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Do Engineers Beget Engineers? Exploring Connections Between the Engineering-related Career Choices of Students and their Families

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Abstract

There are few studies on how a student's choice of engineering is affected by having an engineer as a family member, yet there are persistent hypotheses about these types of familial influences. Engineering major choice is an important step in the engineering pipeline since paths into engineering are relatively closed after the freshman year. In this work, we explore the influence of familial engineers on students' choice of engineering through a mixed methods approach. The quantitative portion of this study comes from the nationally representative Sustainability and Gender in Engineering (SaGE) survey, completed by 6,772 students enrolled in first-year English courses during Fall 2011. The qualitative data come from seventeen interviews of high school students conducted during in-depth observations at two public U.S. high schools in 2013.

A linear regression predicting the likelihood of a an engineering career was constructed with family members' professions and career influence input as predictors, along with controls for students' academic performance, their family's general support for math/science, and their socioeconomic status (SES). From the interview data, students' own narratives about "who has influenced [their] career choice" were coded to triangulate the quantitative data and provide some explanatory power. The results show that siblings or other relatives being an engineer has a stronger positive influence on students' engineering choice than their parents. These results are supported by students' narratives that their "other" family influences are a stronger influence than direct parental influences except for students who reported a strong, positive relationship with a paternal engineering role model. Notably, no gender differences were found in this work.

Introduction

There is relatively little empirical research on how a student's choice of engineering is affected by having an engineer as a family member, yet many people cite familial influences as a reason for students' choice of engineering. Some prior work on family support has appeared in the Social Cognitive Career Theory literature [1,2], but it does not directly address the influence of a family member and focuses on engineering persistence rather than engineering choice. This paper examines the influence of family on students engineering career choice through a mixed methods study. Quantitative connections between having an engineer as a family member and how influential these members were on students' career choices were examined. While these relationships do give a generalizable connection between engineering choice and family influence, they do not describe *how* these influences are exerted. A follow-up qualitative analysis was conducted with student interviews to understand how students perceive these family influences on their career choices.

Literature Review

As the oft used saying goes, "like father like son [or, like mother like daughter]," there are established connections between family background and students' educational aims and outcomes.[3,4] Families are critical to providing support for student attainment through emotional as well as financial dimensions, from purchasing textbooks to paying for college.[3,5] Parents shape children's attitudes, motivations, values, and aspirations through a socialized family culture and are a locus of control in the education of their children.[6,7] Social scientists have noted this influence and the patterns by which students "inherit" the occupational status of their parents. This finding, especially true for sons, and is referred to as occupational inheritance which operates by two primary mechanisms: 1) socialization of skills [8] and role modeling of parents to children.[9] Kohn [8] found that parents' work environments and the challenges that they face shape how they raise their children. Parents in professional jobs succeed through self-regulatory practices that they pass on to their children. While the focus of this original work was mainly on father-son inheritance patterns, a greater focus on mother's roles came in the 1980s. It was found that mothers provided occupational knowledge to their daughters and played a key role in the transmission of occupational values.[10] Later studies showed that a mother's role is as important as that provided by fathers. Parents play a significant role in the occupational aspirations and career development of their children.[11]

One study completed a comparative analysis of how occupational inheritance differentially affects men and women in engineering.[12] This quantitative study examined 861 engineering students from 15 U.S. institutions. Analyses revealed that approximately half of the men and women in the study had an engineer in their family and that women were significantly more likely than men to have an engineering parent. While interesting findings for the engineering education community, these results alone can not conclude that men and women inherit their interest in engineering from family. This work showed a correlation between having an engineering family member and choosing engineering within a sample including **only** engineers. The final sample featured more women (22.4%) than average in engineering and almost forty percent of the sample came from a single institution which introduces the risk of sampling bias into the findings. While these data pose interesting hypotheses and add to the discussion of "engineers begetting engineers", they open the door to further examination of family role in occupational inheritance. Another preliminary study examined *how* parents shape their children's exposure to engineering [13] and found that parents do not explicitly teach their children engineering. This finding is consistent with the literature that many parents are not aware of their influence on children's career trajectories.[14]

Other work has been conducted in the Social Cognitive Career Theory (SCCT) [2] literature on family role as a support/barrier to the choice of engineering. SCCT has been widely used to investigate the choice of engineering as a career. This theory is based on the social cognitive approach introduced by Bandura.[15] SCCT is founded on the triadic reciprocal relationship between personal and physical attributes, external environmental factors, and overt behavior included in social cognitive theory. One part of this relationship is perceived contextual and distal supports and barriers (including family support across both distal and contextual realms) which is linked to choice goals and actions indirectly thorough self-efficacy beliefs.[1,16] In this model, supports and barriers play a more prominent role in informing students' self-efficacy beliefs than in directly influencing particular engineering choices.[1]

Work by Strayhorn, investigating the role of supportive relationships for African American males' success in college, also highlights the importance of support for retention in college.[17,18] Supportive relationships are positively associated with students' satisfaction in their college experiences which, in turn, improves retention.[19] These relationships are especially important to retaining talented engineers. Of all underrepresented minorities in engineering, African American males have one of the highest rates of attrition.[20] Understanding how family support can provide an entrance into engineering and how supportive relationships within college improve retention may begin to stem the tide.

An early decision to major in engineering in college is critical for students – especially students from traditionally-underrepresented backgrounds (e.g. women and minorities). After the freshman year, it is difficult if not impossible, for students to enter engineering and finish a degree within four years due to the large number of required courses.[21] A four year completion time is important to students with loans or scholarships due to the time-sensitive nature of maintaining funding to achieve a post-secondary degree.

In this study, we examine 1) how having an engineer as a family member facilitates a pathway into engineering, and 2) how family influence affects the choice of engineering as a career.

Methods

The data for this mixed methods triangulation study come from a large nationally representative survey and interviews of high school science students. Figure 1 illustrates the national representativeness of the data by showing the home zip codes of students who participated in the SaGE survey. Each dot may represent more than one student and is located in the center of the reported zip code. This representation may visually inflate the populations in some areas like in North Dakota versus the East Coast due to larger areas for zip codes in the western part of the U.S. and more than one student per dot. The number of students in these more remote areas of the U.S. is much fewer than those in the more densely populated East Coast. This form of representation was selected for a concise visual presentation of a large data set.

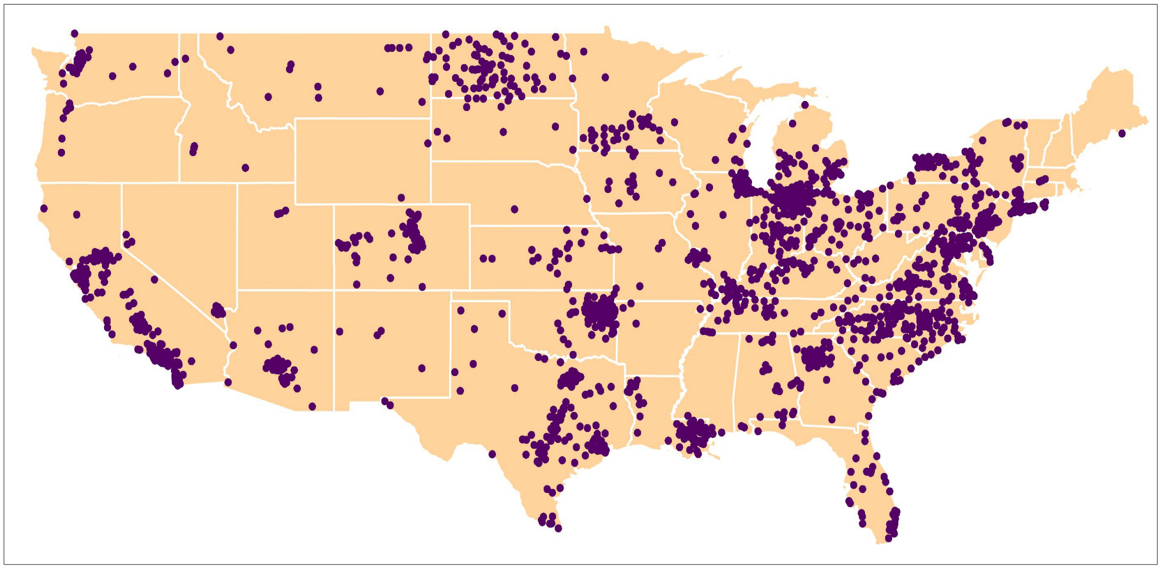

Figure 1. SaGE students' hometowns in the contiguous United States [22,23].

The quantitative data used in this study were drawn from the Sustainability and Gender in Engineering (SaGE) project (http://www.clemson.edu/~gpotvin/SaGE.pdf) which is comprised of a large-scale study of students enrolled in introductory English courses at 2- and 4-year colleges across the U.S. (NSF GSE 1036617 and NSF GRF 0751278). The quantitative data are a sample of college students enrolled in introductory English courses during the Fall semester of 2011. The choice to survey in traditional, introductory English courses allowed for data to be collected from engineering and non-engineering students alike, including a representative fraction of engineering majors. Drawing from a stratified random sample of colleges and universities across the United States taken from the National Center for Education Statistics (NCES), the survey study collected data from 6,772 students attending 50 different post-secondary institutions (see Figure 1). The SaGE survey included questions on students' career goals, family characteristics and support, high school science and math experiences, science enrollment and achievement (courses taken, grades, AP test scores, etc), student attitudes about sustainability, science and engineering, and demographic information.

The development of the SaGE survey was organized into three main components: 1) a literature review to identify factors that may influence increased enrollment in engineering, 2) an extraction of items from previously-used national survey studies (Factors Influencing College Science Success – FICSS [24], Persistence Research in Science & Engineering – PRiSE [25], and Factors Influencing College Success in Mathematics – FICS-Math [26]) and, 3) open-ended responses from 83 high school science teachers across the nation (members of the National Science Teachers Association – NSTA) via a survey administered online.

Multiple aspects of validity and reliability of the instrument were assessed. Lending to content validity, the hypotheses generated from the aforementioned survey of NSTA members as well as an open-ended survey of 82 first-year engineering and 41 non-engineering majors were included as items in the survey. Questions were further refined based on feedback from assessors and the results of pilot-testing in a first-year freshman engineering course. An in-person pilot of the survey and focus groups were conducted with first-year freshmen engineering students. Thus, each item of the survey was further examined for face and content validity. Stability reliability of the items utilized in this analysis was assessed by a test-retest study of 62 students, with an average Pearson's correlation of 0.725 which is in the acceptable to good range.[27]

One question central to the current analysis asked students to "Please rate the current likelihood of your choosing a career in the following:" on an anchored scale from 0 ("not at all likely") to 4 ("extremely likely"). The various career options were "Mathematics", "Science/math teacher", "Environmental science", "Biology", "Chemistry", "Physics", "Bioengineering", "Chemical engineering", "Materials engineering", "Civil engineering", "Industrial/systems engineering", "Mechanical engineering", "Environmental engineering", and "Electrical/computer engineering". Students who indicated a "3" or "4" as their response to a particular engineering discipline were separated out for further analysis. In all, 814 individuals responded with a "4" in at least one engineering discipline, and a total of 1319 individuals responded with a "3" or greater in at least one engineering discipline and did not indicate a greater likelihood of them pursuing another career (see Figure 2).

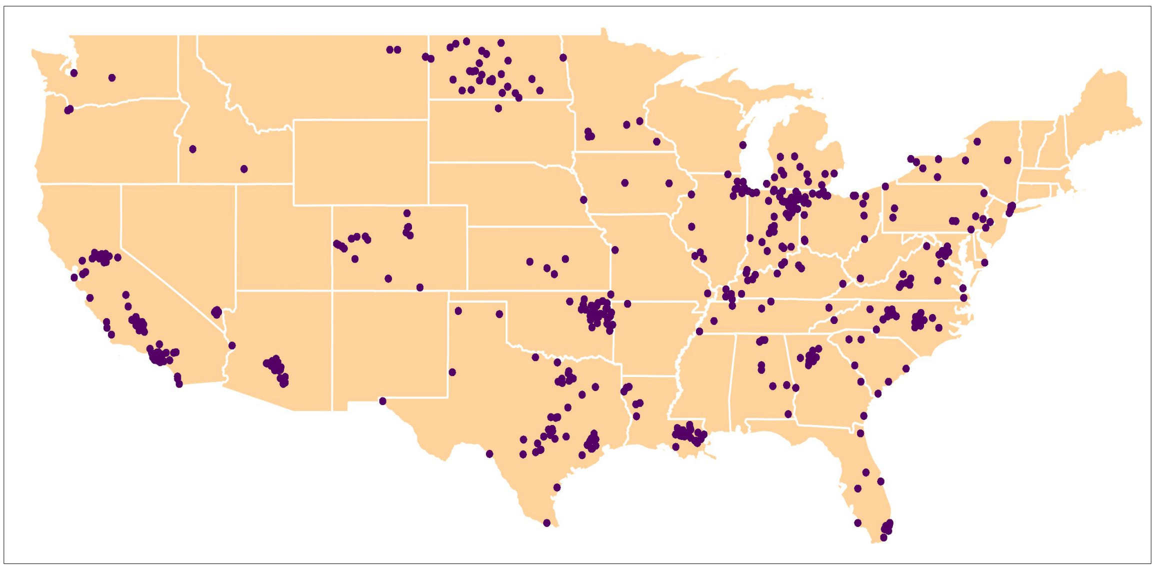

Figure 2. Likely engineering students' hometowns in the contiguous United States [22,23]

These students were compared to all other students (non-engineers) using binomial logistic regression to see if having an engineer as a family member or if having parents, siblings, or other relatives influence student career choices, as well as the interaction between these items are predictive of a choice of engineering. The highest level of education of both father/male guardian and mother/female guardian, proxies for socioeconomic status, were input as control variables. Additionally, general family support of math and science as indicated on a variety of items were used to control for families particularly supportive of or interested in STEM. These control variables allowed the isolation of familial engineers and their influence on career choice by accounting for several alternative hypotheses (e.g. the confounding nature of SES on both parents' career choices and on students' interests). Only statistically significant controls were left in the final model (Table 2). Additional tests were run to determine if gender differences were seen on the type of career influence or which familial engineer impacted choice of engineering. All data processing, statistical analyses, and figures in this paper were created using the R statistical language and software system [28] and the ggplot2 package.[22] Throughout this analysis, the α level, the maximum allowed probability of a false positive (Type I error), has been set at 0.01 or 1%.

The qualitative data for this paper are derived from interviews of 17 high school students attending two public high schools – one in the Midwest and one in mountain region. These high schools were recruited based on the project team's identification of teachers in the national SaGE survey who use specific teaching strategies in their classrooms. These teaching strategies included sustainability topics like discussing energy supply and demand and opportunities for future generations that significantly increased the likelihood of women choosing an engineering career. The teaching strategies and their effects were the focus of a different study and are outside the scope of this paper. Students at these high schools took a brief version of the SaGE survey which included their career interests both at the time and retrospectively as well as their attitudes about STEM. Students were selected for interviews based on their survey responses, previously-observed classroom behavior, and teacher recommendations. Selection criteria for student interviews included: interest in engineering (especially for women), high or low physics and/or math identity, changes in attitudes toward science between middle school and high school, observably engaged classroom participation, and students indicated as interesting cases on the above criteria by their teachers. Eight students were selected from each of the two schools. Student interviews were typically 30 minutes in duration. The types of questions included in student interviews asked students about their perceptions of their class and teacher, attitudes about science, beliefs about the type of people who do physics, math, and engineering, career interests, support they receive for their career interests (including family support), and perceptions about school culture. Table 1 presents some demographic information as an overview of the interviewed students.

Table 1: Students selected for interviews.

High School Classroom	Gender	Self-Identified Race/Ethnicity	Self-described engineering career interest (Low to High)
Midwest – Mr. A	Male	White	High
	Male	White	Mid-High
	Female	White	Low
Midwest – Mr. B	Female	White	Low
	Female	White	Mid
	Male	White	High
	Female	White	Mid
	Female	White	High
Mountain region – Mr. C	Male	White	Mid-High
	Male	Hispanic	High
	Female	Hispanic	Mid
	Male	White/Native American	High
	Male	White	High
	Female	Hispanic	High
	Female	Hispanic	High
	Female	White	Low
	Female	Hispanic	High

The interviews were analyzed using a constant comparative method. This method describes the process of moving between the data collection and the data analysis to inform additional data collection. This method also involves finding similarities between statements and incidences in the same and different interviews and observations [29]. Open coding was conducted for student's accounts of familial engineers and supports and barriers for their choice of a career. The similarities between the interviews were used to construct overarching themes in student responses. The software used for this coding process is RQDA, an open source qualitative analysis tool.[30]

Results and Discussion

The results of the binomial logistic regression of engineering choice is summarized in Table 2. Related variables are grouped together in Table 2: first, controls; second, familial engineers and students perceived family influence on career path. Within the control block, family support for science items are grouped together.

Table 2: Logistic regression of engineering choice. The Estimates are the logit (log of the odds ratio) for each predictor; the Odds ratio is the exponentiation of the Estimate. The Standard error is the error associated to each estimate, and the significance is the p-value estimated for each predictor.

Items	**Estimate**	**Odds Ratio**	**Standard Error**	**Significance§ (**: p<0.01; ***p<0.001)**
Controls				
Father's highest level of education	-0.113	0.893	0.030	***
Family Support				
Science was a hobby	0.317	1.372	0.087	***
Science was important for a better career	0.480	1.616	0.082	***
Family helped with schoolwork	0.250	1.284	0.076	***
Family arranged for science tutoring	0.643	1.903	0.190	***
Predictors				
Father – Engineer	-0.507	0.602	0.181	***
Mother – Engineer	-	-	-	n/s
Sibling – Engineer	0.798	2.222	0.142	***
Other relative – Engineer	0.456	1.578	0.094	***
Mother/female guardian contributed to career path	-0.568	0.567	0.087	***
Father/male guardian contributed to career path	0.388	1.473	0.091	***
Father – Engineer X Father/male guardian contributed to career path	1.321	3.747	0.221	***

§ The level of statistical significance is coded in the final column: ** represents a statistical significance less than 0.01 but greater than or equal to 0.001, *** represents a statistical significance less than 0.001, and n/s represents and non-significant result.

Odds ratios are used to compare the relative odds of the occurrence of the outcome of interest (e.g. engineering career choice), given exposure to the variable of interest (e.g. having a familial engineer). The odds ratio can also be used to determine whether a particular exposure is a predictive factor for a particular outcome, and to compare the magnitude of various factors for that outcome.[27] Having a father/male guardian with a higher level of education is a negative predictor of choice of engineering (reduces the odds of choosing engineering). This finding is consistent with previous work citing that students from high SES that are interested in STEM are less likely to choose engineering than related fields such as science.[31] Another control, family support of science has an average odds ratio of 1.544, meaning that if a student perceived their family to be supportive of science, then they are 1.544 times more likely to choose an engineering career.

Familial engineers other than parental figures are significant positive predictors of engineering career choice. Having a mother that is an engineer is a non-significant predictor, but having a father who is an engineering is actually a *negative* predictor of the choice of engineering. We interpret this finding to mean that simply having a father as an engineer is not enough of an influence on students to choose engineering. In fact, students may see the work that their fathers are doing and disengage from the idea of engineering, or a father may be an engineer, but not have a relationship with his child to be influential on student choice and would push students away from engineering. However, as we will discuss in more detail later, if a father has an influence on a student's career *and* is an engineer, then that combination is more powerful than either being an engineer or having an influence on a student's career path. An engineering father as a negative predictor of engineering choice seems counter to previous work in occupational inheritance in engineering.[12] The current results are from a sample of 6,772 from 50 institutions, a larger, broader sample than previous work. Also, we compare engineering students to non-engineering students, while the previous study compared engineering women to engineering men. Such methodological differences may explain the differences in the results. Within engineering, familial engineers may have a relatively strong impact on why students chose engineering, but when compared to *all* students, these influences are less significant. The influence of familial engineers within the total student population can be mixed. Simply having a familial engineer may be less significant for students not choosing engineering because of a variety of other influences (e.g. interest in STEM, self-efficacy beliefs, other background influences). The students in this work may cite siblings and other relatives (e.g. cousins, aunts, uncles, etc.) more often due to self-efficacy building vicarious learning experiences.[32] Students who see others that are similar to themselves (closer in age or experience) being successful engineers may enable a re-imagining of their possible selves (the selves one believes one might become in the near and the more distal future [33]), to more firmly believe that they can succeed in engineering.

Parental influences on engineering career choice are mixed – fathers are a positive influence on engineering and mothers are a negative predictor of choosing engineering. Students who reported that their mother/female guardian who contributed to the selection of their career path are less likely to chose an engineering career. This finding may be consistent with literature finding that parents have unknown, strong influences over their children's career aspirations.[13,14] Mothers, in particular, may be influencing their children toward careers and values which they find to be important.[8] Since there are more women in a plethora of other fields like business, law, and medicine [34], women may be simply guiding children into fields where they have found success and/or find relevant.[8] Having a father/male guardian who contributed to a student's career choice has a positive effect, meaning that a father's influence on a career makes students more likely to choose engineering. However, this finding may be convoluted with the fact that there are an overwhelming number of men in an engineering career [35], rather than male parental figures guiding children into engineering. However, the effect of having fathers who are engineers and also are reported to have contributed to their children's career selection (an interaction effect) has a compounded effect. Such students are 3.747 times more likely to choose a career in engineering. Students reporting that sibling and other relative had an influence on their career choice were non-significant in this model as well as any interactions. These findings may be due to the overwhelmingly strong influence of parents on their children and their career choice.[6,7] While having a sibling as an engineer is a significant predictor of engineering career choice, students do not report their siblings has having an influence on an engineering career choice. Additionally, all of these findings showed no gender differences. While this work contradicts Mannon and Schreuders [12], it is consistent with other work that children follow their parents into the same field regardless of gender and regardless of field.[4] This latter research examined intragender differences of a female child choosing her father's career versus another field and vice versa for male children. Besides some bias in the study by Mannon and Schruders [12], that study focused on explaining differences between genders *within engineering*. While we do acknowledge the lack of female role models within engineering to "pass on" occupational inheritance to their children, especially women, there is a positive message in these findings. Occupational inheritance is not a closed feed-back loop for women, fathers who are engineers and who influence students is a large effect for both men and women. The lack of many women engineers does not widen the representation gap in engineering from a family influence analysis.

Two primary mechanisms appear to be the underlying routes of familial influence on students engineering careers. Firstly, siblings and other relatives who are engineers (familial engineers) have a strong influence on students' choice of an engineering career. Vicarious learning leading to self-efficacy building may explain the stronger influence of these individuals on career choice. Self-beliefs about one's efficacy shape the way in which one navigates the world.[36] If a scenario is perceived to be too difficult or exceeds one's capabilities then that scenario, such as the choice of engineering as a college major, may be avoided. Self-efficacy also contributes to the persistence and amount of effort one may put into accomplishing a goal in the face of adversity or obstacles. These self-efficacy beliefs are not determined by one's past experiences alone. Efficacy appraisals are influenced by vicarious experiences.[37] Seeing others whose skills are deemed to approximate one's own can successfully raise the self-efficacy of the observer. For example, a student in our interviews who was interested in majoring in electrical engineering (and is now working on a degree at a prestigious engineering school) describes his career influence thusly:

> *My brother's actually becoming – like – he's going to get his Master Electrician's License and he kind of got me interested, always talking about that stuff and I just kind of decided that would be a good fit.*

This mechanism can also work in reverse. If a student does not identify with a vicarious role model in engineering or that model is not successful, then they may decide that a path into engineering is closed to them. A highly-talented female in physics describes her likelihood of choosing a career in engineering:

> *I feel like they're [engineers] a whole bunch of smart people so I, I have no desire to go in engineering…so, I can't.*

Several students, including individuals desiring to enter engineering as well as other fields, described the influence of vicarious role models. One student described how she decided to choose accounting:

> *Accounting? Um, I don't know, because, well, my oldest sister, she's kind of like*

my role model and that's what she did and then like I'm taking an accounting class now and I just thought this is like, um, I just like liked it and I'm going to take another accounting too next year to keep studying and I'm going to go to college for that, too, so.

Another student described the influence of his uncle on his desire to be an aerospace engineer:

Um, well, there are a couple things I've thought about. One is to be a civil engineer with like bridges and roads, but I wasn't too interested in that. Um, I have an uncle that works for Boeing in [a distant city] and he seems to really like his job and he makes pretty good money. I like cars. I could, I enjoy that, something with cars maybe or, um, but mostly with planes because I like planes a lot.

These vicarious experiences may need to come from people with whom students can identify more effectively than parents. While parents do provide an important role in the development and raising of children, across many cultures, siblings, especially, and other family members may be as or more influential than parents.[38] Additionally, siblings spend a large amount of time together which results in a high degree of mutual imitation.[39]

A second mechanism of familial influence is the direct influence of parents on students' career paths. While siblings and other relatives play an important role in vicarious learning, parents, pass on their occupational values and desires through a process known as occupational inheritance. The influence of mothers and fathers on a student's career choices in the quantitative portion of this study is consistent with this literature [3–12], and is supported by students' narratives.

The same student who spoke of his uncle's influence to become an aerospace engineer (quoted above), also talked about the strong influence of his parents. From a discussion of his competing interests, his mother was actively encouraging toward a different career path, based upon her own interests and values:

Well, my mom kind of pushes me more towards [being a] psychiatrist because she's a counselor so she likes that, but my dad is more like whichever way you want to go is good for me, both sound like good careers.

This narrative supports the quantitative finding that if a mother has a reported influence on students' career, it may make them less likely to choose engineering. As expected, other students also reported a parental influence over their career choices. One male student interested in engineering described his parents' influence as supportive of engineering:

My mom and my dad helped me a lot, like getting information. And the internet. I look up stuff on the internet. My parents always ask me about it and I'm better than last year. Last year I had no idea. But I'm starting to get a better idea of what I want to do. I'm trying to think of that and research that.

Another student described her family's influence on her as a student and in her career path:

> *Yeah, they're very encouraging. They're always talking to me about it [being a radiology technologist], saying is that what I want to do, making me look at different aspects about it, um...I feel like since they didn't go [to college] they feel like that urge to, because they see how their life has been hard and difficult and they don't want ours, mine and my brother's, to be like that, so they urge us constantly to do good grades, to like be good in school, go farther than what we can, make life easier on ourselves, I guess. And that's since they didn't have it they want us to have it.*

Many students said that their parents wanted them to be happy and to "do what you want, like do what you love". Some students did not report a direct influence similar to the student with a mother in counseling; the influence of parents on students' values and career aspirations is more subtle. Parents have a strong locus of control in the transmission of values, education, and development of their children.[13] Often, these underlying mechanisms are taken for granted. While this connection is well documented in the literature, often students do not describe this phenomena in their narratives. While parents have been identified as important agents of occupational inheritance, the process of how they transmit their knowledge, values, and behaviors is not well studied.[13,40]

The largest effect found in the quantitative data showed that the interaction of having a father who is an engineer and having reporting an influence from a father on career choice is stronger than the two separate main effects combined. In the interviews, one student described an interest in "radios and electronics". When pushed for an understanding of whether this career interest involved engineering or a technology degree, the student did not offer a clear path but described the influence of his father (who was an state employee who "works on electronics and radios"):

> *I'll be shipping out this summer for basic training. And ah, I want to go into radios and electronics. I've been around the military my entire life. I've moved around, ah, every three years for the last 18 years, and ah, I'm just kind of used to moving around, bouncing around. I've been around military bases my whole life so it's nothing really new to me so **kind of following in my dad's footsteps**...having the military help me get through ah, college and all that stuff so that I can get out, um, come back to [this state] and work for the state and do electronics and radios for them because that's what my dad does and ah, all of it here.*

His father not only had a direct influence on his career, but a direct occupational inheritance was evident in this case. This student did not have a clear path towards achieving his goals beyond joining the military and getting a degree, but he did have a strong commitment to the path he described.

Conversely, another student described a dad who pushed him toward engineering, but was not directly involved in his life. He lived with his mother and only saw his father a few times a year. He had a strong interest in a physics career rather than engineering:

> *Well, my dad, my dad was always, a, talking about how he wanted me to be some sort of engineer or something when I grew up and um, I don't live with him but a, he was definitely interested and we used to argue about science a lot so it was … he wasn't [an engineer]. He was a glass work—an auto glass worker so.*

This student described a strong push toward engineering by his father, but the transmission of occupation did not seem to be as strong in this case, perhaps because his father was not involved in his daily life. These contrasting cases show how the interaction of having a father in an engineering career who is also influential in your career choice can result in a higher likelihood of choosing an engineering degree, but having a father who is not as influential or is not an engineer may have a different outcome, consistent with the quantitative results.

One of the strengths of the mixed methodology used in this paper is that solely using students' narratives of career choice and the path and influences that helped them make a decision is oversimplified. Using quantitative data as well as qualitative narratives in mixed methods allows a bigger picture of predictive factors for the choice of engineering. For example, a student is not likely to say that because he is male, white, and from a middle class background, that he was influenced to choose engineering. Instead, he may describe an interest in math and science and understanding how things work, and the encouragement of his family or teacher or guidance counselor [1] as well as other critical events/experiences in his path to arrive at a decision of a career in engineering. The qualitative portion of this study gives some insight into *why* students make their career decisions while the quantitative data give insight into factors previously unlinked to career choices.

Conclusions

Through a mixed methods triangulation study, two particular mechanisms were found for familial influence on engineering career choice. The first is the strong influence of siblings or extended family members as role models (via vicarious learning experiences) on engineering choice. Seeing a person with whom a student can identify succeed and thrive in engineering may contribute to self-efficacy beliefs with respect to an engineering career. Previous work has shown that this type of self-efficacy building is less important than direct experience-derived self-efficacy, but it does have an effect on career choice as see by students' narratives.[37] Many students see a sibling as similar to themselves and can image that if their own brother/sister can do engineering then they can, too. Another student saw engineers as "a bunch of smart people" and developed low self-efficacy beliefs that turned her away from an engineering career.

The second mechanism of familial influence on an engineering career involves occupational inheritance of specific values and beliefs from parents towards their own careers. A large body of literature in child development documents the strong influence of parents on career choices.

Our work supports the findings that parents' support (rather than siblings or other relatives) have a stronger influence of students' career aspirations. Mothers tend to pass on their occupations which can steer children away from a degree in engineering, while fathers tend to have a more positive influence on engineering career choice. This finding may be due to the low number of women in an engineering-related occupation to “pass on” that job or due to the values that mothers pass on pushing young women away from engineering, resulting in lower numbers of women in engineering. The data necessary to draw conclusions about the direction of causality of this hypothesis are beyond this study, but it does offer an interesting topic for future research. The interaction of having a father who is an engineer *and* who has an influence on a students' career has the largest odds ratio towards a choice of engineering. Throughout this study, no gender differences amongst students were found for either parental figure as influences or familial engineers.

As we seek to increase the number and diversity of students in engineering, considering these findings is important not only for engineering education researchers, but also families, teachers, and guidance counselors. Our future work in this area will seek to incorporate into these models greater details about students’ engineering choices and how to create positive supports for a career in engineering.

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