Parent and Family Influence on First-year Engineering Major Choice

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Abstract

This complete research paper discusses parent and family influences on the selection of engineering as a college major. The choice of a career or profession is a developmental process [1] that is influenced by a diverse set of factors including familial influences [1-12]. Parental career path [5] and perception of other career fields [6] have been shown to influence student career choice. Children with engineers in their families are exposed to engineering as a career at an early age and acquire a greater understanding of the engineering profession through home education [15]. Occupational inheritance is often the result of early exposure to professions, and engineering runs in families much the same way that law or medicine does. An understanding of familial influences may help advocates to determine effective methods to expose more diverse sets of students and parents to engineering as a profession.

The research presented in this paper contributes to the existing knowledge base, providing additional data to support assertions of previous research indicating an influence of familial occupation (in either engineering or STEM) on student engineering major choice, as well as whether this effect has any differences by gender. In this study, 158 first year engineering students from a public midwestern technical university were surveyed to determine if any family members or mentors had a career in an engineering discipline or STEM fields. This work determined that 63% of the engineering students surveyed reported at least one family member that had a career in engineering. When STEM fields are also included, this number increases to 69%. Overall, the most commonly reported family members in engineering/STEM were fathers (46%), mothers (14%), and uncles (9%). Female engineering students were more likely to have a mother as an engineer than their male counterparts. However, a greater percentage of female respondents reported a father in engineering/STEM (42%) than a mother (19%), indicating parents of either gender as possible sources of occupational inheritance. Engineering programs focused on increasing gender diversity might consider targeting recruitment to the daughters of engineers, as well as developing K-12 engineering outreach which includes mothers and daughters together.

Background:

Student determination of career pathway and professional aspirations has been described as a developmental process, one that spans from mid-childhood into the years of adulthood [1]. In engineering there are many factors that can impact these choices. While such factors include interest in the field of study [3, 13], math and science or problem solving [8, 9, 13] and earning potential/money [2, 3, 12]; peer and familial influences are highly reported and cited in research [1-12]. When considering familial influence on career choice, specifically in engineering, three core categories of influencers are established: parents, siblings, and other relatives [14].

Parents:

Research shows that parental figures have a significant impact on the perception of their children towards diverse career pathways. Parents act as the control point for educational exposure [15] and knowledge of occupational roles [16] from a young age. They are responsible for determining what toys their child plays with, what books their child reads, and where their child goes to school. As a result, a student's exposure and perception of different career disciplines and professional roles is highly influenced by the introductory actions of parents.

Parents themselves can serve as role models for engineering if they themselves are engineers [4]. Studies have found that children are often more literate in the professions of their parents and as a result occupational inheritance may occur. This phenomenon has been found to occur in families in which a parent, sibling, or other relative(s) are engineers as well as in families with medical professionals and lawyers. [15]

Parents also provide support for their children when selecting majors [4]. In fact, when 348 English high school aged students were asked who was most influential in helping them select their career path, they ranked parents as the biggest influencers, followed by teachers, friends, and then siblings [1]. It should also be noted that both the male and female students ranked their same-sex parents and siblings as affecting their career choice more than their opposing sex parents and siblings (girls were more influenced by mothers and sisters than fathers and brothers).

The importance of parental influence has also been shown to vary with race as well as gender. When 94 high school students attending a summer technology academy were asked about who and what they felt influences their career considerations in STEM fields, the number one factor affecting career choice was interest in the field of study, regardless of whether students were Black, White, female or male [3]. Black females and White students of both genders indicated their second considering factor in career choice was parental influence. For Black male students, earning potential was the second most important factor in their decision making, while parental influence was the third. For Black females and White males, earning potential was the third factor affecting their career choice. While for White females, the influence of teachers was the third factor affecting their career choice [3]. Additionally, within Black families, mothers and fathers may not impact college major choice equally. In other research, Black engineering students reported that mothers (in both single and two-parent homes) had a greater impact on the development of their academic identities than fathers [17].

The influence of parents on career choice or college major selection may dwindle in its importance after students leave home. An examination of survey data from 6,772 first year college students indicates a stronger influence to study engineering came from siblings than parents [4]. A survey of 1,000 second-semester first year engineering students indicated the

students found other students more helpful than parents in selecting an engineering major [7]. However, this may also be due to lack of parental knowledge in the differences between engineering majors. Differentiation between majors is something that only a parent who is an engineer themselves might be able to help a student navigate. In fact, the influence on engineering major choice has been documented to come from non-family members for engineering students who lack a family member with experience in that major [14]. Thus, other individuals besides family members may influence a student's choice of engineering major and the influence of others may matter more over time. As students who leave home develop new relationships, they may become more influenced by other adults outside their families. In one study of 1,203 juniors and seniors in engineering across 21 institutions, mentor influence was ranked higher than parental influence when students were surveyed about their motivations to study engineering [12].

The dwindling influence of parents on engineering career choice may not be as pronounced in female students as it is in males. The effect of parental influence dwindling with entrance into college may also vary with gender. In an examination of 806 first- and second-year college students in biology, engineering and business, parents and friends were found to play a significant role in female students' selection of an engineering major, but not male students [13].

The importance of parental influence on student pathways to engineering also varies between those attending two- and four-year colleges. In focus groups conducted on engineering majors at two and four-year ABET-accredited programs in South Carolina, family members were found to affect student's persistence in education, choice of major, and choice of institution [14]. When family influences on each group were examined, the dominant family influence theme for students at four-year institutions was that of parental and other relative guidance; whereas for students at two-year institutions, the dominant theme pertained to extensive family responsibilities. Interestingly, guidance from siblings only arose as a dominant theme among two-year engineering students, and not four-year. Thus, the influence of parents on engineering career choice may be stronger for students who start their careers at four-year institutions. As two-year schools are more affordable, this difference may be due to economic class.

Siblings

Educational and Social Cognitive research also suggests that siblings can play an imperative role in influencing the selection of college major of study, and overall educational attainment [6, 18]. Siblings typically spend an abundance of time in the presence of one another and as a result develop a co-partnership. As a result of this partnership, the opinions of our siblings' matter to us. Sibling influence is especially pronounced for students who have an older sibling who has attended or graduated from college. In this case, older siblings who have attended college have the ability to provide detailed guidance from their personal experience [19].When it comes to engineering-related career choices of students, according to research conducted by Godwin,

Potvin, and Hazari, the influence of sibling engineers may be even stronger than that of parents who are engineers [6]. This is especially true for students who did not report a strong positive relationship with a parent.

Extended family:

Extended Family members (aunts, uncles, grandparents and cousins) have been extensively cited by students as general and engineering-specific career or educational influencers [6, 8, 11, 14]. Extended family members have independently been linked to influencing educational attainment through the fulfillment of mentor roles [20]. The influences of these individuals are further amplified when the extended family member reduces the uncertainty of the younger relative towards diverse topics [21]. Educational research also supports that the influence of relatives may change over time, corresponding to the increase in complex interactions through the stages of development, paralleling the student's desire for counsel [22].

Extended familial influence is impacted by the relationship that the student holds with their parents and the level of education that their immediate family possess [20]. Research reports that extended family members with a higher degree of education than the parents may have larger influence on student educational attainment. This influence is typically a result of familial mentoring and familial promotion of completing school. Adversely, extended family may have a counter influence on students if both the parents and extended family members have only a high school degree or dropped out of school at a young age [20].

The influence of extended family members on students may also vary with gender. Social cognitive research on influential groups supports general trends of greater influence between male extended family members and male students and, likewise, female family members on younger female counterparts. [20]. Influence of these extended family members can be measured by the likelihood that a student will turn to these members for advice. Blythe and Foster-Clark discovered that there is an equal likelihood that female and male students will seek counsel from male extended family members. (Uncles, Grandfathers, and cousins.) However, the likelihood of a student to turn to a female family member (Aunts, Grandmothers, and Cousins) for assistance is much higher for female students (reported by 75% of female participants) as opposed to male students (57% of males reporting) [23].

This research was undertaken to add to the body of literature examining the influence of parents and family on students' college major choices. Clearly, occupational inheritance occurs among families with engineering parents [15]. And non-engineering-specific research has found that students may be more likely to turn to same gender family members for advice [23]. Thus, we wanted to explore if the gender of an engineering parent had any potential influence on career inheritance. Specifically, were the daughters of female engineers more likely to become engineers? Essentially, does the presence of mothers in engineering beget more daughters in engineering?

Methods

An IRB approved survey was administered to first year engineering students. The students were enrolled in a first-year engineering fundamentals course at public Midwestern STEM-centered university. The institution is 72.6% male and 88.1% White/Non-Hispanic at the baccalaureate level [24]. Participants in the study belonged to two sections, one having 100 students and the other having 108 students, for a combined possible participant pool of 208 students. An online learning system used by the university was utilized to administer the survey. As approved by IRB, students who completed the survey were rewarded with 10 points of extra credit. The total extra credit category was worth a potential 5% towards their final course grade, and included 59 possible points. Of the 208 students to whom the survey was offered, 158 first year students responded with complete survey data. Student identities were removed from the data set after collection and before analysis.

The survey was composed of questions addressing respondents' demographic information, engineering & STEM occupations of relatives, and major choice. The questions were part of a larger survey designed to determine engineering students' perceptions and understanding of various engineering disciplines. The survey questions which focused on family members working in engineering/STEM are as follows. Multiple choice answers for each question are provided in parenthesis:

1. Which gender do you identify with? (Male, Female No gender identification, Prefer not to answer)
2. Are any of your direct relatives/family members/role models an engineer or in a STEM field? (Engineer, STEM field, Neither, Both)
3. What is your relationship to this person and briefly describe what they do, if applicable? If not, please leave blank. (Short answer)

The goal of this work was to examine the results of these questions for any differences in the family occupations of female versus male engineering students. Specifically, we wanted to see if female engineering students were more likely to have mothers who were engineers. Based on the literature, we hypothesized that engineering students would experience some influence from occupational inheritance. We also expected that same-gender family members in engineering/STEM fields might influence the students more.

The survey results were analyzed in Microsoft Excel using logical counting, summing, and dividing to generate totals and percentages. Of the 158 students, all were sorted into three gender identities: male, female, and nonbinary. Next, a count was used to identify the total number and percentages of students who had a family member or model working in the following categories: engineering, STEM, or neither. Results are also presented for students who indicated one or more, two or more, or three or more family members or role models in engineering or STEM. Following this, categories and logical counts were generated for immediate family, other (extended) family, and types of role models. "Immediate" family is defined as mother/s, father/s, and sibling/s. "Other" family is defined as uncle/s, aunt/s, cousin/s, grandfather/s, and grandmother/s. Two types of mentors were mentioned in the responses: high school mentors and college professors. Due to some students identifying more than one member in their immediate

family and/or other family and/or role models, it should be noted that percentages for the career categories and relationships will not total 100%. It is also possible that students have one parent in engineering and another parent in a STEM field.

Results

The respondents were asked to identify a gender identity. Of the survey participants, 120 (76%) of the students identified as male. Another 36 students (23%) identified as female. The remaining 2 students (1%) identified as nonbinary. Results of family member occupations, and their relationship to the respondents are presented in this section. First, results for respondents of all gender identities are presented, followed by results from female identified respondents, results from male identified respondents, and finally, results from nonbinary identified respondents.

Results for All Respondents (All Gender Identities)

Table 1: Total Survey Population Response Results

Family member or role model occupation	# of Responses	Percent of Total Survey Respondents
Engineering	100	63 %
STEM	46	29 %
Neither Engineering nor STEM	49	31 %
One or more in Engineering or STEM	109	69 %
Two or more in Engineering or STEM	28	18 %
Three or more in Engineering or STEM	6	4 %

Table 1 summarizes the occupations of family members and role models for the total survey responses, including all gender identities. For the total survey population, 100 respondents (63%) identified having a family member or role model who was an engineer, while 46 respondents (29%) indicated having a family member or role model who worked in a STEM field, and 49 respondents (31%) could not identify a family member or role model who worked either as an engineer or in STEM. The survey results were then broken down to identify how many of the students had at least one family member or role model working in an engineering or STEM field. Of the surveyed population, 109 respondents (69%) reported at least one family member/role model in engineering or STEM, while 28 respondents (18%) indicated two or more family members/role models working in engineering or STEM, and 6 respondents (4%) indicated three or more family members/role models in engineering or STEM fields.

The relationship to family members/role models in STEM was then broken down by immediate family (siblings and parents), other family (non-immediate), and identified role models (HS mentors and college professors), as shown in Table 2. Of the survey respondents, 73 (46%) reported fathers in engineering or a STEM field, followed by 22 respondents (14%) indicating mothers in engineering/STEM, and 8 respondents (5%) with siblings in engineering/STEM. Some respondents identified more than one immediate family member who was in engineering or STEM. Thus, the values for immediate family were summed for the *number of respondents* (not family members) with an immediate family member in engineering/STEM. A total of 84

respondents (53%) indicated at least one immediate family member involved in engineering or STEM.

Table 2: Total Survey Population Relationships Results		
Relation	**Responses**	**Percent of Total Survey Respondents**
Immediate family members in engineering or STEM fields		
Father/s	73	46 %
Mother/s	22	14 %
Sibling/s	8	5 %
Non-Additive Immediate Family Total		
	84	53 %
Other family members in engineering or STEM fields		
Uncle/s	14	9 %
Aunt/s	2	1 %
Cousin/s	10	6 %
Grandfather/s	8	5 %
Grandmother/s	1	1 %
Non-Additive Other Family Total		
	30	19 %
Non-Additive Immediate & Other Family		
	106	67 %
Identified Role Models		
HS Mentor/s	2	1 %
College Professor/s	1	1 %

Other family members reported in engineering/STEM included aunts, uncles, cousins, and grandparents. Table 2 also shows that 14 respondents (9%) identified uncles in engineering/STEM, 2 respondents (1%) reported aunts in engineering/STEM, 10 respondents (6%) indicated cousins in engineering/STEM, 8 respondents (5%) described grandfathers in engineering/STEM, and 1 respondent (1%) revealed a grandmother in engineering/STEM. As respondents indicated more than one "other" family member in engineering/STEM, a count of the number of respondents with multiple extended family members as engineers or in STEM was performed, identifying 30 respondents (19%) with non-immediate family members in engineering/STEM. As some respondents indicated both immediate and non-immediate (other) family members in engineering/STEM, a count was again performed to determine that 106 respondents (67%) indicated a family member of *any* type in engineering or STEM. Two types of role models in engineering/STEM were identified by the respondents: high school mentors and college professors. High school mentors were mentioned by 2 respondents (1%), and a college professor was indicated by 1 respondent (also 1%).

Results for Female Identified Respondents

Table 3: Female Student Response Results		
Family member or role model occupation	**# of Responses**	**Percent of Female Respondents**
Engineering	19	53 %
STEM	12	33 %
Neither	14	39 %
One or more in Engineering or STEM	22	61 %
Two or more in Engineering or STEM	8	22 %
Three or more in Engineering or STEM	2	6 %

The total survey results were further broken down by gender identity. Table 3 contains the results of the female respondents' reporting of family members and role models in engineering/STEM. Of the 36 respondents who identified as females, 19 indicated family members/role models in engineering (53% of the female population), while 12 female respondents (33% of the females) identified family members/role models in STEM, and 14 female respondents (39%) indicated having no family members or role models in engineering or STEM. A count of the respondents with a family member/role model in engineering or STEM revealed 22 of the female respondents (61% of the females) who reported at least one family member/role model in engineering or STEM, while 8 female respondents (22% of the females) identified as having two or more family members/role models in engineering or STEM, and 2 female respondents (6% of the females), identified three or more.

The relationship of these reported family members and role models in engineering/STEM to the female respondents is summarized in Table 4. For the surveyed female students, 15 respondents (42% of the females) reported fathers in engineering/STEM, while 7 female respondents (19%) indicated mothers in engineering/stem, and 3 female respondents (8%) identified siblings in engineering/STEM. Again, counting only once those students with multiple immediate family members in engineering or STEM field careers identified 18 female respondents (50% of the females) with immediate family members involved in an engineering or STEM career. Other (non-

Table 4: Female Student Relationship Results		
Relation	**Responses**	**Percent of Female Respondents**
Immediate family members in engineering or STEM fields		
Father/s	15	42 %
Mother/s	7	19 %
Sibling/s	3	8 %
Non-Additive Immediate Family Total		
	18	50%
Other family members in engineering or STEM fields		
Uncle/s	0	0 %
Aunt/s	1	3 %
Cousin/s	1	3 %
Grandfather/s	3	8 %
Grandmother/s	0	0 %
Non-Additive Other Family Total		
	5	14 %
Non-Additive Immediate & Other Family		
	21	58 %
Identified Role Models		
HS Mentor/s	1	3 %

immediate) family members in engineering/STEM careers were also identified by the female respondents, including: 1 respondent indicated an aunt (3% of the females), 1 respondent reported a cousin (3% of the females), and 3 respondents identifying grandfathers (8% of the females). In total, 5 female respondents (14% of the females) identified other (extended) family members in engineering or STEM. The total number of females who indicated a family member of any type in engineering or STEM was 21 respondents (58% of the females). One female respondent also identified a high school mentor (3%) as a role model in engineering/STEM.

Results for Male Identified Respondents

Table 5: Male Student Response Results

Family member or role model occupation	# of Responses	Percent of male respondents
Engineering	81	68 %
STEM	34	28 %
Neither	33	28 %
One or more in Engineering or STEM	87	72 %
Two or more in Engineering or STEM	20	17 %
Three or more in Engineering or STEM	4	3 %

Results for 120 male survey respondents are summarized in Table 5. Overall, 81 respondents (68% of the males) reported engineers as family members/role models. While 34 male respondents (28%) identified family members/role models working in STEM. From the male survey population, 33 respondents (28%) did not identify a family member or role model in an engineering or STEM career. Some of the male respondents indicated family members in both engineering and STEM. Counting only once those respondents with one or more family members/role models in engineering or STEM revealed 87 respondents (72% of the males) reported a family member/role model in engineering or STEM. Of the male respondents, 20 (17%) indicated two or more family members/role models in engineering or STEM, and 4 (3% of the males) identified three or more family members/role models in engineering or STEM.

The breakdown of the relationship of these reported family members/role models is shown in Table 6. Among the male respondents, 58 (48%) reported a father in engineering or STEM, 15 (13% of the males) identified mothers in engineering/STEM, and 5 (4% of the males) indicated siblings in engineering/STEM. Again, counting only once those students with multiple family members in engineers or STEM field careers identified 66 male respondents (55% of the males) with immediate family members employed in engineering or STEM careers.

Recall that “other” non-immediate family identified in the survey were aunts, uncles, cousins, and grandparents. Results from this category are also shown in Table 6. Among this extended family, 14 male respondents (12%) reported uncles in engineering/STEM, 9 (8% of the males) indicated cousins in engineering/STEM, and 5 (4% of the males) identified grandfathers in engineering/STEM. Only 1 male respondent (1% of the males) reported an aunt in

engineering/STEM, and 1 identified a grandmother (1% of the males). Some male students reported more than one non-immediate (other) family member in engineering/STEM. Of the male respondents, 25 (21% of the males) reported extended family members in engineering/STEM. The total number of males who reported a family number of *any* type in engineering or STEM was 85 (71% of the males). Engineering/STEM mentors identified by the male respondents included a single high school mentor (1% of the males), and a single college professor (1% of the males).

Table 6: Male Student Relationship Results

Relation	Responses	Percent of male respondents
Immediate family members in engineering or STEM fields		
Father/s	58	48 %
Mother/s	15	13 %
Sibling/s	5	4 %
Non-Additive Immediate Family Total		
	66	55 %
Other family members in engineering or STEM fields		
Uncle/s	14	12 %
Aunt/s	1	1%
Cousin/s	9	8 %
Grandfather/s	5	4 %
Grandmother/s	1	1 %
Non-Additive Other Family Total		
	25	21 %
Non-Additive Immediate & Other Family		
	85	71 %
Identified Role Models		
HS Mentor/s	1	1 %
College Professor/s	1	1 %

Results for Nonbinary Identified Respondents

Two students responded as nonbinary. Of the two nonbinary students, both had no family members/role models in engineering or STEM career fields.

Discussion

If parental career had no influence on student major, then the surveyed student population would be expected to have a similar percentage of parents who are engineers as the background US workforce. According to the Bureau of Labor Statistics, approximately 6% of the United States workforce has a career in engineering [25]. Considering the total survey results, 63% of student respondents had at least one direct relative/family member/role model in engineering. The survey results indicate that students may be influenced by relatives in an engineering field, and aligns with the work of Shields & Kisi. Their study of 880 high school students enrolled in career technical academies related to architecture, construction, or engineering, found that over half of the students intending to study engineering in college had at least one engineer as a family member [10]. Together, these works corroborate the role of occupational inheritance in engineering program enrollment. However, this effect may vary with the gender of the student.

Recall that 53% of the students who identified as females and 68% of the male-identified students had a family member or role model in engineering. At first glance, it may appear that

male students could potentially experience greater career choice influence by knowing an engineer. However, in non-engineering-specific studies, students have been found to be more likely to be influenced by same-gender immediate family members [1]. As we have yet to reach gender parity within engineering, we would expect that more fathers than mothers are engineers. In fact, 48% of the male respondents and 42% of the females had a father figure in engineering or STEM. While 19% of the females and 13% of the males indicated having mothers working in engineering or STEM. A greater percent of male engineering students (compared to females) had fathers as engineers, and a greater percent of female engineering students had mothers who were engineers. Consider the gender ratio of mothers in engineering/STEM to fathers in engineering/STEM. For the overall population of respondents (including all genders of students), this ratio is 22:73. This ratio is much higher in male students (15:58) than in female students (7:15). Thus, having a mother who is an engineer or works in a STEM field, may be a greater influence to study engineering for female engineering students than for males. As the university at which this study occurred is primarily (88.1%) White, this may be unique to White students. Recall that, for Black engineering students of both genders, mothers have more impact on the development of academic identity than fathers [17].

Overall, only 8 students identified siblings working within engineering/STEM fields, 5 of these were male students and 3 were female, smaller than the number of parents in engineering/STEM. However, one study indicates that engineer-siblings may influence a students desire to study engineering more than parents [6]. The overall effect of siblings may be related to the strength of bonds with parents, and warrants further investigation.

Respondents also reported extended family members (grandparents, aunts/uncles, and cousins) in engineering or STEM fields. Overall, 19% of the students in the study indicated extended family in engineering/STEM, with 9% of the respondents indicating uncles, 6% indicating cousins, and 5% indicating grandfathers. Grandmothers and aunts were each reported by 1% of the respondents. Gender differences were also experienced in the reporting of extended family in engineering/STEM roles. Among the female respondents, 8% indicated a grandfather in engineering/STEM, with one female respondent indicating a cousin, one reporting an aunt, and none indicating uncles or grandmothers in engineering/STEM. Among the male respondents , 12% reported an uncle in STEM, followed by cousins (8%), and then grandfathers (4%). One male respondent reported an aunt in stem, while another indicated a grandmother. Interestingly, we anticipated that female engineering students would report more same-gender extended family engineers, but the greatest reported extended family member for female engineering students was grandfathers. This may be due partly to the lack of women in engineering in previous generations. In fact, if we recall the gender ratio of mothers to fathers in engineering/STEM for the overall population of respondents (22:73) and compared to the grandmother to grandfather ratio (1:8), we can see that there is less representation of women in engineering/STEM among engineering students' grandparents than their parents. This change in this gender ratio from

grandparents to parents may be attributed to a variety of factors, such as the increased entry of women into the workplace within the US. If this were due only to generational differences in workplace demographics, we would expect to see a similar gender ratio in aunts to uncles as we do in mothers to fathers. However, the ratio of aunts to uncles (2:14) in engineering/STEM is much higher than that of mothers to fathers (22:73). Thus, engineering parents may be more important in influencing the decision to study engineering than other family members in engineering. This influence may increase when both parents are engineers. In fact, household-level exposure to engineering may be a key factor here. Research has shown that children of engineers are more likely to be aware of engineering as a career option and know what engineers do because of interactions with their parents [15].

Within the relationship data provided by all survey results, fathers in engineering/STEM (indicated by 46% of respondents), mothers (14%), and uncles (9%) are the most common relationships identified. Overall, engineering students do display some measure of occupational inheritance through family interactions, as 67% of surveyed students identified a family member (immediate or extended) as being an engineer or in a STEM field. When we add in engineering or STEM mentors (outside the family), this number increases to 69%. These results are in line with the work of Nadelson et al., who surveyed 1,327 engineering students across five universities and found that 80% of engineering students knew someone outside of school who was an engineer [9]. Thus, it appears that having a relationship with someone who works in engineering or STEM may positively influence the decision to study engineering.

This work builds on the existing literature by adding to the arguments that engineers as family members positively affect students' choice of engineering major. In addition, it points to the possibility that engineer mothers may have a stronger influence on the career choice of daughters. It also suggests that in the absence of a same-gender engineering/STEM role model, fathers can influence the career choice of their daughters.

Recommendations

A three-year longitudinal study of 906 high school girls determined that students with greater knowledge of engineering were more likely to report aspirations to study engineering in college [26] . Family members of engineers, then, possess an advantage in terms of early exposure to engineering as a career and greater understanding of the profession, as a result of informal discussions, hands-on engineering related play, and at home educational activities [15]. Engineering programs that desire an increase in their female enrollment may then benefit from strategically marketing to daughters of engineers. Follow up work could focus on whether these efforts would be successful at increasing gender diversity in engineering programs.

It is clear that early exposure to the engineering profession through parents often leads to occupational inheritance. The challenge then becomes providing early exposure to engineering as

a profession to children who lack a familial connection to engineering. Engineering exposure experiences which include parents may be particularly beneficial for children who lack home exposure. In fact, successful interventions have been developed for raising both students' and their parents' awareness of engineering. STEM summer institutes (camps) have been shown to increase the understanding of engineering in both high school girls and their parents [27]. While one-day STEM conferences were shown to increase middle school girls' interest in STEM, as well as their parents' perception that their daughters might choose a STEM career [28]. As parents are often the first guides for children's career choices, involvement of parents in these engineering workshops and camps is essential. Middle school girls who worked on engineering activities with a parent have displayed more positive attitudes about engineering than those who worked alone [29]. Thus, outreach programs to encourage girls to study engineering should include parents, especially mothers.

Involvement of parents in engineering workshops and camps may be even more important for under-represented groups within engineering, as those students are less likely to have familial exposure to engineering. Research has shown that inner city under-represented minority parents are interested in STEM for their kids, but are often less aware of opportunities and also have barriers to participating in the activities [30]. As mothers (at least in Black families) have greater influence than fathers on academic identity development [17], targeting parental interventions (intended to increase parental awareness of engineering as a profession) at mothers may be more effective than targeting fathers, especially for under-represented minority students. Thus, in terms of increasing both gender and racial diversity, the involvement of mothers in engineering exploration programs may be key. Follow up research could focus on these programs.

Conclusion

Limited conclusions can be drawn from this study alone. The results presented should be considered with caution as they are limited to a single university, composed of a primarily White student body, and do not represent a diverse sampling. Additionally, statistical analysis was not performed to determine significance of results.

A survey was administered to 158 first year engineering students as a means to study familial influences on student career aspirations and choice of college major. The survey resulted in 63% of students responding that they had at least one family member/role model in engineering. When we include STEM fields, this number increases to 69%. Overall, the most commonly reported family members in engineering/STEM were fathers (46%), mothers (14%), and uncles (9%). It was expected that respondents would be more heavily influenced in career choice by family members that were of the same gender [23]. More female engineering students reported a mother as an engineer than their male counterparts. This possible gender-influence was not displayed by grandparents in engineering/STEM. Perhaps due to the rarity of women in engineering/STEM among older generations, female engineering students were more likely to

have grandfathers (8%) in these fields than grandmothers (0%). It is also important to note that a greater percentage of female respondents indicated a father in engineering/STEM (42%) than a mother (19%). Thus, fathers may also be sources of occupational inheritance for *both* sons and daughters. Engineering programs striving to increase their gender diversity within engineering may do well to strategically target the daughters of engineers and develop engineering exploration programs which include mothers alongside daughters.

The results of this study encourage further research into how familial influences impact students' selection of college major when diversity in relationship intimacy is considered. In this consideration, extended family may be more influential to the student if the member is living in the household or if they frequently spend time with the student. Similarly, parental influences on students may vary with family structure, gender, race, ethnicity, and income. Further research should explore the differences of maternal influence of college major choice among students of varying ethnic and racial backgrounds. In depth understanding of all familial influences are imperative in assisting engineering educators and advocates in exposing parents and students to engineering topics. Additional work could also explore the engineering enrollment gender diversity effects of recruitment efforts targeted to the daughters of engineers.

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