What Do YOU Like to Do?: Exploring Pre-College Students' Career Aspirations and Perceptions of Engineering (Work in progress)

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Introduction

In 2000, educators in the state of Massachusetts took on the task of integrating engineering into K-12 state curriculum frameworks. Over the next 15 years, the K-12 classroom has received increased attention in the creation of national standards that encourage giving equal attention to science and engineering learning. The five dimensions of learning developed by Marazon, Pickering and McTighe (1993) have been mapped onto three educational aims in the K-12 classroom. These dimensions include improving students' attitudes, beliefs, and perceptions of engineering, learning engineering concepts/content, and developing engineering design skills and practices. While considerable steps have been taken in improving attitudes and beliefs around engineering, little change has been seen in the numbers of new or diverse students choosing engineering pathways.

Krapp, Hidi, and Renninger (1992) describe a student's situational interests as the 'interestingness' of the social or nonsocial environment that evoke or encourage interactions while personal interests refer to the characteristics of a person that influence his or her engagement and interaction with the social or nonsocial environment. Traditional engineering activities and learning in K-12 classrooms center on these situational interests. Situational interests do not always correspond to a student's personal interest, which may vary widely depending on their environmental context. This paper considers the impact that could be had if students' engineering experiences appealed to their personal interest as a way of engaging students in engineering activities and disciplines.

The engineering design process is a dynamic setting for incorporating students' personal interest. Carlone et. al (2011) argue that "many students who are academically competent in the school subject matter ultimately view school's knowledge and skills as irrelevant for their future career and/or everyday lives" (p. 2). If we are able to intentionally involve students' personal interest in engineering activities/curricula, we could possibly expand the impact of these experiences and appeal to more students concerning engineering fundamentals as well as consider the field for their career endeavors. While engaging personal interest alone will not improve performance on its own, it can be a groundbreaking entry point for students from underrepresented backgrounds as it may bridge the gap between the classroom and their home learning environments (Cunningham & Lachapelle, 2014).

According to Figueiredo (2008), engineering comprises of four dimensions namely: the basic sciences, social sciences, design, and practical accomplishment. Many definitions in the literature describe the engineer as existing in one of these dimensions; however, one can argue that engineering will only achieve its greatest potential if its practitioners are proficient in each of the aforementioned quadrants. The first quadrant I will explore is that of the basic sciences. In this dimension, engineering is viewed as the application of the natural and exact sciences, stresses the values of logics and rigor, and sees knowledge as produced through analysis and experimentation. The second quadrant, the social dimension sees engineers not just as technologists, but also as social experts, in their ability to recognize the eminently social nature of the world they act upon and the social complexity of the teams to which they belong. This frame of reference implies engineers are capable of interacting with others within society and can accurately determine their needs. The third quadrant, the design dimension sees engineering as the art of design and The fourth quadrant, practical application views engineering as the art of getting things done, valuing the ability to change the world and overcoming complexity with flexibility and perseverance. We argue the intersectionality of the four-dimensional framework Figuieredo (2008) presents is where emphasis should be, because it produces a holistic engineer capable of responsibly addressing issues in society. Moreover, the invested development of each quadrant should be equal, meaning the importance of an engineer's ability to get things done should parallel their ability to appropriately access and engage the social nature of the world in which they work.

This study is situated on the premise that activities which are personally meaningful to students, engaging their intrinsic interests, they will become immersed in the activity at a deeper level which allows for rich learning experiences (Dewey, 1938; Papert, 1980). We are seeking to maximize students' interactions with engineering design and problem solving by providing activities that make engineering personally relevant. Students come to the classroom setting with diverse knowledge, experiences, and motivations; nonetheless, engineering possesses the flexibility to permit varied exploration while satisfying the content demands of the traditional K-12 classroom. Specifically, math, science, and literacy are inherently integrated within engineering, though the contexts to which these competencies can be applied are boundless.

The Study

A total of 29 elementary, middle, and high school students (12 females and 17 males) voluntarily participated in this study. A convenience sampling method was used to select the participants in this study. Although this is a small sample size, this study is part of a broader study that investigates how students' interests (situational and personal) relate to engineering. The data presented in this paper was collected through semi-structured interviews conducted with these pre-college students. The participants represent a diverse group of students, including some that participated in a summer engineering program at a large Midwestern university targeting underrepresented minorities and others that had no prior experience with engineering-related activities. The participants included African American, Hispanic, and White students, exact representation of each race/ethnicity is unavailable because some students chose not to answer this query. The recordings of phone interviews and in-person interviews were then transcribed for analysis. The interview protocol was designed to gain information on three primary areas concerning the student. Following a demographic inquiry, the interviewer sought to establish an understanding of each participant's personal interests—what they typically do on their own time, favorite activities, and things they learn about intrinsically. The next phase of the interview explores the students' favorite and least favorite subjects in school, to investigate if there is a connection or relationship between their interests and favorite/least favorite courses in school. The concluding questions examined the participants' understanding of engineering work and engineering as a profession, as well as their interest in engineering as a career.

Analysis

The analysis began by reviewing the interview transcripts multiple times to investigate whether any themes were present across numerous students in the study. This transcript review focused on specific questions asked during the interview, primarily students' personal interest(s), career aspiration(s), experience with engineering, and understanding of engineering. Analysis was performed by capturing consistencies in the data relevant to the framework of this paper, and then student characteristics were considered for any plausible explanations.

Findings/Discussion

The first theme that became apparent following the analysis of the data is the narrow comprehension of engineers and engineering conveyed by the research participants. When students were probed to relay their understanding of engineers and engineering the most popular answer is that engineers improve lives, and a combination of engineers invent, design, and create things. Each of these responses were mentioned eight times in the descriptions provided by students, the next most frequent answer was that engineers fix things and build stuff, tallying six mentions. Consider the following excerpt of one student that displayed a generic understanding of engineering (I=Interviewer, P=Participant). While the student does not provide any false information, the answer given follows the trend of generality and lack of diversification in the role of the engineer:

1 I: It was SEW ok alright good now um how would you explain what engineering is or what engineers do to someone at school say and that might not know anything about it?
2 P: Bas – well uh, basically I would explain it like they fix things.
3 I: Ok alright
4 P: Solve problems they're problem solvers
5 I: Ok ok um can you say a little bit more about that like um fix things that's kind of broad but?
6 P: Uh
7 I: Could you give
8 P: Well ok they take something let's see... That needs repairing
9 I: Ok
10 P: And figure it figure out how to solve
11 I: Ok

These responses were mapped to Figueiredo's (2008) four dimensions of engineering, this process is displayed in Table 1. We separated the participants' answer between students who had some experience with engineering activities and those that did not, so that we could explore the impact of exposure to engineering activities and/or programs. We are interested in the source(s) where students without engineering exposure formulate their understanding of engineering/engineers, as well as, whether students with engineering exposure have a more complex perspective of engineering/engineers. The four-dimension model implies the expert engineer would be adept in each of these domains, while novice engineers would be building their awareness in each domain. The most common descriptions of engineers provided by students span three of the four domains that comprise engineering. While the student comments spanned the majority of the dimensions, they did not address the intersectionality of these dimensions and how this manifest in the engineer and engineering work.

Understanding of Engineering	Figueiredo's Dimensions			
	Sociologist	Scientist	Designer	Doer
All Students	6	6	4	12
Students with Engineering Exposure*	6	3	3	5
Students without engineering exposure	0	3	1	7

Table 1: Engineering Conceptions

The second theme identified in the data is a perceived disconnection between students' ability to align their career aspirations with their stated personal interests. Admittedly, this inquiry needs further investigation since our protocol did not explicitly ask students to make a connection between their career goals and established extracurricular activities and hobbies. Nevertheless, the data initiated a probe into whether this gap exists because students are consciously pursuing career interests dissimilar to their avocational interests or because they cannot identify opportunities for merging these two interest areas. For example, one student expressed interests in music, sports, writing, and general creativity, but mentioned a desire to become a biomedical engineering following an excitable demonstration experienced during an engineering summer camp. Students' responses to questions about their leisurely activities and career aspirations were coded in categories. The categories for hobbies include language arts, sports, music, social, and performing arts. The categories for career aspirations include science, technology, engineering, mathematics (STEM), military, and education.

Finally, the data revealed a diverse array of personal interests engaged by pre-college students, particularly among students with a declared earnestness for engineering. Often times engineering prospects are thought to be builders, tinkerers, and math and science enthusiasts. Table 2 displays that while these activities rank highly among potential engineers, there are other activities that engineering prospects enjoy as well.

Diverse Student Interest	Personal Interest									
	Building/Making things	Social Interactions	Technology	Physical Games	Math, Science and or Engineering	Reading	Writing	Drawing	Music	Physical Activity	Other
All Students (29)	16	7	14	3	11	7	6	8	5	25	6
Students interested in engineering (8)	5	2	6	2	5	3	4	2	2	5	0
Students not interested in engineering (21)	11	5	8	1	6	4	2	6	3	20	6

Table 2: Students' Personal Interests

Furthermore, there is even an interest among non-engineering prospects in activities that appeal to potential engineers. Students that do not desire to become an engineer still showed care for building/making things, exploring technology, along with science and mathematics. These results offer new insights for richer inquiry as this project expands.

Conclusion

As engineering education continues to spread throughout the pre-college educational domain, students need to have a comprehensive understanding of engineering and engineers.

Establishing a perception of engineering that goes beyond traditional perspectives of engineering may open pathways for students that have potential to succeed, but do not view themselves as hands-on or math/science enthusiasts. Additionally, students that do excel in some aspects of engineering, may be encouraged to develop more holistic personal/intellectual qualities to meet the demands of our ever-changing society. Outreach programs and K-12 educators need to be able to explicitly address the conceptions of engineers held by students, and be equipped to guide students toward accurate and complete impressions.

We are interested in investigating the reasoning students use in selecting their career ambition(s). We acknowledge the difficulty of engaging pre-college students regarding their professional goals, but this is an area worth studying in engineering education. Engineering is a broad field, and we see potential for diverse populations to consider this career if they can envision their intrinsic interests in the context of engineering. These type of connections build confidence and perseverance for students to succeed despite the rigors of engineering curriculum.

Lastly, the diverse interests of students attracted to engineering challenges engineering educators to be hesitant of over-generalization. Frequently, specific people groups are considered like-minded in their interests (e.g. female students, African American students, etc.) but this can be a damaging misinterpretation. Students that participate in varied recreational activities build their capability for greater creativity due to their differing experiences. Engineering education must be a field where students can express the totality of their personality to develop the innovative solutions needed in our complex society.

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