

## **Youth Perceptions of Mechanical Engineering by Race and Gender**

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Chanel Beebe is a first year student in Purdue's Engineering Education PhD program. Her background includes an undergraduate degree in Industrial and Operational Engineering from the University of Michigan and a year of teaching mathematics to 3rd and 4th graders. Her research interest revolve around expanding engineering thinking to under served populations via informal learning settings.

**Youth Ages 9-15 Perceptions of Mechanical Engineering by Race and Gender**

## Abstract

This work is motivated by a larger research study that looks at the experiences of African American students within a College of Engineering at a major Mid-West University. While this larger study will present the perspectives of these students currently enrolled in their engineering discipline, a missing piece of this project revolves around how these students perceived of engineering before they arrived to campus. Thus, the goal of this work is to investigate if and how student perceptions of a specific engineering discipline – in this case mechanical engineering – varies across ethnic or gender demographics among students who have not yet been exposed to engineering experiences. To investigate this question, our research team collaborated with two university sponsored summer programs that taught engineering to young students.

Though the American Association of Mechanical Engineers defines the function of Mechanical Engineers to be creating mechanical systems “concerned with the principles of force, energy and motion, mechanical engineers use their knowledge of design, manufacture, and operational processes to advance the world around us,” our initial hypothesis was that students would not have such a worldly and social view of what mechanical engineers do (Cornerstone, n.d.). Even further, we hypothesized that there may be some difference in these perceptions based on their social demographic. To investigate this hypothesis, our research team collaborated with two university sponsored summer programs that taught engineering to young students.

Before participating in these summer programs, 85 students were interviewed and asked “What do you think mechanical engineers do?” Participant responses and organized by the demographic data of the students. Student responses fell into one of the following six categories: (1) Mechanical/Moving Things, (2) Computers/Electrical Technology, (3) Civil Engineering, (4) Manufacturing/Building, (5) "More than Engineering," and (6) I Don't know. Results indicate that across races and genders, students interviewed primarily associate mechanical engineering with mechanical/Moving things and secondarily with manufacturing/building. There are, however, some interesting trends when you investigate the perception trends more closely. For example, students who identified as American Indian were more likely than other ethnic groups to discuss mechanical engineering as “more than engineering,” citing things like “improving/enhancing materials” as functions of a mechanical engineer.

Given the relatively small sample size of each race, we are careful to not generalize how an entire ethnic or gender group may perceive mechanical engineering. Instead, we point to some possible areas of investigation for researchers to explore. It may be significant that women were more likely to admit to not knowing and that the only men to do so were multiracial, Hispanic or African American. Intersectionality of race and gender, though not quantitatively explored in this work, may be another area of exploration as it relates to student perceptions.

The results of this study suggest that differing demographic groups do in fact have different perceptions of mechanical engineering but that these perceptions all tend to favor the idea of mechanical engineers and designers of mechanical and moving things. Such a finding

leaves the opportunity for designers of summer and university level engineering programs/departments to raise awareness about other facets of mechanical engineering.

## **Literature Review**

Engineering experiences a sharp lack of diversity with respect to the gender and race of those who become engineers. Women make up approximately 20% of engineering undergraduates, and underrepresented minorities (e.g., African American, Latino/a, and Native Americans) are represented at less than half of the nation's demographic representation (National Center for Science and Engineering Statistics, 2013). With such groups in the minority, engineering culture is predominantly created and influenced by white males making it difficult for the culture to become more inclusive of other groups. This is both an issue of social justice where every student should have equal access to pursuing engineering and as an issue of bringing more diverse perspectives to engineering and its subsequent solutions. Wulf, the former President of the National Academy of Engineering (NAE), noted that each is important and that we will benefit from better overall engineered solutions with a greater diversity within the engineering profession (Wulf, 2006).

Beyond Wulf's comments, the NAE separately cited Public misconception of engineering as one of the four problem facing engineering education today. (National Research Council, 2013) Not only do K-12 teachers have a poor conception of what engineers do, the NAE studies found that a majority of students think that engineers build cars, and that adults do not readily associate engineering with creative problem solving that impacts the whole world. If the general populous does not know what impact engineers truly have, their field stands to miss out on attracting young, creative talent which the National Academy of Science sees to be contributing the slip in US competitiveness. (Sciences, Engineering, & Medicine, 2010) If attracting more talent to engineering is a worthwhile goal, it can also be established that attracting a wider variety of students to engineering should be the goal of engineering educational efforts.

The same report by the NAE also cited an encouragement of more race and gender diversity (specifically that of women, African Americans, Hispanics and Native Americans) as crucial to US success and leadership in the future. Historically, however, it has been found that African Americans who do participate in engineering at a collegiate level face a myriad of difficulties matriculating through their programs. (Swail, Redd, & Perna, 2003) A 2005 study connected graduation rates of African Americans with their perceptions of campus climate. (Brown, Morning, & Watkins, 2005) Take collectively, this research illustrates that a major barrier to attracting a wider variety of students can be found by looking at the experiences of underrepresented groups.

As Cummings and Taebel (Cummings and Taebel, 1980) demonstrated, young women and minorities have the greatest affinity toward STEM subjects up until the end of their middle school years at which point this declines. If at this point, underrepresented students are not seeing appropriate role models or people like themselves in engineering they may be less inclined to persist along a STEM or engineering pathway. We believe it is important for students to understand what engineers do and what engineering could be for them. Thus, breaking up the stereotypes perpetuated in our society is an important goal of pre-college engineering education.

## **Background**

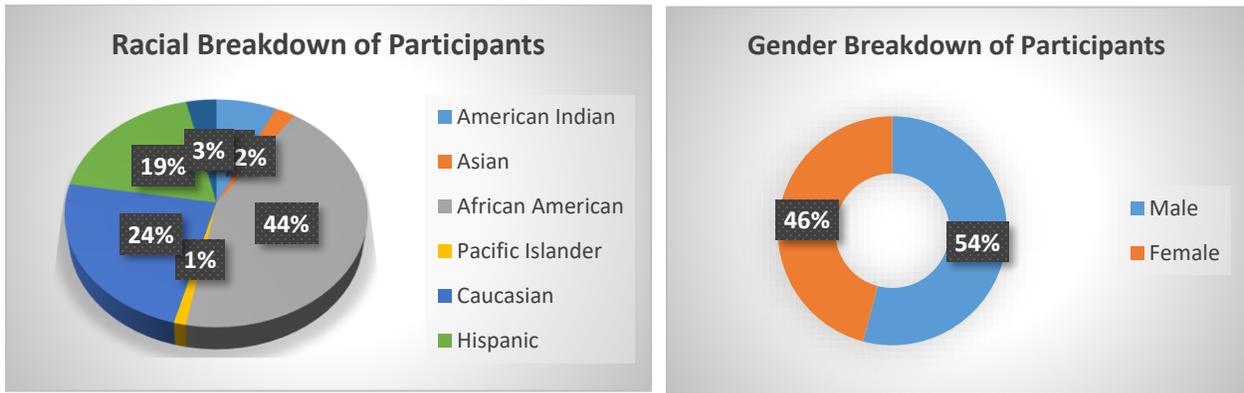
Given the issues of perception of engineering by the general public and the groups we are aiming to better include, the research goals of a larger study are to unpack the experiences of African American students within a College of Engineering at a major Mid-West University. The goals of this work are to illustrate areas of opportunity for university administrators to begin designing interventions to affect change in the existing trends specifically within the department of Mechanical Engineering. To accomplish this, an ethnographic research study has been designed to understand the experiences of African American students within the College of Engineering including observations of study spaces, focus groups across classes, and one on one interviews. While this larger study will present the perspectives of these students currently enrolled in their engineering discipline, a missing piece of this project revolves around how these students perceived of engineering before they arrived to campus.

Thus, the goal of this work is to investigate if and how student perceptions of a specific engineering discipline – in this case mechanical engineering – varies across ethnic or gender demographics among students who have not yet been exposed to engineering experiences. Often engineering perceptions are categorized according to function, as in Figuerdo’s work explaining the four dimensions of engineering (Figueiredo, 2008). Other studies have investigated student perceptions of individual engineering disciplines according to content areas and prospects for employment. (Shivy & Sullivan, 2005) Though the American Association of Mechanical Engineers defines the function of Mechanical Engineers to be creating mechanical systems “concerned with the principles of force, energy and motion, mechanical engineers use their knowledge of design, manufacture, and operational processes to advance the world around us,” our initial hypothesis was that students would not have such a worldly and social view of what mechanical engineers do (Cornerstone, n.d.). Even further, we hypothesized that there may be some difference in these perceptions based on their social demographic. To investigate this hypothesis, our research team collaborated with two university sponsored summer programs that taught engineering to young students.

## **Methods**

Across 3 university sponsored camps, 85 students ages 9-15 were interviewed and asked about their perceptions of various engineering related topics. These questions were asked in the form of semi-structured interviews with protocols aimed at capturing student conception of engineering before they participated in the camp. Among a list of 10 other questions, students were asked “What do you think mechanical engineers do?” Participant interviews were recorded and transcribed. Participant demographic data is illustrated in Figure 1.

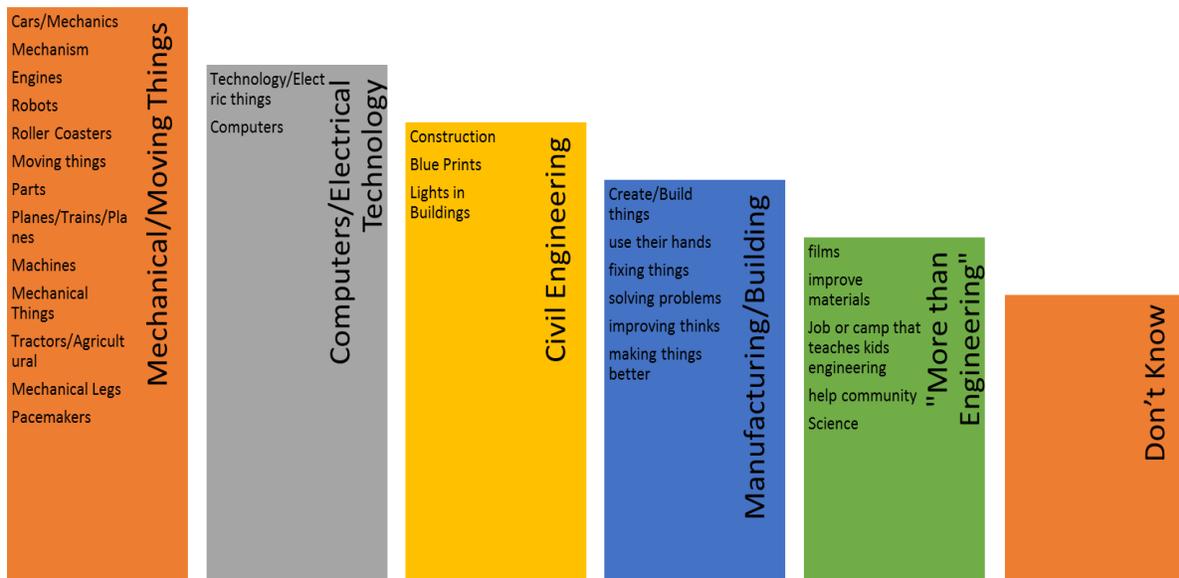
Figure 1. Participant Demographics



### Data Analysis

Participant responses to the question “What do you think mechanical engineers do?” were coded iteratively using an open coding methodology searching for common themes. The first pass of interview responses generated 23 common themes. Next, these themes were organized into larger buckets according to their similarities. The 23 themes and their corresponding larger buckets can be found in Figure 2.

Figure 2. Resulting themes

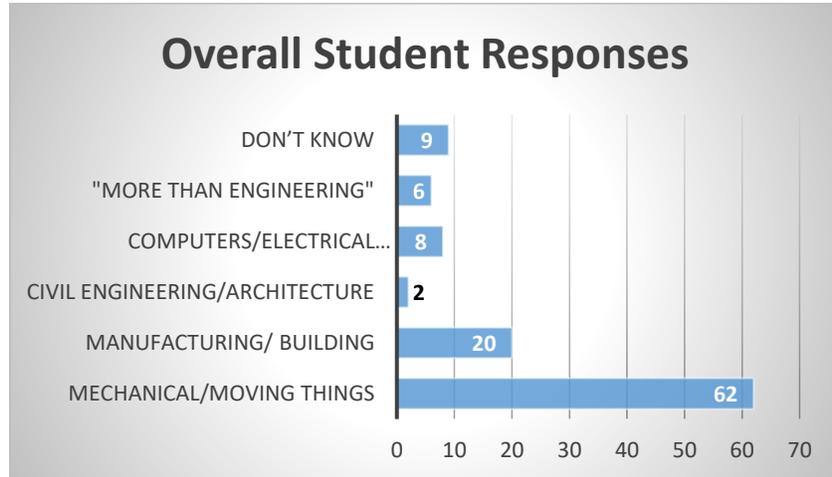


Finally, participant responses were coded again according to each of the larger buckets and organized by the demographic data of the students. Frequency of response type was then graphed according to demographic data and the relationships were illustrated in the form of bar graphs.

### Results

Student responses, regardless of demographic, are demonstrated in Figure 3. Results indicate that across races and genders, students interviewed primarily associate mechanical engineering with mechanical/Moving things and secondarily with manufacturing/building.

Figure 3. Overall Student Responses



Student understanding of Mechanical Engineering according to their self-reported racial background and gender identity have been reported in Figures 4 and 5. When looking at raw counts of responses, it can be seen that 16 white students conceive of Mechanical Engineering as mechanical/moving things where as only 7 Hispanic students shared that view.

Figure 4. Student Responses according to Race

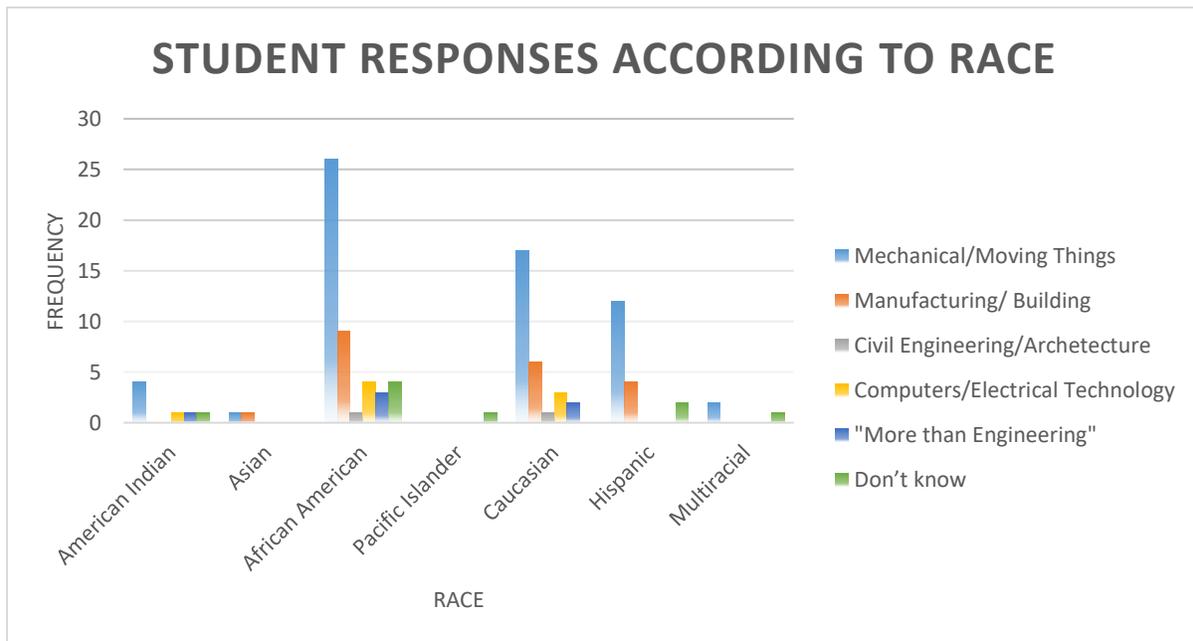
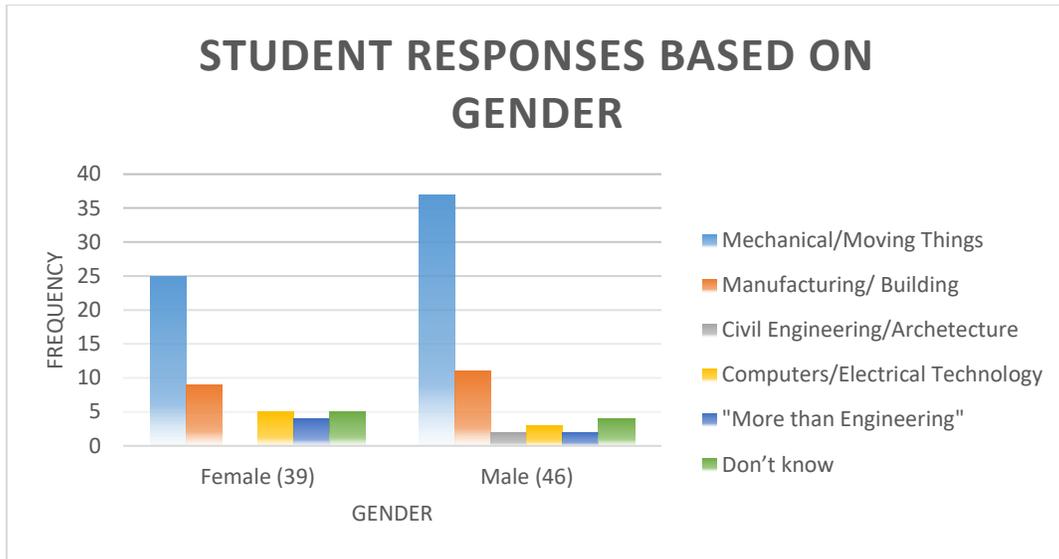


Figure 5. Student Responses according to Gender



Given the skew in representation across races, though, such numbers have little meaning. Thus, Figure 6 and 7 represents responses as a percentage of race/gender representation in correspondence with each theme. For example, 70% of the African American students interviewed considered mechanical engineering to be related to mechanical/moving things in comparison with 85% of White students. For each chart, note that percentages may add up to more than 100% because student responses may have contained elements of multiple categories.

Figure 6. Student Responses per Race Representation

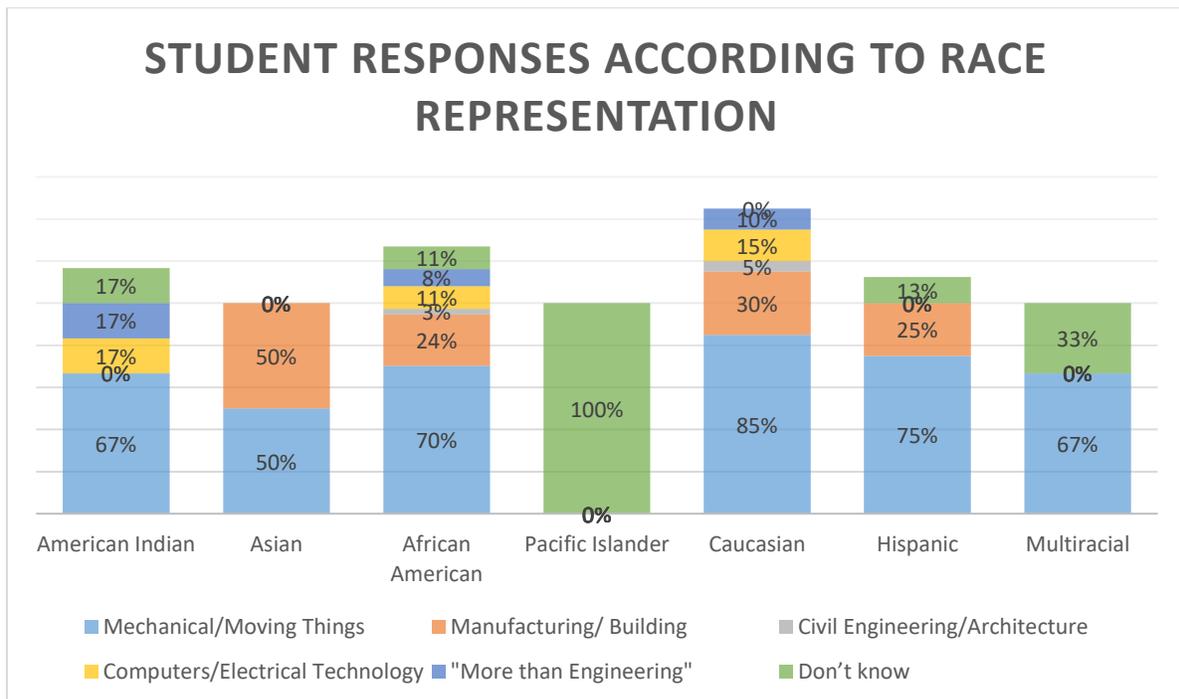
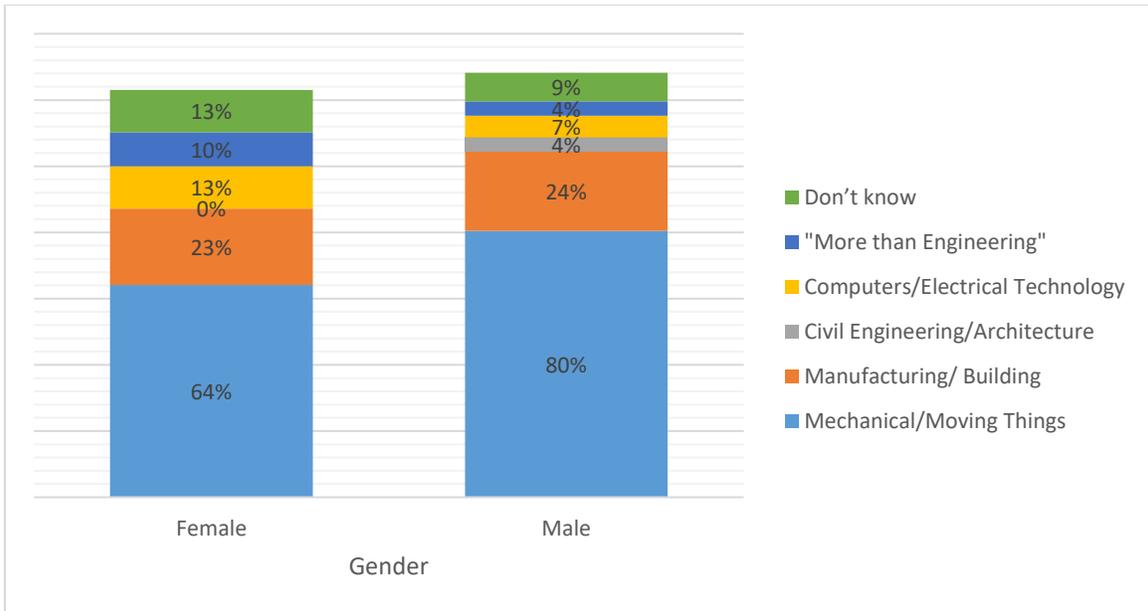


Figure 7. Student Responses per Gender Representation



## Discussion

The results as described above are not surprising – you would expect students with little exposure to engineering to conceive of mechanical engineering as related to work indicated by the name of the discipline: mechanics, mechanisms, etc. There are, however, some interesting trends when you investigate the perception trends more closely. For example, students who identified as American Indian were more likely than other ethnic groups to discuss mechanical engineering as “more than engineering,” citing things like “improving/enhancing materials” as functions of a mechanical engineer. Additionally, African American students were the only group to have conceived of mechanical engineering across all seven categories – explained possibly by the fact that no Caucasian student reported not knowing what mechanical engineers do. But what implications do these findings have for the initial research question?

The initial goals of this investigation were to unpack trends in perceptions of mechanical engineering by race and gender demographics. Results of the study indicate that all races and genders seem to limit mechanical engineering to the design of mechanical and moving things. Students typically underrepresented in engineering tend to mimic this trend, though women are more likely describe mechanical engineering as “more than engineering” citing things like “science” and “community building.” In sum, the results of this study suggest that differing demographic groups do in fact have different perceptions of mechanical engineering but that these perceptions all tend to favor the idea of mechanical engineers and designers of mechanical and moving things.

## **Limitations**

Given the relatively small sample size of each race, we are careful to not generalize how an entire ethnic or gender group may perceive mechanical engineering. Instead, we point to some possible areas of investigation for researchers to explore. First, the lack of Caucasian students who responded “I don’t know” could indicate that students from this group may approach engineering settings with a bit more confidence in their conception of engineering. While the goals of this study was not to compare student perceptions with any “truth” of what mechanical engineers actually do, it is possible for researchers to glean how tightly students from different groups may hold to their conceptions – be they “correct” or otherwise. Thus, it may be significant that women were more likely to admit to not knowing and that the only men to do so were multiracial, Hispanic or African American.

Intersectionality of race and gender, though not quantitatively explored in this work, may be another area of exploration as it relates to student perceptions. Do African American females exhibit certain patterns in their perceptions of mechanical engineering? While the 15 African American women included in this study reported similar perceptions to the larger group, a larger study of this intersection of identities may report otherwise.

An additional unexplored area of this study is the relationship between student perception and their level of exposure to engineering. While students in this study had not yet completed the engineering camp offered by the university, some reported knowing engineers personally and having experienced other camps. Such experiences are likely to affect what students think they know about engineering and could be investigated to unpack exposure trends across demographic groups.

Though data was not available to differentiate student perceptions by age, it is important to note that difference in perceptions of engineering could have also be attributed to varying degrees of awareness of the various career choices possible. Additionally, data on the students’ familiarity with mechanical engineering (like if they had mechanical engineers in their family) was also unavailable and could have affected variations in student perceptions as well.

## **Conclusions and Implications**

This study was positioned to inform a larger study of student experiences with possible data on what students were expecting of their experience of mechanical engineering. If we were able to uncover that say, African American young girls had some trend in how they perceived mechanical engineering as youth, this would have been used to support incorporation of those elements into their further education in mechanical engineering. However, because the study showed that all demographics have majority groups perceiving of mechanical engineering as the function of mechanical things (the first part of ASME’s definition) and relatively little to do with the world around us (the second part of ASME’s definition and a part of the “more than engineering” categorization), there may exist a larger opportunity to expand all students conception of mechanical engineering. This, however, is beyond the scope of this study.

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