helpful while reviewing corresponding students' senior-level courses CEE 4602 and CEE 4606.

Further assessment based on the students' Fundamentals of Engineering (FE)/Engineer In Training (EIT) test results is planned once sufficient before and after course redesign datasets are collected.

REFERENCES

[1]. R. M. Felder and R. Brent, "Learning by Doing," Chem. Engr. Education, 37(4),282-283 (2003)

[2]. Winona State University (n.d.), The Seven Principles for Good Practice. www.winona.edu/faculty/478.asp

[3]. R. M. Felder and R. Brent, "Screens Down, Everyone! Effective Uses of Portable Computers in Lecture Classes," Chem. Engr. Education, 39(3), 200-201 (2005)

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