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Familial Influence on the Choice to Study Engineering: Insights from a Cross-University Study.

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Influences on the Choice to Study Engineering: Insights from a Cross-University Study

Introduction

To improve how students are recruited into engineering, it is imperative for the engineering education community to recognize and understand the factors that influence students' choice to pursue a degree in engineering. Research conducted within this area has identified numerous factors reported by students to have influenced the choice to pursue engineering as a college major. These factors include math- and science-related interest [1-2], prior STEM experiences in elementary and secondary school [3], earning potential [1, 4-5], and positive self-assessment of one's math, science, and/or problem-solving skills [2, 6-7]. Social relationships such as those of family [8-11], peers, and teachers have also been cited by students as key factors influencing their choice to pursue engineering [12]. In fact, Kier and Blanchard [13] report that in addition to a student's secondary school experiences, these social influencers are reported as some of the most influential factors influencing a student's college major decision.

Despite family being recognized as one of the most influential factors on a student's choice of college major, further investigation is needed to understand how the influence of family manifests in the realm of engineering. This study seeks to extend our understanding of factors influencing the choice of engineering major. More specifically, this work seeks to investigate the role of familial influence in this choice. Previous work conducted by the authors [14] indicated a matrilineal link in the choice to study engineering, suggesting that students, especially female students, with a mother in engineering are more likely to pursue a degree in the field [14]. Building on this previous work, this study aims to validate the results obtained from the previous cohort of participants by involving students from other universities for replicability purposes. In reflection of this, the following research questions were identified and investigated in this study:

1. How do familial relationships impact student college major choice? Are there gendered differences across the familial engineering relationships reported amongst respondents?
2. How do the results obtained from the previous study compare to the findings of this cross-university study?

Study Design

To further examine the role of familial influence on student engineering major choice, this study employs a multi-methods approach facilitated through a survey with both quantitative and qualitative components. Data obtained from elements of the survey were first analyzed independently from each other. These independent analyses were followed by a combined interpretation phase that sought to understand the results in reflection of one another. To aid in the analysis and interpretation of results, Social Cognitive Career Theory is used as a theoretical framework for this work.

Theoretical Framing: Social Cognitive Career Theory

Social Cognitive Career Theory (SCCT), developed by Lent, Brown, and Hackett [15-16] as an extension of Bandura's Social Cognitive Theory (1986), posits that career development (career interests, career choice, career performance) is influenced by the interactions of cognitive-person and environmental variables. Cognitive-person variables are described as being made up of three interrelated components: self-efficacy beliefs, outcome expectations, and personal goals. Environmental variables, often referred to as proximate or background contextual factors, refer to influences from the individual's environment (such as the presence or absence of social supports, role models, or access to material/ informational resources.) Unlike the cognitive-personal variables which account for the personal influence one has over their career

development, contextual factors account for influences outside one's control which may enhance or constrain "personal agency" [17, pg. 36] in the career development process. For this study, SCCT was chosen as a lens to analyze and interpret student responses due to its previous applications within literature that explores major selection processes and its ability to study familial influence as a contextual factor.

Positionality

As researchers, we recognize the vital role that we play throughout the process of research design and implementation, data analysis, and disseminating the results [18]. Details of our individual positionalities are included within this section to provide audiences with a lens to view the results. Amanda Singer was a graduate teaching assistant within Michigan Technological University's First-year engineering program at the time of this study's development and data collection. Dr. Michelle Jarvie Eggart is an assistant professor within the Department of Engineering Fundamentals at Michigan Tech and taught the sections of the First-Year Engineering (FYE) courses in which students were surveyed for this work. Dr. Akua Oppong-Anane is an assistant professor and academic advisor within the FYE program at Montana Technological University. Like Dr. Jarvie Eggart, Dr. Oppong-Anane was the course faculty member for the section of students surveyed at Montana Tech in this study. Katrina Carlson is a PhD student in the Cognitive and Learning Sciences program at Michigan Tech who was brought onto the project to assist with data analysis and interpretation. Dr. Sarah Tan assisted the other authors in conducting quantitative analysis.

Participants

Participants in this study were students enrolled in one section of a first-year engineering course at Michigan Tech and Montana Tech during the 2020 fall semester. At both universities, engineering students complete a common curriculum during their first-year classes which teaches baseline engineering skills such as problem solving, teamwork, and communication, familiarizes students with engineering software, and promotes the exploration of the different engineering majors. Both universities present similar institutional contexts regarding department size and student demographic makeup. At Michigan Tech, the College of Engineering makes up about 60% of university enrollment. In the fall of 2020, women represented 28.9% of undergraduate enrollment; while underrepresented minorities (URMs - including American Indian/Alaskan Native, African American/ Non-Hispanic, Asian/Asian American, Hispanic/Hispanic American, Pacific Islander, and Multiracial), encompassed 9.9% [19]. Montana Tech's School of Engineering made up nearly 41% of the university enrollment in the Fall 2020 semester [21] with women representing 37% of the undergraduate enrollment. In the Fall of 2020, the university had the following demographic makeup: 20.5% were underrepresented minorities (URM including Hispanic, Asian, American Indian, or Alaska Native, Black/African American, multiracial) and 79.5% were White [22].

Data Collection

To investigate the identified research questions, a survey adapted from the authors' previous work [14] was administered to a population of students enrolled in a first-year engineering course at both Michigan Tech and Montana Tech. The survey administered for this study was thus composed of 14 multiple choice questions addressing the engineering & STEM occupations of relatives and an open, reflection-style question geared toward understanding the different factors affecting student choice to study engineering and select an engineering major.

Quantitative Analysis

Survey results from the multiple-choice questions were analyzed using logical counting and descriptive statistical procedures. Summaries of familial engineering relationships were developed for each of the identified familial categories and are presented as total counts and percentages within the results section. To investigate differences in familial relationships across gender and institutional categories, statistical analyses were performed on the collected data. Due to the small sample size, Fisher's Exact tests were conducted to examine the significance of association between the type and number of familial relationships and the identified gender of the participants. While statistical analyses were conducted to investigate gendered differences, an investigation into the significance of association between institutions by the number and type of familial relationship could not be conducted due to the small number of respondents within the Montana Tech population.

Qualitative Analysis

Student responses to the short reflection questions were analyzed using both inductive and deductive coding techniques [23]. Student responses were initially analyzed using inductive coding methods. In this approach, codes and themes are identified in an exploratory manner by allowing them to emerge from the student narratives organically [24]. To increase the trustworthiness and validity of the data, methods of constant comparison [24] and investigator triangulation [25] were employed during the data analysis phase. As recommended by Saldana [23], multiple cycles of coding were conducted to ensure interpretive convergence. Following the inductive coding procedures, deductive coding cycles informed by the principles of Social Cognitive Career Theory [15-16] were conducted. In this phase of coding, the themes and codes identified during the inductive phase were further categorized across the following core concepts related to Social Cognitive Career Theory: Self-Efficacy, Prior Experiences, Outcome Expectations, and Contextual Factors.

Results and Discussion

At the conclusion of the fall 2020 semester, the adapted survey instrument was offered to a population of 216 students (91 from Michigan Tech and 125 from Montana Tech) for extra credit. In total, 94 students across both institutions completed the survey with informed consent, resulting in a 43.5% completion rate. Analysis of the survey responses from both universities resulted in a similar gender and race/ethnicity breakdown amongst participants. Of the 58 students who completed the survey at Michigan Tech, 39 (67.2%) identified as male and 18 identified as female (31.0%.) At Montana Tech, a similar gender breakdown was observed, with 26 of the participants (72.2%) identifying as male and 10 students (28.8%) identifying as female. The race/ethnic makeup of the sample population between the two schools was relatively homogeneous, with all respondents at Montana Tech identifying as white and respondents from Michigan Tech identifying as white (91.4%), Asian/Pacific Islander (3.4%) and Hispanic/Latino (1.7%).

Quantitative Results: Familial Engineering Connections

Students at both universities were first asked to report whether they had a family member with a career in engineering. Across the combined survey population, nearly 29% of students reported having at least one family member that was an engineer, and an additional 16% of students indicated having family members with careers in both engineering and other STEM fields. Across both universities, female participants reported having a family member in engineering at higher rates (32.1%) than their male counterparts (26.2%.) When considering institutional context, a higher percentage of student respondents attending Michigan Tech reported having a family

member in engineering (34.5%). A full summary of results, broken down by familial relationship, is depicted in Table 1.

Table 1: Reported Familial Relationships with Engineers across Gender.

Familial Relationship**	Michigan Tech (n=58)		Montana Tech (n=36)		Combined (n=94)	
	Male (n=39)	Female (n=18)	Male (n=26)	Female (n=10)	Male (n=65)	Female (n=28)
Father/father figures*	20.5%	50.0%	11.5%	30.0%	16.9%	42.9%***
Mother/mother figures	5.1%	22.2%	3.9%	10.0%	4.6%	17.9%
Siblings	15.4%	27.8%	7.7%	20.0%	12.3%	25.0%
Grandfathers	18.0%	33.3%	3.9%	10.0%	12.3%	25.0%
Grandmothers	0.0%	5.6%	0.0%	0.0%	0.0%	3.57%
Cousins	18.0%	38.9%	15.4%	20.0%	16.9%	32.1%

***** Indicates an association of significance across gender as identified by Fisher's exact test.
**Values reported as percent of male/female/total population respectively.
*** One student from Michigan Tech preferred not to disclose their gender identity. This student reported one father/father figure in engineering.

Fisher's exact tests were conducted to assess the association between gender and the number of familial relationships in engineering a student possesses. This form of analysis was compared across both immediate (mother, father, siblings) and extended familial (grandfathers, grandmothers, and cousins) relationships. From this analysis, statistically significant relationships between gender and the number of fathers in engineering (X^2 (2) = 5.32, p = .050, Cramer's V= .239) were identified, with female students more likely to report at least one or more fathers/father figures in engineering than male students. An investigation into the significance of association between institutions and the type of familial relationship were not conducted due to the small sample size within the Montana Tech population. Thus, the results from the cross-university study suggest that a familial link, specifically one that is paternal in nature, may be present. These findings align with other study which recognize the influence of fathers who are engineers. This link may be more prominent as engineering is a male-dominated field.

Previous work conducted by the authors [14] indicated a matrilineal link in the choice to study engineering. This link, which suggested that students, especially female students, with a mother in engineering were more likely to pursue a degree in the field [14], is seemingly contradicted by the findings of this study. The results of this cross-university study suggest a patrilineal link, with students more likely to report a father or father figure in engineering. Although the results of our analysis indicate a statistically significant relationship for fathers in engineering, this finding could be explained by the male-dominated nature of the engineering field. While the only statistically significant relationship identified was that with fathers/father figures, the frequency of engineer relationships reported by students across all familial categories should not be ignored. If familial career had no influence on student engineering interest and engineering major selection, we would expect to see the percentage of familial engineers to be within a similar

range to the engineering population within the US workforce (~6%) [26]. Thus, in line with the work of Shields and Kisi [27] and our previous study [14], the results obtained within this study suggest that occupational inheritance is operationalized within the engineering profession.

Qualitative Results: Influences on Selection of College Major

To provide further insight into the role of familial engineering influence, survey participants were asked to respond to the following open-ended, reflection question: *How did you choose your college major?* Upon reaching interpretive convergence during the data analysis phase, the following SCCT themes, in order of combined overall prevalence, were identified within student responses: engineering **self-efficacy**, the role of **prior experiences**, student **outcome expectations**, and **contextual factors** outside of oneself that influenced major choice. Definitions to each of these criteria as well as example student quotes are provided in Table 2.

Table 2: Deductive Coding Results

Category	Definition	Example Responses
Self-Efficacy	Beliefs about one's capacity to be an engineer: individual recognizes they possesses skills necessary to be an engineer; interest and feelings toward being an engineer.	*"I became good … in Math, such as Calculus… and Statistics. So, I decided to take a Computer Aided Design class and …* [decided to] *major in Biomedical."* *"I find a lot of enjoyment in coding and designing new projects. I love … the engineering process and testing out my prototypes"*
Prior Experiences	K-12 exposure to engineering and other STEM topics. Prior STEM courses taken during high school; participation in STEM extracurriculars.	*"I chose my college major because I took a circuits class when I was in high school, and I was very interested in it, so I knew I wanted to do something in the electrical field… Enjoyed this type of work in FIRST robotics."*
Outcome Expectations	Expected outcomes of choosing to major in engineering: promise of job opportunities, pay, and high diversity of work.	*"I wanted a degree that utilizes STEM courses and has high job placement."* *"They make a lot of money".*
Contextual Factors / Social Influences	Consideration to the role of family, peers, teachers, and other external factors that influence one's desire to choose engineering.	*"I wanted to go into aerospace engineering so I visited a family friend … working at the Johnson Space Center in Houston. We discussed the different options I had, and they recommended that I go into a broader engineering field so that I have more job opportunities … Therefore, I decided on mechanical engineering"*

Consistent with the presentation of the quantitative results, findings from the thematic analysis of the open, reflection-style questions are distinguished based on gender and institution to identify potential trends. These results are presented in Figure 1.

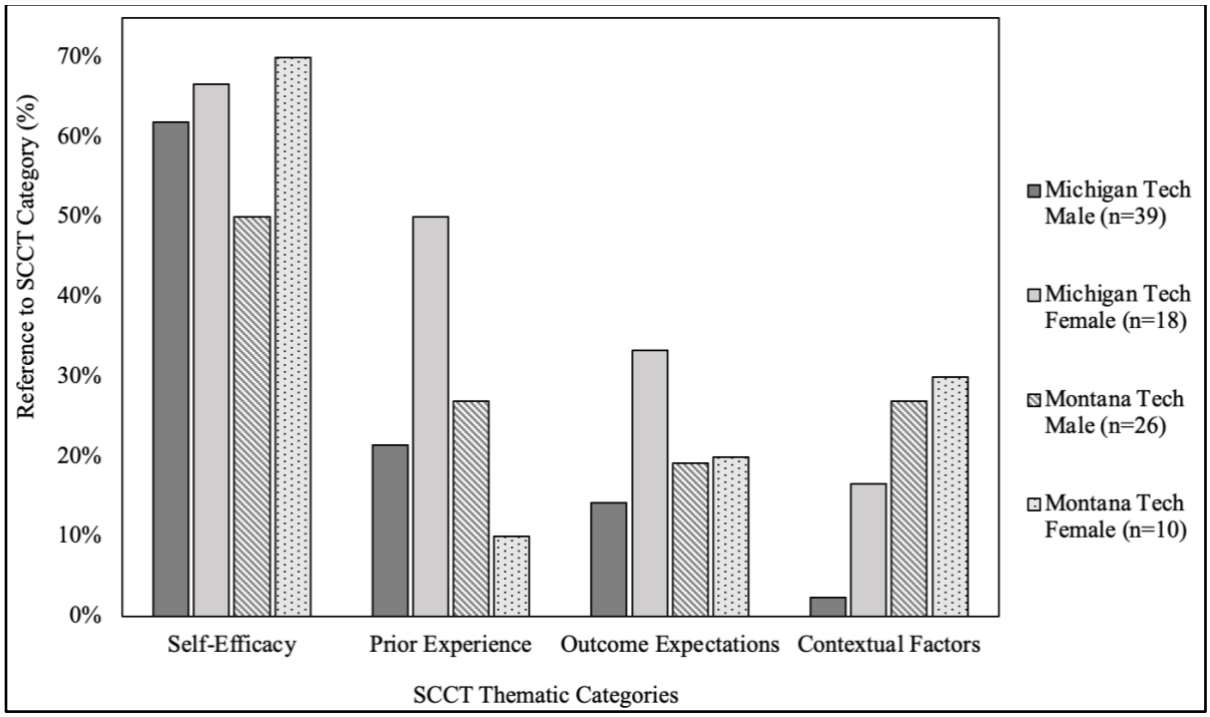

Figure 1: Deductive Coding Results Organized by University and Gender

Across universities and gender identities, factors related to engineering self-efficacy were reported at higher frequencies than the other SCCT themes, suggesting that student interest and feelings toward engineering and their perceived ability to see themselves as an engineer were the most important factors impacting their decision to pursue an engineering major. In contrast, contextual factors such as the influence of family, were reported at lower frequencies than the other SCCT categories. When considered across institutions, students at Montana Tech referred to contextual factors at higher frequencies than their peers at Michigan Tech. Similarly, female student responses highlighted contextual influences at higher frequencies than their fellow male peers. This result is in line with work conducted by Madjar and colleagues [2] which suggests that familial influence may be more pronounced in female students.

When viewed in reflection of each other, the results of the quantitative and qualitative phases present new information considering the existing literature. Although students at both universities report higher numbers of family members who are engineers than the background population of engineers in the US workforce (6%), the influence of family is largely absent from student descriptions of factors that influenced their choice of college major.

Future Work

The results of this study highlight the need for further investigation into the role of immediate and extended family in the process of deciding to pursue engineering and selecting a college major. Although students surveyed within this cross-university study reported high numbers of engineers within their family, the influence of these people were largely absent from student responses when asked to discuss the factors that impacted their choice to study engineering. Thus, further work should focus on understanding the potentially nuanced role that family plays in this decision-making process. Additionally, this study surveyed student populations across two universities that were homogenous in their demographic makeup (i.e., primarily male, and

white). Future work should focus on surveying a more diverse population to understand how familial influences change across different demographic groups.

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