

Freshman Engineering Student Perceptions of Engineering Disciplines

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Abstract – As part of an ongoing effort to expand the engineering enrollment at the University of Memphis, the Department of Civil Engineering has undertaken a study to examine how entering engineering students view the various fields of engineering science and technology that are available at the university. One part of the study consists of a perceptions survey given to entering freshman in the college. The survey was given to students in the freshman classes presented by the engineering and engineering technology programs. The college has majors in Biomedical, Civil, Computer, Electrical, and Mechanical engineering as well as an Engineering Technology program with concentrations in computers, electronics, and manufacturing.

This paper presents preliminary results and basic analysis of the survey data from the Fall 2009 Herff College of Engineering students. The data indicate that students selecting an engineering or engineering technology major view the major as having a significant impact on society and strong career opportunities, but do not perceive creativity to be important in these disciplines. Future efforts for refining the survey instrument and expanding survey participation are described at the conclusion of this paper.

Keywords: freshman, perceptions, recruiting, women, minorities

INTRODUCTION

As engineering educators attempt to respond to the dynamic technological and global issues associated with 21st century advances, statistical data indicates alarmingly low levels of retention for students majoring in science, technology, engineering, or math (STEM) fields. Researchers have noted both a decrease of high school graduates choosing to major in engineering fields and significant difficulties in completing engineering degree programs for approximately 40-70% of engineering majors [1,2,3]. Collectively, high-ranking administrators and researchers have described these trends as a “leak in the engineering pipeline” [4,5,6,7,8,9]. Locally, a review of data of Engineering majors at The University of Memphis collected over a 10-year period from 1998-2008 reports a particularly high point of attrition after the freshman year at a rate ranging from 30-60%. These statistics are of particular concern because engineering programs do not typically attract students from other fields, but instead rely mostly on retaining students who originally enrolled as Engineering majors [10]. These data further underscore the importance of attracting more students to engineering majors.

One key factor in the low number of students entering engineering majors may be inaccurate perceptions of the disciplines. The 2008 report from the National Academy of Engineering, “Changing the Conversation: Messages for Improving Public Understanding of Engineering”, cites the lack of consistent messages regarding engineering as one source of confusion and misperceptions of engineering disciplines [11]. Findings indicate that the main message that most people understand regarding engineering is that it requires people that are “good in math and science.” However, they also found this was not a successful means of attracting students to engineering majors.

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Gender differences were identified, in that girls were more successfully attracted to engineering when the relevance to society was demonstrated effectively while boys were more interested in examples of engineering design. No significant differences were found in perceptions between ethnic groups, although some differences were noted between boys and girls within ethnic groups. Innovative technologies and the engineer's role in their development was identified as a message that held strong appeal for both boys and girls. Additionally, the study revealed that the most effective message for attracting students to engineering is the concept of engineers "making a difference." [11] In an effort to determine factors that may influence students' selection of engineering majors at the University of Memphis, faculty in the Department of Civil Engineering in the Herff College of Engineering have developed a survey designed to identify student perceptions of engineering majors. This survey is part of a larger effort underway in the department to improve recruiting and retention of civil engineering majors. The study methodology and results are described in the following sections.

METHODOLOGY

Survey Design

The survey developed during this research consisted of fourteen questions targeted to obtain information regarding factors that might influence a student's selection of an engineering major, perception of engineering majors, and demographic data. The perceptions addressed through the survey included the following:

- Impact of engineering disciplines on society
- Importance of current technology
- Importance of creativity and imagination
- Availability of career opportunities
- Level of academic difficulty
- Associated professional responsibility.

The perception questions were designed using a Likert scale with five possible ratings. In addition, questions pertaining to why the student selected an engineering major, most influential persons in their decision, and whether or not the student had previous interactions with an engineer were included. Other data collected included information on the student's major, whether or not they are a first time freshman, gender, ethnicity, and academic strengths.

Survey Population

One hundred and thirty students responded to the survey, which represents 85% of the students registered in the freshman classes in the college in the Fall semester of 2009. One hundred and ten of the responses were from male students and twenty from female students. Seventy-seven of the respondents identified themselves as Caucasian, thirty-six as African-American, seven as Asian, three as Hispanic, and seven as other.

RESULTS

Impact on Society

The first question from the survey asked students to respond to how each of the disciplines represented impacted society. There has been much written about engineering not being perceived as important to society so this question was designed to determine how students who have chosen to study engineering considered the impact. The responses from this question are shown in Figure 1.

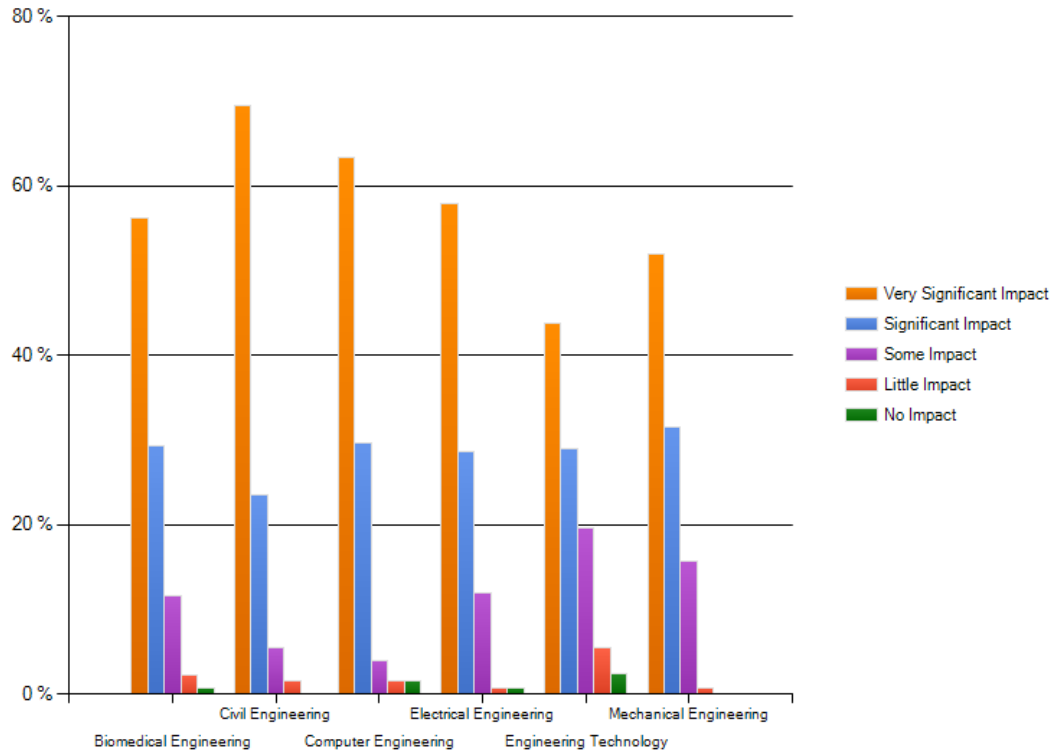


Figure 1 - Perception of Field's Impact on Society by Discipline

From these results, 85.38% perceived that biomedical engineering, 92.97% that civil engineering, 92.97% that computer engineering, 86.51% that electrical engineering, 72.66% that engineering technology, and 83.46% that mechanical engineering has at least a significant impact on society. The results were analyzed using a Wilcoxon Rank-Sum test to see if there was any significant variation by gender as to perception. For all the fields, there was a significant ($P < 0.10$) difference between the attitudes of male and female students. For example, for civil engineering, the male students evaluated the impact as slightly higher than the female students. When the results were analyzed for difference between race/ethnic groups, the small number of Asian and Hispanic students were isolated from the analysis and only the African-American and Caucasian cadres considered. When comparing the responses from these groups, a significant difference resulted across all the disciplines, with all $P < 0.10$. These differences will be further analyzed and described in future publications.

Use of Current Technology

The second area of interest was the students' perception regarding the field being up-to-date in implementing and using current technology. The aim was to allow the students to evaluate how they thought the engineering fields rated in the implementation of what they considered state-of-the-art technology. This question focused on the engineering fields rather than the majors to try to gauge whether or not this may have been an attractive factor for students selecting a career.

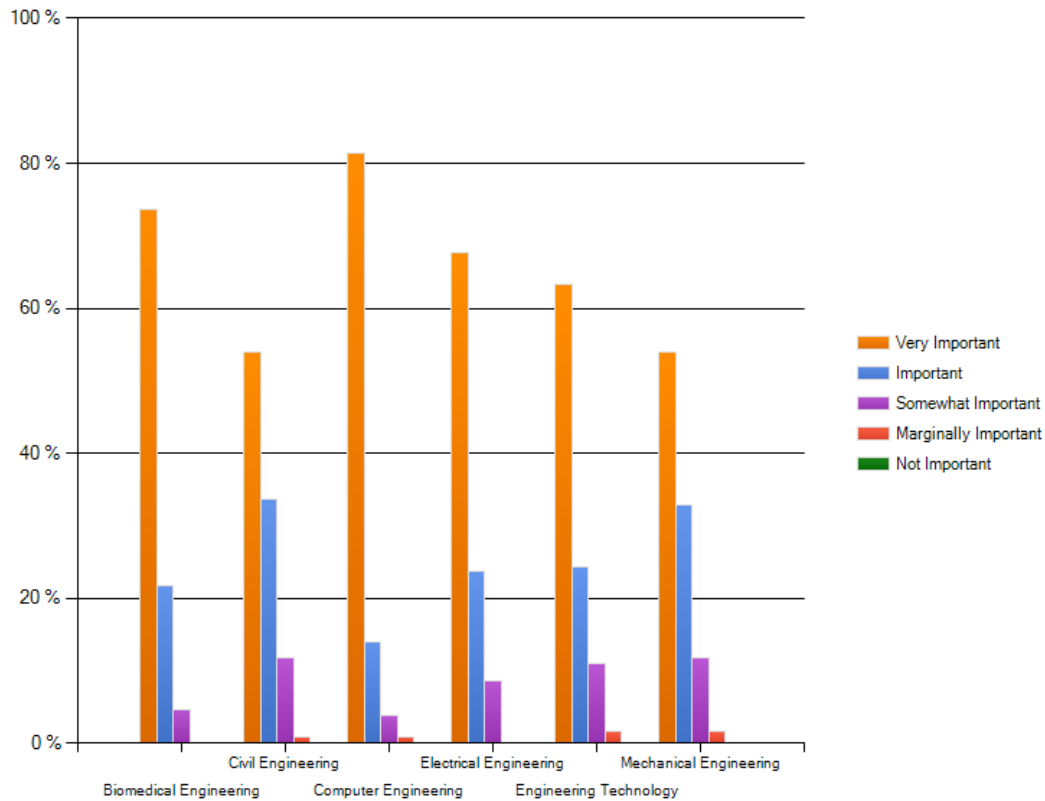


Figure 2 - Perception of the Use of Current Technology by Discipline

The overall response by discipline is shown in Figure 2. A breakdown by percentage of responses by disciplines and by response level is shown in Table 1. Computer engineering shows a strong response with over 80% responding that the field uses current technology as an integral part of their profession. Both civil and mechanical engineering have much lower responses but when important and very important responses are combined, all of the disciplines have a response greater than 85%. These responses were not analyzed according to gender or race/ethnic group.

Table 1 - Level of Perception of Use of Current Technology by Discipline

	Biomedical Engineering	Civil Engineering	Computer Engineering	Electrical Engineering	Engineering Technology	Mechanical Engineering
Very Important	73.6% (95)	53.9% (69)	81.4% (105)	67.7% (86)	63.3% (81)	53.9% (69)
Important	21.7% (28)	33.6% (43)	14.0% (18)	23.6% (30)	24.2% (31)	32.8% (42)
Somewhat Important	4.7% (6)	11.7% (15)	3.9% (5)	8.7% (11)	10.9% (14)	11.7% (15)
Marginally Important	0.0% (0)	0.8% (1)	0.8% (1)	0.0% (0)	1.6% (2)	1.6% (2)
Not Important	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)

Creativity and Imagination

Often we hear from our colleagues in the Liberal Arts that engineers just utilize formulas and rules and don't allow for creativity, yet most engineering design professionals would value creativity and imagination as critical skills in the professions. The experience of the researchers also shows that students respond favorably to this "advertisement" for engineering. The students in this study were asked how important creativity and imagination were to the relative fields. Overall results from this question are broken down by discipline in Table 2 and graphically presented in Figure 3.

Table 2 - Level of Perception of Importance of Creativity and Imagination by Discipline

	Biomedical Engineering	Civil Engineering	Computer Engineering	Electrical Engineering	Engineering Technology	Mechanical Engineering
Very Important	52.7%	55.9%	54.3%	41.7%	42.2%	54.3%
Important	28.7%	28.3%	27.9%	30.7%	30.5%	35.4%
Somewhat Important	14.0%	12.6%	14.0%	17.3%	20.3%	7.1%
Marginally Important	4.7%	3.1%	2.3%	8.7%	7.0%	3.1%
Not Important	0.0%	0.0%	1.6%	1.6%	0.0%	0.0%

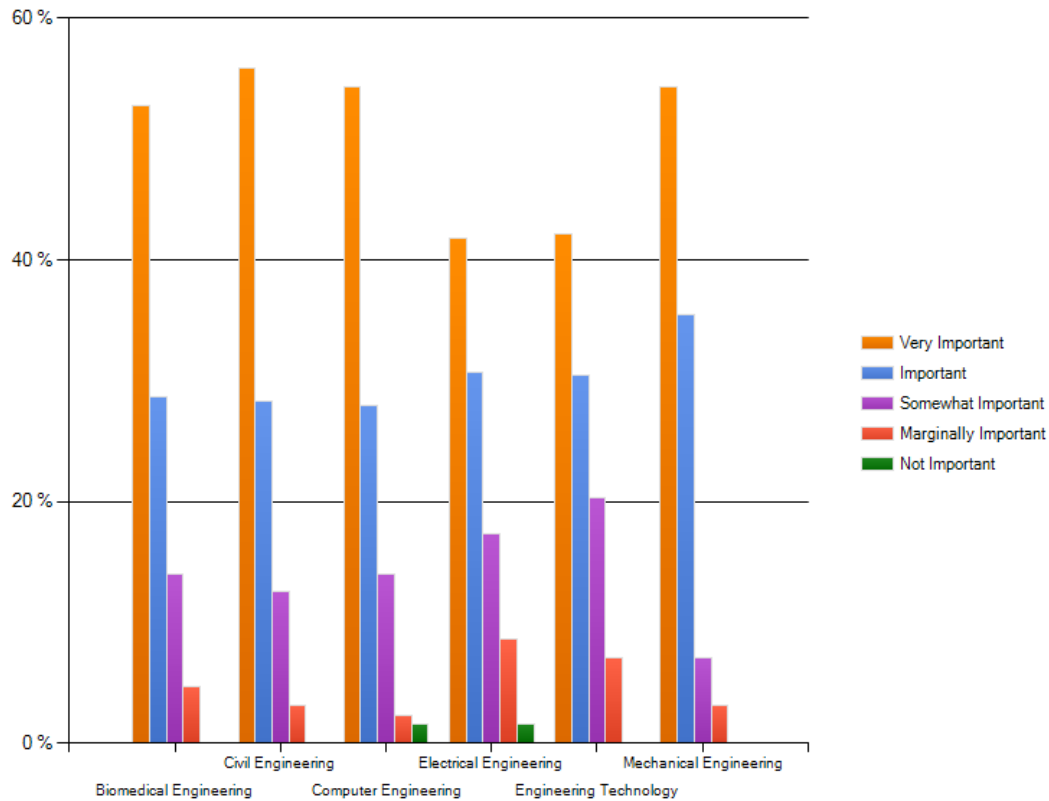


Figure 3 - Perception of the Importance of Creativity and Imagination by Discipline

It may be of concern that in some of the disciplines, one in four of the students who chose engineering and engineering technology as a professional field rated creativity and imagination as somewhat important or less and that just slightly more than one half of the students rated these skills as very important in their profession.

Career Opportunities

One point that is made repeatedly in recruiting efforts is that jobs in engineering are well paid and that graduating engineers are in demand. With the recent economic downturn, it was of interest to the researchers to see if this is an important consideration in the career choices of incoming students. Do they still believe that engineering offers a bright career future? Responses to question are summarized in Figure 4.

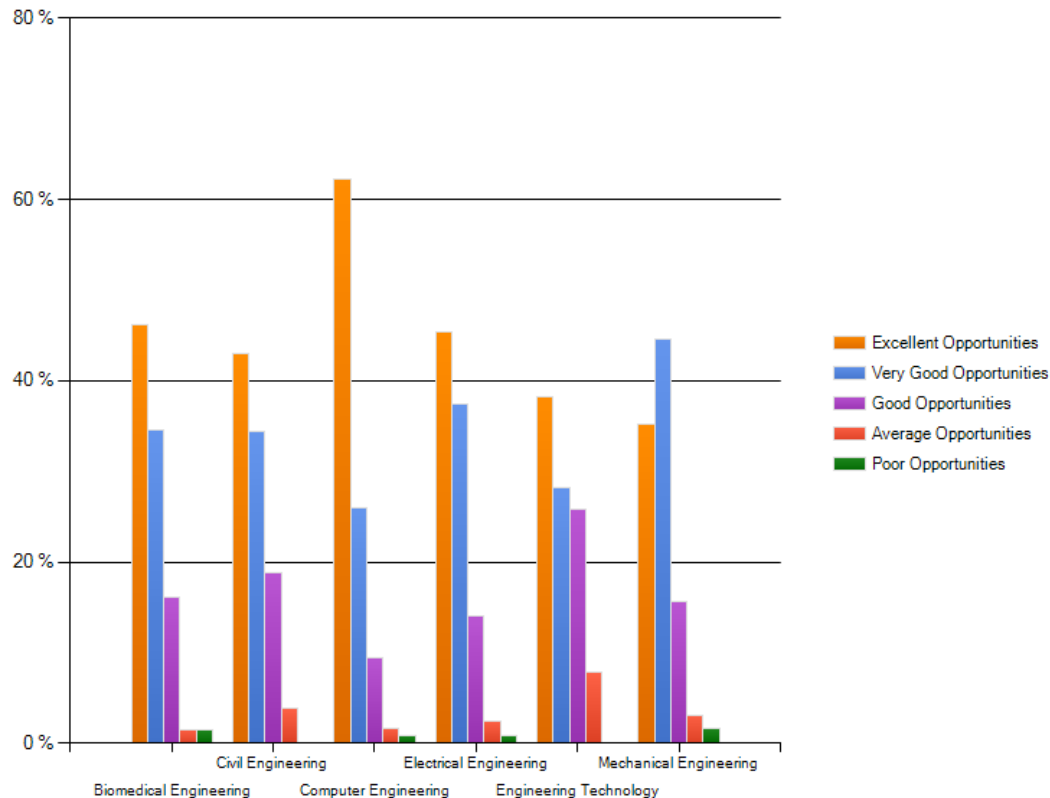


Figure 4 - Perception of Career Opportunities by Discipline

There is a strong belief that computer engineering holds the best opportunity for career growth with almost 20% more of the respondents indicating that it has excellent opportunities. This may be linked to the responses that computer engineering is the most technically up-to-date of the engineering fields considered. There also seems to be some level of concern, even at a very low response level, of futures in biomedical, computer, electrical, and mechanical engineering based on the total number of responses of Good or better.

Professional Responsibility

A final perception question was poised as to how much professional responsibility would be required from a graduate in each of the disciplines examined. No further information was given so as to allow for the respondent to choose what they considered professional responsibility. At the point in the initial class, they would have met for approximately nine hours (three weeks) and some discussion of each profession would have been held in their respective freshman class. The responses to the question are shown in Figure 5.

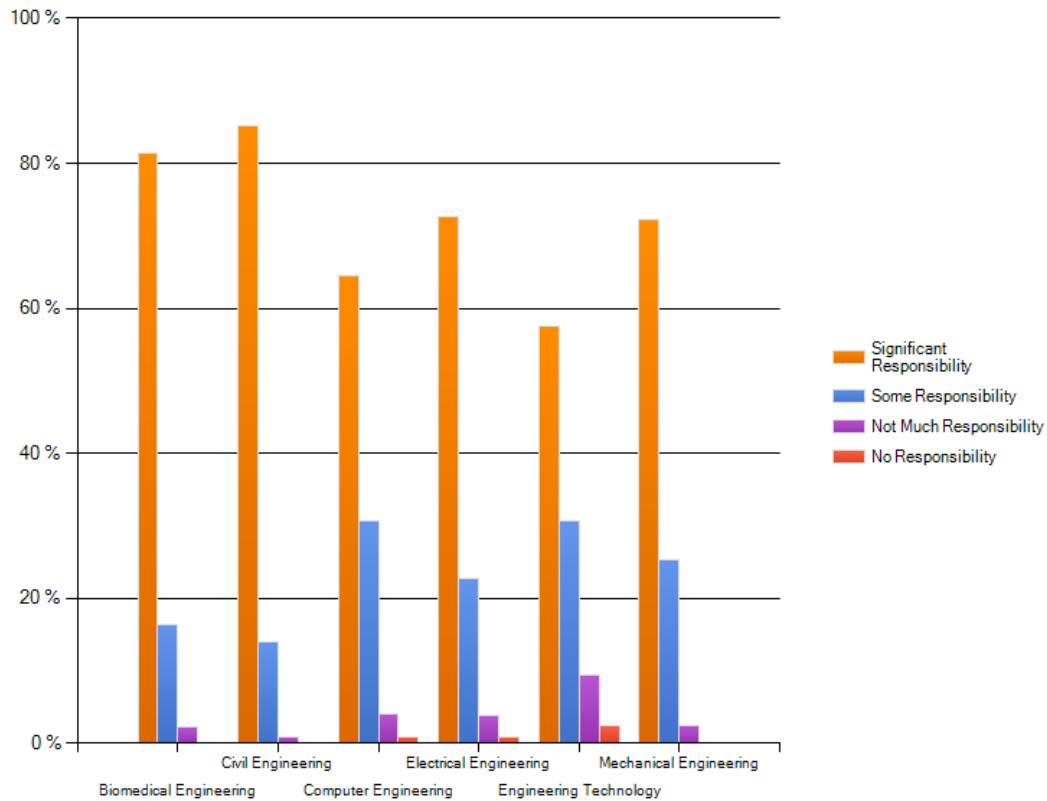


Figure 5 - Perception of Professional Responsibility by Discipline

There was a stronger response for both biomedical and civil however; strong positive responses were also obtained for the other disciplines. There was a slightly higher negative response for engineering technology but this may have come from the lack of understanding of engineering technology held by some engineering students.

Factors for Selecting Engineering

There have been a number of factors presented in the literature as to why students do and do not choose engineering as a career path. Within the limited sample of students who did make the choice, the question was asked as to what drew them to the field. They were allowed to choose multiple responses to the question. The results of this are shown in Figure 6.

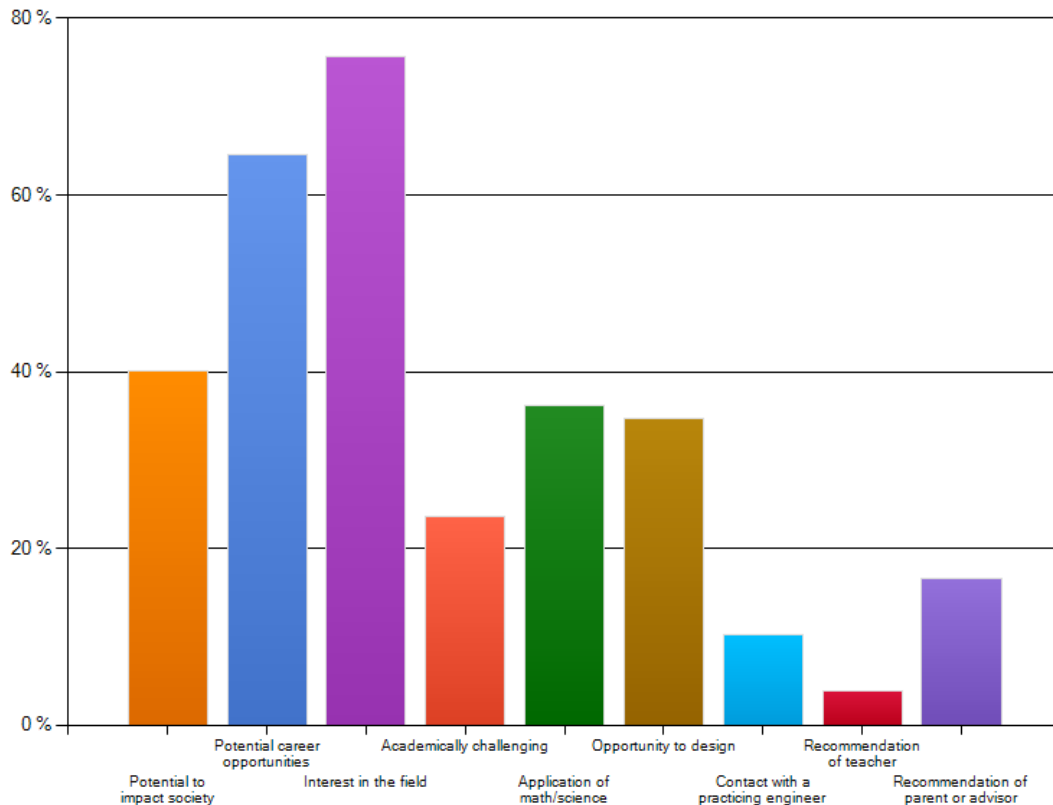


Figure 6 - Most Influential Factor(s) in Selection of Engineering as a Major

It appears many respondents perceive the field of engineering as an interesting field of study. Without a strong television presence (at least on broadcast channels) it is an alluring question that deserves more study in depth to identify the most effective means for dissemination of this message. No matter which area of engineering is considered, the field of engineering as interesting appeared on almost 80% of the responses with job opportunities at just over 60% of the responses. No other response appeared more than 40% of the time.

As a follow up to this question, the students were asked to identify their strongest academic areas in high school. The responses came as no surprise when mathematics was identified on more than three out of four responses. Belying the stereotypical image of the freshman-engineering students, were the one in five responses identifying social studies and communications as strengths at levels almost as high as chemistry and physics.

CONCLUSIONS

This preliminary study is in no way meant to be an exhaustive overview of why students choose engineering rather than another field. The snapshot of one semester's data at a single urban university for one small population actually raises more questions than it answers. It may be significant to see that impact of engineering on society is well sold to the students that enter engineering but without asking the question to a broader audience, especially students who were well prepared for engineering but chose other fields, it is impossible to say if the message is being widely understood.

One of the most telling concerns was the recommendation that teachers had on guiding students into engineering. Without the research to support the conclusion, it is impossible to provide a definitive reason for this very low value but the fact that teachers at the middle and high school level are not encouraging students to enter engineering is troubling. The second iteration of this survey planned for Fall of 2010 may provide more insight. A companion survey of teachers from schools which provide the majority of students to the college of engineering is also planned.

The perception of the use of current technology seems to be tied to the perception of the computer as the current technology. Fields, such as civil and mechanical engineering, may not be seen as utilizing computers and innovative technology as much or as widely. This is an assumption that is not borne out by the data but which leave a question for the next iteration of this work.

To build on the strengths shown in this study, an emphasis on the societal impact, career opportunities, and the broad variety of interesting work in engineering would seem to be fertile areas for development.

Future work for this team of faculty researchers will include revising survey questions, expanding survey participants to include multiple universities as well as to include students who did not choose engineering as their field of study.

REFERENCES

- [1] National Science Foundation, Science and Engineering Indicators 2006. <<http://www.nsf.gov/statistics/seind06/c2/c2h.htm>> (May 14, 2009).
- [2] R. Felder, and R. Brent, Understanding Student Differences. J. Engineering Edu. 94, 57-72 (2005).
- [3] H. Hartman, and M. Hartman, Leaving Engineering: Lessons from Rowan University's College of Engineering. J. Engineering Edu. 95, 49-61 (2006).
- [4] E. Seymour and N. Hewitt, Talking About Leaving: Why Undergraduates Leave the Sciences, 444 pgs. Westview Press, Boulder (1997).
- [5] N. Hewitt and E. Seymour, A long, discouraging climb. Prism: J. of the American Society for Engineering Edu. 1, 24-28 (1992).
- [6] T. Hilton and V. Lee, Student interest and persistence in science: changes in the educational pipeline in the last decade. J. of Higher Edu., 59, 510-526 (1988).
- [7] W. Massey, Science education in the United States: what the scientific community can do. J. Science, 245: 915-921 (1989).
- [8] National Academy of Engineering, The Engineer of 2020: Visions of Engineering in the New Century, 118 pgs. National Academies Press, Washington, DC (2004).
- [9] National Academy of Engineering, Educating the Engineer of 2020: Adapting Engineering Education to the New Century, 208 pgs. National Academies Press, Washington, DC (2005).
- [10] S. Courter, S. Millar, and L. Lyons, From the Students' Point of View: Experiences in a Freshman Engineering Design Course. J. Engineering Education 87, 283-288 (1998).
- [11] Committee on Public Understanding of Engineering Messages, Changing the Conversation: Messages for Improving Public Understanding of Engineering, 164 pgs. National Academies Press, Washington, DC (2008).

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