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Including Multi-Disciplinary Project Awareness in First Year Introduction to Engineering Courses

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Full Paper: Including Multidisciplinary Project Awareness in First Year Introduction to Engineering Courses

Abstract

Subsequent to their selection of a particular major, First Year engineering students often identify themselves as their selected major ("I'm an Electrical Engineer") with the preconception that there will be no interaction with engineers from other disciplines (or other professional entities) when they practice engineering in their educational and professional careers. In an effort to broaden the students' perception and understanding of the existence of multidisciplinary interaction on design projects, engineering programs at four U.S. Universities included course materials in their Introduction to Engineering classes to address this topic in the first year. The courses included lecture and experiential components. Student surveys were subsequently administered at each of the universities in order to assess the effectiveness of the teaching methods. This paper presents the teaching methods and materials employed, as well as recommendations of which material or activities should be included in the course to promote multidisciplinary project awareness in the future. Results of the survey will be presented in a subsequent paper.

Introduction

Freshman engineering students often identify themselves as one particular type of engineer ("I'm an Electrical Engineer") without understanding the multidisciplinary nature of both engineering and engineering projects. Indeed, an engineering project may often involve professionals from many disciplines outside of engineering. Collaborative efforts have been made among faculty members at four U.S. Universities to broaden the students' awareness of this subject through lecture and experiential classroom activities. Additionally, a common lecture was presented to the students at all four institutions.

Much discussion has been held in recent years concerning the advantage of having engineering students work on multidisciplinary design teams. The Multidisciplinary Division of ASEE has addressed this issue at its annual convention for over a decade, and its recently issued Survey for Skills Gaps in Recent Engineering Graduates highlights this need yet again [1]. Benefits of multidisciplinary teamwork have been identified to include: the development of technical skills in each student's particular discipline, the development of professional skills (communication, presentation, conflict resolution, group dynamics) and exposure to (and further technical understanding and recognition of) disciplines other than each student's own [2]. Many universities define the term "multidisciplinary" as relating to groups comprised of diverse engineering disciplines only, whereas other universities include in the definition disciplines outside of engineering (such as sciences, humanities, business) [3]. Many universities relegate multidisciplinary team experiences to senior/capstone projects only [4,5] and some include sophomore to senior courses. Other universities run programs that include multidisciplinary design group experiences for freshmen through seniors such as: the Engineering Projects in Community Service (EPICS) Program, Vertical Integrated Programs (VIP) [6,7] and other

Service-Based Learning initiatives in support of Engineers Without Borders [8], UN Development Programme Sustainable Development Goals and National Academy of Engineers Grand Challenges whose purpose is to serve humanity on a larger scale.

Whether an introductory engineering course for first-year students is offered to students of a single engineering discipline, or students from a variety of engineering disciplines, the lack of domain-knowledge among the first-year students means that the cohorts can be considered students of one discipline – aspiring engineers. Having students complete team projects during their first semester can provide invaluable opportunities for interpersonal and professional skill development and introduce students to diverse perspectives. However, since the students are not likely to have developed discipline-specific knowledge that differentiates them from their peers at this academic level, it is unlikely that team projects will lead to first semester students building an appreciation for working with someone from a different professional background and skillset.

The authors incorporated lectures and experiences for first year, first semester engineering students that were designed to help the students appreciate the need for professionals from multiple disciplines when solving problems of human import, and the interdisciplinary nature of the engineering profession. The subsequent sections of this paper will detail the introductory course demographics from the participating universities, the approach taken in developing and delivering the lesson, and results and recommendations based on the experience.

Profile of each university

Engineering Student and Institutional Student population characteristics for each of the Universities who collaborated in this effort are provided in Table 1 below.

Table 1: Summary of institutional metrics.

Institution	On Campus Enrollment #	Total Engineering Enrollment #	Majors Enrolled in First Year Engineering Program
Norwich University	2600	348	ECE, ME, CE, CM, Gen
Virginia Military Institute	1700	475	ECE
Drexel University	15,350	2720	CAEE, MEM, ECE, CMGT, BusENG, Undeclared, ChemE, MSE
Wentworth Institute of Technology	3864	1545	CP, EE, CE, BioE, BioM, ELME, IntE, ME

ECE = Electrical & Computer ME/MEM = Mechanical CE = Civil CM/CMGT = Const Management Gen = General CAEE = Civil Architectural Environmental BusENG = Business and Engineering ChemE = Chemical MSE = Material Science CP = Computer EE = Electrical BioE = Biological BioM = Biomedical ELME = Electro-mechanical IntE = Interdisciplinary

Characteristic components of first year programs

Each University has its own curricula, however common objectives, course materials and exercises regarding exposure to the awareness of the multidisciplinary nature of engineering projects were noted across all four universities as: 1. Engineering as a Profession; 2. Development of Presentation and Communication Skills; 3. Development of Problem Solving Skills in a Group Setting; and 4. Practicing Teamwork. A summary of course structure for each institution is provided in Table 2 below.

Table 2: Summary of introductory course structure.

	Norwich U.	VMI	Drexel U.	WIT
Lecture / Lab Hrs	2/2	1/2	2/2	1/4
Credit Hours	3	2	3	3
Total Weeks	15	15	11	15
Delivery Method	Hybrid and Remote Synchronous	Hybrid and Remote Synchronous	Remote Synchronous	Hybrid and Remote Synchronous

Project Approach

Regardless of other curricular material presented in the First Year Engineering course by each University, all institutions included a common 50-minute lecture on the subject of Multidisciplinary Collaboration in Engineering Projects. The intent of the lecture was to impress upon the students that engineering projects almost always contain multidisciplinary engineering teams plus public Stakeholders/entities in professions that are outside of engineering. The common lecture was delivered to all students across the four universities remotely. An unanticipated benefit to this method of delivery for two of the institutions was that the lecture could be delivered on dedicated "off-hours" - that is, on hours outside of normal class time. In this regard, the lecture could be presented to several sections at once thereby minimizing the lecturer's time commitment. Due to off-hour scheduling restraints, one institution required the lecture to be delivered to separate sections at their regularly scheduled lecture time. The fourth institution offered the lecture as extra credit during off-hours, and the result was that the lecture was poorly attended.

To bring relevancy and currency to the presentation, a Case History (on the Block Island Wind Farm – the first offshore wind farm in the United States) was presented. In that scenario, over 150 Stakeholders had input on the project. During the presentation emphasis was also placed on the importance of both human-centered design and empathy. Student reactions to the lecture (and course material) included comments such as "I never thought about engineering designs affecting others than the designers", and "He also talked about how engineering disciplines 'commingle', and we should use this time to learn as much as possible about all areas of engineering. One thing he said that stuck with me is 'be an engineer first - then focus on your specific discipline'.

He talked about how much engineering overlaps with itself and how it's beneficial to learn about other tracks″.

Arc of Case Study

The Case Study (common lecture), although case-specific, provided the opportunity to emphasize several elements common to all engineering projects starting with the concept of engineers as public servants whose responsibility is to provide the quality of life that we all enjoy. Emphasis was placed on the idea that initial project approaches need to include human-centered design and understanding of the needs of Stakeholders whose population may contain both engineers and non-engineers. All engineering projects affect the populous. Therefore, empathetic approaches to engineering projects are to be considered. Once these Stakeholder concerns are identified, engineers do what they do best – that is, solve problems. Several techniques of Problem Solving were discussed during the lecture, including 1. The process of evaluating several solutions to a problem and selecting one; 2. Solving by analogy; and 3. Dividing large problems into smaller ones and solving the smaller problems until the large problem is solved. Project Management elements were also discussed to emphasize the impact of the global economy upon the selection of vendors, product delivery methods (including pricing, manufacture, and lead time), installation techniques and scheduling that need to be coordinated between many parties.

Student Survey

Students at all institutions were administered surveys on their awareness of the subject of the multidisciplinary nature of engineering projects at the beginning of the semester (or quarter) and near the end of the semester (or quarter). The results of the surveys revealed that their course-long exposure to the topic was effective. Preliminary observation of the student survey self-reported data shows an increase in understanding of the need for multidisciplinary engagement (including disciplines outside of engineering) in engineering practice. An analysis of the survey results is the subject of a separate paper-in-progress. Table 3 below presents a summary of the student population who were engaged in the lecture presentation.

Table 3: Summary of engineering course that survey was administered in.

Institution	# Students Enrolled*	On-hours or Off-hours	Timing of Presentation (Week # of Semester or Quarter)	# Students Attended Presentation	# Students Participated in Pre-survey	# Students Participated in Post-survey
Norwich	89	Off	7/15	77	60	74
VMI	27	Off	8/15	28	23	25
Drexel	522	On	9/10	515**	494	515
WIT	480	Combination	9/15	82	22	13

*End of semester enrollment **Estimate

Results and Discussion

Representatives of First Year Engineering Programs at four (4) U.S. Universities collaborated on a project centered on promoting student awareness of the subject of multidisciplinary project collaboration on engineering projects. A semester-long (or quarter-long) effort was made to reinforce the subject through curricular exposure to lectures and experiential components. One 50-minute common lecture was presented remotely at all of the institutions which included a Case Study of the Block Island Wind Farm and presented a current, relevant example of a project that contained over 150 Stakeholders. Emphasis was placed on student awareness of human-centered design, empathy and required interaction between technical and non-technical parties.

Advantages of delivering the common lecture remotely (synchronously) were defined as follows: 1. Delivery of the lecture can occur without excessive travel to the four institutions; 2. Delivery of the lecture in “off-hours” provided the ability to combine many lecture sections into one; 3. By combining lecture sections, there was less required time commitment for the Instructor; 4. Synchronous delivery allowed for Q&A and interaction with the students.

Based on the foregoing, it is recommended that: 1. Objectives of the First Year course should include the topic “Awareness of the Multidisciplinary Nature of Engineering”; 2. Attendance at the common lecture is a requirement of the course; 3. The common lecture includes a Case Study for relevancy and currency; 4. The Case Study illuminates the subjects of human-centered design and empathy as critical components of the engineering profession; 5. The Case Study emphasizes that interaction between engineering disciplines is commonplace on engineering projects; 6. The Case Study emphasizes that interaction between technical and non-technical parties is commonplace on engineering projects.

Future work/work-in-progress

The plan for the future is to explore the self-reported student “increase in understanding” responses to the survey and evaluate them through a qualitative analysis of open response questions. Considerations include refining the survey to reveal specific components of lecture and course material that influenced student perception of the issue and will inform potential modifications to the curricula. It appears that even one hour of intervention can have an effect on student perception. Therefore, identification of critical course components is essential.

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