



Examining Reflections of Current Engineering Students on Educational Outreach

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This study was conducted to explore the experiences of engineering students that helped them learn about engineering. The hope is that understanding which experiences made the most impact may improve the planning of student outreach activities. 974 students in the first-year of their engineering program were asked to describe the experiences and interactions that had the most influence on them when contemplating an engineering career. Results indicate that knowledge about what engineering is and outreach experience, and therefore the reasons that students go into engineering, vary greatly. Future directions for follow up research were proposed in directions of how to refocus and improve outreach engineering programs and their effectiveness and improve recruiting activities according to the main themes of *Changing the Conversation*.

I. Introduction

Outreach programs are extremely important in increasing the percent of students interested in pursuing engineering. There are many examples of engineering outreach activities designed to educate students about the wide variety of jobs available to those with an engineering degree, demonstrate the accessibility of engineering knowledge, and encourage students who would otherwise have steered clear of engineering to take another look ^[1, 2, 3,4]. Early outreach also allows students to start thinking about the possibility of engineering far enough in advance to make sure they take the requisite high school courses to enter an engineering program ^[5,6,7].

The most effective way to assess the success of such outreach programs is to follow the participating students and determine whether they successfully entered engineering programs. This however, is difficult to do because outreach programs are often without the necessary resources to keep track of students. An alternate means of achieving the same objective is to consider the pre-college experiences of currently enrolled students. An examination of experiences that encouraged students to pursue engineering, with determination of how and why they led to successful enrollment in engineering, provides an indicator of what program elements could be the most effective if included.

Since the release of *Changing the Conversation*^[8] there has been several studies and research that has been conducted on how the message of engineering as a whole is presented ^[9,10,11]. Themes from *Changing the Conversation* have been increasingly represented in engineering outreach programs. Further, such programs have seemed to become more effective in reaching and convincing potential engineering students to pursue engineering. While there is a substantial amount of literature about engineering outreach programs, qualitatively investigating the impact

of a large number of students' experiences and examining if these experiences coincide with most of inclusive images described in *Changing the Conversation* is less complete.

The purpose of this study was through collection of descriptions of the engineering student's pre-college experience to 1). Determine if there was any impact on students' experiences by pre-college engineering outreach programs and 2). Compare those experiences to *Changing the Conversation*. This was facilitated by attentive listening and allowing students to provide a voice on how they learned about engineering. In hope to gain a discerning record of the variety of student experiences in which to allow for improved experiences for others that follow ^[12] our study was guided by the question "what is the array of experiences that lead students to learn about engineering?"

II. Methodology

The data for this study was collected at large Midwest University using a convenience sample of first-year engineering students. An electronic survey was administered to the first-year class. 974 students representing approximately 85% of the class responded to the survey. The data was collected in the middle of the students' first semester in college. Participants were asked two questions and allowed to provide open ended responses in short answer form. This format allowed students to respond in their own way and allowed the researchers to explore new ideas about the topic based on the respondent's emerging view ^[13].

The students were asked the following research questions:

1. "What experiences helped you learn about engineering?"
2. "What did you learn from these experiences?"

The students were also asked to provide basic demographic information. All data was analyzed using qualitative methods. Qualitative research is defined as 'an array of interpretative techniques which seek to describe, decode, translate and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world' ^[14], (p. 85). The student response data was coded and as patterns emerged, these were clustered into meaningful categories. Initial coding was completed by one researcher, and then to establish reliability, two other coders each recoded 50% of data using the same coding scheme. Reliability was calculated by comparing the number of agreements and disagreements of each researcher with the initial coder's evaluation, and calculating the average percentage of agreement. Reliability was found to be 83%.

In order to address the validity of the findings we utilized peer examination (asking colleagues to comment on the research findings as they emerged).

III. Findings

From the data analysis ten categories emerged as the primary channels through which students learned about engineering. The categories and the percentage of the sample who indicated them as a major factor are shown in Table 1 below.

Table 1. Primary channels influencing students learned about engineering

Factors	% of respondents
Family	33.8
Curriculum	22.3
Teachers/Counselors	13.3
Peers	10.0
Classes	8.7
Interest/experimentation	8.7
Work experience	5.7
Interpersonal Communication	5.4
Personal research	4.9
Media	3.4

Family emerged as the greatest contributor to students learning about engineering. Family in this case was characterized as references to parents, siblings, grandparents, relatives (uncles, aunts, cousins). One third of all students (33.8%) pointed to family as the most significant influencing factor impacting their decision to contemplate an engineering career. For most of the participants, it was a father, grandfather, and/or uncle, that contributed the most. As one student expressed it: *“A few things that helped me learn about engineering is the vast number of them in my family. All of my uncles, grandfather, and father are engineers. So, albeit their conversations, usually turned to their work and their engineering professions. Naturally being a curious young person you tend to want to know more about what they are talking about which lead to a curiosity to become and engineer”{sic}.*

First-year lectures, seminars, extra curriculum. The second most frequently noted source of student exposure to engineering as a profession (22.3%), was from seminars, lecture programs and other curricular programs they were engaged in. Though some of them mentioned these in the context of their college classes, the programs were also referenced as being offered during their high school years.

Teachers/Counselors. The third most commonly reported source of engineering influence (13.3%) is a grouping of student references to educators/teachers, counselor, mentors, and faculty.

“I think the most influential experience that taught me about engineering were my engineering classes in high school, which i really loved to do”{sic}.

“Teachers at my high school told me I would be successful at it” {sic}.

“My high school physics and math teacher taught me a lot about engineering and I got really into it”{sic}.

Peers. Ten percent of all students claim their peers as the greatest influence factor in learning about engineering.

“I learned through working with my group buddies and friends, when we would sit down to work on a homework assignment or problem i felt that i comprehended more of what we were learning”{sic}.

“Talking with upper classman about their particular course of study I learned about the work load expected and what i have to look forward to upon graduating. I also learned what was involved in various courses of study” {sic.}.

“Class work and upperclassmen helped me learn about engineering” {sic.}.

Subject ability. The next category that emerged consists of students (8.7%) who believe that their love of math, science, and technology led them to an engineering career.

“I didn't know much about engineering until I reached college. All I knew is I enjoyed math and loved physics and that engineering involved both” {sic.}.

“The idea of engineering and me becoming an engineer was prompted mostly by my mathematical background and ability to solve problems. I really chose the major out of fear that anything else would feel awkward and out of place” {sic.}.

In most of these answers there appears to be a link between parents/teachers encouragement towards an engineering career due to students' interest or strong performance in math and science coursework: *“My parents and teachers convinced me to go into engineering, mostly because I am more interested in math and science as opposed to English and social studies. I learned that engineering has a lot to do with math and science” {sic.}.*

General curiosity and interest in how things work. Less than ten percent (8.7%) of the participants described their general curiosity and interest in how things work as a reason for choosing engineering as an academic course of action.

“I've always been into building things and taking things apart. I like to find out how things work by my own experimentation, so I look things up and test them and expand upon that reading through further experimentation. For example, I'd build electric motors or split water through electrolysis and rig it up to explode. All that scientific interest, combined with my thoroughly logical approach to problem-solving and thinking in general, make engineering the right choice for me” {sic.}.

Again, there is linkage between this detected category and the category of love of math, science, and technology, and/or the family category. It appears that in most cases where students have curiosity of how things work, they also have an interest in math and science and are usually encouraged to go into an engineering career from their parents or teachers.

“ A natural fascination with how things work and why drove me to want more knowledge, and eventually I realized that there was still room to make all of these things in life better (to make life cooler as I described it at a young age). Most of the people who helped me did so without really knowing. My teachers, especially in high school, really showed me what all there is out in the world as far as knowledge, and they showed me a lot of doors to walk through to that would have some new thing or piece of the universe on the other side” {sic.}.

Sources of lesser influence

The next four categories that emerged, shared an almost equal portion of participant responses: work experience 5.7%, interpersonal experience 5.4%, student research 4.9%, TV and media 3.4%. While these categories share a smaller percentage of influence, they still indicate forms of meaningful assistance for students in their choice to pursue engineering as a career. They are as follow:

Work experience

“My dad owns a construction company and I wanted to pursue that profession ever since I learned about it from my dad. I also worked for his company over the summers and I really love the field and the profession. It is very challenging, but fun and interesting at the same time” {sic.}.

“Growing up on a farm where I had to work with mechanical devices and machining equipment made an impression on me to pursue a technical, scientific field” {sic.}.

Interpersonal experience. These responses relate to student experiences with individuals who were neither family members nor teachers. As a result of student’s interactions with these individuals, they learned something meaningful about engineering.

“I also liked talking with people with a lot of professional experience, because they have a better insight of what is important to achieve professional success” {sic.}.

Students own research on internet. A number of students indicated having gone online or to libraries to look up information on careers and specifically engineering. As a result of reading and watching videos online, they learned about engineering and decided to pursue it:

“I researched the internet and the media to look into engineering more to make sure it was what I wanted to do” {sic.}.

TV shows, media, science magazines. Other students indicated having learned about engineering through media reports and television programs:

“Popular Science and Popular Mechanics magazines. I have been reading them for a while and I enjoy what’s inside them” {sic.}.

“I got into engineering by building with Lego’s and Knex models. At later ages I started to build Model airplanes. At some point I started to watch the discovery channel. At that point I knew that I wanted to design and test new machines that could eventually take the human race into the stars” {sic.}.

IV. Conclusions

Assessing student experience represents a critical step in enhancing education. As Upcraft and Schuh point out, “Any effort to gather, analyze, and interpret evidence which describes institutional, divisional, or agency effectiveness can only serve to improve the undertaking” [15] (pg. 36). Accordingly, we believe this study adds significant value to the related body of research, as it offers insights for expanding and improving outreach programs that are designed to help students choose engineering as a plan of study.

The purpose of this report was to present the results of an exploratory study investigating the experiences and interactions that had the most influence on students when students contemplating engineering as a career. Students’ pre-college experience and their reasons for going into engineering are different, at the same time there exists commonalities unique to certain groups of students, particularly those with like socio-economic background, and those choosing specific engineering disciplines.

Across these results, few things in particular stood out. First, results indicate that pre-engineering knowledge and experience, and therefore the reasons that students go into engineering, vary greatly. There were ten categories that emerged from the survey as the most common venues and pathways through which students learn about engineering coursework and careers. Second, the most common and influential of these categories appear to be the presence of family in engineering, aspects of the first-year college curriculum, and the influence of teacher, faculty and peers. These results are in line with *Changing the Conversation*^[8] and current research findings that family, peers and faculty are important influences in career choice. Finally, these findings suggest that students glean great influence from these particular venues, further implying that outreach program geared towards teaching students about engineering would do well to emphasize or harness these influencing factors to maximize impact.

The results indicate that pre-college outreach programs were not a major factor in learning about engineering before enrolling in an engineering degree program. Pre-college outreach impact on students' learning about engineering falls under few of the ten categories - television shows, media, and science magazines. This finding allow for two possible conclusions; either there are still not enough pre-college outreach programs to reach enough students or pre-college outreach and engineering outreach programs have not effectively incorporated systematic ways to incorporate the suggestions given from *Changing the Conversation*^[8]. Regardless of which aforementioned conclusion is most relevant. It seems to be apparent that engineering outreach programs' messages may not be as effective when compared to the time commitment and resources needed to educate and entice students to engineering. Specifically, if a large group of first-semester engineering students at one university make little reference or specific mention to engineering outreach programs. This suggests that there may be a need for further refocusing of engineering outreach programs.

V. Next steps

The results of this study elaborate on ways in which students gain meaningful information regarding the profession of engineering. The next phase of our research will be to investigate why students find these particular engagements and interactions so persuasive. This topic would benefit from future research which expands on interpretation of the findings specific to gender, racial groups, and connections between student's multiple responses. We believe the experiences noted by women and minorities for being attracted to engineering, will be of particular interest to the community of engineering educators. In addition a cross-case analysis between these factors, their learning about, the tenets of *Changing the Conversation*^[8] and what, if any engineering outreach programs were available around each student would provide us with a very comprehensive view of the current status and methodologies of engineering outreach programs.

While there is further research to be completed this work is very promising and seems to give a refocused look at the nature of our engineering outreach programs. The question arises, are we just running business as usual as engineering educators or are we trying to move into the paradigm of *Changing the Conversation*^[8] that actually focuses our messages to the environment of the student. As the results indicate the direction in which engineering outreach programs will continue in order for these programs to make an exponential and sustainable

impact on pre-college students, one thing is clear - outreach programs must use a holistic outreach approach. One that focuses on the family and then is spread out over teachers, friends, etc. Engineering outreach programs should utilize methodologies consistent with this approach.

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