Development and Assessment of a Freshman Seminar to Address Societal Context

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Abstract
ABET Criterion 3 mandates 11 assessable outcomes (lettered a-k) to ensure that engineering graduates have the nontechnical skills and context to practice as responsible professionals. A perennial problem in freshman retention is lack of exposure to engineering before students decide to switch to another major. Many freshman engineering programs and courses focus on problem-solving and design, outcomes c and e. As a result of this effort, many successful models exist. Nonetheless, retention of freshmen in engineering remains a problem.

In this paper, we describe development of a seminar course to address other ABET Criterion 3 outcomes in the freshman year, particularly global and societal context (h), contemporary issues (j), and lifelong learning (i). Objectives-based course design was used to develop activities directed toward these outcomes. Assessments of both the pilot and the full program involving all USC engineering freshmen are presented. Improvements made and future plans will also be discussed.

Introduction
The Accreditation Board for Engineering and Technology (ABET) EC 2000 Criterion 3 mandates 11 program outcomes common to all engineering degree programs seeking accreditation to ensure that engineering graduates have the nontechnical skills and context to practice as responsible professionals. A perennial problem in freshman retention is lack of exposure to engineering before students decide to switch to another major. Many freshman engineering programs and courses focus on problem-solving and design, outcomes c and e. As a result of this effort, many successful models exist, but retention of freshmen remains a problem.

Similar introduction to engineering courses exist at the University of Southern California (USC), but as 10 different discipline-specific courses in 8 departments. (Three-quarters of incoming engineering freshmen already have majors, while the other 25% take a general introduction to engineering course that surveys the majors.) These courses feature design projects and other forms of active learning to varying degrees; approximately 50% of the freshman class completes a design project in their introductory course.

Like most science and engineering courses, the focus is on technical content, resulting in dense courses with little room for the addition of societal context and other less technical topics. Thus, the decision was made to create a new interdisciplinary course for students from all engineering majors. The goal of the Engineering Freshman Academy seminars is

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to provide a framework for students to see how the challenging technical content in their other courses will be applied later to creative careers which impact society. Engineering students are often motivated by practical significance, and these seminars provide broader context for their required math, physics and chemistry courses.

A key element of the courses is small class size, enabling faculty to facilitate original team projects. In the four introduction to engineering courses which feature projects, the section size is 50 or more students. Each team uses an identical set of raw materials to meet identical design specifications. These projects have powerful instructive value in the context of discipline-specific content, and students greatly anticipate testing of the final products. However, limitations in class size and learning objectives prevent these courses from addressing perceptions of engineering as an inflexible discipline. In contrast, the interdisciplinary nature, small class size, and guest speakers of the seminar course directly address attrition due to perceptions of engineering as a rigid and uncreative field.

Table 1 below illustrates the different focus of the seminar course with respect to ABET Criterion 3 outcomes. It is clear from this chart that existing introduction to engineering courses address many of the technical criteria, while the seminar courses provide students with context. An important factor in approval by the curriculum committee was illustrating the lack of overlap between existing and proposed courses.

Table 1. ABET Criterion 3 outcomes addressed in existing introduction to engineering courses and the new societal context seminar.

Existing Introduction to Engineering Courses	**New "Engineering Academy" Seminars**
(a) an ability to apply knowledge of **mathematics, science, and engineering**	
(b) an ability to design and conduct **experiments**, as well as to analyze and interpret **data****	
(c) an ability to **design** a system, component, or process to meet desired needs*	
	(d) an ability to function on **multi-disciplinary teams**
(e) an ability to identify, formulate, and **solve engineering problems**	(e) an ability to identify, formulate, and solve engineering problems (through "brain-teasers")
	(f) an understanding of **professional and ethical responsibility***
(g) an ability to **communicate** effectively*	(g) an ability to **communicate** effectively*
	(h) the **broad education** necessary to understand the impact of engineering solutions in a **global and societal context**
	(i) a recognition of the need for, and an ability to engage in **life-long learning**
	(j) a knowledge of **contemporary issues**
(k) an ability to use the techniques, skills, and **modern engineering tools** necessary for engineering practice	

*These criteria are addressed in some, but not all, introduction to engineering courses.
**Design of Experiments is typically covered in upper-level courses for which the department's introduction to engineering course is a prerequisite.

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Description of the Pilot Course

In Fall 2003, two sections of the pilot Engineering Freshman Academy course were offered as a 2-unit special topics course. The course was graded credit/no credit and did not fulfill any requirements other than free electives. Each section met twice a week on Tuesday and Thursday afternoons. During summer orientation sessions, new freshmen with space in their schedules were encouraged but not pressured to enroll in this experimental course. By the end of the summer, when most electives had closed, this course remained an option for all students. Final enrollments for the two sections were 13 and 25 students, respectively. (The later time slot fit more students' schedules.)

Guest speakers were frequently invited to speak with students on a variety of topics including life as an engineer, current construction projects on campus, entrepreneurship, art and engineering, and robot choreography. The instructors often invited the other section to their class to hear invited speakers, but students' tight schedules often made attendance difficult. A common meeting time was strongly recommended by the faculty for future semesters.

Each section also attempted a project related to the course themes. The larger section was broken into teams who completed reports on different energy sources and published the information, links, figures and animation to a web site[1]. The smaller section attempted two smaller projects for a local nonprofit shelter: installing solar panels and building a composting area. Complications (including evacuations from seasonal forest fires) prevented the community service projects from being completed, but important lessons for balancing freshman projects with other coursework demands were learned.

Student Feedback

Feedback was obtained principally from two focus groups with students from both pilot sections present at each session. The students were asked about several aspects of the course, including content, project scope and management, and scheduling. The main points voiced by the students in the pilot section are enumerated below:

1. Far and away the most enjoyable aspects of the course were exposure to guest speakers and getting to know engineering faculty and students in a small-class setting.
2. Students preferred to meet once a week for the entire year because they missed the interaction in spring and felt there wasn't enough content to sustain meeting twice a week.
3. When asked about cohorting the course with math and assigning peer mentors to each section, students were indifferent. They made it very clear that study sessions and other out of class events should be completely optional. (It is interesting to note that many of the students participating in the focus groups were later hired as mentors the following year.)

As retention in engineering is the ultimate goal of this course, the retention rate of this pilot group was compared to that of the entire engineering freshman class. The freshman year return rate (the percentage of students entering as engineering freshman who return

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next fall for their sophomore year) was higher for the students in this course: 95% versus 86%. There may have been some degree of self-selection on the part of students taking this course, but the numbers were promising enough to proceed with a scale-up to include the entire incoming freshman class the following year.

Data from other sources also supported expanding this program for Fall 2004. At the end of the 2003-04 academic year, all USC engineering freshmen were invited to complete a survey of their experience (32% response rate). Students were asked whether they had definite plans to continue in engineering and if not, why not. The most frequent types of responses dealt with perceptions of engineering as an inflexible, uncreative, boring field:

- Loss of interest in engineering or required courses (26%)
- Lack of creativity in engineering/ perceived inability to complete a minor (26%)
- Disappointment with teaching or relationships with faculty (17%)
- Difficulty of courses or overwhelming course load (17%)

In this same survey, exposure to mentors was also shown to play an important role in retention. The frequency with which students interacted with engineering faculty outside class was correlated with both satisfaction with engineering and understanding of engineering. Satisfaction and understanding, in turn, were correlated to self-reported retention in engineering. Nearly 30% of freshmen responded that upperclass students and professors were the most helpful resource in learning more about engineering, second only to their introduction to engineering courses.

Additionally, negative perceptions of engineering—not necessarily academic deficiency—drives students to consider other majors during the freshman year. Of the USC freshmen who left engineering majors during the 2002-2003 academic year, a full 90% were in good academic standing, and 46% had cumulative GPAs of 3.0 or above at the end of their final semester in engineering. These results, coupled with a successful pilot program, encouraged the expansion of the course to include all incoming engineering freshmen in Fall, 2004.

Objectives-Based Course Design

Objectives-based course design was selected to articulate goals and help select activities for two major reasons. The course was to expand to include 6 or more instructors; having a solid course structure and content bank would be a valuable faculty recruitment tool. Also, the student focus groups perceived a lack of structure to the course, suggesting that there were not enough related topics to warrant meeting more than once a week and recommending that lessons be more prepared in future offerings of the course.

Objectives-based course design is described in detail elsewhere[2]. It is a system to better align assessments and assignments to the goals of a course. Before selecting or creating any readings, assignments, or tests, the instructor first identifies the learning goals for the course. Wording is important, since the statements should describe an outcome that is assessable. For example, it is challenging to prove that students “appreciate” a particular discipline, but far easier to show that they can “list” or “define” certain terms or even “discriminate” between different types of problems. Two resources that can be

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particularly helpful in writing learning objectives are the learning objectives inventory in *Classroom Assessment Techniques*[3], which lists general objectives in a variety of areas which the reader can rank by importance, and Bloom's Taxonomy[4,5], which frames cognitive levels to help ensure inclusion of higher levels of thinking.

The final list of course objectives developed for the engineering and society freshman seminar is listed in Table 2. For clarity, the learning objectives are grouped into four categories, with an additional category of retention through community-building to capture the goals of increased mentoring and peer interaction among the students.

After high-quality learning objectives are defined, assessments and activities are relatively easy to select. In fact, the Teaching Goals Inventory in *Classroom Assessment Techniques*[3] is designed to point the reader to specific assessments based on those objectives scored as highest priority. This was the method used for the course described here. For example, some of the ethics activities were altered to draw students from diverse disciplines into the discussion and to help them begin to see themselves as engineers. For homework, students wrote a rebuttal memo as Ford engineers to management following the decision to sell dangerous Pintos based on a cost-benefit analysis. (*Classroom Assessment Techniques* describes the memo-to-management assignment in detail[3].) After in-class discussion of the case, students met in groups to brainstorm ethical dilemmas specific to their chosen field.

Structure of the Scaled-Up Course

Based on feedback from the pilot sections, the course was divided into a year-long sequence of two courses of one credit each. Content was collected and developed to explore societal transformation through history, technology, professional ethics, and safety factors in engineering design during the fall semester course. In the spring, students would focus on a group project. The content bank proved useful for recruiting faculty and moving the course through campus curriculum committees; however, faculty ultimately deviated from the prepared content, focusing to varying degrees on new technologies, engineering as a profession, engineering disasters and ethics, and history.

In Fall 2004, 376 students enrolled in 12 sections of 20-36 students. Sections were scheduled once a week for 50 minutes on Mondays, Tuesdays, Wednesdays, or Thursdays at 9am, 10am, 11am, 1pm, or 3:30pm. All but one of the sections was linked to a specific lecture of Math (Calculus I, II, or III in proportion to projected freshman class placement). Since the freshman writing course schedules large group evening sessions for Wednesdays at 7pm, two large group engineering speakers were scheduled for evenings not used by the Writing program. To allow students to concentrate on exams and final projects for their other courses, the seminar course meets only during the first 12 weeks of each semester. Through a group effort in which each faculty member coordinated tours in his or her respective department, all sections visited at least three engineering research labs during the semester.

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Table 2. Course objectives developed for the engineering and society seminar. For clarity, the learning objectives are grouped into four categories or "themes," while the additional category of retention through community-building captures the goals of increased mentoring and peer interaction among the students.

	Objectives	**Activities**
Thinking like an Engineer Develop skills in thinking like engineers by developing students' problem-solving and teamwork skills.	• Learn concepts and theories of engineering (systems thinking, the design process). • Develop ability to think creatively about solutions to problems. • Develop project management skills. • Develop ability to work productively with others.	• Readings and assignments on team types and stages of team projects. • Puzzles and case studies. • Team project. Each team is responsible for its own time and project management.
Social and Historical Context Develop an understanding of the social and historical reach of engineering.	• Develop an informed concern about contemporary society-technology issues. • Develop an informed historical perspective of technological innovation. • Develop an informed understanding of the role of engineering and technology in society. • Learn to appreciate important technological contributions to society.	• Readings, assignments, and class discussion examining the social and technical effects of broad engineering topics (e.g. "Mars Exploration"). • Case studies of engineering disasters (e.g. Challenger and Columbia tragedies). • Lecture, readings, and discussion on the history of innovation.
Potential of Engineering Develop an understanding the vast potential of engineering and engineering degrees in relation to other professions and disciplines (emphasis through guest speakers and lab tours in both semesters).	• Learn to understand perspectives and values of engineers. • Develop an understanding of the diversity of applications of engineering and engineering degrees.	• Reading, assignments, and discussion of engineering as a profession versus other professions. • Guest lectures by USC faculty, alumni, and industry representatives. • Readings, assignments, lectures and discussion of other technical topics chosen by students and instructor. • Campus lab tours and field trips to local industry.
Ethics Component Develop an understanding of ethical issues and concepts related to engineering through discussion of current events and other related activities.	• Develop awareness for the complexity involved in making ethical choices. • Recognize that there are ethical issues involved in most areas of technology.	• Case studies and discussions of ethical dilemmas. • Discussion of ethical aspects of activities listed under "Social and Historical Context."
Retention Through Community-Building	• Develop a support network of peers and mentors.	• Small class size. • Assignment of 3 upperclass mentors to each class section. • Social events (funding) for informal interaction with professors, upperclass mentors, and classmates.

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The existing engineering mentoring program, which paired freshmen who sign up with the program with an upper-class mentor, was combined with the freshman seminar course[6]. Each section was assigned three "coaches" who were given a budget with which to plan out-of-class activities with the students. Through this new program structure, each freshman has access to three upper-class students, assigned based on a diversity of backgrounds. The funding for this program was obtained through a campus-wide grant competition for innovative approaches to mentoring. Activities planned by the mentors during the Fall 2004 semester included:

- Industry tours
- Installing donated computers and software for a local women's shelter
- Lunch or Dinner on or off campus in groups
- One-on-one meetings with students over lunch or coffee
- "Office hours" with snacks students can grab on their way to class
- Study nights preceding a midterm exam in the cohorted math course
- Trips to area amusement parks
- Bringing donuts, pizza or sandwiches to class
- Trips to local museums

To complement existing discipline-specific introduction to engineering courses, the grouping of students in the seminar was planned to encourage an interdisciplinary focus on course topics. The times were selected to minimize conflict with these introduction to engineering courses, and as a result several options were available to students in each major. Orientation staff members were fully prepared to control access to the sections for specific majors to ensure diversity, but this level of control was not necessary.

Course Assessments

Since the course has been expanded to two semesters, the main assessment conducted at the end of the Fall semester 2004 was a survey of student attitudes toward engineering and the seminar course. The most striking result of this survey is an awareness that many students did not know what to expect from the course or understand its goals. These and other results are discussed later in this section.

Perhaps a more valuable measure of whether learning goals are being met is a classroom assessment used by one instructor, who closely followed the objectives and activities discussed above. As part of a homework assignment, students in two of the seminar sections were asked to "List three things you learned in your Engineering Academy this semester." 57 of the 376 enrolled students completed this assessment. The results are summarized in Table 3. The three most popular categories of student responses were: ethics, societal impact, and/or safety (67% of respondents); engineering in relation to other professions and/or what engineers do (60% of respondents); and problem solving, teamwork and/or communication (42% of respondents). Other responses fell into the categories of: engineering majors and/or college success, new technologies, history of technology (WWII atomic bomb development was most popular), and specific on-campus research.

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Table 3. Most popular responses to "List three things you learned in your Engineering Academy this semester." 57 of the 376 enrolled students completed this survey as part of a homework assignment. All students surveyed had the same instructor, who most closely followed the objectives and activities discussed above.

Top Response Categories*	Sample Student Comments
Ethics, Societal Impact, and/or Safety (67% of respondents)	"Engineers are the reason why products are being implemented and technology is always advancing" "The purpose of engineers is to serve people and improve life." "The depth of the ethics dilemma, involved in the production and sale of the Ford Pinto was quite thought provoking, and I realized what an essential part of engineering ethics are."
Engineering in Relation to Other Professions and/or What Engineers Do (60% of respondents)	"Gave me a broader perspective of what engineering is" "I also enjoyed reading some of the articles. It showed the "real life" application of engineering." "I learned about real and very practical uses of the future of engineering, such as creating a more efficient fuel."
Problem Solving, Teamwork and/or Communication (42% of respondents)	"Cooperation is key, working in groups and discussing recent occurrences introduces contradictory opinions that may challenge your knowledge and pressure you to have a better or more accurate explanation of why you are correct." "How much thought goes into the final design collaboration and trial and error until a final product is finally established." "Engineers need to worry about teamwork more than I had initially estimated"
*Each respondent listed three items. Other responses fell into the categories of: engineering majors and/or college success, new technologies, history of technology (WWII atomic bomb development was most popular), and specific on-campus research.	

As mentioned above, the most striking result of the end-of-fall student survey, which all 376 students were invited to complete (response rate of 82%), was a lack of understanding of the course goals by many students. Overall, the survey results indicate that the major goals of the course were met, and only 2% of respondents stated that the course was "a waste of time" and should not be offered or required.

In addition to students directly stating that they did not understand the purpose of the course or did not receive enough information at Orientation, others requested subjects outside the scope of the course objectives. For example, even though discipline-specific intro courses are designed to serve this purpose, 10% of student respondents wanted to see a review of the various engineering majors, or wanted their particular major be better represented in the seminar course. Since the course had some activities centrally coordinated, there was probably some expectation on behalf of the instructors and administration that the other would articulate the course goals to students. As a result of this survey, Orientation materials will be updated and seminar staff and faculty will work more closely to send a consistent message.

A related issue is the inevitable variation in focus of the various faculty members, who often brought current events related to their engineering sub-discipline into the

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classroom. Students began to realize over the course of the fall semester that each section was different, despite what they were told during busy course registration sessions at Orientation. As a result of this variation and the students' feeling that they were not given a choice, themes and related course descriptions were developed for each instructor. Themes for Spring 2005 included:

- Ethics of Emerging Technologies
- Technology and Policy
- Technology and the Environment,
- Technology and Society Service Projects
- Communicating Engineering to the Non-Engineering World.

During the registration period for Spring and in the end-of-fall survey, students responded positively to this change; a similar format is being considered for the Fall 2005 course.

As an indication that course learning and community-building goals are being met, students often responded to open-ended survey questions with positive statements directly related to the goals. When asked to list additional topics they'd like to see covered in the future, the highest percentage of students advocated active learning techniques (group work, projects, demonstrations, etc.), which will be the focus of the spring course. Specific topics suggested were also related to the original course objectives: details of what it is like to be an engineer, more ethics, business and management, and pursuing a minor. When asked if and how the course changed their attitude toward engineering, most students stated that it merely refined their existing knowledge, but described benefits including many of the original course objectives:

- A broader view of engineering and/or helping society
- More exposure to engineering, or exposure to different majors
- Ethics and professional responsibility
- What to expect from their engineering education and career
- Becoming more sure about or more interested in engineering
- Mentoring and peer interaction

Responses related to the mentoring component of the course were the most consistently positive. Students who attended out-of-class events planned by peer mentors ("coaches") were well-articulated, positive accounts. A few students who were not as active displayed a misunderstanding of the purpose for this component of the course, in a few cases suggesting that coaches were not necessary.

Finally, a few additional adjustments will likely be made to the Spring and Fall 2005 offerings based on student comments:

- Sections will not be taught before 1pm.
- Students liked that the course was only once a week, although the pilot faculty felt less connected to students meeting once a week rather than twice.
- Unfortunately, the student consensus on cohorting math with the seminar course was that the additional scheduling constraints were not worth the benefit of having some of the same students in multiple courses. Some students indicated in their comments that they expected more crossover in content between the two

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linked courses. (Instructors generally did not discuss math content, but some teams of coaches coordinated study sessions before math exams.) As a result, half or fewer of the Fall 2005 seminars will be cohorted with math.

A pre-test, with four questions focusing on the major themes of the course, was also given to each student on the first day of class in the fall semester. It is expected that a similar post-course assessment will be administered at the end of the spring course to more directly measure the learning outcomes.

Summary

This paper describes development of a seminar course to address ABET Criterion 3 outcomes in the freshman year: particularly global and societal context (h), contemporary issues (j), and lifelong learning (i). After a successful pilot course offering, objectives-based course design was used to develop activities directed toward these outcomes. Students in the pilot sections (current sophomores) were retained in engineering at a higher rate than other students. Assessments of the scaled-up fall semester offering to all freshmen suggest that course goals are being met but that many students still do not understand the purpose of the course. The spring continuation will focus on group projects and clarifying goals to students.

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