2006-1129: PERCEPTIONS OF ENGINEERING DISCIPLINES AMONG HIGH SCHOOL STUDENTS

Cassandra Elrod, University of Missouri-Rolla

Cassandra C. Elrod is doctoral student in the Engineering Management and Systems Engineering department at the University of Missouri – Rolla. She holds a Bachelors degree in Engineering Management with an emphasis in Management of Technology (2003), and a Master's degree in Engineering Management (2004), both from UMR. Her research interests include learning styles, engineering education, and organizational behavior issues.

Leroy Cox, University of Missouri-Rolla

Leroy R. Cox is a postdoctoral fellow in the Engineering Management and Systems Engineering department at the University of Missouri – Rolla. He holds Bachelors degrees in Mechanical Engineering and Engineering Management (1999), a Master's degree in Systems Engineering (2002), and a PhD in Engineering Management (2005) all from UMR. He has industry experience in the areas of process improvement/reengineering and mechanical design. His research interests include organizational behavior, virtual teams, and managing people in organizations.

PERCEPTIONS OF ENGINEERING DISCIPLINES AMONG HIGH SCHOOL STUDENTS

Abstract

According to the 2004-2005 Occupational Outlook Handbook[1], engineers, whose work is the link between scientific discovery and commercial application, apply the theories and principles of science and mathematics as a means of researching and developing economical solutions to technical problems. However, one would not receive as concise a definition of the profession if they were to ask the average high school student. Individuals who have the necessary skills and talent to be successful engineers often have no idea as to what engineering, on the whole and with respect to particular discipline, is about.

To understand high school students' perceptions toward engineering, sophomore-, junior- and senior-level high school students enrolled in chemistry, physics, upper-level mathematics courses, and an interdisciplinary engineering course offered in partnership with the University of Missouri - Rolla were surveyed to learn what they knew about particular engineering disciplines, engineering in general, and how they acquired this knowledge. Results of this exploration, as well as implications for recruitment efforts, are presented.

Introduction

Two students, one a high school senior and the other a junior, are walking together from their morning classes. The older turns to the younger and says, "You are pretty good in math and science. You should consider, as I am, becoming an engineer." The younger student turns to his friend and responds, "Why would I want to spend the rest of my life driving trains?"

From our earliest encounters with the question, "what do you want to be when you grow up?" we have identified ourselves in professions that are relatively familiar – doctor, lawyer, teacher, firefighter, etc. Perhaps this stems from the fact that we have a favorite teacher, or firefighting is perceived to be an exciting career. Careers in medicine and the legal profession have been lauded via television – for almost as long as the medium has existed – as possessing the excitement, as well as material and altruistic rewards, that one seeks from a career. Who would not want to be involved in saving someone's life, or bringing justice to someone who has wronged another – and make a lot of money doing it?

Unfortunately, the same cannot be said for the engineering profession. Seldom do we hear young people in elementary and junior-high school specify an interest in becoming an engineer, and it is almost unheard of for a young person to be as detailed as to express an interest in a particular engineering discipline. For the majority of our young lives, to be an engineer was to be exactly as mentioned in the anecdote above – a driver of trains.

The national demand for an abundant, diverse, and talented engineering workforce remains strong due to continued growth in national productivity. Overall employment in engineering is expected to increase 9.7 % during 2002 - 2012. By discipline, employment is expected to increase 10% to 20% in traditional (civil, mechanical, electrical, and aerospace); 21% to 35% in

the disciplines of biomedical and environmental engineering; and 36% or more in disciplines such as computer software engineering[2,3]. Despite this positive outlook, however, the number of engineering degrees awarded during the same time period is expected to remain stable. Even more disturbing is the realization that the number of students who plan to major in engineering upon college entrance has decreased.

According to the ACT policy report Maintaining a Strong Engineering Workforce, among the more than 1.1 million seniors in the class of 2002 who took the ACT Assessment college entrance and placement exam, fewer than 6% planned to study engineering in college, down from a high of nearly 9% in 1992[4]. In addition, average ACT scores for potential engineering students had declined, as had the number of potential engineers in graduating classes' top quarters. Also determined by Noeth was a decline in the number of female students who expressed an interest in engineering. This demographic represents an untapped source of talent to lead our high-tech economy and culture, and yet, in 2002, only 9,345 females planned to major in engineering (representing a twelve-year low of 18%).

Engineering is a high-paying occupation that is only expected to grow in the future. The science of engineering impacts many important aspects of our day-to-day lives, from the cars we drive and the roads we travel upon to the food we eat. It should be an attractive and popular field of study for today's top high school students, and yet, recent studies have shown that this is not the case.

The purpose of this paper is to attempt to understand the reason for the lack of interest in the engineering profession among high school students by evaluating their perceptions and knowledge of engineering – the field as a whole, and with respect to discipline. By its very definition as "insight, intuition, or knowledge gained by perceiving; an idea or notion"[5,6], perceptions are often substantially different from objective reality. Further, since perceptions stem from stimuli, we hypothesize that students that are acquainted with someone that is an engineer would have more knowledge regarding the profession. In addition, we sought to understand the reason for the gender gap as it pertains to engineering. Our central question in this regard was to know if male students were more knowledgeable about engineering than female students, and if so, the reason for the disparity in knowledge levels.

At a time when enrollment in engineering is on the decline, it is imperative that high school students have a clear understanding as to what a major and subsequent career in engineering entails, so as to make the conscious choice to join our ranks. Individuals who have the necessary skills and talent to be successful engineers often have no idea as to what engineering, on the whole and with respect to particular discipline, is about.

Sample

This study surveyed sophomore-, junior-, and senior-level high school students who were taking either Physics, Calculus, or Chemistry courses, or an interdisciplinary engineering class offered in partnership with the University of Missouri - Rolla (UMR) at Rolla High School (RHS). RHS offers college preparatory coursework that has a distinctively technological focus. Further, the school is in close proximity to the University of Missouri – Rolla, which has a strong reputation

for producing quality engineers. Additionally, many of the university's professors have children who attend RHS.

Measures

The measurement instrument began with a demographic section which asked the students to rate their overall knowledge of the engineering profession and whether or not they knew someone that was an engineer or held an engineering degree. In the event that they did know someone, we asked the nature of the relationship, in terms of whether that person was a close or distant relative or a friend. This was followed by a survey that asked them to rate, on a scale of 1 – 5, with '1' being "not familiar" and '5' being "extremely familiar," their knowledge of various engineering degree programs. Also, a qualitative measure was used to understand their thinking with regard to the previously-rated degree programs. Respondents were asked to respond with the first word or phrase that came to mind when presented with various engineering disciplines. For example, when presented with "mechanical engineering" the respondent may have written "automobiles" or "manufacturing."

Data Analysis and Results

One hundred seventeen individuals, of which sixty-three were male and fifty-four were female, responded to the survey. This number represents approximately 10% of RHS total enrollment.

The mean level of knowledge of the engineering profession as expressed by these students was 2.53. Responses for each discipline were then evaluated; a table representing the results of this analysis appears below. These findings are interesting, given the technological focus of the high school and its close proximity to UMR, in addition to a course offered in Interdisciplinary Engineering.

Table 1.

Discipline	Mean Understanding
Aerospace Engineering	2.14
Architectural Engineering	2.35
Ceramic Engineering	1.62
Chemical Engineering	2.04
Civil Engineering	2.08
Computer Engineering	2.18
Electrical Engineering	2.10
Engineering Management	1.62
Environmental Engineering	1.80
Geological Engineering	1.79
Mechanical Engineering	2.26
Metallurgical Engineering	1.56
Mining Engineering	1.92
Nuclear Engineering	1.86
Petroleum Engineering	1.51
Interdisciplinary Engineering	1.30

As displayed above, the top engineering disciplines with which students expressed a level of familiarity were the "traditional" areas, (Mechanical Engineering, Aerospace Engineering,

Electrical Engineering, Civil Engineering, and Chemical Engineering); Architectural and Computer Engineering were also familiar to the students. Students showed little familiarity with disciplines related to materials science, energy, or to the discipline of Engineering Management.

Bivariate Pearson correlations were performed to understand whether or not students knew of the engineering profession by virtue of being exposed to someone close at hand (family member or friend) who was an engineer. There was a positive, significant, but weak correlation between these two variables ($r = 0.287$, $p < .01$). This finding supports our hypothesis, suggesting that there is an influence, albeit slight, on students' knowledge of the profession.

Given the relatively small number of women who specified an interest in the engineering profession as compared to men in the Noeth[4] study, we wanted to understand whether or not men had more of an interest in the subject area because they knew more about engineering. One-way ANOVA produced no significant difference in knowledge of engineering for males as compared to females, $F(1,116) = 3.888$, $p > 0.05$. Both groups displayed relatively little knowledge of what engineering entails.

The one-word or phrase perceptions of engineering were analyzed to understand the frequency that certain terms were used to describe various engineering disciplines. The results here are startling, as, in many cases, the one-word responses are not closely related to what the actual degree program entails. Most often, the responses provided spoke to an element of the profession, or what one would normally think when presented with the name of a discipline. A summary table with the most frequent responses appears below.

Table 2.

Discipline	Most Frequent Responses
Electrical Engineering	electricity, circuits, wires, wiring
Ceramic Engineering	pottery, pots, tiles, ceramics
Geological Engineering	earth, rocks, land
Petroleum Engineering	oil, gas, fuel
Engineering Management	manager/managing, boss
Chemical Engineering	chemicals, Chemistry
Metallurgical Engineering	metals
Interdisciplinary Engineering	
Civil Engineering	bridges, buildings, people, roads
Aerospace Engineering	space, airplanes, NASA
Computer Engineering	computers, programming, computer chips
Mining Engineering	mines, mining, explosives
Mechanical Engineering	cars, engines, robots, machinery
Architectural Engineering	buildings, houses
Environmental Engineering	environment, trees, tree huggers
Nuclear Engineering	nuclear reactors, bombs

Discussion and Implications

This study has highlighted that an issue to consider when recruiting would-be engineers is the knowledge of what engineering entails. At a time when we expect students to be in a position as

to make a conscious choice regarding their proposed careers, many are ignorant of engineering, with regard to discipline and overall career. Even in an environment as technologically charged as the school in our study, students held a limited knowledge of engineering, overall, and erroneous notions of particular engineering disciplines.

These findings prompt a reexamination of current recruiting efforts. Recent studies indicate that it is beneficial to have students consider their chosen profession at earlier ages, perhaps even as early as seventh grade[7,8]. This time is when adolescents begin to experience more freedom, getting the opportunity to make various choices for themselves. To encourage students at this age that engineering is a viable career option to consider may engender more exploration into the profession.

Recruiting efforts need to consist of talks about what it means to be an engineer, but they also should consist of formal presentations about the kinds of problems that particular engineers solve. For example, mechanical engineers could speak about design issues, and perhaps lead students as they participate in small-level design projects so as to reinforce these concepts. Students have to "see" engineering, and the fruits thereof. Providing this glimpse could be as simple as pointing out the work of engineers in structures around us (bridges, cars, or buildings), tangible things with which students can readily relate.

As we progress into the twenty-first century, we need a cadre of talented individuals to meet the demands of a changing and progressive society. The individuals that would make up this cadre are currently sitting in middle and high school classrooms around the country, and have little idea of a wonderful career that could be theirs. As engineers, we need to reach them with truthful information so that they can choose to become one of us.

Bibliography

1. Occupational Outlook Handbook, 2004-2005 edition, from (http://www.bls.gov/oco/ocos027.htm)
2. Bureau of Labor Statistics (2002), from http://www.bls.gov
3. National Science Board (2004), from http://www.nsf.gov/nsb/documents/2003/nsb0369/start.htm
4. Noeth, R. J. (2004). *Maintaining a Strong Engineering Workforce*. Iowa City, IA: ACT.
5. http://www.ask.com/reference/dictionary/ahdict/64777/perception
6. http://www.question.com/dictionary/perception.html
7. Wimberly, G. L., & Noeth, R. J. (2004). *College Readiness Begins in Middle School*. Iowa City, IA: ACT.
8. Tracey, T., Robbins, S., & Hofsess, C. (2005). Stability and change in interests: A longitudinal study of adolescents from grades 8 through 12. *Journal of Vocational Behavior*, 66(1), 1-25.