Impact of Early Exposure to Engineering Practice on Retention Rates among Engineering Students

Matthew J. Traum*
Assistant Professor
Department of Mechanical and Energy Engineering
University of North Texas
PO Box 311089
Denton, TX 76203-1089

Sharon L. Karackattu
Research Coordinator
Planning and Advancement for Student Development
University of North Texas
PO Box 305358
Denton, TX 76203-5358

Christopher Heiden
Associate Director, Academic Services
College of Engineering
University of North Texas
PO Box 310440
Denton, TX 76203-0440

Abstract

Preliminary data critical to assessing the effectiveness of teaching new students about the careers of practicing engineers is presented and analyzed. A new course has been developed for mechanical and energy engineering (MEE) majors at the University of North Texas (UNT) that includes exposure to engineering practice as a significant component of the first-year experience. Through survey data collected from students enrolled in this course, we test the hypothesis that educating new engineering students about the responsibilities, activities, and projects they may encounter as practicing engineers will have a positive impact on retention rates.

Summary

The United States has magnified its call for professionals trained in science, math, and engineering; in response, many universities have bolstered their efforts to recruit and retain students in these fields [1]. With particular emphasis on the first year of college, engineering educators recognize the benefits and ultimate need to expose undergraduate students to engineering practice alongside the traditional pedagogical curriculum to enhance the education experience, help students make informed career decisions, increase student satisfaction, and decrease attrition rates [2].

Background

Conventional "first-year experience" courses focus on teaching college survival skills, providing orientation to campus resources, and building cohorts and communities of peers to support students as they embark on higher education. These foci are believed to improve student retention by providing or reinforcing critical skill sets, knowledge, and networks essential for the ensuing college years [3]. Nonetheless, the engineering education literature suggests a new approach and calls for studies highlighting the impact of redesigned courses on students' early exposure to post-graduate engineering practice and careers. Most of these first-year engineering programs are geared toward integrated curricula to support students through the prerequisites of physics, calculus, and chemistry that account for much of the early attrition [4-8]. Other programs concentrate on first-year engineering design practice to give students "hands-on" experience and

* Corresponding author. E-mail: mtraum@unt.edu, Phone: (940) 565-3446

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stimulate interest and retention [6, 7, 9, 10]. Here, we provide preliminary data critical to assessing the effectiveness of a unique first year experience concept: teaching new students about the careers of practicing engineers.

Undergraduate students express many reasons for their choice of a major discipline, especially engineering students. A large fraction of these students choose engineering for pragmatic reasons, believing that completion of an engineering degree will guarantee stable and abundant employment prospects with higher starting salaries [11]. Unfortunately, many of these students also elect to major in engineering by way of an "uninformed choice"[11]; that is, they envision an engineering degree as the means to fulfill childhood fantasies (such as spaceflight). Studies indicate that high school students typically have limited understanding of the activities and responsibilities undertaken by professional engineers [12, 13]. Moreover over 13% of students who ultimately leave engineering and over 6% of those who persist designated themselves as science, technology, engineering, and math (STEM) majors despite self-recognizing their insufficient comprehension of what their chosen discipline or career entails. In addition, students who leave the STEM disciplines express concerns about the job prospects, remuneration and lifestyle appeal associated with STEM careers that are not shared by students who persevere to graduation [11]. These data suggest that an introductory course designed to expose freshman engineering students to experiences faced by practicing engineers may assist in both informing them about career options and in motivating them to persist in engineering.

Topic and Aim of the Presentation

We report on an in-progress initiative for incoming students to the mechanical and energy engineering (MEE) major at the University of North Texas (UNT). A course entitled "Mechanical and Energy Engineering Practice" has been developed that includes exposure to engineering practice as a significant component of the first-year experience. Our new first-year experience course highlights activities and responsibilities that practicing engineers encounter after college as they join the engineering profession. Through data collected from students enrolled in this course, we test the hypothesis that educating new engineering students about the responsibilities, activities, and projects they may encounter as practicing engineers will have a positive impact on retention rates.

Methodology

Mechanical and Energy Engineering Practice is offered in a series of one-hour seminars. Classes are team-taught by the UNT MEE faculty in concert with five practicing engineers from local industry. Faculty share their careers as research engineers, and practicing engineers expose students to projects encountered in industry. The benefits are deemed mutual; students learn about engineering employment options, and faculty and practicing engineers have an opportunity to market their research and companies to the next generation of engineers. In addition, several interactive ethics seminars illuminate the underpinning principles and ethos adhered to by engineers in research, academia, and industry.

To gauge whether early exposure to engineering practice increases students' comprehension of what their chosen discipline or career entails, an anonymous survey was prepared. This survey probes students' familiarity with engineering practice, asks them to gauge their familiarity with engineering careers, and allows them to quantify their intention to continue as engineering students. All students enrolled in Mechanical and Energy Engineering Practice took this survey on the first day of class and then re-took the same survey on the last day. Differences in students' survey responses before and after the class were compared to gauge the impact of exposure to engineering practice.

Results

We will present results from the student survey and illuminate the correlation between early exposure to engineering practice and students' self-reported comprehension of what their future engineering careers may entail. We will also show that the students express an increased understanding of how the work of engineers positively impacts society. Finally, we will analyze the general effectiveness of teaching first-year undergraduates about the careers of practicing engineers upon students' desire to persist in an engineering major.

In addition to reporting on the validity of our hypothesis, this presentation will also elucidate best practices gleaned from the experiences of faculty and industry co-teaching a first-year experience course together. This initiative also aspires to assist in developing solid partnerships between academia and industry and generating potential co-op and internship experiences for students as well as research collaborations for faculty.

Future Directions

Since no students have yet graduated from UNT's program, comparison of retention rates among peer universities is not possible at this time. Once our program graduates its first undergraduate class in 2010, a cohort study will track retention and graduation rates of students exposed to the practice-focused course. This future study will allow comparison among UNT's peer universities whose engineering students participate in a conventional first-year experience program versus our engineering-practice-oriented program to ascertain whether either approach improves retention.

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Matthew J. Traum, Ph.D.[1] ; Sharon L. Karackattu, Ph.D.[2] ; and Christopher Heiden[3]

Department of Mechanical and Energy Engineering[1], Division of Student Development[2], College of Engineering[3] University of North Texas, PO Box 311089 Denton, TX 76203

Abstract

Many universities have bolstered efforts to recruit and retain students in science and engineering in response to federal reports citing a dearth of trained professionals in these fields [1]. Particular emphasis has been placed on enhancing the first-year experiences of science and engineering majors in an attempt to expose these students to practical experience alongside traditional pedagogical curricula [2].

In this study, preliminary data critical to assessing the effectiveness of teaching new students about the careers of practicing engineers is presented and analyzed. A new course developed for mechanical and energy engineering (MEE) majors at the University of North Texas (UNT) includes exposure to engineering practice as a significant component of the first-year experience. Through survey data collected from students enrolled in this course, the following hypothesis is tested: **educating new engineering students about the responsibilities, activities, and projects they may encounter as practicing engineers will impact retention rates**.

Preliminary results indicate that knowing more about engineering practice and research does not impact students' inclination to remain in an engineering major. However, students do seem to be driven away from their current engineering program. This trend does not necessarily indicate the need to eliminate practice exposure from the first-year engineering curriculum. Instead, early engineering practice exposure allows students to make informed decisions about their future career paths without navigating multi-year degree programs. Students who are not passionate about the particular engineering field they choose as freshmen are likely to eventually be forced out of that engineering degree program by poor performance. We feel that students experience less trauma and have a more positive overall academic experience after leaving a particular engineering program if they choose to change disciplines on their own before experiencing hardship in major-specific upper-division classes. We call this academic self-selection process "soft weeding".

Introduction

Conventional "first-year experience" courses focus on teaching college survival skills, campus orientation, and building camaraderie to support students as they embark on higher education. These activities are believed to improve student retention by reinforcing critical skill sets, knowledge, and networks for ensuing college years [3]. The engineering education literature calls for studies on how redesigned courses impact students' early exposure to post-graduate engineering practice and careers. Most of these first-year programs involve integrated curricula to support students through math and science prerequisites that account for much of the early attrition [4-8]. Other programs concentrate on design practice to give students "hands-on" experience and stimulate interest and retention [6, 7, 9, 10]. This study preliminarily assesses the effectiveness of a unique first-year experience concept: teaching new students about the careers of practicing engineers.

Many students choose engineering for pragmatic reasons, believing that completion of an engineering degree will guarantee stable employment prospects with higher starting salaries [11]. Unfortunately, students also elect to major in engineering by way of an "uninformed choice"[11]; that is, they envision an engineering degree as the means to fulfill childhood fantasies. Studies indicate that high school students typically have limited understanding of the activities and responsibilities undertaken by professional engineers [12, 13]. Moreover, students who leave the science, technology, engineering, and math (STEM) disciplines express concerns about the job prospects, remuneration, and lifestyle appeal associated with STEM careers not shared by students who persist [11]. This finding suggests exposing freshman to practicing engineers and the daily activities of the engineering profession may both inform them about career options and motivate them to persevere in engineering.

Methods

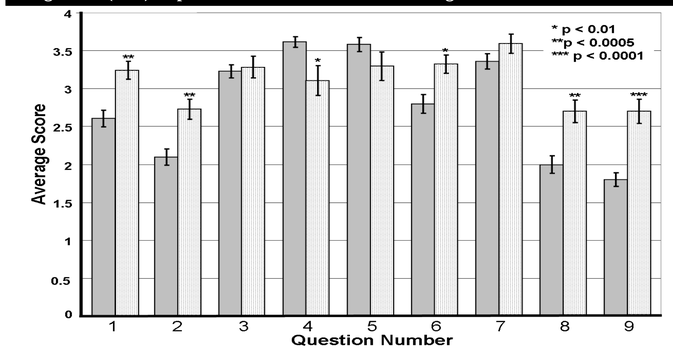
The Mechanical and Energy Engineering (MEE) Department at the University of North Texas (UNT) offers a first-year experience course called MEE Practice I, which is offered in a series of one-hour seminars. Classes are team-taught by the UNT MEE faculty in concert with five practicing engineers from local industry. Faculty share their careers as research engineers, and practicing engineers expose students to projects encountered in industry. The benefits are deemed mutual; students learn about engineering employment options, and faculty and practicing engineers have an opportunity to market their research and companies to the next generation of engineers. In addition, several interactive ethics seminars illuminate the underpinning principles and ethos adhered to by engineers in research, academia, and industry.

To gauge whether early exposure to engineering practice impacts students' comprehension of what their chosen discipline or career entails, an anonymous survey was prepared. This survey probed students' familiarity with engineering practice, asked them to gauge their familiarity with engineering careers, and allowed them to quantify their intention to continue as engineering students. All students enrolled in MEE Practice I (Table 1) took this survey on the first day of class and then re-took the same survey on the last day. Differences in students' survey responses before and after the class (Figure 1) were compared to gauge the impact of exposure to practice.

Table 1: Gender and ethnicity data for survey respondents

	Initial		Final	
Ethnicity	**Count**	**Percentage**	**Count**	**Percentage**
Asian	2	3.3%	1	2.7%
Black	6	9.8%	3	8.1%
White	40	65.6%	23	62.2%
Hispanic	9	14.8%	5	13.5%
Mixed	1	1.6%	0	0.0%
Unknown	3	4.9%	5	13.5%
SUM	61	100.0%	37	100.0%
Gender	**Count**	**Percentage**	**Count**	**Percentage**
Female	6	9.8%	4	10.8%
Male	53	86.9%	30	81.1%
Unknown	2	3.3%	3	8.1%
SUM	61	100.0%	37	100.0%

Figure 1: (Left) Impact of MEE Practice I on knowledge and attitudes about mechanical and energy engineering from the beginning to the end of the class. (Right) Survey questions to which students responded.



Question Number	Question
1	I am aware of what practicing engineers in industry do on a daily basis
2	I am aware of what research engineers at universities do on a daily basis.
3	Based on my current understanding of what practicing and research engineers do on a daily basis, I would enjoy engineering as a career.
4	It is my intention to continue as a mechanical & energy engineering major.
5	It is my intention to continue as a student within UNT's College of Engineering.
6	I understand how ethics guide the practice of engineering.
7	I am familiar with how the work engineers do impacts society.
8	I am familiar with the faculty of UNT's Mechanical & Energy Engineering Department.
9	I am familiar with the research conducted in UNT's Mechanical & Energy Engineering Department.

Students were asked to rate each of these questions according to the following scale:
1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree

Table 2: Factors influencing decision to major in mechanical engineering

Reason	Initial Responses		Final Responses	
	Number	***Percentage*†**	***Number***	***Percentage*†**
Interest/love for science/math/technology/logic/problem solving	35	33.7%	17	32.1%
Money/Employment/Job Security/Versatility of degree/Relevance	16	15.4%	5	9.4%
Perceived aptitude	4	3.8%	1	1.9%
Aspiration/Career goal/Desire for engineering degree	11	10.6%	5	9.4%
Desire to help society	4	3.8%	5	9.4%
Desire to help environment	1	1.0%	2	3.8%
Novelty of program	4	3.8%	1	1.9%
In lieu of other major/curiosity/"seems interesting"	7	6.7%	2	3.8%
Perceived need for engineers	2	1.9%	0	0.0%
Parent is engineer/family or mentor's influence	4	3.8%	1	1.9%
Challenge/test intelligence‡	3	2.9%	1	1.9%
Alternative energy prospects/energy research	13	12.5%	6	11.3%
Changing majors or transferring	N/A	N/A	5	9.4%
Expressed displeasure after class	N/A	N/A	2	3.8%
No Comment	18		21	
Number of students responding	61		37	
Sum of actual responses	104		53	
Total number of expected responses	122		74	
Response rate	85.2%		71.6%	

‡ "No comment" refers to responses in which this open-ended question was left blank.
† "No comment" responses were not included in calculation of percentages of responses indicating factors influencing decision to enter the MEE program.

Analysis

Between the beginning and end of class, students self-reported a statistically-significant increase in awareness of what practicing and research engineers do on a daily basis (Figure 1 - Questions 1 and 2). Students also reported a dramatic increase in familiarity with the MEE faculty and the research areas in which these professors are engaged (Figure 1 - Questions 8 and 9). Furthermore, students reported increased understanding of how ethics guides engineering (Figure 1 – Question 6). Thus, the course was successful in exposing students to the engineering profession and to the professors in the MEE Department as well as their ongoing research.

Interestingly, while students' self-reported level of interest in pursuing an engineering career remained positive and unchanged (Figure 1 - Question 3), students reported a statistically significant desire to leave the MEE Department and the UNT College of Engineering (Figure 1 - Questions 4 and 5). This result indicates that early exposure to engineering practice does not wane early enthusiasm for engineering. However, it suggests that the MEE curriculum and/or the style of teaching in the UNT College of Engineering is not palatable to some students.

By taking a low-risk, introductory-level, one-credit-hour course, students obtain the program exposure they need to decide whether the major and university they have selected is the correct long-term choice for them. They can choose to change programs for a better fit. We call this academic self-selection process "soft weeding"; juxtaposed against "hard weeding" where a student is forced out of a program against their will after poor performance in several high-risk upper division courses. We feel that students experience less trauma and have a more positive overall academic experience after leaving a particular engineering program if they choose to change disciplines on their own before experiencing hardship in major-specific upper-division classes.

Importantly, about 10 students out of 61 enrolled chose not to turn in class assignments and therefore knew they were receiving failing grades in the class when they took the exit survey. Comments written on surveys believed to be from these students suggested respondents used the survey to berate the instructor or express frustration with the university, the college, the department, the course or a combination of these items. The exit surveys in question reported "*1 – strongly disagree*" for all questions. Despite the negative skew these extreme responses put into the results, it was decided not to remove these surveys from the data pool. In addition, many students enrolled in MEE Practice I were also co-enrolled in the freshman-level math and science courses, prerequisites to the MEE program. Many students knew they had failed these classes when they took the MEE Practice I exit survey. Being hard-weeded out of the MEE program, these students may have wished to continue in engineering but could no longer do so at UNT; hence the disparity between responses to Question 3 versus Questions 4 and 5.

Conclusions and Future Research

Preliminary data from this study indicate that MEE Practice I provides many students with a realistic perception of the careers of practicing engineers and familiarizes them with ethics, departmental faculty, and research while simultaneously reaffirming their commitment to complete engineering degrees. Further demonstration of these course benefits are encapsulated in comments drawn from student assignments in which they reacted to industry presenters (Table 3). For many students, the course serves as a positive, introductory experience and cements relationships with future peers and colleagues. At the same time, this course facilitates early self-selection of students out of the MEE major via a low-risk academic environment. We have introduced the term "soft weeding" to distinguish this informed self-selection from the "hard weeding" that students may experience as they struggle academically through required major-specific coursework.

Future work includes longitudinal analysis of the impact of MEE Practice I on retention rates within the Department of Mechanical and Energy Engineering and propensity of students to engage in academic auxiliary programs including undergraduate research, professional societies, and career internships. The influence of MEE Practice I on retention rates in mechanical engineering will ultimately be compared against similar departments at UNT's peer institutions that have no "first-year experience" program.

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Table 3: Student quotes reflecting on speaker presentations about engineering careers.

[The speaker] made an interesting observation regarding his duties as an engineer; *in a day's work, he spends only a small fraction of his time performing engineering related tasks*
A typical day in the life of an engineer is not typical at all
Overall, the presentation provided me with a renewed sense of purpose and direction
I am happy to say that [the speaker] truly inspired me to be an engineer. I am excited about the future outlook of my career.
With all of these facts, [the speaker] successfully made me desire to be an engineer even more than I did before I enrolled at UNT.
Being an engineer requires a lot of time and work. [The speaker] put that concept into full perspective.
Everyone I spoke to about the presentation said that it is what they needed to confirm that they wanted to get into engineering.
[The speaker's] description of his employer made me want to be in his shoes at this point in his career. His job is one that involves a lot of work, but is enjoyable and productive at the same time.
[The speaker's] presentation in his experiences as a professional engineer provided valuable insight into the day-to-day real

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