



First-year Student Assumptions on Diversity in Engineering Education

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Introduction

In engineering education, we are seeing an increasing trend towards greater diversity in the classroom. This diversity comes in a variety of forms including: age, gender, ethnicity, and other social identities, and extends to both the student and instructor population at many North American universities. Though there is much work in investigating the features of diverse learning environments, there is limited work in the area that bridges student assumptions in first-year engineering and diversity in the classroom. The need to investigate this area becomes increasingly important as instructors try to design and understand strategies for creating inclusive learning environments.

Fostering an inclusive learning environment is a goal of engineering educators, especially at the first-year level. First, research has shown that feeling a sense of belonging is an essential component to retention. According to a recent White House report, students leaving science, technology, engineering and mathematics (STEM) cite an uninviting atmosphere along with lack of topic relevance as top reasons for leaving the field.¹ This may be addressed by acknowledging this deterrent and putting forth intentional efforts to create a culturally-relevant and inclusive climate for all students.

Second, as students enter university, they bring with them a wealth of learning and experience that may reflect their diverse backgrounds. Similarly, faculty may also bring new knowledge into their role as instructors, often borne from their international experiences. With the potential for so many differences in knowledge and perspective, the prospect for learning barriers to affect the inclusivity of classroom instruction is high. Accordingly, the richness of perspectives may be lost if effective efforts are not made to create a safe environment with a sense of belonging and collective ownership.²

As a first step toward investigating the effects of diversity on the interface between students, instructors and the learning environment, a group of instructors at Northeastern University in Boston, Massachusetts, initiated a study that attempts to acquire student assumptions.

The larger goal of the research is to create an up-to-date resource for engineering educators of first-year students, which outlines some of the assumptions on diversity that first-year students have. This resource will contain anonymized student input as well as a contrast to what the existing literature states about student assumptions on diversity – the intent is to use this as a starting point for more in-depth investigations on ways in which a first-year engineering classroom can be made more universally accessible by all students.

The specific research questions are:

- What prior assumptions do students have of diversity in the engineering classroom as they start their first-year engineering program?
 - What assumptions do students have about the diversity of their instructors?
 - What assumptions do students have about their peers (students)?
- Are there any connections between what students say and prior studies on student assumptions in engineering education, and if so, what are they?
- What are some of the general themes that students identify with diversity in engineering education?

Our goal is to create a starting point for research that identifies the assumptions and stereotypes that engineering students have as they enter first-year engineering, and as they move on to the second-year. We hope that by detecting preconceived notions, we can create a body of knowledge that may assist educators as they design more inclusive learning environments. The value of this research is that it provides a starting point for further studies in attempting to identify, characterize, and mitigate learning barriers in STEM education for an increasingly diverse learning population. This includes beginning to understand interactions between and among students and instructors of diverse backgrounds.

This database will NOT contain student names or any other information that can identify the student. This database will contain self-reported student responses to questions that probe for any assumptions on diversity in the first-year engineering curriculum. It will be a repository of opinions on diverse learning environments, as authored by first-year engineering students. Specifically, an online questionnaire asks students – anonymously – about their pre-conceived assumptions as they entered first-year engineering at Northeastern University. These questions attempt to uncover what first-year students had thought about with respect to what they thought their professor would be like, what they would look like, how diverse their classroom would be, etc. This data is collected in addition to non-specific demographic information, which is used to broadly connect common misconceptions to background at a future date.

Background

Diversity levels in STEM have been and are currently being reported, monitored, and addressed extensively.^{1,2,10-12} The research outlined in this paper addresses the attendant component of this condition, namely *perception*. We also seek to examine the degree to which these perceptions are (1) precursors for or (2) outcomes of the ongoing diversity conditions, both challenges and successes.

There are multiple and varied definitions of the terms *diversity* and *inclusion (D/I)*. For specific consideration in educational settings, several factors have been outlined here. This is to create an environment in which students of all races and national origins, ethnic and cultural backgrounds, ages, religious affiliations, sexual orientations, gender identities, political beliefs, physical abilities or qualities, and social identities (diversity) have comparable opportunities to achieve,

excel, and feel an ongoing sense of membership and connection (inclusion) in their academic experience. The notion of diversity and associated inclusion can be extended to account for, support, and even promote variety and depth in philosophical stances, thought processes, and ethical value systems as well. These latter traits are more difficult to map to external affiliations, and at times are overlooked.

To extend the above description, *inclusion* has been further defined by one university as -

*“Involvement and empowerment, where the inherent worth and dignity of all people are recognized. An inclusive university promotes and sustains a sense of belonging; it values and practices respect for the talents, beliefs, backgrounds, and ways of living of its members.”*³

Adding to this concept of availing opportunity is the recognition that biases and stereotypes can effectively hold students back. Expanding inclusion: “Our vision is one where all [students] are free from oppression and are provided equal access to resources to realize their full potential”.⁴ This is true whether the source of oppression is real or perceived internally.

An inclusive classroom environment can help develop a supportive environment for students. In an educational commentary entitled “Why Students Leave STEM” author Ramirez notes, that -

*“Harvey Mudd College in Claremont, California is showing that it is indeed possible to create a positive culture that increases diversity.... The college president, Marie Klawe, is a woman computer scientist who knows how to make the environment more hospitable.”*⁵

One barrier that Harvey Mudd College works hard to demolish is the ‘impostor’ syndrome -

*“Not seeing one's own reflection in teachers or other students makes one feel as if s[he] doesn't belong. The need for role models to help overcome the ‘impostor’ syndrome cannot be emphasized enough.”*⁵

Ramirez concludes with, “One approach to address the leaks [in the STEM pipeline] is more mentoring, and by tuning the culture so that students don't feel excluded”. This is essential to the broader discussion of diversity and inclusion in the classroom by associating with accessibility and student support. Specifically, the work in this area suggests that inclusive environments promoting diversity can lead to greater access to learning.

Learning environments that ignore or do not discuss cultural differences of its students can negatively affect their ability to develop an inclusive environment. In a paper written by Pollock, he introduces the idea that educators should be culturally competent.⁶ He explains that knowing one's own culture plays into this concept as well. Specifically, by encouraging students to understand and speak about their cultural identities, they may bridge the gap between the educators and the other students from considerably different cultures leading to more inclusive environments. Also, an educator can encourage students to realize commonalities in their

interests and break down some of the divides that separate students from different backgrounds. By establishing an open and friendly learning environment, students can make connections and break down cultural barriers. This literature suggests that such cultural exchanges will allow for a more open-minded learning environment that enables students to become more culturally competent.

Sonia Nieto, one of the leading authors and teachers in the field of multiculturalism, explains that dominant cultures believe that they are superior to minor ones. This could lead to unfair classroom environment where students of certain cultures are perceived to be superior to other students of other cultures.⁷ This divide is now affecting our classrooms as the amount of students from other countries and cultures is increasing. This has increased the amount of deficient thinking in our classrooms, meaning students who have not grown up in America are considered less smart because they may speak and act differently. As educators, we need to break this cycle and stop feeding into the idea that since these students are different they are treated differently.

Paulo Freire reinforces this idea by explaining that there is a need to treat each student the same, no matter their background. This is also seen as a need to realize that each student comes from a different background, has gone through different experiences, and they all come in with a different amount of knowledge in a multitude of different areas.⁸ We first need to find out what knowledge the students come into our classrooms with and then we need to utilize this information in order to help them expand and build on that knowledge. This will require individualized learning about our students' background.⁸ This will allow for a more inclusive classroom where students understand other student's cultures and backgrounds and allow for students to overcome learning barriers that may occur from insufficient knowledge of others' cultures.

Methodology

The notion of endorsing and promoting diversity and inclusion is commendable; it is strongly fostered at Northeastern University and countless others. As recently as 2012, it was noted in a STEM-focused publication entitled *Literature Overview: Diversity, Inclusion, and Cultural Awareness for Classroom and Outreach Education*⁹ that "Although the education system is becoming more diverse, students who come from stigmatized groups (e.g., groups that are the target of negative stereotypes, prejudice, and discrimination) still perceive barriers to education."

Recognizing that existing D/I barriers originate from a variety of influences, the work in this paper sought to benchmark and characterize the perspectives of our incoming first-year engineering students. The findings from this inquiry will help formulate and/or strengthen strategies to offset and overcome unfounded biases that students may hold as well as reinforce and build on diversity-forward perspectives they do possess.

Two surveys were administered to a pool of over 600 students that are in a first-year engineering course; one at the beginning of the Fall semester during the first week of class, and another at the

conclusion of that same semester. Not all course sections participated and in the end there were 10 sections and approximately 300 students given the first survey. There were approximately 1/3 fewer students taking the second survey, due to logistical issues at the end of term. Both surveys were administered online, and most participants were given an opportunity to take the survey in class. Accordingly, some may have taken it outside of class. The first survey was intended to be administered very early in the semester, even before they had formed any impressions, but since it was not possible to survey them before they started class, they were instructed that on some questions, think back to before they came, and consider what they had expected. An example is asking about their expectation on instructor. Since they had met us when they took the survey, they had to harken back to before that time.

The questions themselves on all surveys were discussed beforehand among all of the authors in order to ascertain which questions would focus most clearly on our research goals. The demographic questions were also carefully designed, with one of the authors having worked in a diversity grant office assisting with current choices for categories and descriptors. All authors agreed on the questions, in terms of which were needed and how to ask them. The surveys are located in the appendix.

Institutional Ethics Review Board (IRB) approval was obtained to conduct the surveys. The surveys and the research objectives were presented to and reviewed by the IRB. The surveys are anonymous and not linked to any of the student data. It is used in the aggregate, with individual comments and open-ended responses. The data is not associated with any of the specific instructors. The directors of the First-year Engineering Program provided approval for the surveys and supported the IRB.

Between the pre and post surveys, the students went through a first-year engineering design course. This course was taught by the authors of this paper, who are a group of very diverse engineering professors (age, gender, culture, backgrounds, etc.). As part of the learning experience, the courses incorporate active learning, teamwork, discussion, debates, and also have several complex design/prototype exercises. There are two major projects, for which teams must use the design process to plan and build working machines based on engineering principles, with particular attention to critical thinking. In general, the first-year curriculum is one very involved diverse learning experience for all.

Once the data collection was completed, the results were compiled and stratified in some cases, by demographic information, by gender and other strata to identify patterns that may emerge along those factors. Likert-scale comparisons in such cases were managed by a comparison of the central measures and data variability, accounting for the ordinal scale of the data pool.

The qualitative data were manually binned into categories that emerged as the responses were tallied.¹³ Each of the student responses were individually sorted into groups based on how frequently they occurred, and this frequency helped develop the charts seen in the results section.¹⁴

Results/Observations

The first step taken was a pre-survey of first-year students in most sections of the initial design course (n = 374). Students completed the survey the first week of the semester (Appendix A) that focused on their perception of engineering professors and student population, gender, confidence in persistence in engineering as well as questions relating to engineering family members and birth location. The second survey (n = 204, Appendix B) was given at the end of the course, with similar questions to reveal whether there had been any shift in perceptions about what to expect in future courses, what they have experienced in terms of diversity as well as an opportunity to suggest ways to enhance diversity. For the open-ended content analysis, a single researcher first looked at all of the responses in order to delineate the categories of responses that students give when asked to reflect on a question. Further content analysis was then performed to tally occurrences.

Perceptions on Faculty

Response analysis of the open-ended survey questions revealed some interesting patterns. The results of the first question *“Go back to when you were unpacking on move in day. What did you envision your first-year engineering professor to be like?”* are shown in Figure 1. Of the 374 students who responded with a selection of gender, 69% were male and approximately 30% were female, indicating that the ratio of male responses to female responses is 2.3 to 1. Percent responses are broken out in terms of gender and the total response of all students is the sum. Categories that arise the most from the responses are keyed with the words “Old or Older”, “Educated or Smart”, “White Male”, “No Expectation”, “Foreign”, “Female”, “Strict or Challenging”, and finally the stereotypical “Boring or Weird or Nerdy”.

Go back to when you were unpacking on move-in day. What did you envision your first-year engineering professor to be like?

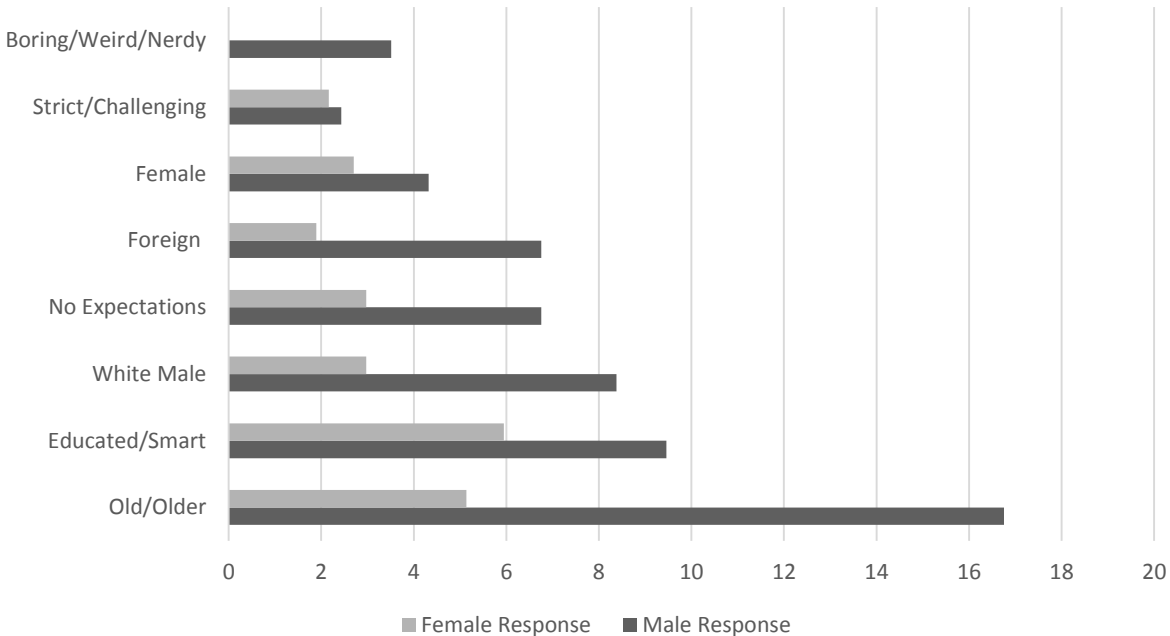


Figure 1. Percent response of students to perceptions of their first-year professor

The results show that the students expected an old, white male, well-educated. The largest response is with 22% of the students reporting “Old” broken out with 17% of the response being from our male students and 5% from the female students. These students, who are just out of high school, might be forming this perception based on a typical stereotype of a professor being someone with experience and that comes with age. The second highest overall response of 15.5% was “Educated or Smart”. Some of the comments mention a Ph.D. or Master’s degree required, needs to be intelligent or is smart. In identifying with believing their Professors would be “Caucasian or White” the total response rate was 11%, with not much difference in gender in this category: the students almost-always associated this with being “male”. A sampling of comments confirm these responses:

- “I imagined my professor as an old man with white hair and glasses.”*
- “I would have guessed my professor would be a white male between age 40 and 70.”*
- “Education-wise, I anticipated having a teacher with a Masters or Doctorate.”*
- “I thought it would most likely be white male, most likely a Ph.D., and all around smart.”*
- “Caucasian, male, glasses, introverted but well educated.”*

Approximately 9% of the overall responses indicated that they expected a “Foreign” Professor. Roughly 7% of all responders mentioned “Female” in their response. Neither gender had a high expectation that their faculty would be female.

“Foreign male with a heavy accent and a PhD...”
“I thought my professor would be an Asian man...”
“I expected my teachers to be female with PhDs and American.”

One category was related to typical stereotypes of an engineering professor such as “Boring, Weird, or Nerdy”. We can happily report that our students listed this category at less than a 4% response rate. There were no female responses in this category, maybe males did not take this survey with the same seriousness as our female students.

A surprising result is that less than 5% of all respondents indicated that they envisioned their professor to be “Strict or Challenging”. A possible reason for this is that our students are typically at the top of their class and may not have been challenged in high school –presuming that this trend would continue. Some comments were *“I imagined he/she would be strict and straightforward”* and *“Someone who would challenge me and get me to think harder.”* Only 10% of students mentioned that they had no expectations of what the profile of their professors might look like, with no gender differences, *“I honestly didn't think too much about it.”*

The post-survey follow-up question *“After completing this semester, what do you envision your future engineering professors to be like?”* results are shown in Figure 2. Of the 204 students who responded with a selection of gender, 70% were male and approximately 27% were female indicating that the ratio of male responses to female responses is 2.7 to 1. Categories that arise from the responses are keyed with the words “Enthusiastic, Helpful or Passionate”, “Educated or Smart”, “Mention of Age” such as middle aged, old or young, “Strict, Challenging or Demanding”, “Mention of Gender”, “Mention of Race” and finally the typical engineering stereotypes such as weird, nerdy, and others categorized under “Engineering Stereotypes”.

Our students have clearly refocused their perception that a university professor is someone who is “old” as now ~30% of all responses mention that they now expect their professor to be helpful, caring, enthusiastic, and passionate or motivated to teach – instead of just “old”. Possible reasons for this change is due to a dedicated team of first-year instructors who are making a difference in changing the perception of these students moving forward. Some of the commentary was:

“I think my professors will be enthusiastic and helpful as well as intelligent.”
“Excited about the field of engineering, helpful whenever possible, challenges students.”
“Passionate and intelligent.”

As with the pre-survey the category with the second highest overall response of 23% was “Educated or Smart”. This is an increase of 10% in the number of responses from the pre-survey. Here students again mentioned an advanced degree, needs to be intelligent or is smart, with similar comments as seen in the pre-survey.

After completing this semester, what do you envision your future engineering professors to be like?

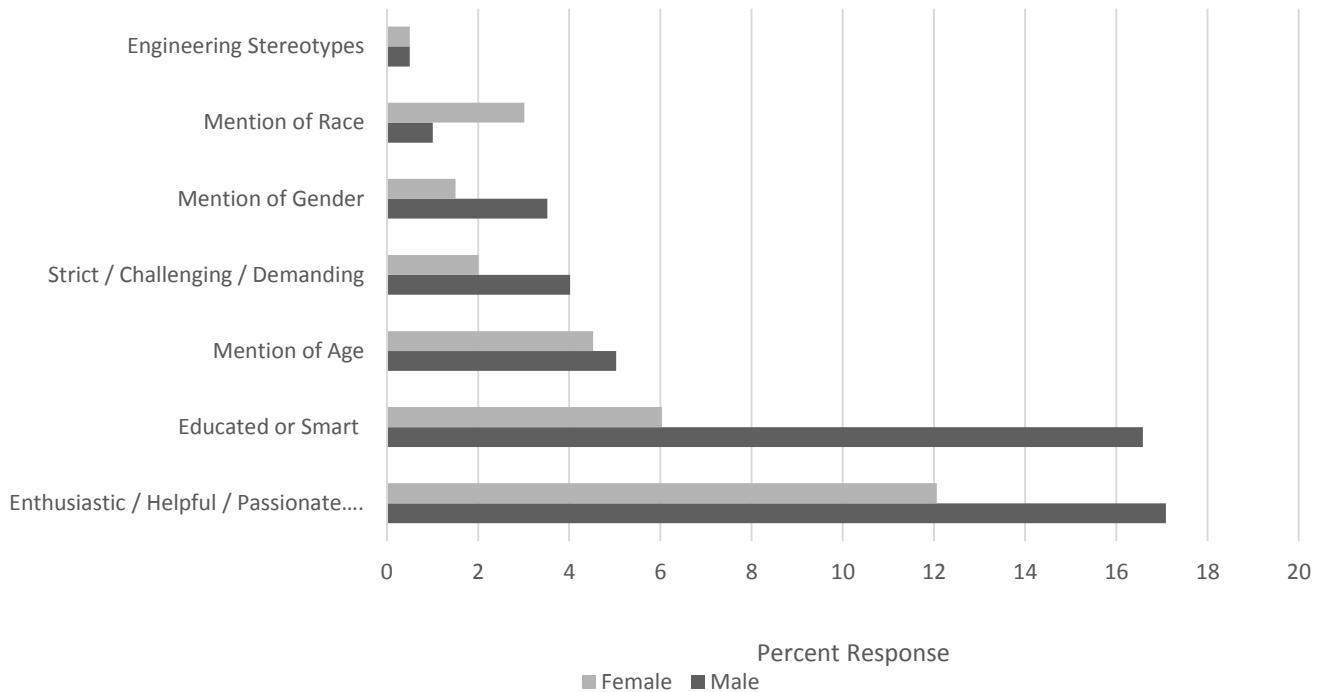


Figure 2. Post survey percent response of students to envision of their professors moving forward.

The students now only report less than 10% of the time any mention of age such as “young”, “middle age” or “old”. This is a striking result because in the pre-survey the preconceived notion was that their professors would be “Old” as reported in 22% of the respondents.

When comparing the pre and post surveys for “Strict or Challenging” the students did not change their opinion. The post-survey result is ~ 5%. Any mention of gender or race in all of the results were both at ~5% as our students now seem to be more in-tune with the possibility of experiencing a diverse faculty. Finally while 3.5% of the males expressed a typical engineering stereotype in the pre-survey less than .5% have now made mention of one. Their opinions have certainly changed after experiencing our first-year faculty.

The instructors of the first-year courses on which this part of the survey is based come from a variety of backgrounds and ages – the demographics of this group range from recent Ph.D. graduates to senior members who have been teaching for over 25 years. The ethnicities of the instructors vary significantly as well, as do the disciplines of engineering that they represent.

Perceptions on Students

The results of the third question *“As you begin first-year, what do you envision your engineering class student population to be like?”* were compiled into theme areas, and most-occurring keywords from each area are shown in Figure 3. The horizontal axis show some of these keywords, with the asterisks representing root-words. For example, “educat*” could refer to “education”, “educate”, and “educated”, etc. The data shown in this figure represent the most frequently occurring words from the student responses. The data here were collected from the same survey as the question presented in Figure 1.

Figure 3 shows that the students envisioned their first year class student population as being male students, either white or of Asian descent, highly-educated, smart, and quite “nerdy”. These characteristics were most commonly occurring and do not represent a comprehensive synopsis of what students think their class population ought to be like – it is a snapshot of words that students use to describe what they think they will see in the classroom. Of the terms mentioned, the word “Male” is used about 40% more frequently as the next highest-used term, “Asia*” or “white”. This shows that the students overwhelmingly believe that their engineering student population will be predominantly male. Similarly, the students do not imagine their first-year student population to be much culturally diverse, other than being white or Asian; though they mention the root word “diver”, the permutations of that word are not used to describe other ethnic groups. In addition, students believe that their classmates are educated, smart, and are of high academic standing. Though, the frequency of occurrence of these keywords are roughly 25% lower than the words used to describe ethnic background.

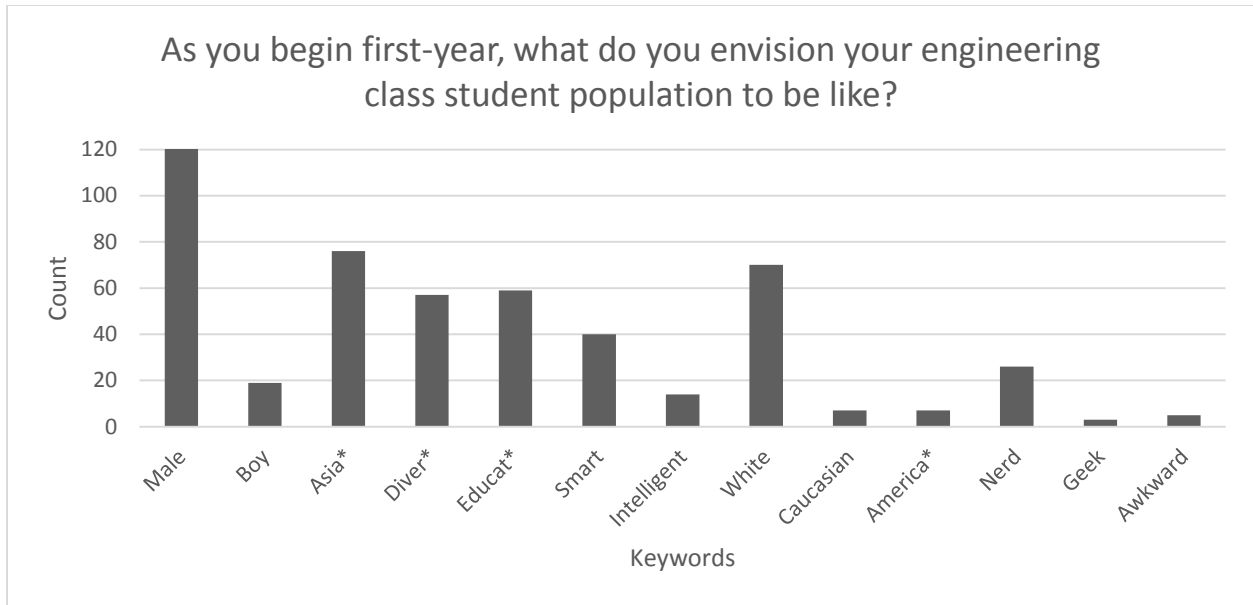


Figure 3. Count of keywords used to describe first-year engineering class (surveyed at start of term) – the “*” represents root words that were mentioned but ones that could have different lexical understandings (e.g. Asiatic vs Asian)

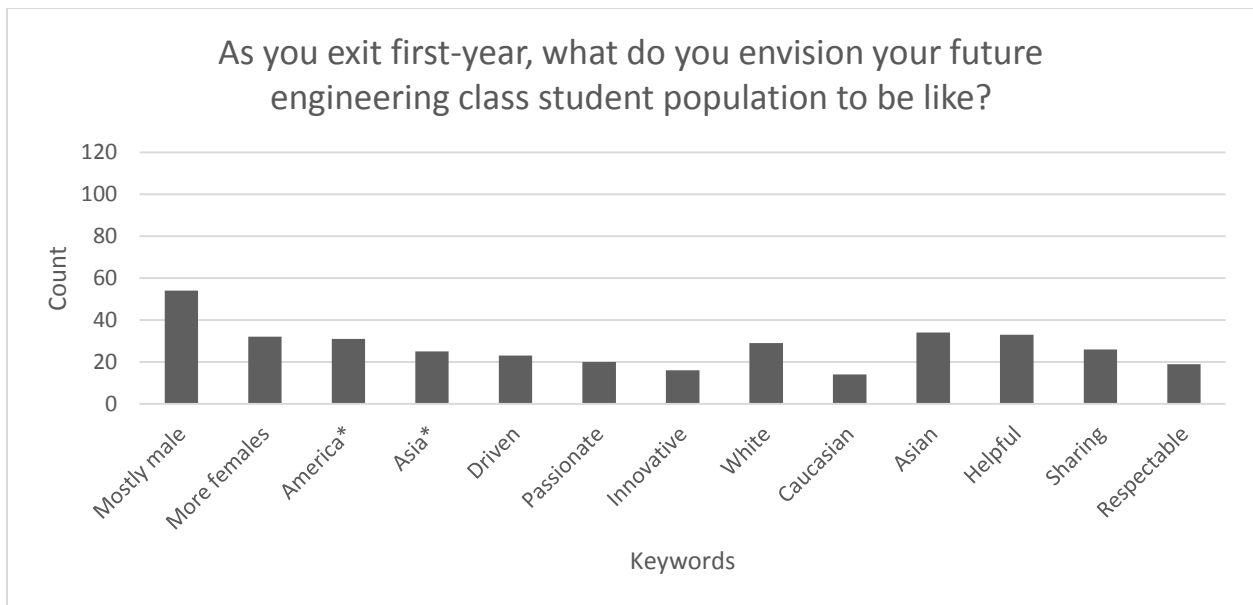


Figure 4. Count of keywords used to describe future engineering classes (surveyed at end of term)

The results of the fourth question “As you exit first-year, what do you envision your future engineering class student population to be like?” are shown in Figure 4. This question was posed to the students as they exited the first year engineering program, and was intended to generate keywords that students used to describe what their future engineering student colleagues in second-year (and other) classes would look like. Categories that arise from the responses are keyed with the words “Mostly Male”, “America”, “Helpful”, “white”, “sharing”, “driven”, “respectable”, and several others. A number of responses included mentioning that students foresee their classes having far more female students than they thought initially.

Figure 4 shows that students predict their future engineering classes to continue to be mostly male, albeit with a greater female student population, even though their responses on culture are not significantly different. The number of keywords about “America*” and “Asian*” are still higher than other cultural and ethnic descriptors (“European”, “African-American”, etc). As such, the data shows that though student’s perspectives on the cultural make-up of their classes do not change significantly between Figure 3 and Figure 4, they do feel that future engineering classes will have more female students.

The student’s responses also suggest that their peers are more helpful, respectable, passionate, and innovative than they had originally assumed. When starting first-year, students generally thought that their peers would be “smart” and “nerdy”. However, the vocabulary used to describe attitude has shifted to “driven”, “helpful”, etc – and, this shows that students are beginning to perceive their colleagues as perhaps friendlier than they had originally thought.

The data presented in Figure 3 and 4 show that student assumptions about their peers have shifted. They initially thought that their engineering class would be almost entirely male-dominated with either American or Asian students, all quite “nerdy”, to one that has more female students, one that is more helpful and innovative, but yet still quite ethnically-limited.

Perceptions on Engineering in General

The results to the question “*Why did you pick engineering as your major?*” are shown in Figure 5. Categories that arise from the responses are keyed with the words “Science or Math”, “Problem Solving”, “Change the World”, “Was Encouraged”, “Creative or Hands on”, “Stability or Money”, “Fun or Interesting”, and “Be Challenged”.

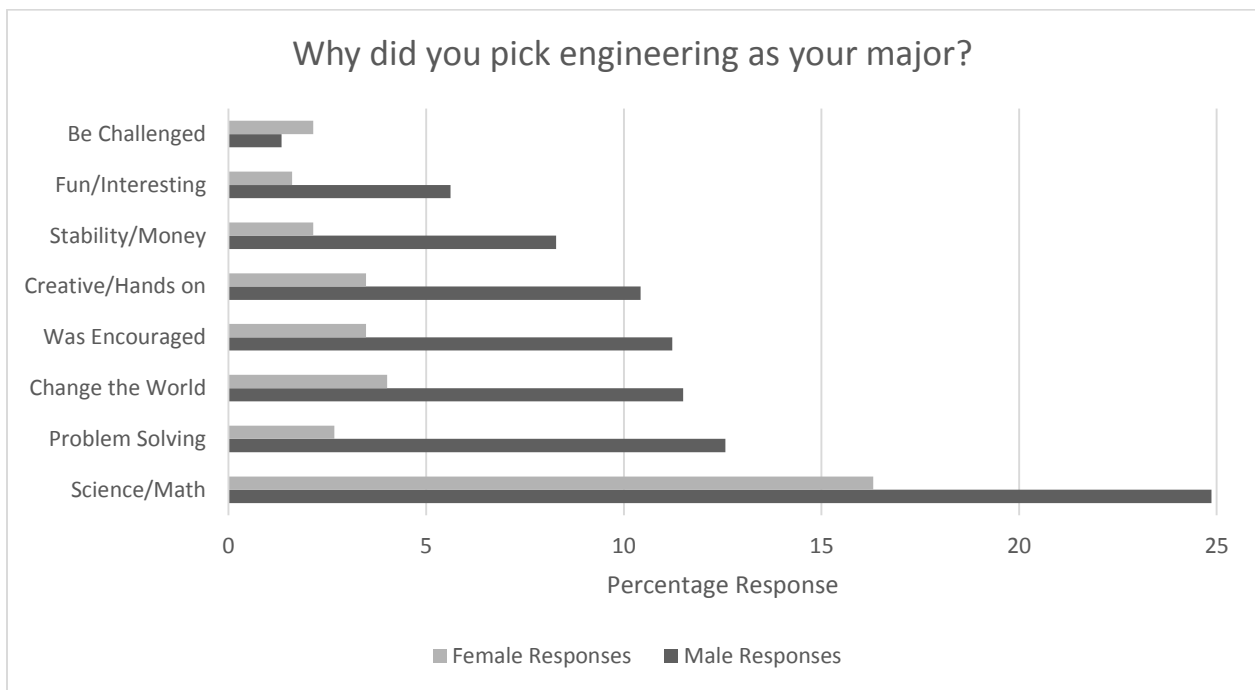


Figure 5. Percent response of students to reason for choosing engineering as a major.

The most common response, at 41% of all students (broken out as 25% male and 16% female responders), to the reason they chose this major was that they thought themselves to be good at math and/or science. Comparing this to the gender breakdown of respondents (69% males, 30% female) it appears that more than half the women agreed with this sentiment in choosing engineering as their major. Typical comments included:

“... I wanted to learn the practical side of math and physics.”

“... I love math and science and it just made sense for me to go into engineering.”

“I enjoy math and science, and I believe that engineering is the perfect blend”

After choosing engineering for their math/science skills, other answers that occurred with similar frequencies included sentiments that the students wanted to solve problems, change the world, use their hands, or that they were encouraged by a family member or friend to choose engineering. Some examples of their commentary include:

“I enjoy building and creating things. I want to improve the world around me and make it more efficient.”

“My family has all really wanted me to be an engineer for a long time.... I like the idea of designing new things and being able to come up with and implement revolutionary ideas”

“I picked engineering as my major so I could work hand-on and try to impact the world in a positive way through problem solving.”

“I had one person in my family who was an engineer....He never got his degree ... He wanted one of his grandchildren to be an engineer so in a way I'm kind of doing it in his memory ...”

“... I want to be able to graduate and find a job that has meaning to me. Engineers are the men and women that are solving everyday problems and making the world a great place. I want to be one of those people...”

The answers to the question of why our students chose engineering that occurred with the least frequencies included a desire for a stable/well-paying career, because it is fun/interesting, and because they desire a challenge. Notable in this last group of responses is that more women than men cited that they were looking for a challenge within engineering. Typical comments included:

“I think it's a fulfilling and interesting career path, one that will help the world and allow me to explore fields that interest me.”

“...engineers are wanted in Kuwait in large numbers, so I know that I am able to secure a job that I like and that pays well after college.”

“... I believe it will offer me a career that not only pays well, but also challenges me on a daily basis and allows me to better the lives of others.”

“I thought it was a fun major that challenged me because I had never done anything quite like it.”

“Engineering seemed like an enjoyable challenge, and I hope that it will also lead to a successful career.”

To follow up this question we asked on our post-survey: “After having taken a semester of engineering, why (if yes) do you want to persist in being an engineer?” Results to this question are provided in Figure 6.

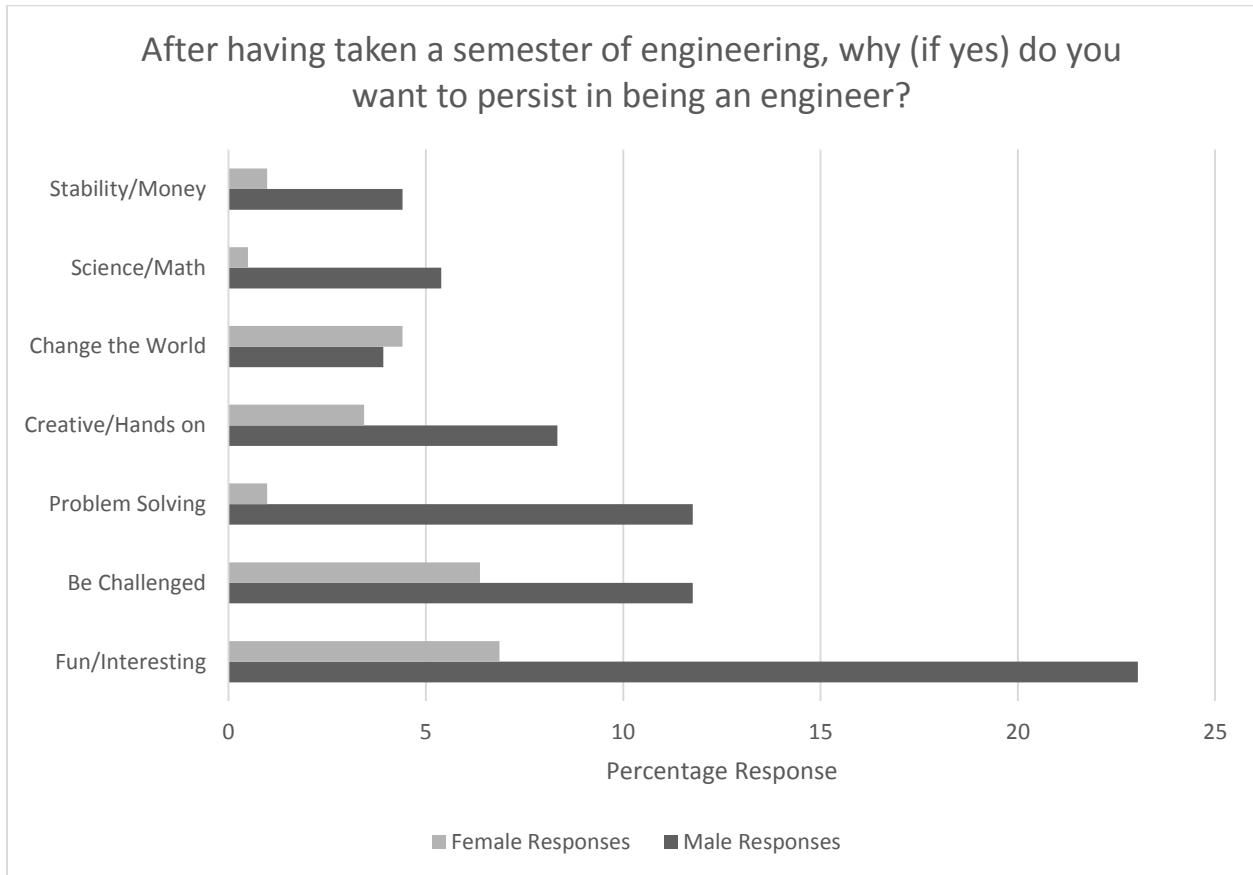


Figure 6. Percent response of students as to why they persist as an engineering major.

Though many of the theme areas from the pre- to post-survey were similar, there were some differences that ought to be noted. The largest difference was that the math and/or science theme was severely minimized (35% reduction) and the fun/interesting (27% increase) and challenging (15% increase) themes moved to the forefront of the student’s opinions for persisting in engineering. The majority of students in the post survey said things like the following:

“The challenges are evidently going to be pretty substantial, but the thrill of completing these challenges is part of the reason I’m interested in continuing to pursue engineering.”

“I find the course material keeps me interested while also providing the challenge that I have been looking for since high school.”

I want to persist in being an engineer because I love a challenge and this semester was one. Seriously though, I don't ever want to be bored in my career and this semester has shown me just how interesting engineering is, no matter what field one chooses.”

The middle categories of solving problems, changing the world, and using their hands remained within a few percentage points of their pre-test values. One item to note is that the “change the world” response became a more common female answer. Some examples of their commentary include:

“I definitely want to persist in being an engineer. I want to do so mainly because I have realized that in this profession I can help make a serious impact on the world we live in.

“I enjoy the problem solving that is used in the engineering field while working to make the world a better place to live in.”

“I want to persist in being an engineer because it is a profession that is very hands-on and focused around solving problems.”

Discussion

The purpose of this study is not to provide a comprehensive model or to predict student behavior, but rather to help first-year instructors begin to understand that preconceived notions do exist and to measure changes in student perspectives. The study was conducted to help identify what, if any, changes our student population would go through, as they entered and then subsequently exited the first-year engineering program at our institution. Part of this was to help see if exposure to diverse learning environments in terms of instructor and student gender and ethnicity would have any impact on student assumptions on what a first-year engineering learning environment would be like. By surveying students about their preconceived notions about what their peers and faculty would be like, before and after the first-year experience, the authors tried to see if these responses changed – and if so, how.

The results show that the student perspectives on faculty, their peers, and engineering did change as a result of going through the first-year engineering program at Northeastern University. These data were roughly grouped based on similarity of responses, and were shown in the previous section. When we begin to compare and contrast the before/after responses of students, it is possible to see some intriguing findings, as summarized in the table below.

Table 1. Shows a condensed and summarized list of keywords used before/after the first-year experience

	<u>Before starting first-year</u>	<u>After exiting first-year</u>
<i>Perspectives on Faculty</i>	“old”, “nerdy white guy”, “old-fashioned”	“enthusiastic”, “passionate”, “educated”, “diverse”, “younger”
<i>Perspectives on Peers (students)</i>	“nerdy”, “young”, “smart”, “white/Caucasian”, “Asian”, “Boys”	“helpful”, “innovative”, “smart”, “white/Caucasian”, “Asian”, “with some females”
<i>Perspectives on Engineering</i>	“in it because I’m good at Science and Math” “because my [relative] is one, and says it’s good”	“in it because I find it fun/interesting/challenging” “because I can solve real problems”

Table 1 summarizes the outcomes of this study into a condensed snapshot of the student responses before/after the first year experience. It shows that student’s perspectives on faculty, peers, and engineering were characteristically different after one term in the university. Though it is difficult and inappropriate to generalize the data in this exploratory study, we can begin to see what these characteristic changes can look like.

The student’s perspectives on their instructors changed from being “old”, “nerdy white guy”, to one that is more diverse and wide-ranging. Many responses from the initial study cited that professors would look homogenous in their appearance, often wearing an “old-fashioned” suit, look bland, and perhaps also have a bland teaching style and no sense of humor. However, these misconceptions about the faculty were clearly changed, as noted in the exit study. The students began to perceive the character traits of their instructors, instead of their age, appearance, and clothing. This shift in perspectives could be because the first-year engineering instructors at Northeastern University are a group of diverse people, ranging in age, ethnicity, and personality.

The student’s perspectives on their peers (students) changed from being “nerdy”, “white/Caucasian”, “Asian”, “boys”, to being slightly more diverse. Although their observation that the student population at this particular institution was largely male Caucasian and male Asian, they began to appreciate the presence and contributions of female students in the classroom. The student perspectives went from being “nerdy” to “helpful” and “innovative”, and they clearly began to notice the camaraderie and social-openness of their peers. This shift in

perspectives could be attributed to the large number of group projects that take place in the first year engineering curriculum, as this promotes and encourages students to work with one another and get to know each other more closely than in a “traditional” lecture-based teaching model. Furthermore, it is worth noting that the demographic assumptions the students had about ethnic background were largely unchanged. Though, while students are not changing their perspectives on the ethnic background of their peers before/after the first-year experience, they are beginning to detect the social characteristics that make each individual unique, smart, innovative, and helpful.

Table 1 shows that the assumptions of what the students expect from engineering are changing as well. Initially, students cited their perspectives on engineering as being largely founded on technical skills alone. They believed that engineers were just people who were good at math and science. Furthermore, students cited their reasons as being in engineering because they, too, were good at math and science. Very rarely did students describe the larger context of engineering – including viewing engineers as problem solvers – in their responses. In the exit study, student perspectives on engineering shifted largely towards more character-building traits; students felt that engineers were contributors to society, and that they worked on fun/interesting/challenging problems to make the world a better place. These shifts in perspective begin to show the impact of diversity in the classroom: it shows that engineers are not homogenous white nerdy males good at just math and science, but rather that engineers have a variety of diverse backgrounds and skills, and are all invested in applying those skills in improving society.

Student’s perspectives have changed over the span of these surveys. An overwhelming majority of responses show that students are shifting their perspectives on engineering from looks to qualities. Students now focus less on what engineers look like, and instead, focus more on the characteristics of instructors, peers, and the engineering profession. Students now appreciate that this profession is not about “us and them” but is instead more inclusive: you don’t have to look a certain way to be an engineer.

As instructors try to create more inclusive learning environments, it is imperative that we begin to appreciate the value that diversity brings to the first-year engineering learning environment – and very importantly, the impact that has on changing student perspectives. The students in this study see that first-year engineering instructors are excited about engineering challenges and can detect the emphasis on problem solving. As instructors, we acknowledge the limitations of the findings from this study – but emphasize that this is an exploratory first-step towards a more rigorous and systematic research goal of recording student assumptions. However, the importance of this study is highlighted when we begin to see that students feel more inclusive in environments where diversity is high, and where instructors are invested in promoting cross-cultural and team-based learning. This can be seen in the shift of responses from wanting to be an engineer because they are good at math/science to finding it fun/interesting and challenging. A first year course in engineering with a diverse engaged faculty has provided an unexpected (as per their preconceived notions) notion of the face of engineering and the result is that they may see diversity of their learning environment encouraging broader characteristic development.

In the context of the literature, this study clearly adds to the body of work described earlier. The study builds on Ramirez's work by supporting the notion that the 'imposter syndrome' can be overcome by building an inclusive environment in the first-year engineering curriculum.⁵ By supporting students in developing a notion that their learning environment is diverse, students begin to see engineering as an entity built on character traits and values instead of just technical skills. By viewing the engineering learning environment as being a place where instructors and students of different backgrounds can work together, students see that they can help and support one another through this learning process, developing a sense of camaraderie in the process. With respect to Strayhorn et al, findings show that encouraging contact among students from different economic, social, or racial/ethnic backgrounds can produce greater perceived learning gains amongst engineering students.²

In the context of Pollock's work about cultural identities, this study takes on the lack of literature about cultural assumptions in the first-year engineering learning environment directly.⁶ By beginning to explore the pre-conceived notions of our incoming student population, and comparing it to their exit assumptions, we as instructors can begin to map the cultural identity development of our students. This can lead to a more inclusive learning environment because we are no longer exclusively focused on the technical ability of our students, but also their capacity to detect and appreciate the role of integrated values and contexts in the development of these first-year students.

With respect to the work by Nieto and Freire, this study saw that the initial student assumptions of "old white nerdy male professor" can be seen as a "superculture" where each student is taught the same way irrespective of diverse background.^{7,8} However, the exit survey clearly shows that via the first-year engineering learning experience, students no longer see their instructor as a homogenous and "old-fashioned" individual, but rather as a person who embodies a new, more inclusive definition of engineering in terms of gender and ethnicity. As such, the students begin to appreciate their class as one where their instructor and peers can work together cooperatively. By shifting the perspectives of instructors as being "the sage on the stage" to one that is more "down to earth", students are able to internalize a model of engineering that is more personal and socially-constructed, rather than one based exclusively on technical skills.

Conclusion

The faculty at Northeastern University serves first-year students with the mission to provide the appropriate technical skills and mindset necessary to excel in engineering. The diverse team of instructors, who vary in age, gender, ethnicity and other attributes, are focused on learning about how students evolve over the duration of their first-year engineering experience. In addition to designing a learning environment that focuses on professional skills including teamwork, communication, computing, and service, they thought it would be useful to share their findings of the mindset of their learners to the rest of the first-year teaching community.

The exploratory study discussed here forms a starting point for further research at the nexus of diversity, accessibility, and first-year learning. As we begin to measure the changes in engineering perspectives, we can use research to develop more inclusive learning experiences for

all students based on fostering a mindset that values diversity –and the impact of diversity– in a first-year engineering classroom and program. The outcomes of the research suggest that student perspectives change from viewing engineering as a purely technical profession with monotonous lecturers to one that appreciates and embodies a greater sense of diversity, particularly in an environment that intentionally fosters this mindset.

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ASEE. : Pre-survey questions

* Required

- 1. **Go back to when you were unpacking on move-in day. What did you envision your first-year engineering professor to be like? ***

(please try to incorporate thoughts on gender, race/ethnicity, level of education, etc. into your response below)

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- 2. **Again, prior to your first engineering class, what did you envision your engineering class student population to be like? ***

(please try to incorporate thoughts on gender, race/ethnicity, level and assumptions of education, etc. into your response below)

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- 3. **Besides yourself, do you have anyone in your family (who you are close with) who is an engineer? ***

Check all that apply.

Yes

No

- 4. **What is the gender of this family member? If there is more than 1, select only 1 who may be the most influential to you and select the most appropriate response below ***

Mark only one oval.

Male

Female

Other:

5. **Again, prior to your first engineering class, how confident were you that you would successfully graduate as an engineer? ***

Mark only one oval.

- I am confident I possess the required skills to do well in the classes to become an engineer.
- I think I can do it and will do OK in the classes needed to become an engineer.
- I might be able to, but will struggle in some classes needed to become an engineer.
- I am not sure. I might struggle in many of the classes needed to become an engineer.
- I think it will be too hard.

6. **Prior to coming to college, is there anyone that you are close with, but not in your family, who is an engineer? ***

Mark only one oval.

- Yes
- No

7. **Are you the first in your family to attend university/college?**

Mark only one oval.

- yes
- no

8. **Were you born and raised in North America?**

Mark only one oval.

- Yes
- No
- Other:

9. **What is your gender?**

Mark only one oval.

- Female
- Male
- Other:

10. **Who is your Professor for GE1110? ***

Mark only one oval.

- Dr.
- Dr.
- Dr.
- Dr.
- Dr.
- Dr.

11. **Why did you pick engineering as your major? ***

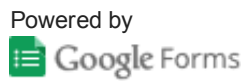
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Post Survey Questions - GE (Fall 2014)

* Required

1. After completing this semester, what do you envision your future engineering professors to be like?

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2. Similarly, moving forward, what do you envision your engineering class student population to be like?

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3. Describe a specific situation (in class) in which you worked with a diverse group of people. Based on this experience, what did you learn?

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4. After having taken a semester of engineering, why (if yes) do you want to persist in being an engineer?

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5. Do you have any suggestions on ways to enhance diversity and inclusion in the classroom?

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6. What is your gender?

Optional

Mark only one oval.

- Female
- Male
- Other

7. What ethnicity do you identify yourself as?

Optional

Mark only one oval.

- White
- Black
- Hispanic/Latino
- Middle Eastern
- East Asian
- South Asian
- Other:

8. Who is your professor for GE? *

Mark only one oval.

- Dr.
- Dr.
- Dr.
- Dr.
- Dr.
- Dr.