# The Role of Empathy in Choosing Majors

**Dr. Eddie Jacobs P.E., University of Memphis**

Eddie L. Jacobs holds a B.S.E.E. (1986) and M.S.E.E. (1988) degree from the University of Arkansas, and a D.Sc. degree in Electro-physics from the George Washington University (2001). Dr. Jacobs is a licensed professional engineer in the state of Tennessee. Dr. Jacobs began teaching in 2006 after a 17 year career as a US Department of Defense researcher. He currently serves as the Undergraduate Coordinator for the Electrical and Computer Engineering Department of the University of Memphis. He is actively involved in curriculum development and in efforts to form the professional identity of students. He serves as the faculty sponsor for IEEE-HKN honor society and a faculty advisor for IEEE. He provides numerous research experiences for undergraduates, primarily in the fields of optics and imaging which are his major areas of research. Dr. Jacobs is fellow of SPIE and a senior member of IEEE.

**Dr. Amy L. de Jongh Curry, University of Memphis**

Amy L. de Jongh Curry, PhD, is an Associate Professor in the Department of Biomedical Engineering at University of Memphis (UM) with secondary appointment in the Department of Electrical & Computer Engineering. She also holds an adjunct position in the Department of Orthopaedic Surgery and Biomedical Engineering at University of Tennessee Health Science Center (UTHSC) through the Joint Graduate Program in Biomedical Engineering at UM/UTHSC. Dr. Curry received B.S. and M.S. degrees in electrical engineering and Ph.D. in biomedical engineering from the University of Memphis.

Her current research interests include cardiac and neural electrophysiology with applications in cardio- and neuro-modulation via implantable electrostimulation devices, computational modeling and visualization, and best practices in undergraduate engineering education. These efforts have been funded by the National Institutes of Health, National Science Foundation, and American Heart Association. Dr. Curry is a member of Tau Beta Pi, American Society for Engineering Education, Society of Women Engineers, and a Senior Member of IEEE Engineering in Medicine and Biology Society.

**Dr. Carmen Astorne-Figari, University of Memphis**

Assistant Professor of Economics, Fogelman College of Business and Economics, University of Memphis

**Dr. Russell J. Deaton, University of Memphis**

Dr. Russell Deaton is currently Professor of Engineering and Associate Dean of the Herff College of Engineering at the University of Memphis. From 2012-2017, he was chair of Electrical and Computer Engineering at the University of Memphis. From 2000-2012, he was a professor in the Computer Science and Computer Engineering Department of the University of Arkansas, and from 1992-2000, was on faculty in the Electrical and Computer Engineering Department of the University of Memphis. He has a Ph.D. and M.S. in Electrical Engineering from Duke University, a B.S. in Electrical Engineering from the University of Memphis, and a B.A. in English from the University of North Carolina. In addition, he held engineering positions at UTC-Mostek and General Electric. He has published extensively in the area of DNA Computing and Molecular Programming, including DNA-guided self-assembly of nanostructures. He was organizing and program chair for 15th International Conference for DNA Computing and Molecular Programming (DNA15), and co-editor of a Springer volume of Lecture Notes in Computer Science with selected conference papers.

**Ms. Wesam M. Salem, University of Memphis**

Wesam M. Salem is a doctoral student of the Department of Instruction and Curriculum Leadership at the University of Memphis. Her research focuses on qualitative research with particular attention to postqualitative and critical research methods. Her research interests include mathematics identity and the intersectionality of race, gender, religion, and national origin in education drawing on postcolonial theory.

**Dr. Yonghong Jade Xu, University of Memphis**

©American Society for Engineering Education, 2019

Professor of Educational Research, Quantitative Methodology.

**Shelby G. Roberts, University of Memphis**

Shelby G. Roberts is a doctoral student in the Department of Counseling, Educational Psychology and Research at the University of Memphis. Her interests focus on higher education retention efforts for underrepresented populations in STEM fields.

©American Society for Engineering Education, 2019

# The Role of Empathy in Choosing Majors

Eddie L. Jacobs *[1], Amy L. DeJongh Curry[2], Yonghong Jade Xu [4], Carmen Astorne-Figari[3], Wesam M. Salem[4], Shelby G. Roberts[4], and Russell Deaton[1]

[1]Department of Electrical and Computer Engineering, The University of Memphis
[2]Department of Biomedical Engineering, The University of Memphis
[3]Department of Economics, The University of Memphis
[4]Department of Counseling, Educational Psychology, and Research, The University of Memphis

## Abstract

In this research, the role empathy plays in women's choice of major is investigated with particular emphasis on engineering disciplines. We began by formulating a survey instrument that measured the level of empathy of the survey participant, the perceived level of empathy of various academic disciplines, the likelihood of majoring in a discipline, and the perception of empathy among the faculty and fellow students within their current major, along with demographic information. To measure the level of empathy of an individual, a modified form of the Empathizing/Systematizing Quotient (EQ-SQ) developed by Simon Baron-Cohen was used. The survey produced 517 valid responses. Of those responses, 46% were female. In addition, 257 were STEM majors with 231 of those being engineering majors. Of the engineering majors, 69 were female. Results from this survey indicate that 1) women are more empathetic than men, 2) students in engineering and other STEM majors are less empathetic than those in non-STEM majors, 3) engineering disciplines are perceived as less empathetic than other majors, and 4) empathy is negatively correlated with choosing engineering as a major.

Following these quantitative results, a qualitative focus group study was developed to delve deeper into some of the reasons behind the quantitative results. The focus groups were women in STEM (non-engineering) disciplines, women in engineering disciplines, and women in non-STEM disciplines. These studies are ongoing but to date, we have had three engineering women and two non-STEM women participate in the study. Using thematic analysis, an early result emerging from this part of the study is the role that fathers and math teachers play in the choices women make to study engineering.

*eljacobs@memphis.edu

## Introduction

While care for humanity is included in our professional engineering organization mission statements, it is seldom discussed or taught in our classrooms. We believe that this fact betrays a general lack of empathy in engineering. Since there are observed gender differences in empathy, it is logical to suspect that empathy may be a factor in the low representation of women in engineering. However, when the distribution of women in the various engineering disciplines is examined, a more nuanced picture appears. Disciplines such as electrical engineering have very poor representation by women while environmental engineering has near gender equity.

The main claim of this research is that empathy is a factor in the distribution of women across engineering disciplines. Some of the literature that supports this idea is reviewed below. A more detailed investigation of the literature on this subject has been given by Jacobs [1].

Verdín [2] studied the attitudes, beliefs, career expectations and aspirations of first year female engineering students. They found that women's attitudes match those of the sub-disciplines of their choice. In particular, the attitudes of women in male-dominated subfields resemble the masculine traits found in those subfields. While this study did not include empathy directly it did include many factors that are related.

Rasoal [3] examined empathy as measured by the four subscales of the Interpersonal Reactivity Index, empathic concern, perspective-taking, fantasy and personal distress. They found that students in two different engineering programs (applied physics and computer engineering) are less empathetic than students in care-giving disciplines (medicine, nursing, psychology, social work), with weaker results after correcting for gender.

Fox [4] looked at the characteristics of successful and unsuccessful undergraduate engineering programs in terms of outcomes in undergraduate degrees awarded to women. Successful programs view the main issues faced by women as rooted in structural issues, while unsuccessful ones view these issues as rooted in women's individual characteristics. That is, those programs that "adapt" their environments to be more inclusive, instead of having women "adopt" the features of their environment are more successful.

Empathy has received a great deal of attention in engineering education over the last several years. Much of this research has been centered around creating opportunities to demonstrate and develop empathy within engineering as a whole in order to address what Cech has referred to as a "culture of disengagement"[5]. This is essentially addressing the structural issues mentioned above in the work of Fox. Examples would include Walther's development of a synthesis and design studio for an environmental engineering course[6]. However, as cited earlier, environmental engineering is a discipline in which gender equity exists.

Our research specifically addresses how empathy affects women and is aimed at understanding the differences we observe in the representation of women in various engineering disciplines. In this respect, our research is in line with the recent work by Verdín in which the attitudes and goals of women were examined and found to affect their choice of major [2]. Although the methods used differ substantially, the conclusions are very similar - traits associated to a greater degree with women (which would include empathy) are correlated with choices of major.

Based on our review of the literature, we have formed two hypotheses; 1) A perceived lack of empathy is a barrier to women entering engineering, the strength of that barrier varying by discipline with respect to the perception of empathy; 2) This perception and, in turn, participation can be improved by intentionally incorporating empathy into disciplines with the largest barriers. Our research to date only addresses the first hypothesis.

To investigate our first hypothesis, namely whether a perceived lack of empathy is a barrier to women entering engineering, a mixed methods analysis approach was employed. A quantitative study was conducted to answer broad questions related to empathy and the choice of major. Those questions specifically are

1. How do male and female students differ with respect to empathy ?
2. How do gender-based empathy differences, if any, relate to students' preferences of academic majors?
3. What evidence supports that empathy, or the lack of it, is a factor in the under representation of women in certain engineering majors?

This research also uses a qualitative approach incorporating semi-structured individual interviews and focus group interviews in order to gain an in depth understanding of how empathy affects choice of major. At this writing final interviews are wrapping up and the results are being coded. Though this work is still in progress, a discussion of some preliminary findings of our qualitative study are given.

The following sections of the paper go into detail regarding the methods used and the results obtained.

## Methods

### The Quantitative Instrument

A survey instrument was constructed that measures the following.

1. Empathy based on Baron-Cohen's Empathizing/Systematizing Quotient
2. Perception and choice of majors
3. Perception of empathy of students and faculty
4. Knowing an engineer
5. Demographic information

Baron-Cohen has hypothesized that empathizing and systematizing are two fundamental ways that people interact with the world. His research team has constructed a survey instrument that measures a Systematizing Quotient (SQ) and an Empathizing Quotient (EQ)[7]. This survey has two forms, the shortest of which contains 22 EQ questions and 25 SQ questions. For our survey 8 EQ questions and 4 SQ questions were included. A total of twelve questions from the original

instrument was used because the total number of questions was too large to accommodate in the current study. A subset of questions was chosen based on factor analysis of the original instrument and content check to match the goal of the present study.

The online survey additionally included items measuring 1) the level of empathy perceived by the student for a list of twenty-one academic majors and 2) their self-reported likelihood of pursuing one of those majors. The perceived level of empathy was measured by the question

> "Empathy is defined as an ability to identify on an emotional level with another person, group, or society as a whole, coupled with a desire to help them. What are your beliefs regarding the level of empathy associated with practitioners of each of the following professions?"

with responses ranging from Strongly Unconcerned to Strongly Concerned on a 5-point Likert scale. Likelihood of pursuing a major was similarly measured with the question

> "How likely would you be to choose to major or minor in each of the following subjects if you were free to make the choice ? "

with responses ranging from Highly Unlikely to Highly Likely on a 5-point Likert scale. The list of majors used can be found in Table-2 and was restricted to majors offered at the university where the majority of participants attended.

There were also a series of statements designed to measure the level of empathy they perceived among faculty and other students within their major. These were formulated as a series of statements focused primarily either on fellow students or faculty. The respondent was then asked to rank each statement between Strongly Disagree to Stongly Agree on a 5-point Likert scale. Equal numbers of positive and negative statements concerning faculty and fellow students were presented. An example of a positive statement concerning fellow students was

> "I feel supported by other students in my department."

An example of a negative statement concerning faculty was

> "Faculty are seldom helpful when I have a problem."

In an attempt to discover any influence of mentorship or role models, we asked a few questions regarding whether the participant knew an engineer. First we asked the question

> "Do you personally know an engineer?"

with a response of yes, no, or maybe. If the response was yes or maybe, we followed up with the question

> "Did the engineer you know change your perception/likelihood of entering an engineering major?"

with a response of yes, no, or maybe.

Finally, the survey captured basic demographic information such as gender, age, current or planned major and status in undergraduate education (Freshman, Sophomore, Junior, Senior). A copy of the survey is available upon request.

## Quantitative Sampling and Participants

Data was collected using stratified sampling at an urban university in the mid-south area in the spring of 2017. In 2017, the university had an enrollment size of over 20,000, of which approximately 1,000 full-time students were in the College of Engineering. In order to have sufficient representation of engineering students, all undergraduate students in the College were contacted by email and encouraged to respond to the online survey. We also partnered with two other mid-western universities who solicited responses to the survey from their engineering colleges. For non-engineering majors, a sample of 3,000 students from the mid-south university was randomly selected and contacted. A total of 639 responses were recorded by the end of May, 2017. The final sample of respondents, after data cleaning and preparation removing incomplete and invalid responses, included 517 undergraduate students. The majority of these were from the mid-south university. The sample comprised of 54% male and 46% female. Respondents were also identified as STEM (n = 257) vs. non-STEM (n = 260) majors. Of the students who were engineering majors, 162 self-identified as males and 69 self-identified as females.

## Quantitative Analysis Procedures

The primary measure of interest in this study was empathy as captured by the EQ question. Since the literature suggests that empathizing (EQ) and systematizing (SQ) are two fundamentally related, but practically opposite ways that individuals interact with their surroundings, we combined the two measures by forming a ratio of EQ/SQ scores. We coded the questions so that EQ/SQ = 1 indicates a balance between the two traits; EQ/SQ > 1 indicates a stronger trait of empathizing; and EQ/SQ < 1 indicates a stronger trait of systematizing. To answer the question of how students differ with respect to empathy, descriptive statistics and preliminary comparisons were used to examine gender differences in the EQ/SQ ratio and how the differences manifest in various academic majors. To answer the question of how gender based empathy differences relate to students' preference of major, an Analysis of Covariance (ANCOVA) was used to investigate students' likelihood of choosing differing academic majors varied between genders, controlling for their differences in the EQ/SQ ratio. For the question of evidence that empathy is a factor in the under-representation of women in certain engineering majors, a multiple regression analysis was used to examine whether students' beliefs about the level of empathy associated with various disciplines predicted their likelihood of choosing that major, controlling for other related factors. We further explore this question by investigating the relationship between the probability of enrolling in engineering and the perception of empathy in engineering by gender and EQ/SQ ratio. We also study the relationship between engineering student's perception of empathy in engineering and their perception of the faculty and peers, controlling for gender, EQ/SQ ratio and other characteristics. For both empirical exercises, we use Ordinary Least Squares (OLS).[1]

[1]For the probability of enrolling in engineering disciplines, OLS and probit estimation yield similar results.

## Qualitative Methods

### Qualitative Sampling and Participants

This study employed qualitative focus groups and individual interviews for data collection. The focus groups and interviews were conducted throughout the spring and fall of 2017, fall of 2018, and spring of 2019. Convenience sampling was conducted from the pool of undergraduate students at the University of Memphis who fit the following criteria: a) traditional track students, b) self-identified as female; and c) enrolled in an undergraduate program at the University of Memphis. The researchers utilized a campus information system available to advisers to create a data set from the pool of traditional undergraduate students according to the three identified focus groups (i.e., engineering majors, non-STEM related majors, engineering majors who left to enroll in non-STEM related majors). Accordingly, the researchers sent a recruitment email inviting the undergraduate students on the generated list to participate in the focus groups. A total of ten participants, divided over three focus groups, accepted the invitation to participate in the focus groups. The participants were divided into 3 groups according to their major (engineering majors, STEM related majors, and non-STEM related majors). In addition, some non-STEM female students were recruited through an undergraduate course which required participation in a research study. Focus groups participants were given a monetary compensation in the form of $10 gift card at the conclusion of the focus group. Additionally, three of the non-STEM women were also given course credit for participating in the research study.

### Qualitative Analysis Procedures

Upon completing transcription of the focus groups and interviews, we used thematic analysis to analyze the data [8]. During the first cycle of coding, two of the researchers individually coded the interviews using initial coding [9]. Then the results were compared to identify similarities and differences. This was followed by a second cycle of coding in which we used descriptive and process coding [9]. Then we used axial coding to make connections between the categories we identified to generate themes.

## Results

### Quantitative Results

Based on the sample of 517 students, female students had an average of 1.37 EQ/SQ ratio, which was significantly higher ($p < .001$) than the average of male students ($\bar{X}_{EQ/SQ}$= 1.05). The values suggest a relative balance between empathizing and systematizing for male college students, whereas female students reported a much stronger tendency to empathize. Further examination of the data (see Table 1) also revealed that students in non-STEM academic majors had higher EQ/SQ ratios than their counterparts in STEM majors, with female students in non-STEM majors having the highest EQ/SQ ratio ($\bar{X}_{EQ/SQ}$= 1.49). It is clear that gender difference in EQ/SQ ratio was smaller in STEM majors (1.16 for females vs. 1.02 for males) than in non-STEM majors

(1.49 for females vs. 1.12 for males). In engineering majors that had sufficient sample sizes (n > 5), the general pattern was that female students had higher EQ/SQ ratios than male students. However, for the three engineering majors with very small sample size (civil engineering, computer/electronic engineering, and engineering technology), the few female students reported lower EQ/SQ ratios than their male peers (see Table 1).

Table 1: Comparison of EQ/SQ ratio between genders.

| Major | EQ/SQ Ratio (n) | | Test of Significance | *F* | *p* |
|---|---|---|---|---|---|
| | Female | Male | | | |
| STEM | 1.16 (85) | 1.02 (172) | Female vs. Male | 41.576 | <0.001 |
| Mechanical Engineering | 1.11 (17) | 1.00 (74) | | 2.085 | 0.152 |
| Biomedical Engineering | 1.28 (35) | 1.10 (22) | | 5.350 | 0.025 |
| Electrical Engineering | 1.12 (6) | 0.97 (21) | | 2.357 | 0.137 |
| Civil Engineering | 0.83 (1) | 1.09 (14) | Unavailable due to small number (n < 4) of female students in the sample | | |
| Computer Engineering | 0.69 (3) | 1.07 (12) | | | |
| Engineering technology | 0.76 (2) | 0.96 (8) | | | |
| Non-STEM | 1.49 (144) | 1.12 (94) | STEM vs. Non-STEM | 30.779 | 0.000 |
| Total | 1.37 (229) | 1.05 (266) | Female vs. Male | | <0.001 |

Because the data suggested that female students have stronger empathizing traits than male students, we conducted analyses to answer the second research question (how gender-based EQ-SQ differences relate to students' preferences of academic majors) taking into consideration their EQ/SQ variation. For the analyses, likelihood of choosing an academic major was used as the dependent variable. This value was determined from the statistics of the 5-point Likert scale responses to the questionnaire (see descriptive information in Table 2). As shown in Table 3, we found a clear trend that a higher EQ/SQ ratio was positively related to students' likelihood of choosing a non-STEM major (e.g., psychology, elementary education, nursing), while it was negatively related to their likelihood choosing a STEM major (e.g., civil engineering, mechanical engineering, electric engineering, computer sciences, and computer engineering). This pattern was particularly strong for choosing engineering majors. With female students having higher EQ/SQ ratios, it is also clear that empathy is a factor in their preference of academic majors. Of note is that, although no differences were found between genders in their likelihood of choosing statistics, chemistry, biomedical engineering, music, business administration, and history majors, individuals' EQ/SQ was still a factor positively determining the likelihood of majoring in biomedical engineering ($p = 0.001$). Also, the significantly lower likelihood of women choosing engineering majors, after controlling for EQ/SQ ratio, suggests that empathy level is an important factor associated with the under-representation of female students in engineering.

The question still remains whether students of different genders perceived different levels of empathy associated with practitioners in various academic disciplines and whether their perception of empathy influences their choices of majors. As shown in Table 2, male and female students' evaluations of empathy were similar for the majority of the disciplines. However, female students perceived engineering majors as having lower levels of empathy than male students with the exception of biomedical engineering. Likewise, female students rated the perceived level of empathy associated disciplines that have predominantly women practitioners

Table 2: Descriptive Information

| | Perceived empathy of a discipline | | | | Likelihood to major in a discipline | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 Male | | 2 Female | | 1 Male | | 2 Female | |
| | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev |
| Biology | 3.35 | 0.95 | 3.41 | 1.02 | 2.16 | 1.25 | 2.58 | 1.51 |
| Statistics | 2.81 | 1.03 | 2.74 | 0.93 | 2.15 | 1.14 | 1.83 | 1.04 |
| Psychology | 3.78 | 1.2 | 4.24 | 1.05 | **2.25** | **1.27** | **2.99** | **1.42** |
| **Civil Engineering** | **3.38** | **1.07** | **3.24** | **1.03** | **2.76** | **1.29** | **1.95** | **1.13** |
| Mathematics | 2.81 | 1.23 | 2.58 | 1.04 | 2.81 | 1.35 | 2.3 | 1.43 |
| Accounting | 2.85 | 1.09 | 2.86 | 1.05 | 2.54 | 1.32 | 2.03 | 1.26 |
| **Mechanical Engineering** | **3.26** | **1.23** | **2.92** | **1** | **3.43** | **1.49** | **2.22** | **1.43** |
| Chemistry | 2.98 | 1.1 | 2.98 | 1.07 | 2.39 | 1.35 | 2.24 | 1.41 |
| **Electrical Engineering** | **3.19** | **1.16** | **2.86** | **1.05** | **3.07** | **1.48** | **2.02** | **1.27** |
| Nursing | 4.03 | 1.15 | 4.45 | 1.02 | 1.99 | 1.11 | 2.87 | 1.56 |
| Economics | 3.02 | 1.11 | 2.99 | 1.02 | 2.46 | 1.26 | 2.08 | 1.2 |
| Elementary Education | 3.83 | 1.3 | 4.33 | 1.09 | 1.75 | 0.97 | 2.65 | 1.39 |
| **Biomedical Engineering** | **3.57** | **1.13** | **3.77** | **1.09** | **2.81** | **1.39** | **2.68** | **1.63** |
| Computer Science | 2.98 | 1.13 | 2.82 | 1.01 | 2.94 | 1.33 | 2.26 | 1.4 |
| Art | 3.25 | 1.36 | 3.63 | 1.16 | 2.1 | 1.33 | 2.74 | 1.5 |
| Music | 3.41 | 1.25 | 3.71 | 1.16 | 2.26 | 1.39 | 2.41 | 1.45 |
| **Computer Engineering** | **3** | **1.18** | **2.82** | **1.05** | **3.06** | **1.41** | **2.16** | **1.36** |
| Business Administration | 3.02 | 1.08 | 3.1 | 1.14 | 2.77 | 1.36 | 2.59 | 1.51 |
| History | 3.07 | 1.08 | 3.28 | 1.06 | 2.32 | 1.26 | 2.28 | 1.36 |
| English | 3.12 | 1.14 | 3.35 | 1.05 | **1.86** | **1.12** | **2.55** | **1.5** |
| Physics | 2.91 | 1.21 | 2.73 | 1.04 | **3.06** | **1.34** | **2.04** | **1.27** |

Table 3: Relative likelihood of choosing a discipline as a function of gender, controlling for EQ/SQ ratio and STEM/non-STEM major. ($\alpha$ = .01 to lower the chance for Type I error) . * indicates a significant effect of EQ/SQ ratio in the logistic regression model.

| Major | Female | Male | EQ/SQ ratio | Gender difference | |
|---|---|---|---|---|---|
| | | | (covariate) | (EQ/SQ Controlled) | Sig. |
| Females significantly more likely than males to choose these majors | | | | | |
| Biology | 2.57 | 2.16 | F = .007, p =.934 | 0.41 | 0.002 |
| Psychology* | 2.99 | 2.25 | F = 23.1, p <.001 | 0.53 | <0.001 |
| Elementary Education* | 2.65 | 1.74 | F = 11.02, p =.001 | 0.78 | 0 |
| Nursing* | 2.87 | 2 | F = 10.53, p =.001 | 0.73 | <0.001 |
| Economics | 2.46 | 2.08 | F = 0.38, p =.538 | 0.34 | 0.003 |
| English | 2.54 | 1.86 | F =4.90, p =.027 | 0.59 | <0.001 |
| Art | 2.74 | 2.1 | F = 1.77, p =.185 | 0.58 | <0.001 |
| Females significantly less likely than males to choose these majors | | | | | |
| Civil Engineering* | 1.94 | 2.77 | F = 10.98, p =.001 | -0.71 | <0.001 |
| Electrical Engineering* | 2 | 3.09 | F = 28.81, p <.001 | -0.94 | <0.001 |
| Mechanical Engineering* | 2.21 | 3.44 | F = 36.48, p <.001 | -0.85 | <0.001 |
| Physics* | 2.03 | 3.07 | F = 21.77, p <.001 | -0.81 | <0.001 |
| Computer sciences * | 2.25 | 2.98 | F = 26.30, p <.001 | -0.47 | 0.012 |
| Computer engineering* | 2.15 | 3.08 | F = 39.61, p <.001 | -0.65 | <0.001 |
| Accounting | 2.03 | 2.53 | F = 6.01, p =.015 | -0.41 | 0.001 |
| Mathematics* | 2.3 | 2.83 | F = 27.1, p <.001 | -0.3 | 0.022 |

(psychology, nursing, elementary education, and arts) much higher than their male counterparts (see Table 2). Further analysis using multiple regression indicated that student beliefs about the level of empathy associated with practitioners of differing disciplines significantly predicted their likelihood of choosing a given major, after controlling for individual EQ/SQ ratio (see Table 4). The only exceptions to this pattern were nursing and elementary education. The lack of relationship could be due to the limited variation in students' responses. Overall, the findings not only confirmed that higher scores in EQ negatively predict the likelihood of choosing STEM (especially engineering) majors, but also that the perceived level of empathy associated with practitioners in various disciplines is highly related to the likelihood of choosing engineering majors. With female students rating engineering as having lower empathy levels, their likelihood of choosing those majors would be lower as well.

Next, we analyze correlates for the probability of enrolling in engineering disciplines. In particular, we are interested in the effects of empathy related traits and potential mentoring roles on engineering enrollment. For this purpose, our dependent variable is a binary variable indicating whether or not students are enrolled in engineering disciplines, and our independent variables are the students' perception of empathy in engineering disciplines, the student EQ/SQ ratio and a binary variable indicating whether or not students personally know an engineer, controlling for race. To account for potential differences in major choices by gender, we ran separate regressions for men and women. Table 5 shows the coefficients for these regressions, with the standard deviations in parentheses. Our results show that, for both men and women, enrollment in engineering disciplines is significantly and positively correlated with a higher perception of empathy in the Engineering discipline. This effect is larger for women compared to men, as the respective coefficients show. While a higher perception of empathy in engineering is related with a 0.202 increase in the probability of enrolling in engineering for women, it is related with a 0.114 increase in such probability for men. Although both men and women who are enrolled in Engineering are less empathetic than their counterparts enrolled in other disciplines, the relationship between this lower predisposition towards empathy (reflected by a lower EQ/SQ ratio) and the probability of being enrolled in engineering is only significant for female students. Finally, we find that only for women, knowing an engineer is positively and significantly correlated with the probability of choosing to major in engineering, suggesting a positive role for role-modeling or mentoring. We must note that the questionnaire did not inquire about the gender of this known engineer. However, our qualitative results suggest that gender of such known engineer may not matter.

Finally, we use regression analysis to investigate the relationship between student perception of faculty and peers, and their perception of empathy in the engineering discipline (dependent variable), restrict attention to engineering students only. Since the perception of empathy in engineering is likely to be affected by other student characteristics, we control for EQ/SQ ratio, gender, race and whether or not students know an engineer. Table 6 shows the coefficients from this regression. As seen, the most significant factor associated to students' perception of empathy in engineering is the perception of their fellow students: those who like their peers have a higher perception of empathy in engineering than those who don't. Perhaps surprisingly, students' perception of engineering faculty was not significant, although the coefficient is positive. We also did not find any significant effects of gender or the EQ/SQ ratio, though the coefficients suggest engineering is perceived as less empathetic for women and for students with a lower EQ/SQ ratio.

Table 4: Standardized regression coefficients in models predicting likelihood of choosing majors. PLOE is the perceived level of empathy. Standardized regression coefficients are reported to allow comparison between models and gender.

| Discipline | Female | | | Male | | |
|---|---|---|---|---|---|---|
| | ( n= 229) | | | (n = 266) | | |
| | Model $R^2$ | EQ/SQ | PLOE | Model $R^2$ | EQ/SQ | PLOE |
| Biology | 0.072 *** | -0.003 | 0.267 *** | 0.054** | 0.027 | 0.230*** |
| Statistics | 0.074*** | -.136* | 0.211** | 0.051** | -0.044 | 0.223*** |
| Psychology | 0.176*** | .188** | 0.352*** | 0.129*** | .206** | 0.285*** |
| Civil Engineering | 0.153*** | -.238*** | 0.276*** | 0.141*** | -0.026 | 0.376*** |
| Mathematics | 0.110*** | -.250*** | 0.184** | 0.110*** | -.182** | 0.287*** |
| Accounting | 0.111*** | -0.124 | 0.293*** | 0.092*** | -0.023 | 0.301*** |
| Mechanical Engineering | 0.184*** | -.275*** | 0.294*** | 0.171*** | -.201** | 0.352*** |
| Chemistry | 0.063** | -0.086 | 0.230*** | 0.059*** | -0.092 | 0.230*** |
| Electrical Engineering | 0.149*** | -.239*** | 0.268*** | 0.117*** | -.201** | 0.264*** |
| Nursing | 0.093*** | .211** | 0.196** | 0.012 | 0.006 | 0.11 |
| Economics | 0.098*** | -0.024 | .310*** | 0.091*** | 0.001 | 0.302*** |
| Elementary Education | 0.060** | .201** | 0.116 | 0.008 | 0.021 | 0.087 |
| Biomedical Engineering | 0.180*** | -.157* | 0.373*** | 0.066*** | -0.069 | 0.248*** |
| Computer Science | 0.129*** | -.232*** | 0.234*** | 0.051** | -.160* | .147* |
| Art | 0.077*** | -0.045 | 0.279*** | 0.157 | -.158** | 0.348*** |
| Music | 0.076*** | -0.069 | 0.274*** | 0.162*** | .160** | 0.359*** |
| Computer Engineering | 0.171*** | -.283*** | 0.255*** | 0.128*** | -.214*** | 0.276*** |
| Business Administration | 0.135*** | 0.024 | 0.369*** | 0.191*** | 0.017 | 0.437*** |
| History | 0.087*** | -0.036 | 0.296*** | 0.150*** | 0.063 | 0.381*** |
| English | 0.080*** | 0.049 | .276*** | 0.141*** | 0.1009 | 0.345*** |
| Physics | 0.174*** | -.306*** | .243*** | 0.074** | -0.091 | 0.256*** |

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Table 5: Engineering Enrollment: coefficients

| | (1) Men | (2) Women |
|---|---|---|
| Perception of Empathy | 0.114*** | 0.202*** |
| | (0.0329) | (0.0360) |
| EQ/SQ | -0.0423 | -0.196** |
| | (0.0876) | (0.0657) |
| White | -0.00143 | -0.0722 |
| | (0.0568) | (0.0703) |
| Knowing an Engineer | 0.0905 | 0.195* |
| | (0.0989) | (0.0805) |
| Constant | 0.439** | -0.0179 |
| | (0.167) | (0.171) |
| $N$ | 194 | 186 |
| $R^2$ | 0.0965 | 0.1917 |

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Finally, our results show that non-white students' perception of empathy is higher than of white students, but only at the 10% significance level.

**Qualitative Results**

The preliminary results from the focus groups can be categorized into several thematic elements. First, the women who were majoring in engineering had rigorous high school courses specifically in math and sciences. The culture and rigor of these courses was continually cited by these women as important in selecting a field of study. Amber, a rising senior in engineering, stated,

> "I think that they push us [the honors students] more. ... I like challenges. That's one of the many reasons that I chose engineering, because it's a continual challenge. Every day will be something different, something new, something unknown, and that's challenging, and that's scary to some people."

Sam, who completed one year as an electrical engineer reflected on her high school courses and how that impacted her decision to major in engineering,

> "I started with standard classes. And then, I went there. It's hard, you know, ultimately to do, you know, better and stuff, but once I got accepted to honors classes and then to AP's, I really felt like I can do anything. And that's why like I chose Electrical Engineering. I thought if I could do math because I took AP Math, AP

Table 6: Perception of Empathy in Engineering: Coefficients

| | Dependent Variable: Perception of Empathy |
|---|---|
| Perception of Faculty | 0.0218 |
| | (0.0137) |
| Perception of Students | 0.0560** |
| | (0.0184) |
| EQ/SQ | 0.217 |
| | (0.178) |
| Gender | -0.0334 |
| | (0.109) |
| White | -0.261* |
| | (0.114) |
| Knowing an Engineer | 0.417 |
| | (0.232) |
| Constant | 1.754*** |
| | (0.435) |
| $N$ | 234 |
| $R^2$ | 0.1220 |

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

> Calculus, you know, then I got Engineering. So, I chose Electrical Engineering. ”

Summer, who had recently finished her freshman year in engineering, compared how the honors students acted in comparison with how the standard track students acted in her split math course,

> “They [non-honors students] don’t want to be here. They—all they want to do is crack jokes, make noise, disrupt the class and it’s very distracting. Sam agreed with Summer’s assessment of the differences in how students approached classes and school, So, it’s different for different teachers, but the environment for Honors and AP’s especially does effect students I think to take bigger challenges and achieve higher.”

All the women who majored in engineering traced their choices back to knowing an engineer, typically their father, or an influential STEM teacher and how those relationships cemented their decision to also major in engineering. Some of the women saw their engineering dad as a superhero while others were able to experience the joys of math through an excellent teacher’s math course. Summer reflected on her childhood memories of her father and how those influenced her decision to major in engineering,

> “Growing up, I thought that my dad was the coolest person because— my dad was the only engineer in my family. And so, we frequently got phone calls [like], "Hey, this is broken. What do you do?" And then, of course, dad would tag me along and we’d go look at stuff. Then I’d hand him stuff and I don’t know. It was kind of like my dad knew everything. Like he had it all figured out, and he knew how everything worked. And it just—it—it blew my mind. It was like you said, he had super powers. Like, "How do you know everything? How do you understand that that’s what’s wrong with everything? How do you problem-solve that?" So, it was very inspiring I guess to have someone in your life that not only knew the machine—knew the maintenance behind it, but also knew the engineering.”

A third common theme that developed through coding was how empathy could be seen as a core tenant of engineering. All the engineering students discussed how fixing things, making the world better and healthier through technology, and understanding the people who they are designing for make engineering an empathetic field.

Amber,

> “So, you know, maybe [nursing is] the most empathetic field. But at the same time, none of the technology that they have would be there if there wasn’t an electrical engineer behind it. So, you know, if they didn’t have a machine that can do your heart rate or your blood pressure, then, there’s someone that’s like, "I want to make the health-care a better place". And so, they had to have had some sort of empathy to be able to say, "We need this for people." And that’s what engineering is, you know.”

However, the women were quick to curtail their answers with the fact that not all engineers elicit

empathy in their work. For example, Sam, who ended up switching out of engineering stated,

> "So, anyone—any engineer can be empathetic, but also any engineer can be, you know, not empathetic. . . . I can see how engineers can be empathetic. I can see also how they can be not empathetic because if you were in a company or a workplace and you have these problems or projects, you'll just do them because it's your work. But you can be empathetic and have the deeper purpose behind doing your work."

After a few minutes talking about empathy in engineering, Amber eloquently summed up the focus group's view on the topic,

> "The whole point of engineering is to make people's lives better."

## Discussion

Many of the general results we find are consistent with other studies of empathy and gender. They are also consistent in large part with the study by Verdín cited in the Introduction [2]. This study finds that women gravitate to various engineering disciplines based on their individual match with several male associated qualities found in that discipline. We find similar trends with respect to empathy. Women with levels of empathy closer to those observed in men appear more frequently in under-represented engineering disciplines.

Our finding that a lower EQ/SQ ratio is associated with a higher probability of enrolling in engineering is consistent with Rasoal's finding that students in two different engineering programs are less empathetic than students in care-giving disciplines, with weaker results after correcting for gender [3]. We add to their results by extending this comparison to other less empathetic fields such as business related disciplines, and still find that there are no major significant differences in predisposition towards empathy across men in all majors. However, we find that the relationship between empathy and the likelihood of choosing engineering is significant only when comparing female engineering majors with women in other majors.

One thing to be noted is that, as opposed to the study by Rasoal et. al., we are not comparing absolute empathy measures, but students' predisposition towards empathy relative to their predisposition towards systematizing. Our result could indicate that women who choose engineering have a comparative advantage towards systematizing (or, alternatively, a comparative disadvantage towards empathizing) with respect to women in other majors and not that they are overall less empathetic. In this sense, our findings could be interpreted in the light of the results in Fox [4] concerning women adopting the idiosyncrasies of their respective fields of engineering in order to succeed. It could be the case that women who choose engineering are less empathetic than women who choose other fields as in Verdín [2]. On the other hand, it could be the case that women who choose engineering become less empathetic in order to stay in engineering. Unfortunately, our questionnaire does not include the year of studies, and cannot distinguish between the two interpretations.

Our preliminary results from the focus groups show some patterns that are consistent with our quantitative findings. The female engineers mentioned feeling different from other students in

terms of their level of interest, ambition and desire for challenge. These characteristics could explain the lower EQ/SQ ratio observed in Table 1. Also, these students mentioned the important role of inspiring educators (a Math teacher, in particular) and role models (their fathers) in choosing to major in engineering. This provides support for the positive correlation between knowing an engineer and majoring in engineering that we observed for female students, suggesting that the gender of such mentor or role model may not be relevant. This observation may be helpful as we consider the development of mentorship programs for women in engineering. It has long been recognized that women need good female role models in engineering. Programs that use men in mentoring women may also help fill this need as was suggested in 2007 by Schreuders [7].

Additionally, upon some reflection, all female engineering majors agreed that they perceived engineering as an empathetic profession, although they recognized that the members of the profession may not always be empathetic. One participant in the focus group who switched out of an engineering major corroborated this last point. She described the lack of empathy from her classmates, which ultimately determined her switching away from engineering.

This study has limitations imposed by time, place, and scope. The majority of the participants were from a single university and so our results must be viewed as limited to that particular place, time, and culture. This study is also limited in its scope. We are only addressing the aspect of empathy. We know that choices women make include many more factors than empathy alone. We are not considering these other factors and as a result, cannot speak to the relative importance of empathy in making those choices. However, given that we have evidence in our focus group study that empathy may be a factor in major switching behavior, empathy is a factor of some importance in the decisions women make regarding majors.

## Conclusion

We conclude that the empathetic nature of the individual and the perception of empathy among students and practitioners appear to be factors in women's choice of major. This may be indicative of a matching taking place between the empathy of the individual and the environment of study. Additionally, this could also reflect an adaptation strategy for women to adjust and survive in a male-dominated environment. This observation may be helpful in the future as we consider ways to improve participation of women. Since empathy is a human trait not tied specifically to gender and can be improved or learned, changing the environment of engineering could result in improvements in the representation of women. This study also reinforces the importance of knowing an engineer (role models or examples) for women in their choice of engineering as a major.

## References


[1] E. Jacobs, A. Curry, R. Deaton, C. Astorne-Figari, and D. Strohmer, "Empathy and gender inequity in engineering disciplines," in *Proceedings Of The ASEE Annual Conference & Exposition*, 6 2016, 123rd ASEE Annual Conference and Exposition ; Conference date: 26-06-2016 Through 29-06-2016.

[2] D. Verdín, A. Godwin, A. Kirn, L. Benson, and G. Potvin, "Engineering Women's Attitudes and Goals in Choosing Disciplines with above and Below Average Female Representation," *Social Sciences*, 2018.

[3] C. Rasoal, H. Danielsson, and T. Jungert, "Empathy among students in engineering programmes," *European journal of engineering education*, vol. 37, no. 5, pp. 427–435, 2012.

[4] M. F. Fox, G. Sonnert, and I. Nikiforova, "Successful programs for undergraduate women in science and engineering: Adapting versus adopting the institutional environment," *Research in Higher Education*, vol. 50, no. 4, pp. 333–353, 2009.

[5] E. Cech, "Culture of disengagement in engineering education?" *Science, Technology, & Human Values*, vol. 39, no. 1, pp. 42–72, 2014. [Online]. Available: http://sth.sagepub.com/cgi/doi/10.1177/0162243913504305

[6] J. Walther, S. E. Miller, and N. N. Kellam, "Exploring the role of empathy in engineering communication through a trans-disciplinary dialogue," in *American Society for Engineering Education*. American Society for Engineering Education, 2012.

[7] A. Wakabayashi, S. Baron-Cohen, S. Wheelwright, N. Goldenfeld, J. Delaney, D. Fine, R. Smith, and L. Weil, "Development of short forms of the Empathy Quotient (EQ-Short) and the Systemizing Quotient (SQ-Short)," *Personality and Individual Differences*, vol. 41, no. 5, pp. 929–940, 2006.

[8] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, 2006.

[9] J. Saldaña, *The Coding Manual for Qualitative Researchers*. Sage, 2014.