# Why I Am an Engineering Major: A Cross-Sectional Study of Undergraduate Students

**Dr. Louis Nadelson, Boise State University**

Louis S. Nadelson is an associate professor in the College of Education at Boise State University, with a PhD in educational psychology from UNLV. His scholarly interests include all areas of STEM teaching and learning, inservice and preservice teacher professional development, program evaluation, multidisciplinary research, and conceptual change. Nadelson uses his over 20 years of high school and college math, science, and engineering teaching to frame his research on STEM teaching and learning. Nadelson brings a unique perspective of research, bridging experience with practice and theory to explore a range of interests in STEM teaching and learning.

**Mrs. Dee K Mooney, Micron Foundation**
**Janine Rush-Byers, Micron Technology Foundation, Inc.**

Janine Rush-Byers has been with the Micron Foundation since 2006 as the university relations manager. Janine works with domestic and international universities to build strategic, long term partnerships focusing on engineering programs, students and faculty members. The Foundation funds $5 million in grants annually around the world, including $2 million to universities. Janine holds a bachelor's degree in engineering from the University of Washington and an MBA from Boise State University.

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**Nathan Dean, Boise State University**

Nathan Dean began work at Boise State University in 2013 as a research assistant to Dr. Louis Nadelson in the College of Education. He is currently pursuing his M.S. in STEM Education and expects to graduate in 2015. Before beginning graduate school Nathan taught secondary math and science and worked at the district level developing curriculum and assessment items to meet the Common Core State Standards of Mathematics. He earned his B.S. in Earth Science Education from Boise State University in 2011 with a minor in Physical Science and was a NSF Robert Noyce Scholar. Nathan's research interests include STEM education, grading and assessment practices, self-efficacy, and student conceptions of science.

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## Abstract

According to a recent report [1] K-12 students tend to like mathematics and science. Further, in a survey of desirable STEM careers the students selected engineering with very high frequency which was matched only by nursing in terms of student selection as a desirable STEM career [1]. Yet, when the K-12 students were asked if they would like to work in a career that applies mathematics and science a majority of the students responded "no" indicating that there is a disconnect between their career preferences, expectations, aspirations, and their understanding of engineering as a career. These results led us to wonder what influences a student to be an engineering major.

We hypothesized that students become engineering majors because they like to work on problems and develop solutions. Similarly, we anticipated students want to be nurses because they like to help people (this is a separate research project that is currently under development). We posit even though engineering involves substantial application of math and science the primary goal is to identify and work on authentic problems and develop meaningful solutions which overshadows that necessity to apply math and science. Further, we speculate that success in engineering requires the application of multiple other skills such as communication, collaboration, creativity, computing, etc. which are likely to dilute the thought of engineering as a career in which people focus on the application of mathematics and science. Finally, we predicted that there would be shifts in the answers based on experience, with first year engineering students holding different views than fourth year students.

Using the report [1] as a reference we developed an online based survey which included a combination of selected and free response items. We distributed the survey to the undergraduate engineering students at multiple institutions in the United States. We began by asking the students to share why they are engineering majors in a free response question. Specifically we sought evidence to determine who influenced the students' choice of engineering as a major, their motivation for pursuing engineering as a major, how much they like math and science, and how well they do at math and science. We also sought to determine what they like or do not like about math and science. We included an item to determine the students' involvement in extra-curricular activities that may be aligned with engineering. In addition to the engineering major focus survey we also gathered demographic data.

Our analysis of over 1,300 completed surveys revealed our participants were most interested in being engineers to solve problems, because they like math and science, were greatly influenced by parents to be an engineering major, and had above average success with mathematics and science with an alignment with their liking for math and science. About 80 percent know someone outside of school who is an engineer, and about 40 percent had engaged in out of school activities that are associated with engineering. Implications and recommendations for future research are shared.

## Introduction

Our research project was motivated by the recent release of a research report indicating that younger K-12 students tend to like mathematics and science, but they also tended not to want to work in a job that uses math and science [1]. Ironically, many of the same students voiced a desire to become engineers, a profession that relies heavily on mathematics and science. This led us to wonder what motivates students to select engineering as a major and to pursue engineering as a career. The students' perceptions, performance, and preference, for mathematics and science seems to be an important proxy for considering engineering as a career. Further, experiences with peers, faculty, the way subjects are taught, and how students are supported in learning math and science may be key indicators of their choice to become and engineer and their persistence and retention as engineering majors.

Before we present our research and results, we discuss some of the relevant literature – which tends to be scant in terms of students choices to become engineers. Thus, we build a case using research on STEM student motivation, engagement, persistence, and identity, to support and justify the importance of learning more about what motivates students to become engineers. We also examine the literature on the shifting characteristics of engineers, again building a case for what may be motiving students to become engineers.

Our research addresses the gap in the literature that explicitly addresses the association between performance and perceptions of both mathematics and science, external influences, experiences with engineering activities, and motivation for becoming and engineer. Previous research may have addressed aspects of these variables, but not combined, and not specific to engineers, as we have.

Following the report of our results we discuss the outcome of our research, offering potential explanations for our findings and propose some potential implications. We conclude with some limitations of our research, suggestions for future research, and closing comments with regard to our study.

## Review of Literature

### Pursuing an Engineering Degree and Career

The process of choosing a career is influenced by many factors. Research indicates that the greater the alignment between students' images of themselves and images of those associated with a favorite subject, the stronger the preferences are for that subject [2]. Thus, we anticipate that students' perceptions of themselves as engineers likely influences their choice to study engineering and pursue an engineering career. Students' perceptions of themselves as engineers do not appear to be bound by gender, yet students tend to maintain images of engineers that are historically masculine [3]. Wyer and colleagues [3] suggest that students tend to hold complex and sometimes contradictory images of STEM professionals. We maintain that the complexity of student images is likely influenced by the models of engineering they hold based on the people that they interact with, in particular professional engineers.

Evidence suggests knowing or having a relationship with an engineer, or having experienced the activities associated with being an engineer influences a student's choice to consider a career in engineering. As Fadigan and Hammrich [4] assert, students' academic and career choices were influenced by having professionals to talk to and by having learned associated job skills. Similarly, Amelink and Creamer [5] report that engineering majors' interactions with faculty and their peers can have long term impact on the choice to pursue and maintain study and a career in engineering. Thus, the interactions with engineering professionals are likely to influence a range of students' perceptions and understandings of engineering as a career. As Schnieder [6] explains, STEM students' positive perceptions of the professional and interpersonal competencies of STEM professionals was positively correlated with their STEM career intentions.

The learning processes that students engage in have also been found to influence their career choices. Interest and attachment to a STEM related career are formed early in life, often by primary education [7], suggesting that finding the roots of a justification for the pursuit of an engineering career is likely a multifaceted endeavor. Heilbronner [8] claims that the quality of students' academic experiences are predictors of their pursuit of STEM degrees and careers. Building on these data, Lavigne and colleagues [9] have created and verified a model of student learning and motivation, influenced by teacher support of autonomy during learning, and including students' perceptions of their competence. The model indicated that certain learning experiences can have a positive influence on the students' choices to pursue a STEM related education and careers. Confidence can be a predictor of persistence, such that higher confidence contributes to student retention [10]. The influence of confidence suggests that if students perceive themselves as successful in certain subjects such as science and mathematics, they may be more likely to pursue a career in engineering and persist in completing the career [11]. Increased confidence in learning success can lead to stable or increased levels of self-efficacy which further contributes to positive academic and career outcomes [12]. Again, the most salient academic areas for an engineering major are likely mathematics and science [11], as study in these areas begin early and success in the areas is essential for success as an engineer. Thus, school experiences, in particular, are crucial in attracting young people to STEM careers.

**Traits of an Engineer**

Perceptions of engineers may be based on stereotypes that may or may not be representative of reality [13, 14]. Some of the perceptions include engineers as autonomous, technically inclined, persistent, male, introverted, and socially limited. However, the evolution of global perspectives and the involvement of engineers in international situations requires a capacity for high levels of social interaction, sensitivity, conscientiousness, and the need to be emotionally stable – suggesting that traditional stereotypes may not hold for the present day engineer [15, 16]. In Robbins [17] report on "reflexive engineers" it is apparent that the skills needed to be an effective engineer are inconsistent with some of the traditional stereotypes, yet there is a persistent need for high levels of technical and STEM knowledge. Thus, achievement in science and mathematics is fundamental to being an effective engineer, as is ability to collaborate, be persistent, and be socially effective [18]. Ironically, Hirsch and colleagues [19] report that even though students may hold positive attitudes about studying engineering and pursuing engineering careers, they tend to have very limited understandings of the actual work of engineers.

An additional element that seems to be influential on student choice of career is their work values [20]. The research of Balsamo and colleagues [20] suggests how students' value work is related to their choice of career. We maintain that student engagement and completion of coursework are proxies for how much value engineering students place on the work needed to be prepared and successful in an engineering career.

Given the qualities of an effective engineer and the shifting focus on the skills required to be successful in the field, we wondered why students chose to study engineering and were seeking to become engineers. In the past, a propensity for technical work that could be done autonomously – work that aligns with certain personalities – could explain why students would pursue an engineering career. However, the shift toward greater social interaction, social conscientiousness, emotional sensitivity, collaboration, and group communication – skills that are arguably common to a wide range (if not all) modern professional careers – suggests that other variables are at play to explain the pursuit of a career in engineering.

## Methods

### Research Questions

We used the following questions to guide our research:

- *What are the mathematics and science academic characteristics of students pursuing an engineering degree?*
- *What are the mathematics and science course performances, preferences, and perceptions, of engineering majors?*
- *What influenced the participants' choice of engineering as a major?*

### Participants

The 1327 participants in our study were drawn from the engineering colleges at five large universities across the United States. The average age of the participants was 21.65 ($S$ = 6.93), with 29% being female and 71% being male. Caucasians made up 83% of the participants with Asians at 7.5%, Latinos/Latinas at 3.2%, African Americans at 1 %, and Native Americans at .3%. Nearly 62% of our participants were from suburban communities, while 26% were from rural communities, and 12% were from urban communities. The year of college of the participants was nearly equally distributed from freshman (25.1%) to senior (27%), with a similar distribution for anticipated year of graduation. The dominant major was mechanical engineering at 29%, followed by electrical engineering (18%), chemical engineering (13%), civil engineering, and computer science each at 9%, with the remaining 22% of the majors distributed among other majors such at manufacturing engineering, biomedical engineering, industrial engineering, and aeronautic/aerospace engineering. The participants had taken an average of 4.58 ($S$ = 2.83) college level science courses and 4.42 ($S$ = 2.40) college level mathematics courses.

### Measures

The overarching question of our research was "why do students want to be engineers?" We developed a brief demographics and engineering focused survey to gather information that we felt was necessary to answer our research question. As a team we created an initial list of items, keeping in mind the desire for the survey to be completed in about 10 minutes. After several rounds of item development, we vetted the survey with a dean and a coordinator of advising in a college of engineering. Based on their feedback we made some small modifications to our survey and determined it was ready for data collection (our final survey is appended).

**Demographics**. We created our demographics measure to assess our participants' age, gender, and ethnicity. We developed items to determine the participants' academic major, number of years of college, current year in their program, anticipated graduation date, and number of college level mathematics and science courses. We also created items to gather the participants' university, and community of origin.

**Survey of Interest in Engineering**. To achieve our goal of learning more about the profile of engineering majors, we developed several items with potential association to the important indicators of student pursuit of an engineering degree. We examined some of the factors that were known to be associated with being an engineer such as student perceptions, preferences, and performance in mathematics and science [11]. We were interested in the primary reason our participants choose to pursue an engineering career, if they knew an engineer (outside of school), and if they had participated in any engineering activities prior to enrolling in their engineering degree program. We also created an item to explicitly ask the participants about the biggest influence on their decision to be an engineer, and at what age they decided to become an engineer.

### Data Collection

For our cross-sectional study we determined that it would be most effective to gather the desired data using surveys. We also selected surveys because of our intent to gather data from multiple institutions spread across the United States. We secured oversight of our human subjects from the lead author's institution which was accepted by five of the participating institutions who granted us authorization to survey their students, and worked with us to distribute the link to our survey. We ported our survey into an online survey site for data collection. We drafted an invitation email with a link to a consent form that led to our demographics measure, which was linked to our survey of interest in engineering. We collected data over three weeks with reminders sent after the second week.

## Results

We began our data analysis by conditioning our data, which included removing the responses for those who did not complete the surveys, removing obvious repeats, and pairing the demographics and engineering interest surveys responses based on the IP addresses and time stamps. Once conditioned we conducted our analysis using SPSS for the quantitative data and Excel for the qualitative data. More of our process of analysis and the results follows detailed by research question.

**Student Characteristics**. Our first research question asked**,** *What are the mathematics and science academic characteristics of students pursuing an engineering degree?* To answer this question we conducted a correlational analysis using several of the quantitative variables we gathered. Our analysis revealed some interesting correlations (See Table 1). For example, the rather weak positive correlation between success with math and liking math, which suggests many students may be successful at math but not like math or the inverse which may be they like math but are not successful at math (*r* = .054, *p* <.05). The outcome was similar for science (*r* = .045, *p* <.05). However, we found a strong positive correlation between like for math and like for science (*r* = .256, *p* <.01), and an even stronger positive correlation between success with math and success with science (*r* = .974, *p* <.01). We also found positive correlations between the number of math courses taken and success with math (*r* = .123, *p* <.01) and liking math (*r* = .119, *p* <.01). Again we exposed a similar situation for science, with success in science (*r* = .183, *p* <.01) and like for science (*r* = .251, *p* <.01) each positively correlated with the number of science courses taken.

Table 1
*Mathematics and Science Academic Characteristics of Engineering Majors*

| | Yr in College | Number of yrs of college | Number of credits | Like math | Success with math | Like science | Success with science | Number college science classes | Number college math classes | Age |
|---|---|---|---|---|---|---|---|---|---|---|
| Yr in College | -- | .779** | -.095** | .018 | .045 | .073** | .067* | .610** | .695** | .282** |
| Number of yrs of college | | -- | -.175** | .012 | -.015 | .075** | .019 | .524** | .605** | .338** |
| Number of credits | | | -- | -.002 | .027 | .011 | .045 | -.006 | -.057* | -.154** |
| Like math | | | | -- | .054* | .256** | .034 | .049 | .119** | -.022 |
| Success with math | | | | | -- | .004 | .974** | .084** | .123** | -.062* |
| Like science | | | | | | -- | .045 | .251** | .068* | .054* |
| Success with science | | | | | | | -- | .183** | .062* | -.006 |
| Number college science classes | | | | | | | | -- | .595** | .227** |
| Number college math classes | | | | | | | | | -- | .234** |
| Age | | | | | | | | | | -- |

**Math and Science Course Performance, Preference and Perceptions.** Our second research question asked: *What are the mathematics and science course performances, preferences, and perceptions, of engineering majors?* To answer this question we examined the relationships among our participants liking for math and science, their success with math and science, what they liked about math and science, and what they did not like about math and science. Our analysis used mixed methods [21], with the ratings of how much the participants liked math and science, and their success with math and science determined quantitatively, while what they liked and disliked coming from the coding of their responses.

In Figures 1 and 2, we report the distribution of the students liking of math and success of math. An examination of the figures reveals that engineering majors tend to like math and are successful with math, with the majority answering above average for both variables.

**Rate the level of how much you like math (1 "Do Not Like" to 10 "Like Very Much")**

| Rating | Freq. |
|---|---|
| 1 | 19 |
| 2 | 17 |
| 3 | 28 |
| 4 | 33 |
| 5 | 68 |
| 6 | 81 |
| 7 | 242 |
| 8 | 381 |
| 9 | 275 |
| 10 | 193 |

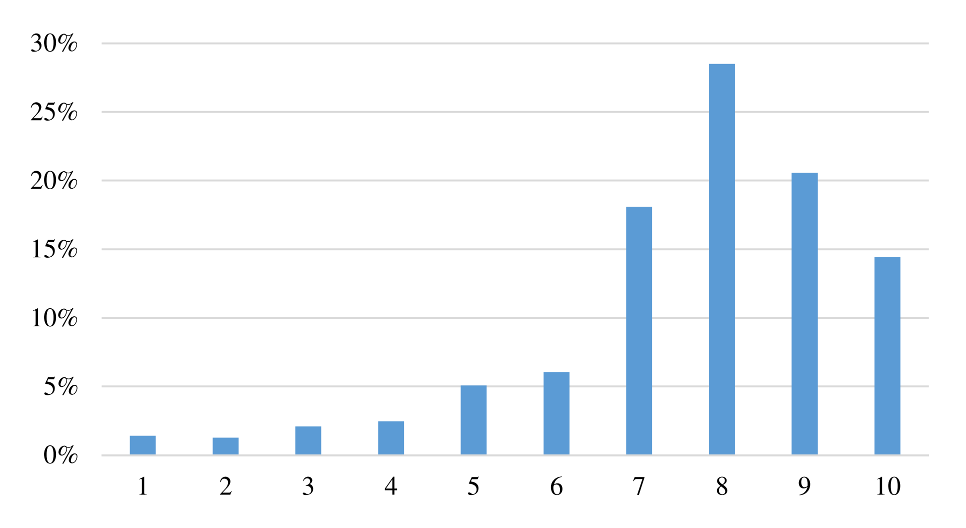


*Figure 1*. Participant ranking of *liking of math* from "1" (do not like) to "10" (like very much).

**Rate the level of success you have with math (1 "Low Success" to 10 "Very High Success")**

| Rating | Freq. |
|---|---|
| 1 | 5 |
| 2 | 9 |
| 3 | 13 |
| 4 | 26 |
| 5 | 74 |
| 6 | 78 |
| 7 | 225 |
| 8 | 373 |
| 9 | 343 |
| 10 | 191 |

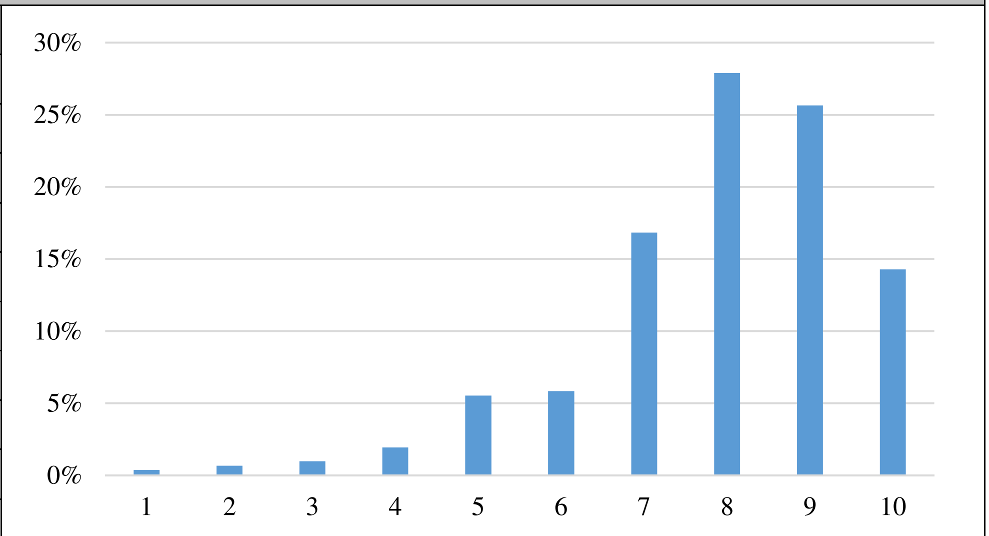


*Figure 2*. Participant ranking of success with math from "1" (low success) to "10" (very high success).

To determine what the students liked about mathematics we did a content analysis of their replies to our item asking them to share what they liked about mathematics. The responses were rather consistent, readily falling into eleven categories. Our examination of the participants' responses to what they liked about mathematics was dominated by four areas. The first area was the problem solving challenge that working with mathematics poses. The second was the logic, structure, and consistency of mathematics. The third was the possibility of definite solutions, and the fourth was the utility of mathematics for solving problems. The enjoyment, elegance, beauty was mentioned by some, but these were rare responses.

**What do you like about math?**

| Response Category | Freq. |
|---|---|
| Definite Solutions | 311 |
| Multiple Approaches | 46 |
| Problem Solving / Challenge | 461 |
| Logical Structure | 386 |
| Universal / Consistent | 130 |
| Useful Applications | 303 |
| Objective | 133 |
| Enjoyable | 173 |
| Easy | 101 |
| Elegant / Beautiful | 41 |
| Nothing | 22 |

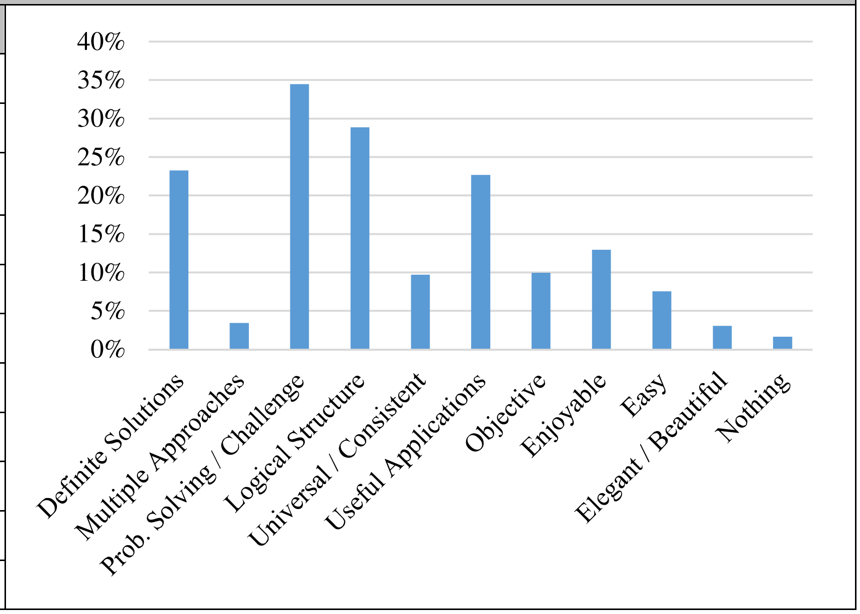


*Figure 3*. Coding outcome of what the participants like about math.

Similar to the coded responses to the item asking student to share what they liked about math, the responses for dislikes about mathematics were dominated by four groups. The first was the difficulty and complexity of mathematics, the second was the abstraction of mathematics, and third was the tedious nature of mathematics. The fourth was nothing, suggesting that many of the engineering major were ambivalent in terms of their dislike for mathematics. Other answers included poor instruction, the consumption of time associated with learning mathematics, proofs, and the lack of flexibility, again, these answers were more rare but notable responses.

**What do you dislike about math?**

| Response Category | Freq. |
|---|---|
| Proofs | 69 |
| Difficulty / Complexity | 372 |
| Abstract Concepts | 303 |
| Poor Instruction | 140 |
| Time Consuming | 117 |
| Tedious | 233 |
| Memorization | 72 |
| Unforgiving / Inflexible | 69 |
| Elitism | 9 |
| Nothing | 275 |

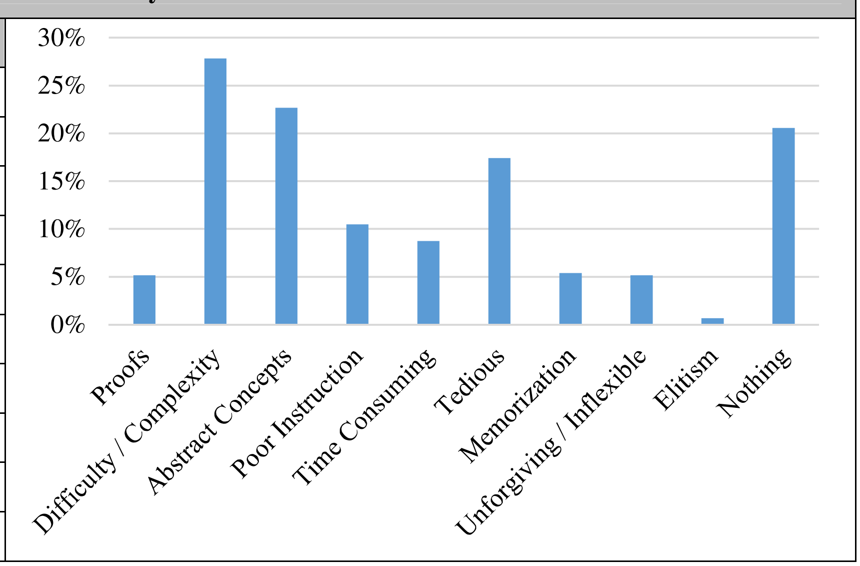


*Figure 4*. Coding outcome of what the participants dislike about math.

The participants' responses to like for science were notably more positive than mathematics, with many more responses toward the higher end of the scale (see Figure 5). However, the responses for success with science (see Figure 6) were more closely aligned with those for success with mathematics (see Figure 2).

**Rate the level of how much you like science (1 "Do Not Like" to 10 "Like Very Much")**

| Rating | Freq. |
|---|---|
| 1 | 5 |
| 2 | 3 |
| 3 | 18 |
| 4 | 16 |
| 5 | 64 |
| 6 | 84 |
| 7 | 216 |
| 8 | 308 |
| 9 | 288 |
| 10 | 335 |

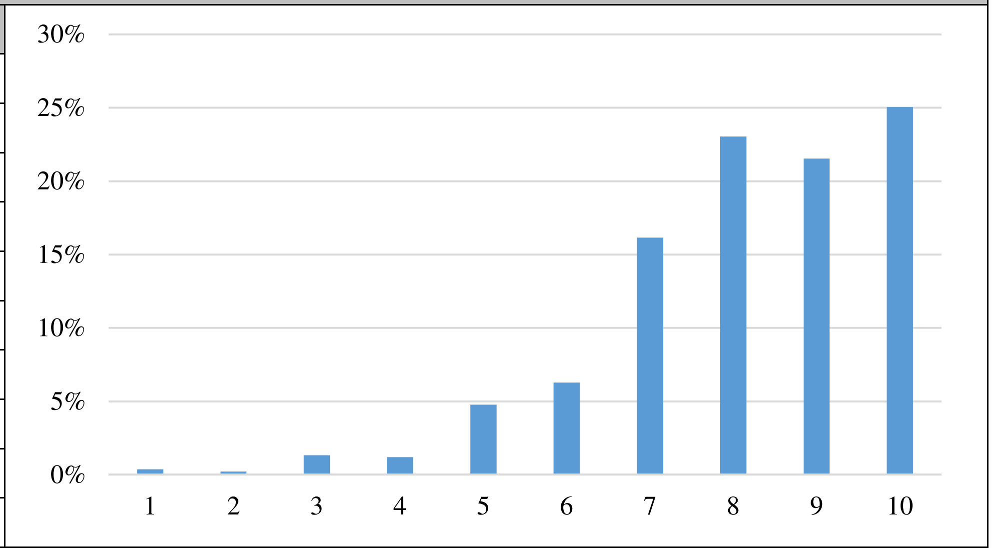


*Figure 5*. Participant ranking of *liking of science* from "1" (do not like) to "10" (like very much).

**Rate the level of success you have with science (1 "Low Success" to 10 "Very High Success")**

| Rating | Freq. |
|---|---|
| 1 | 4 |
| 2 | 3 |
| 3 | 7 |
| 4 | 18 |
| 5 | 65 |
| 6 | 109 |
| 7 | 252 |
| 8 | 402 |
| 9 | 310 |
| 10 | 167 |

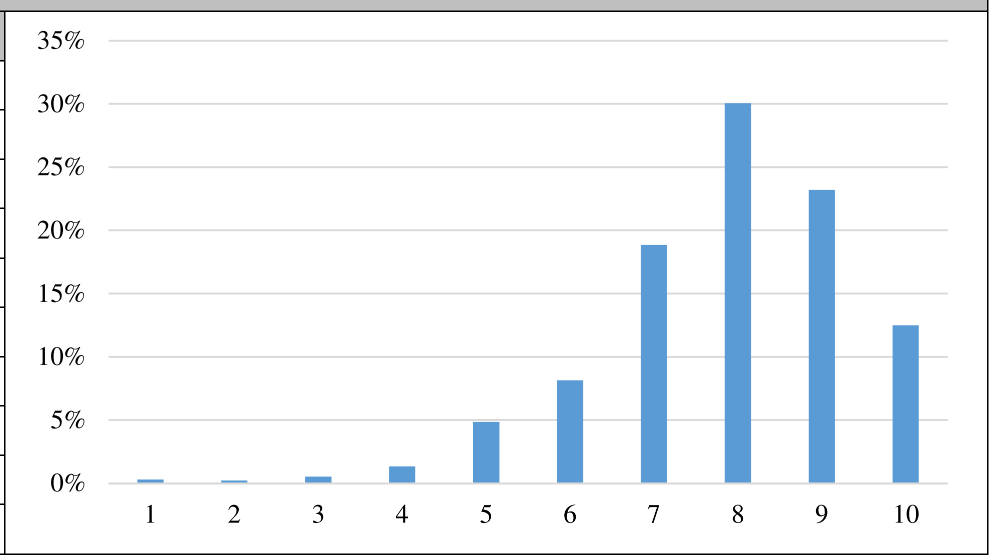


*Figure 6*. Participant ranking of success with science from "1" (low success) to "10" (very high success).

In our codings of the responses for like of science we revealed two dominate responses (see Figure 7). The first was the increased understanding that scientific discovery and research produce. The second was a more individual response related to students voicing personal interest in and aptitude for science. The ability to apply science knowledge was a distant third.

It is interesting to note that there was no significant overlap in responses to the similar item for mathematics (see Figure 3).

**What do you like about science?**

| Response Category | Freq. |
|---|---|
| Factual / Verifiable | 88 |
| Labs & Experiments | 65 |
| Problem Solving / Challenge | 94 |
| Logical Method | 90 |
| Interest / Aptitude | 415 |
| Application | 278 |
| Memorization | 6 |
| Discovery / Understanding | 769 |
| Applied Math | 96 |
| Nothing / Unsure | 17 |

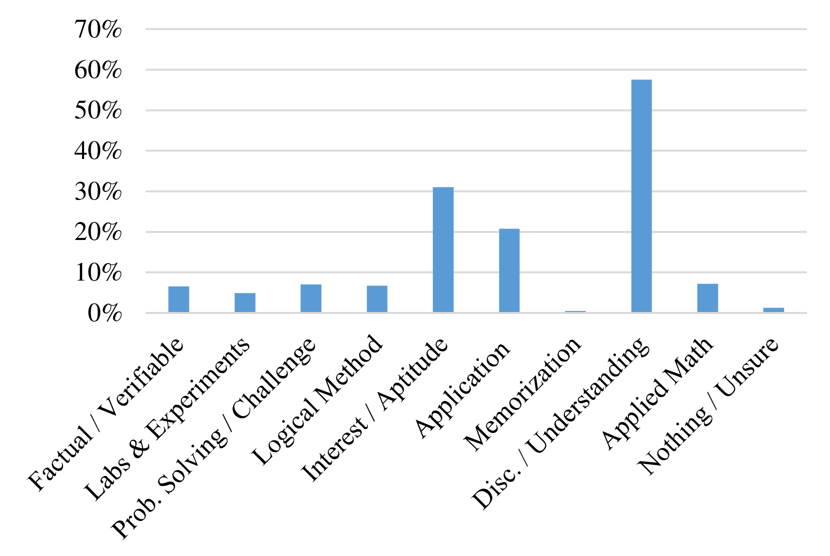


*Figure 7*. Coding outcome of what the participants like about science.

The coding of the responses to the dislike of science (see Figure 8) revealed more overlap with the similar item regarding dislike of mathematics (see Figure 4). Again, "nothing" was a dominant answer, as was the complexity and difficulty of the subjects. Parallel to the answers for mathematics were responses such as memorization, and the tedious nature of the work. Also for the dislike of science there was a greater diversity of responses than the dislike of mathematics indicating that although the students tended to dislike science less than mathematics, those who did had a wider range of reasons for their dislike of science.

**What do you dislike about science?**

| Response Category | Freq. |
|---|---|
| Uninteresting Topics | 131 |
| Complexity / Difficulty | 322 |
| Calculations | 43 |
| Memorization | 139 |
| Uncertainty / Change | 63 |
| Poor Instruction | 91 |
| Tedious Work | 153 |
| Abstract / Inapplicable | 124 |
| Subjective / Controversial | 46 |
| Elitism | 34 |
| Nothing / Unsure | 459 |

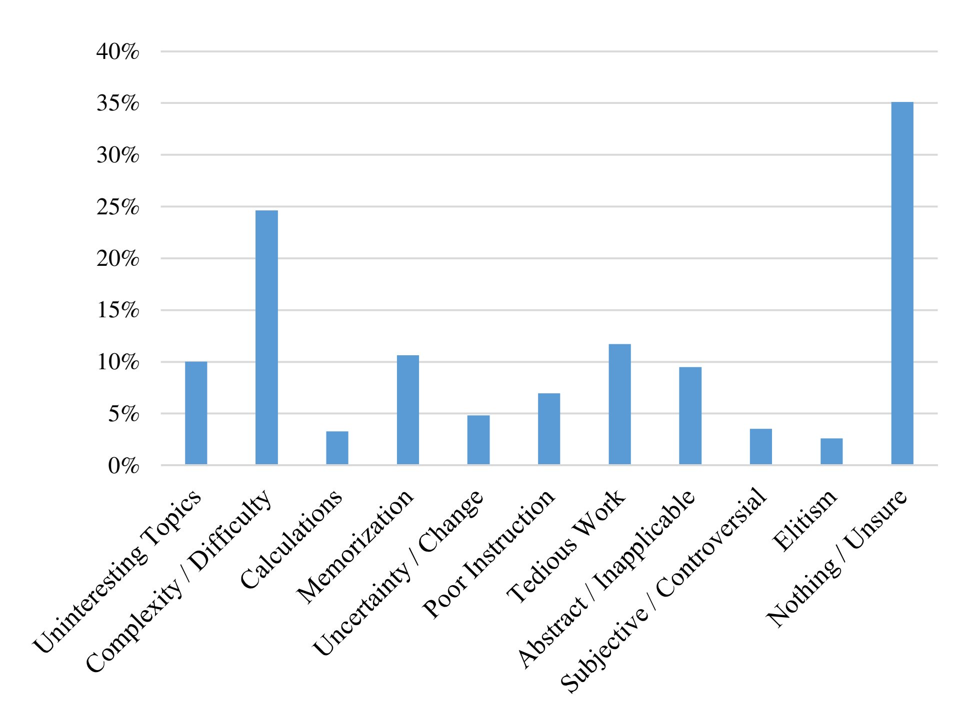


*Figure 8*. Coding outcome of what the participants dislike about science

**Influence**. Our third research question asked: *What influenced the participants' choice of engineering as a major?* To answer this question we examined and coded the answers to the items which asked the students to share why they wanted to be an engineer, the greatest influence on their decision to be an engineer, if they knew an engineer outside of school, and if they had participated in an extracurricular engineering related activity such as a robotics club.

Our coding of the item asking the participants why they wanted to be an engineer revealed four dominant answers (see Figure 9). The greatest number of responses were associated with problem solving, the next were responses associated liking mathematics and science, the third was compensation and pay, and the fourth was a desire to help people. Family and other social structures and an array of other responses were shared by a minority of the participants.

| What makes you want to be an engineer? |
|---|

| Response Category | Freq. |
|---|---|
| Money | 778 |
| Helping People | 609 |
| Problem Solving | 1053 |
| Math / Science | 984 |
| Family Recommendation | 275 |
| Social Influence | 130 |
| Career Motivation | 45 |
| Creation/ Innovation | 52 |
| Interest / Aptitude | 82 |
| Don't Want To | 6 |

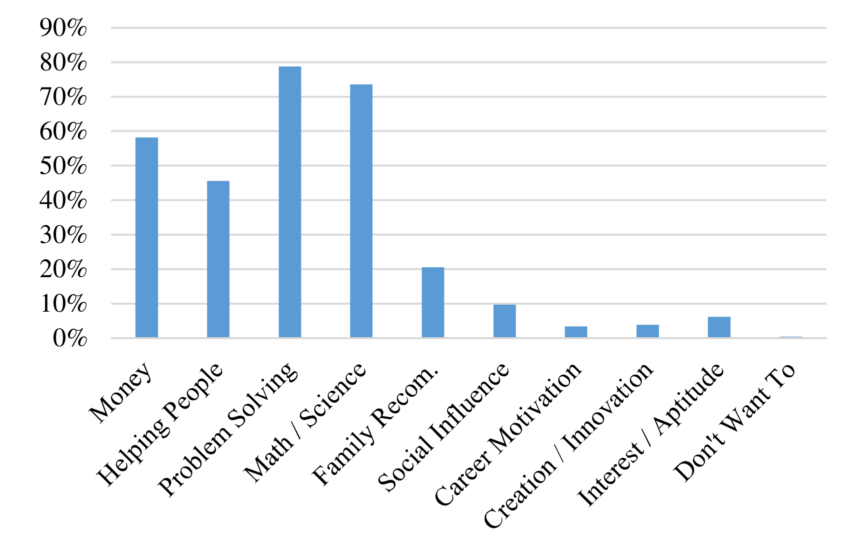


*Figure 9.* Coded participants' responses to why they want to be engineers.

We next examined and coded the participants' responses to the single biggest influence on becoming and engineer. Our results revealed three dominant sources of influence with family being the largest, followed by self, and then by teachers (see Figure 10). There were an array of other answers, but individuals or groups of people were by far the most common response in terms of influence to become an engineer. Related to this finding is the 83% of our participants who know an engineer outside of school, most of who were identified as relatives or community members.

| What is the single biggest influence to become an engineer? |
|---|

| Response Category | Freq. |
|---|---|
| Parents | 494 |
| Teacher | 206 |
| School Councilor | 35 |
| Friend | 72 |
| Brother/Sister | 46 |
| Other Relative | 73 |
| Community Member | 43 |
| Interest/Fulfillment | 233 |
| Aptitude | 10 |
| Career Motivation | 31 |
| Cultural Motivation | 27 |
| Social Responsibility | 10 |
| Prior Exposure / Experience | 44 |
| Unsure / None | 12 |

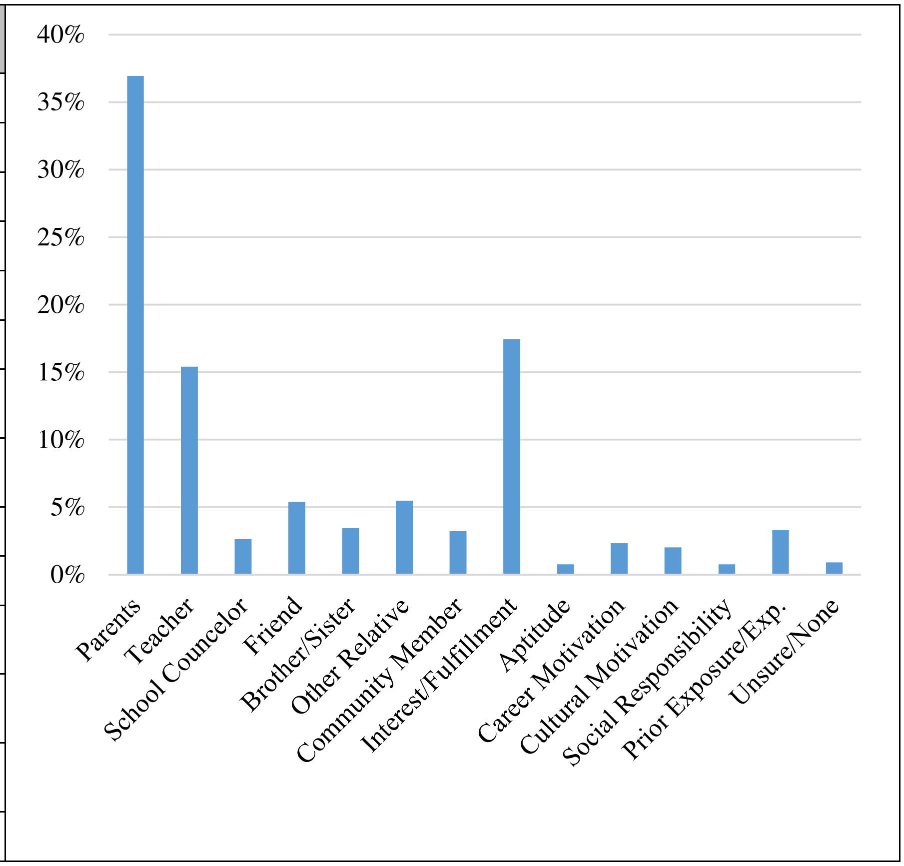


*Figure 10.* The participants' coded responses to the greatest influence on their career choice as an engineer

The examination of the responses to our selected item asking the participants if they had engaged in an engineering focused extracurricular activity revealed over half had not attended related offerings (see Figure 11). Of those who had they selected some of the more popular national/international programs such as FIRST Robotics, Science Olympiad, and Future City. However, job shadowing or internships were selected by over 15% of the participants.

| Have you ever attended an engineering camp, competition, or other event that enhanced your interest in engineering? | |
|---|---|
| **Response Category** | **Freq.** |
| Discover Engineering Day | 69 |
| e-Camp | 17 |
| TEAMS Competition | 18 |
| Science Olympiad | 106 |
| Future City Competition | 12 |
| First Robotics | 117 |
| Internship / Job Shadow | 231 |
| None | 713 |
| Girl's STEM Program | 35 |
| Other STEM Program | 181 |

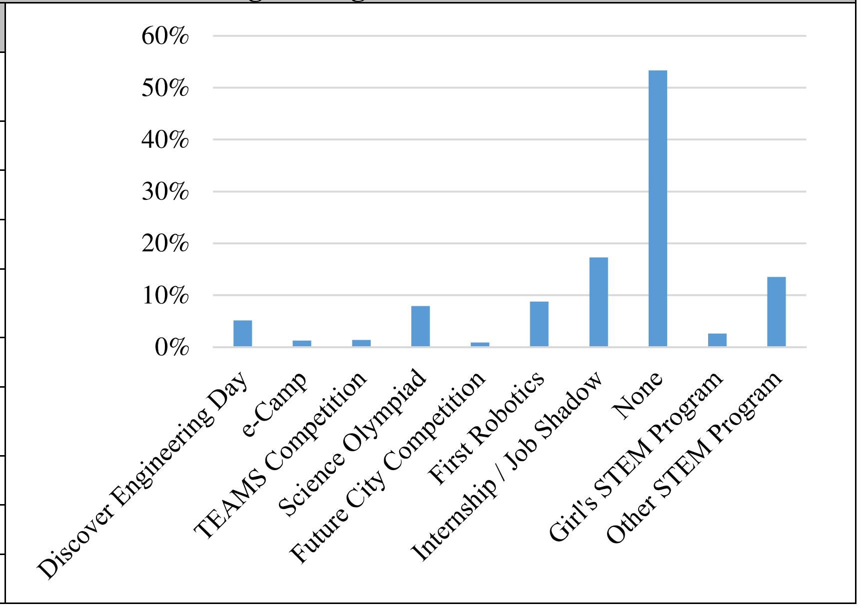


*Figure 11*. The participants' engaging in engineering related extracurricular activities.

Our final item asked the participants to share how engaging in the research impacted their interest in being an engineer. Many did not answer the question. However, for those that did the answers were very consistent in that it affirmed what they had already decided.

## Discussion

We set out to determine why students elect to become engineering majors and pursue a career in engineering. Our research was motivated by the desire of K-12 students to become engineers while not wanting a job that applies math and science. The dearth of current research on why people become engineers has challenged us in our efforts; as there is a shifting landscape in the characteristics of engineers that is not consistent with historical stereotypes [13, 14, 17]. This is leading to the development of new paradigms and ideas about influences on engineering majors, and the associated potential proxies need to be considered [11].

In our research we found some apparent relationships between mathematics and science abilities, engagement, and success of engineering students. Taking the work of Cech et al. [10] into consideration we posit that the science and math aptitude are critical considerations for why students consider engineering as a degree program and as career. The positive relationships can be important indicators for the development of confidence and self-efficacy in relation to learning and applying science and mathematics, conditions that are key to the success of STEM professionals [11, 12].

We were intrigued by the weak correlations between the students' liking of math or science and their corresponding perceptions of their levels of success within the domains. The weak correlations may suggest that the students' confidence and efficacy is tenuous and could easily take a downward shift given the wrong learning environments or interactions. The examination of the longitudinal ramifications of those engineering majors who hold disparate views of their liking for math or science and their success in the domains is an excellent direction for future research.

We next examined what the participants liked and did not like about science and math. Our results revealed the utility of knowledge, explanatory power associated with application of knowledge, and the challenge of mastering the information as major reasons that participants tended to like each domain. It is apparent from these reasons, and the reasons that the participants disliked the domains, that the students were considering math and science knowledge necessary to be effective as engineers. They were not considering math and science as engaging bodies of knowledge that were unique, inspiring, or fulfilling to learn for the sake of learning. The importance of these findings is the potential to assure engineering students learn math and science in the context of engineering so that they may develop success in the subjects, but also develop images of themselves as being engineers. We maintain that achievement in engineering requires students to view themselves as having the ability to successfully solve engineering problems, most of which include the applications of math and science. Thus, appreciation of (and success in) math and science is likely to influence students' images of themselves as engineers, and determine both why they choose to become engineers and their persistence as engineers.

The findings in the third area of our research were related to the work of Fadigan and Hammrich[4], who reported that knowing someone who is an engineer or working on engineering like activities are influential on a student's choice to become an engineer. Our research revealed similar data, with evidence that suggests personal interaction with an engineer is highly influential on a student's choice to pursue a degree or career in engineering. Further, activities that allow students to explore the work of engineers may help them develop a deeper understanding of the work of engineers, a condition that has not traditionally taken place [19]. Thus, mentoring, internships, extracurricular activities, and connecting personally with an engineer are likely to be highly influential on students' choice of a career in engineering.

The results of our question asking students why they wanted to be an engineer was different than we had anticipated. We expected money to be at the top of the list followed by status. However, our results indicated that desire to problem solve, enjoyment of math and science, and wanting to help people, in addition to money, were top reasons students choose to consider careers in engineering. Our findings are aligned with the work of Robbins [17] who reports on the shift in the focus of engineering toward a more reflective perspective, in which engineers are socially engaged, community minded, and conscientious about the cultural and economic influences on society and the role engineers can play in making the world a better place. Thus, we have likely gathered data that is representative of the shift in the stereotype of engineers. The shift in stereotypes suggests that additional skills beyond being good in math and science need to be considered and attended to far before students enter the university. As Schoon and colleagues share [7] student consideration of STEM careers starts early in their education; therefore, students need to be exposed to conditions that require them to apply both technical and social skills so that they may develop progressive engineering habits of mind that will increase the likelihood of their success as engineering professionals.

## Limitations

The first limitation of our research is associated with the nature of survey research. Survey research relies of the self-reporting of conditions or circumstances that may not be consistent with the actual situations. Interviewing students about their perceptions, preferences, experiences, and performances may result in a deeper understanding of why they became engineering majors, and the associated influences. However, we maintain that our large sample size (over 1300 students from five institutions in different locations in the United States) likely produced data highly representative of engineering majors.

The second limitation of our study is associated with our coding and subsequent interpretation of our participants' responses. Although we were simply conducting a content analysis of the responses, we could have misinterpreted what the students were trying to share. Again, interviews or focus groups may bring clarity to the thoughts, experiences, and perspectives of the students. However, we again maintain that our large and diverse sample provided us with data representative of the perspectives of engineering majors and our interpretation of those perspectives produced accurate representations of engineering students.

## Conclusions

Motivated by the paradox that K-12 students indicate that they like math and science and want to become engineers, but at the same time don't want a job that applies math and science, we set out to study why students become engineers. We found shifts in the traditional stereotype of engineering, reaffirmed the complex and yet predictable relationship to achievement in math and science, and identified the powerful influence of personal contact with an engineer on a student's decision to become and engineer themselves. We have addressed the dearth of research on this topic while exposing new and important directions for future study. As the demand for and evolution of engineering continues, it is important that we engage in ongoing research to determine the influences, perspectives, and preferences of students choosing to pursue degrees and careers in engineering.

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APPENDIX

## Demographics

1. What university are you attending?

Please specify ______

2 Please enter your AGE: ______

3 Gender:

| Female | Male |
|---|---|
| ☐ | ☐ |

4 Ethnicity:

- ☐ African American
- ☐ Native American
- ☐ Asian
- ☐ Latino/a
- ☐ Caucasian
- ☐ Other, please specify ______

5 Description of type of community of the primary location you grew up:

- ☐ Rural
- ☐ Suburban
- ☐ Urban

6 What year in college are you?

- ☐ Freshman
- ☐ Sophomore
- ☐ Junior
- ☐ Senior

7 Number of years of college education

| **1** | **2** | **3** | **4** | **5** | **6+** |
|---|---|---|---|---|---|

8 When do you plan to graduate?

- ☐ 2014
- ☐ 2015

☐ 2016

☐ 2017

☐ 2018

9 Engineering major:

Please specify

10 Number of credits you are currently taking

11 How many college level ***science*** classes have you taken?

**1 2 3 4 5 6 7 8 9 10+**

12 How many college level ***mathematics*** classes have you taken?

**1 2 3 4 5 6 7 8 9 10+**

## Survey of Student Interest in Engineering Careers

What is the single biggest influence to become an engineer?
Parents
Teacher
School Counselor
Friend
Brother/Sister
Other relative
Community member
Other

What makes you want to be an engineer?
Money
Want to help people
Like to problem solve
Like math and science
Family recommendation
Peer influence
Other

Rate the level of how much you like math (1 “Do Not Like” to 10 “Like Very Much”)
1 2 3 4 5 6 7 8 9 10

Rate the level of success you have with math (1 “low success” to 10 “very high success”)
1 2 3 4 5 6 7 8 9 10

What do you like or not like about math?

What do you not like about math?

Rate the level of how much you like science (1 “Do Not Like” to 10 “Like Very Much”)
1 2 3 4 5 6 7 8 9 10

Rate the level of success you have with science (1 “Low Success” to 10 “Very high success”)
1 2 3 4 5 6 7 8 9 10

What do you like about science?

What do you not like about science?

Do you know someone who is an engineer (outside of school)? If yes, who?

At what age did you consider being an engineer?

Have you ever attended an engineering camp, competition, or other event that enhanced your interest in engineering?
Discover Engineering Day,
e-Camp,
TEAMS competition,
Science Olympiad,
Future City Competition
FIRST Robotics
Summer Internship
Other

How did participation in this event affect your interest in becoming an engineer?