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Motivating Factors for Choosing Engineering as Reported by Racial and Ethnic Minority Students

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Fundamental: Motivating Factors for Choosing Engineering among Minority Students

Introduction

Minority populations continue to be underrepresented in the fields of science, technology, engineering, and math (STEM).[1] Increasing the diversity in these fields must start with growing minority students' interest in pursuing STEM undergraduate degrees. In 2009 less than six percent of undergraduate engineering students were African American, ten percent were Hispanic, and less than one percent were Native American.[1]

Klotz compares the need for diversity in engineering to the need for biodiversity in an ecosystem in order to prevent disease and resource shortages.[2] Similarly, a lack of diversity in the group of professionals that works to overcome many of today's greatest challenges weakens the group by narrowing their view to only that of the majority.

This study focused on discovering what motivates minority students to pursue engineering degrees and how these motivations relate to their professional goals. A set of preexisting interviews with African American (AfA), Asian American (AsA), Hispanic American (HA), and Native American (NaA) engineering students was analyzed to determine the students' reasons for choosing to major in engineering. These motivational factors were then categorized using a parent –child hierarchy based on the Social Cognitive Career Theory.[3]

The Social Cognitive Career Theory explains how a student's self-efficacy, interests, outcome expectations, social supports, and barriers influence their decision to pursue a certain career goal.[3] The first influence in the SCCT model is self-efficacy. Self-efficacy is a person's belief in their ability to perform a certain task. Self-efficacy has been shown to predict career aspirations. Students with a higher competency score in math are more likely to pursue a math related profession.[4]

Intrinsic values and interests, the second aspect, describe the enjoyment associated with an activity. Therefore, student interest in math and science is expected to be strong motivation to enter engineering.

The third aspect of SCCT is outcome expectations. This aspect describes a person's beliefs about the potential from pursuing a particular career path. For example, a student may choose to enter engineering based on their belief that they can accomplish meaningful work in the field.[2] In this study outcome expectations were often expressed as the choice to enter engineering due to job availability or a high earning potential.

Social supports and barriers are also an important component of Social Cognitive Career Theory. For example, support could be receiving career advice from an engineer, or receiving advice from a parent or guardian to pursue engineering. Parental support is often a positive predictor that a student will choose to enter the field.[2] First-generation college students and immigrants often experience social barriers.[5] These barriers also affect minority students and result in limited knowledge of financial aid opportunities and the important factors in choosing a college.[6] It has been found that such supports and barriers more strongly affect a student's self-efficacy than they do their goals.[7]

Expectancy-Value Theory is similar to SCCT, but uses small variations in how the component aspects are described.[8] The theory refers to competence beliefs, which are analogous to self-efficacy. Intrinsic values are another aspect of Expectancy-Value Theory and are related to the interests construct included in SCCT. Matusovich et al. used this theory in an analysis of eleven engineering student interviews.[8] They found that the intrinsic values aspect of expectancy-value theory had a stronger influence on activity choice than competence beliefs.[8] Although not applying the same theoretical framework, our paper expands on the case study by Matusovich and co-authors by disaggregating by racial/ethnic group membership.

The factors that motivate minority students to enter engineering must be understood in order to find effective strategies to increase diversity in the field. Strategies to increase student enrollment in engineering derived from student narratives will be discussed later in this paper.

Methodology

To study the factors influencing the choice of an engineering major, minority undergraduate engineering students were interviewed. Our interview population included 29 Native American students, 37 Hispanic American students, 35 Asian American students, and 37 African American students. The students graduated from one of several engineering majors at a large, comprehensive research institution located in the Southwest United States.

These students participated in one-to-two hour semi-structured interviews. Pre-determined questions were supplemented with additional probe questions when needed to encourage the students to elaborate on their educational and personal experiences. The interviews were transcribed, reviewed for accuracy and removed of any personally identifying information. For this analysis, initial coding of the student responses to one specific interview question (and subsequent probe questions) was completed using NVivo qualitative data analysis software.[9] This question directly asked students "Why did you choose your major?"

In the first coding pass, student responses were examined for emergent categories of influence. We compared these categories with several conceptual frameworks and determined that Social Cognitive Career Theory provided the best interpretive match to our categories. We mapped the following codes to the dimensions of SCCT (Table 1). A detailed description of what influences fall within these categories can be found in Appendix A.

Once the SCCT framework was applied, the coding of the interview passages was reviewed to ascertain that all categories of influence were appropriately coded. Trends were identified within as well as across the four minority groups: Native American, Asian American, Hispanic American, and African American. The relative importance for each coding theme, and collectively, for the SCCT construct, was determined as the fraction of all coded passages related to motivation for choosing engineering coded to that particular theme for that group of students. Thus in Figure 1, within each racial/ethnic group, the percentages are calculated as the number of passages coded to one emergent theme divided by the total number of passages coded for that group of students under the generalized theme of motivations for studying engineering. Although these percentages are useful for determining proportional representation, because of the open-ended interview nature of the data, they should be viewed, and will be discussed, as relative trends and not as absolute values.

Table 1. Mapping SCCT component constructs to coding themes

SCCT construct	Emergent coding themes
Self-efficacy	Degree difficulty Personal ability
Interests	Interest in STEM Preferred industry
Outcome Expectations	Financial goals Employment prospects Social recognition
Social supports	Influence from others Financial availability College activities Pre-college activities Recruitment
Social barriers	Not included in this analysis

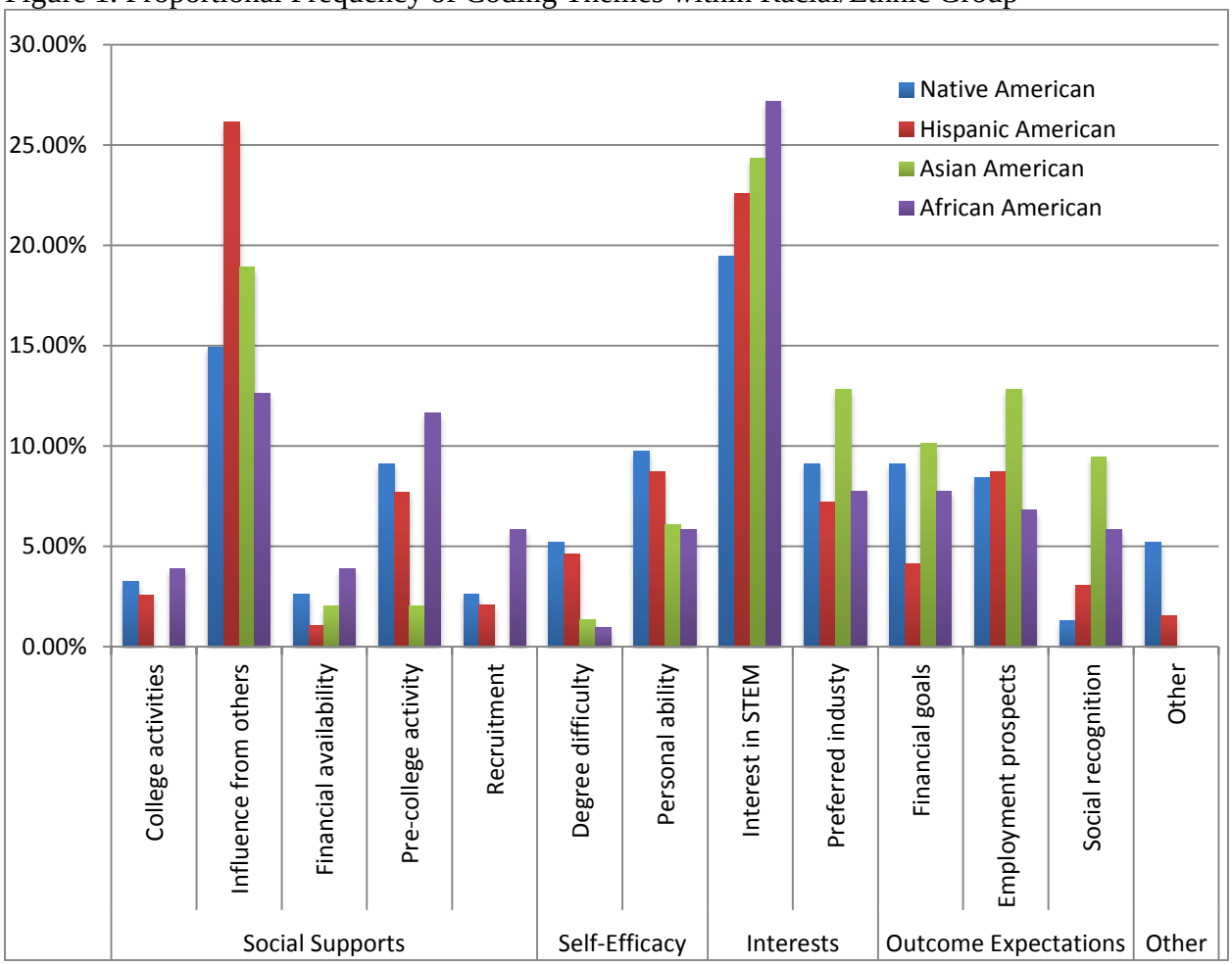
Results

General Trends

The trends in our findings for all groups show that *interest* is one of the most powerful influences with *self-efficacy* being the lowest. This trend extends the previous findings by Matusovich et al. to students from racial/ethnic minority groups.[8] In addition, influence from *social supports* was also very high for all groups. Influence from *outcome expectations* was moderate for all groups except AsA, where it was one of the largest influences. In support of an earlier survey showing math self-efficacy to have a lower impact on STEM major choice for minority students than for white students,[10] our qualitative analysis also shows *self-efficacy* does not have as large an influence as the other SCCT themes for students from minority groups.

In our analysis, not all coding themes were equally represented in the SCCT facets. Two SCCT constructs were each heavily influenced by only one of the mapped coding themes. Most of the influences mapped to *interests* arose from remarks coded to *interest in STEM*. This trend suggests that students who chose engineering were actually interested in concepts related to science, math and problem-solving. The *social supports* aspect of SCCT was populated mostly by responses coded to the category *influence from others*. Thus, having family, friends, and teachers motivating students to choose engineering is also influential in a student's decision across all ethnic groups. Although the AsA group was by far the most influenced by *outcome expectations*, these factors had some influence on all four groups. Of the *outcome expectation* influences, *employment prospects* and *financial goals* were strong motivating factors for each group. Students chose to major in engineering because they thought their decision would lead to the ability to find a well-paying job.

Figure 1. Proportional Frequency of Coding Themes within Racial/Ethnic Group



Hispanic American Trends

Unique trends for Hispanic American students (HA) were found in the SCCT theme of *social supports*. The category, *influence from others*, was the most cited influence for HA. While it was a high influence for every ethnic group, it was exceptionally noticeable for this group of students. Most of this influence came from family and teachers. This *influence from others* is not unique to our sample, as Hispanic American students in other studies have been found to be far more influenced by family when choosing a major, compared to other populations.[11]

Another interesting trend among HA students was a lack of motivation from *social recognition* and *financial goals*. While *social recognition* and *financial goals* were large motivators for some other groups, HA students were influenced very little by these factors. This indicates that the Hispanic American group is relatively less influenced by *outcome expectations* compared to the other groups.

Native Americans Trends

What is interesting about our sample of Native Americans is that there was no factor that stood out relative to the other groups. Within their influences, Native Americans followed the

general trends of the other groups with relatively high influence from *interest* and *social supports*, and moderate influence from *outcome expectations* and *self-efficacy*. In the same vein as Hispanic Americans, Native Americans were minimally motivated by *social recognition*, and in fact had the lowest level of influence from that category.

Asian American Trends

Interests, including both factors of *interest in STEM* and *preferred industry*, was the strongest factor that AsA students reported for choosing their major. In fact, their proportional frequency for this SCCT category was higher than for any other racial/ethnic student group.

The most noticeable difference between Asian Americans and the other three groups was the level of influence from *outcome expectations*. The strong influence from *outcome expectations* suggests that the AsA group was highly influenced by career goals. In fact, every category that was related to one's career (*preferred industry*, *financial goals*, *employment prospects*, and *social recognition*) was higher for Asian Americans than they were for every other group in the study. This is especially true for students seeking a graduate degree. AsA students were roughly four times more likely to use their engineering degree to go to medical school than the other three minority groups.

Social supports were relatively lower for AsA compared to the other three groups. While they had a relatively average level of *influence from others*, influence from *college activities, pre-college activities*, and *recruitment*, were almost non-existent in our sample. This lack of influence, especially from areas such as high school classes, has been a noticeable trend in other studies.[10] While the AsA students in this study are the least influenced by math and science classes, another study reported that AsA students outpace all other ethnic groups in pursuing math and science courses in high school.[12]

African American Trends

African Americans were most influenced by the SCCT category of *interests*. The coding factor, *interest in STEM*, impacted African American students more strongly than any other minority group. AfA students were also influenced by *social support*s. Compared to the other groups, AfA were less influenced by *influence from others* but had a higher level of influence from *pre-college activities*.

The relatively high influence from *interest in STEM* as well as *pre-college activities* is most likely explained by the fact that many of the African American students in our sample went to STEM focused high schools and were recruited specifically from them. Our data reflect this potential explanation, as AfA were relatively more influenced by *recruitment* and *financial availability* (scholarships) compared to their peers. The finding that exposure to STEM classes motivated these AfA students to choose engineering is consistent with national studies that have shown those experiences to correlate with higher education STEM enrollment for all minority students.[11-14]

Conclusion and Recommendations

Because this work is based in the words and experiences of students from each of the four racial/ethnic minority populations, it extends previous work related to SCCT and engineering major choice. Our results show the similarities and differences among the groups and can be used to help guide outreach and recruiting efforts to emphasize those facets with larger influence on particular groups.

Provide Early Exposure to Engineering

The early engineering exposure experienced by many of the AfA students in our sample had a large influence on their choices to enter engineering. This exposure to pre-college engineering programs was more important than math and science courses in shaping the choice of major for AfA students. Asian American students reported very little influence from any kind of early exposure to engineering. This lack of influence suggests that these AsA students do not have such opportunities available to them, which could be the result of the relatively low proportion of AsA students in our sample whose parents have four-year degrees.[13] *Interests* often have the largest influence on students' choices of major and matching their majors with interests is a top priority for students.[8,15] Providing similar engineering experiences to the other groups of minority students who indicated stronger influence from math and science classes would spark interest and lead more students to choose engineering majors.[11-13,16]

Although STEM focused high schools attended by many of the AfA participants are ideal for students interested in engineering, they may not always be an option. Minority students living in low-income households may have limited access to math and science education and may experience less qualified teachers.[17] Students in these circumstances can still be influenced towards engineering by small events. Even small engineering experiences have been shown to have a large effect on a student's choice to major in engineering.[18]

Offer Relevant Visions of Potential Career Paths

Employment prospects and *preferred industry* had a moderate and consistent effect on all four groups. When a student named more than one motivation for choosing engineering, the ability to find a job was often one of the factors mentioned. Some students stated that the high demand for engineers in the job market was the only reason they chose an engineering major. Because this factor was so influential for these students, increasing other student's knowledge about engineering career opportunities might influence them to enter the field.

Influence by *outcome expectations* could also be based on what students believe they can accomplish in their careers. Students who enter engineering are more likely to want to address energy issues, climate change, environmental degradation, water supply, terrorism, and opportunities for future generations.[2] On the other hand, students who are not interested in engineering often have *outcome expectations* related to disease, poverty, and equality for underrepresented groups. Increasing student knowledge about the ways that all of these issues can be impacted by engineering may educate students about how engineering can help them achieve their career goals.

Build Strong Collaborations between Engineers and Pre-collegiate Influencers

Influence from others as a feature of *social supports* was a strong motivator for every group. Parents provided general influence towards attending college and choosing majors with professional opportunities. Few students in our sample have parents with engineering experience. For the AsA students, high school teachers provided the engineering influence. Hispanic students' engineering encouragement was more likely to originate from teachers and family friends. This relationship with school personnel could help more Hispanic culturally identified students or other minority students make up for lack of parental experience and knowledge of engineering.[5]

Many students' knowledge about engineering is very limited when they choose a major.[18] Ensuring that students have access to knowledgeable teachers and counselors in high school would help students to make informed decisions when it is time to choose a major.

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Appendix A

Self-Efficacy

Degree Difficulty – This factor involves students choosing a degree either because they believe it is easier than other degree interests, or choosing a degree because they believe it is the harder than other degree interests.

Personal Ability – This factor relates to a student's self-perception on their capabilities related to STEM subjects. Factors such as a student's confidence in their math and solving capabilities, problem solving abilities, and building or designing capabilities were categorized here.

Interests

Interest in STEM – Being interested or enjoying aspects related to STEM. This includes interests such as math and science, building, construction, problem solving, or a specific degree.

Preferred Industry – This includes factors related to a specific job or industry a student is interested in as well as wanting to go into a graduate school such as medical school.

Outcome Expectations

Financial Goals – This category dealt mainly with student's perception that engineers make a lot of money and/or able to support their family.

Employment Prospects – This category revolved around a student's perception that engineers have a high employment rate, have high opportunities to pick where they work and the type of work they do, and have overall job flexibility.

Social Recognition – This category includes both the prestige and pride the students associate with engineers as well as the perception that engineering provides the ability to contribute to society.

Social Supports

Influence from Others - This category consists of students being influenced towards engineering, either directly or indirectly, from family, friends, advisors, or teachers.

Financial Availability – This factor consists of students choosing engineering due to the financial support, such as scholarships, they receive to major in engineering.

College Activities – This factor includes areas such as college classes and college clubs/associations that convinced students to go into engineering. For the most part, this factor contributed mainly to switching between engineering degrees.

Pre-College Activity – This consists of influences from activities before college such as High School Classes, Extracurricular activities, such as engineering competitions, and pre-college jobs.

Recruitment – This category is populated by instances where students were influenced from high-school recruiters, college tours, and college pamphlets.

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