



Young Adolescent Perceptions of Engineers Within a Summer Outreach Program (Work in Progress)

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(Work In Progress)**

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Abstract

Over the past decade, there has been a continued increase of K-12 STEM programs across the United States that focus on promoting the development of youths' engineering identity and interest in STEM-related career paths. In this paper, we present work in progress, focusing our discussion on rising 7th and 8th grade youth drawings and accompanying explanations of “an engineer in action,” as part of a summertime STEM summer outreach program for underrepresented minority middle school youth. Our work is an adaptation of Draw an Engineer Test (DAET) [1] which focuses on the stereotypical understandings and (mis)conceptions adolescents have of scientists and engineers in traditional PK- 12 classroom settings. The context of this study, however, is an informal STEM learning environment, entitled *Bulls-Engineering Youth Experience for Promoting Relationships, Identity Development and Empowerment* (Bulls-EYE PRIDE) at the University of South Florida. The question that guided this study was: What are youths' perceptions of engineers and the work that they do? Our data consisted of (n=72) mentee drawings of engineers and their explanations, during focus group interviews, about the gender and the specific tasks the engineers in their drawings personified. A preliminary analysis of the results shows the emergence of two themes: (1) confirmed and contradictory engineer gender stereotypes, and (2) varied engineer roles. This paper will describe the preliminary findings from the first and second year of the research and describe implications for future research and engineering education.

Introduction

Despite efforts to promote STEM education in the US, student interest in pursuing college majors in STEM remains relatively low [2]. As a result, in recent years, there has been a growing interest in exploring STEM identity, including student perceptions of STEM professions and STEM professionals, as a factor that may improve our understanding of the difficulties involved in motivating and retaining youth in STEM fields [3]. Career development theorists (e.g. [4]) have long argued that occupational perceptions are fundamental for understanding one's career aspirations. Youths' occupational perceptions are considered to be key antecedents of their career preferences (e.g. [5]). As adolescents grow, they progressively narrow their scope of acceptable occupation options by comparing their self-images to those of different career alternatives and eliminate the incompatible alternatives. Once an occupational field has been ruled out, it will rarely be reconsidered again. Youth' misconceptions associated with engineering may result in premature rejection of this profession from their scope of acceptable alternatives [6]. Further, young individuals' images of engineers affect their inclination to approach or avoid the profession depending on the extent to which they identify with the images [7]. Thus, it continues to be "extremely important" [7, p.1] to understand how young adolescents perceive engineering and engineers.

Knight and Cunningham [8] developed a Draw an Engineer Test (DAET) where elementary and secondary youth provided written and drawn responses to a set of questions regarding their preconceptions about engineers. Their responses were found to be generally simplistic, for example, engineers were commonly depicted as workers who constructed buildings or repaired car engines, though older participants more frequently mentioned engineering design tasks. The most common stereotypical actions youth perceive engineers to do are to design, plan, and or perform physical labor. Common images included tools, cars and computers. Consistent findings were reported by a number of subsequent investigations using similar data collection methods (e.g. [1], [9]–[12]). Further, youth displayed signs of gender stereotypes and the majority of participants across these studies, perceived engineers as being "male". Specifically, Gülhan and Sahin [11] found that as the grade level of the girls increased, perceptions of engineers as being female decreased. Chou and Chen [9] further noted that adolescents' responses were influenced by their close family members and mass media.

In this paper, we present work in progress, focusing our discussion on rising 7th and 8th grade adolescents' drawings and accompanying explanations of "an engineer in action," as part of a summer outreach program for underrepresented minority middle school youth. Our work is an adaptation of the DAET [1] which focuses on youths' stereotypical understandings and (mis)conceptions of scientists and engineers in traditional PK- 12 classroom settings. The research question that guided our study was: What are adolescent perceptions of engineers and the work that they do?

Methods

The current study is part of a larger three-year National Science Foundation (NSF) grant funded (1734878) study exploring engineering identity development among underrepresented middle school youth (i.e., mentees) in a five-week (100 contact hours), summer outreach program at the University of South Florida. Unlike the aforementioned studies that have explored student

perceptions of engineers in formal school settings, the context of this study is an informal STEM learning environment, entitled *Bulls-Engineering Youth Experience for Promoting Relationships, Identity Development and Empowerment* (Bulls-EYE PRIDE). The Bulls-EYE PRIDE program is located in a predominantly Black and Hispanic community in the southeastern part of the United States and uses a culturally responsive approach [13] to facilitate learning engineering practices, develop participants' engineering identity, and improve participants' life skills through mentoring support. Program participants are recruited through flyers in the community and school guidance counselors. There are four instructors in the program, including two men and two women. One instructor is a mechanical engineering professor, and one instructor is an early-career elementary school teacher. Two instructors are undergraduate engineering students.

There were 72 participants in this study; 25 girls and 47 boys. The mentees participated in two, one-hour focus groups with one of the research team members. There were four researchers who led the research; they were not involved in any aspect of program delivery. For the purpose of this paper, the researchers focused primarily on the DAET exercise and subsequent questions about the content of participants' drawings captured during the first focus group, which occurred during the second week of the program. As part of the interview protocol, participants were asked to tell the researcher about their drawing and explain why they assumed certain features about the look and role of engineers. Focus group interviews were recorded and professionally transcribed verbatim prior to analysis. During data analysis, each transcript and drawing was coded by two members of the research team. We developed codes to analyze the data from both *a priori* codes found in the literature and open coding using participants' words and phrases, as well as several rounds of discussion about the potential codes. We then developed a code book that included definitions and exemplar quotes. The final codes, definitions, and exemplar quotes were loaded into Dedoose qualitative data analysis software for further analysis. We identified emergent patterns from the codes and categorized them under two overarching themes: (1) confirmed and contradictory engineer gender stereotypes, and 2) varied engineer roles. Drawing from the work of previous DAETs, the drawings were then analyzed based on gender categories to identify patterns in frequency and code co-occurrence. Data from previously coded focus group transcripts were used to triangulate findings in the drawings.

Findings

Confirmed and Contradictory Engineer Stereotypes

Confirmed and contradictory engineer gender stereotypes refers to how participants depicted the gender of an engineer in their drawings. The DAST used by Chambers [14] demonstrated the tendency for youth to draw depictions of scientists as men. Additionally, the stereotype was considered confirmed if the participant drew an image of an engineer as a man or boy. However, if the participant drew an image that depicted an engineer as a woman, girl, or non-binary then this contradicts the stereotype of engineers being traditionally perceived as a man. Masculine and feminine drawings were determined based on style of dress, hair, and written descriptions from participants [15] Non-binary images depicted persons who did not conform to either masculine or feminine characteristics. Others were images that did not depict a human being (e.g., robot). Lastly, 'could not be determined' was used when the researcher could not detect the gender of the person or people in the drawing and did not include any distinguishable gender characteristics. Table 1 demonstrates an inverse relationship between the gender of the

participant, and the gender of their drawings. Out of all masculine drawings, 82% were drawn by boys, while 80% of all the feminine drawings were drawn by girls.

Table 1: Engineer Drawing Gender Disaggregated by Participant Gender

	Masculine Drawing, (n=28)	Feminine Drawing, (n=15)	Non-binary Drawing, (n=3)	Other & Could not be determined, (n=47)
Boy	82.14%	20.00%	66.67%	76.60%
Girl	17.86%	80.00%	33.33%	23.40%

To illustrate findings presented in the table, we share an exchange from a focus group session. During this focus group, the interviewer probed participants about their depictions of masculine drawings:

- Interviewer: Why do we think we didn't have more women in our pictures?
 Interviewee: I just think of men.
 Interviewee: Cuz we're males.
 Interviewee: Cuz like when you don't know someone's gender the proper thing to say is he.

A girl in the study drew an engineer with feminine characteristics, emphasizing that an engineer could be anyone. She explained:

- Yeah. I just drew a normal person, and it just happens to be a girl. I think an engineer can be anyone who actually wants to come up with an idea that can help any problem in the world, so it can be whatever gender, or whatever idea, whoever, wherever, whenever.

It is also important to note that many girls called their engineers a "person", "normal" or "my engineer" rather than assigning a gender to their drawing right away in their explanations. In contrast, boys assigned their drawing a pronoun almost immediately. For example, one participant discussed:

- Interviewee: ...That's an engineer. He's building a car.
 Interviewer: He's building a car. Why did you make him a man? Do you know?
 Interviewee: What?
 Interviewer: Why is he a man? Why is he a "he"?
 Interviewee: I don't know.

Furthermore, boys seemed to automatically draw "masculine engineers" without realizing it or having a rationale for doing so. While one participant pointed out that the participants' gender identities influenced their drawings, other participants noted that it was an intrinsic response to envision men when imagining an engineer. To this end, the findings from the current study show that boys are more likely to confirm gender stereotypes about engineers, whereas girls did not. It is possible that either gender simply drew a depiction of themselves as some of the participants highlighted during the focus groups, but the images did not consistently depict other physical features that demonstrated self-portraits.

Varied Engineer Roles

Engineering roles refer to the jobs and or tasks the participants depicted in their drawings. Boys tended to show engineers doing an action and had words that accompanied their drawings that described their actions. Feminine drawings depicted women as not having a distinct role as an engineer, and there were less descriptive words that explained their actions. Table 2 presents engineering role codes (that emerged from open and a prior coding) and the frequency with which they appeared in participants' drawings based on feminine and masculine depictions of engineers.

Table 2: Occurrences of Engineer Roles Identified by Feminine and Masculine Drawings

Engineer Role	Description	% Total Frequency of Code (n = 112)	% Feminine Drawing	% Masculine Drawing
Fixing things (n = 5)	Engineering/engineers as fixing things	2.6%	0%	80%
Rocket (n = 7)	Engineers with images of a rockets	3.7%	0%	75%
Working with Computers (n = 7)	Engineering tasks or duties related to working with or being competent with computers	3.7%	0%	30%
Creating (n = 9)	engineers as creators or engineering as creating	4.8%	20%	70%
Cars (n = 10)	Engineering as related to automobiles	5.8%	10%	50%
Teamwork (n = 13)	Working with others to complete a task or project	6.9%	8%	15%
Problem Solving (n = 12)	Engineers as problem solvers or using engineering to solve a problem	6.3%	25%	33%
Unrelated (n = 14)	Drawing was unclear, or about a topic unrelated to other categories, doesn't count for any other categories	7.4%	29%	21%
Building or builders (n = 24)	Engineers as builders/engineering as building/construction	12.7%	4%	33%
Engineering Tools (n = 33)	Tools mentees perceive are used by engineers	17.5%	6%	27%

Engineer roles depicted within drawings were more distinct and detailed for masculine drawings when compared to feminine drawings. In particular, the boys demonstrated how implicit biases shaped the ways they saw engineers and the types of work engineers were more likely to engage in. As discussed below, such attitudes were also shaped by gendered cultural norms. For example, during a focus group, the following conversation took place:

- Interviewee: I would say it kind of could be for a couple of reasons including that we are all men or boys. Engineering sort of jobs things that generally involve—
- Interviewee: Men.
- Interviewee: No. [Chuckle] No, things that generally involve creating, building, designing is generally biased to be done by men. Or it could just be easier to draw cuz no one wants to draw long hair.
- Interviewee: I think they're doin' it because men are generally—they generally have more

mass, and they generally work out more than ladies do. I think that's why because they think of engineering as picking up stuff and moving it around with their hands and stuff like bricks and stuff that they can easily move around without having a whole truck.

Several girls also pointed out common stereotypes that suggested women were less capable of engaging in certain careers. For example, girl stated “Yeah, like what Brandi said, most of the world is sexist to think that only men can do hard jobs. People think that women can't fix cars or build buildings.” They also spoke about the hardships of having to prove gender biases wrong. For instance, one girl explained “Also, the men, I think they judge the women too quickly because, yes, women do get their hair and nails done, but also, women like to do hard work and try to prove... we can do the same things that they can do.” Participants alluded to external forces influencing the controlling images that signaled men as engineers. Yet, girls largely resisted such notions and disrupted this masculine-dominated archetype with drawing of women and/or non-binary images.

Discussion and Next Steps

Research supports that gendered experiences foster a sense of disconnection from engineering and threaten to disrupt engineering identity development [16]. These influences can occur from familial expectations, interpersonal relationships within and outside of the classroom environment, and the greater society. Underrepresented girls often enter school and informal learning settings fully aware of gendered inequalities. Catsambis [17] explains that despite the equalization or high rates of the achievement of girls in science in comparison to their male counterparts, girls of all ethnicities have more negative views of science and overall fewer science learning experiences. Other research highlights that Black girls specifically come to school aware of stereotypes and negative images about their gender which lowers the expectations and affects their self-esteem in comparison to white counterparts [18], [19]. This supports the girls’ in this study strong connection to understanding how women are seen in engineering communities and their willingness to correct their misrepresentation by including women, and nonbinary gender identities in their drawing of engineers. The boys however, did not see their lack of gender inclusion despite opportunities to include them when asked why they only drew male gendered characters.

In addition to the differences in gendered attitudes concerning engineering roles and responsibilities, one dominant narrative that underscored the participants’ perceptions of engineers (across all genders) were notions of building, fixing, and creating, mostly by hand. Rarely did participants highlight other kinds of engineering jobs that did not require these tasks such as coding or working with chemicals. Given these findings, it seems that youth may be primed to think of engineers as mostly mechanical engineers with some attention toward computer engineers who focus on the hardware aspects of research, design, and development.

Finally, during the remaining year of the grant, the research team will conduct the DAET exercise and measure trends in participant drawings over a three-year period. In particular, we will measure changes, if any, in the drawings of participants who participated in the program in subsequent years (also known as returners).

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