Board 173: Results of Girl Scouts Taking the Draw-an-Engineer Test: Where Do We Go from Here? (WIP)

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Abstract

This work-in-progress (WIP) paper discusses the results of one study focused on an informal engineering experience for middle school girls. Informal engineering experiences may be a crucial component in understanding how pre-college students decide to become engineers. Data was collected from middle school Girl Scouts regarding their initial conceptions of engineers using the Draw-an-Engineer Test and a short interview. While many aspects of their drawings, such as the tasks they illustrated the engineers performing, were similar to previous studies employing the DAET, the distribution of genders of the engineers in the drawings was not. Possible sources for this deviation from previous studies, such as influence from troop leaders or parents, and future work to further investigate this deviation are discussed.

Introduction & Background

For more than 30 years, there have been concerted efforts to increase the gender parity within engineering (e.g. [1]–[3]). While progress was made in the early years of these efforts, for the past two decades progress has slowed to nearly a standstill. For the last two decades, only 20% of engineering degrees have been awarded to women [4]. If the engineering field wishes to increase gender parity in the field, we first must understand how women decide to become engineers.

Efforts to recruit women into engineering begin long before they set foot in a college classroom. These efforts include formal educational experiences in the classroom (e.g., [5], [6]), as well as informal experiences outside of the classroom in settings such as museums (e.g., [7]), youth programs (e.g., [8]–[10]), and at-home experiences (e.g., [11], [12]). While formal educational experiences have been frequent subjects of educational research, informal experiences are less researched, and their impacts are less understood [13]. However, pre-college children spend significantly more time outside of formal education settings than they do in them [14], making these informal settings crucial to understand.

One informal setting of particular interest is the Girl Scouts of the United States of America (GSUSA), as they recently began a focus on STEM opportunities, with the stated aim of bringing 2.5 million girls into the STEM pipeline by 2025 [15]. Because of their stated purpose, as well as the broader interest in increasing women's participation in engineering, the Girl Scouts may be a critical place to better understand how pre-college girls come to understand and ultimately become (or not become) engineers. This WIP is part of a larger study focusing on the impact of a Girl Scout engineering badge experience on middle school girls' views of themselves as future engineers and knowledge about engineering.

For this WIP, we focus on the participants' conception of engineering at the beginning of the study. Their impressions were gathered using the Draw-an-Engineer Test (DAET) [16] and an associated interview. The DAET was initially developed by Knight and Cunningham [16] and was based on the more-established Draw-a-Scientist Test (DAST) [17]. The DAET seeks to understand how participants view engineers and their work [16]. Understanding what pre-college students think an engineer does and who an engineer can be inform outreach efforts as we seek to recruit pre-college students to engineering. Knight and Cunningham [16] asked participants to sketch an engineer at work and provide short written responses regarding the engineer's work. Later, others (e.g., [18]) added a short interview to the DAET to focus on the participant's understanding of engineering, rather than relying on the researcher's interpretation. The DAET has been widely used across a variety of contexts to understand perceptions about engineers and engineering (e.g., [16], [18]–[23]). The data collected using these instruments was used to answer the question: *How do middle school girls conceptualize engineers and engineering?*

Methods

In early 2020, 20 participants were recruited following a multiple-step process, using IRB-approved recruitment procedures. First, Girl Scout troops were recruited from regional service unit meetings. This recruitment focused on Cadette (Grades 6-8) troops and multi-age troops which had Cadette members. Middle school aged girls were selected because middle school is a key turning point, as there is a well-documented drop in math interest and perceived ability (e.g.,[24], [25]), as well as science interest (e.g., [26], [27]). This decline is particularly pronounced in middle-school girls (e.g., [24]). Given that engineering is perceived as a career for people who are good at math and science (e.g., [28]) and the documented drop in math and science interest, middle school girls are at a critical tipping point where future outreach may be ineffectual. Once the troops were selected, the research team attended individual troop meetings to ask parents to grant permission for their child to participate in the study. The minor participants provided verbal assent to the study prior to the initial interview. It is important to note that troop members were not required to participate in the study to take part in earning the engineering badge; however, most troop members ultimately decided to participate in the study.

Prior to beginning any engineering badge work, the lead author asked all participants to complete the DAET [16]. Participants were given 15 minutes to complete their drawing and a short response. The participants then took part in a 15-20 minute semi-structured interview via Zoom. Some questions which focused specifically on the DAET were:

- Please tell me about your drawing
    - What is your engineer doing?
    - What is your engineer like?
    - What are they good at/not good at?
    - What do they use to do their work?
    - How are you like/unlike this engineer?

The interviews were recorded and transcribed, with filler words (e.g., “um”) removed for clarity as part of the transcription process. The DAET images were also captured.

The interviews and DAET images were analyzed following methods used by previous studies that employed the DAET (e.g., [18], [22], [23]). Using both the images that the participants drew and their descriptions, the images were categorized for features such as the activities depicted. This included “fixing something” or “assembly”; the objects in the picture, such as tools and vehicles; and the characteristics of the person depicted, such as gender. As much as possible, drawings were characterized based on how the participants described their drawing. The results of this analysis are presented below.

Limitations

Two primary limitations should be acknowledged. First, the research team is composed of women who hold engineering degrees. While efforts were made, such as limiting discussion of our roles as engineers and our perceptions of what engineers do, it is possible that this influenced the participants. Additionally, our population is relatively homogenous, particularly regarding race and geographical location. This was primarily a result of COVID-19 pandemic restrictions, which started near the beginning of the recruitment process and restricted recruitment activities.

Results

The results of the DAET analysis are described below. While the drawings were analyzed for gender, objects depicted, and actions depicted, only the gender results differed substantially from what has been

found in previous studies using the DAET (e.g., [22], [23]), therefore will be the focus of this WIP. The gender distribution for the drawings can be shown in Table 1, below:

Table 1: Gender distribution across DAETs

Gender	Percent (n=20)
Woman	50%
Men	15%
No discernable gender	20%
No people	15%

Discussion

This study resulted in a surprising gender distribution of DAET images. As seen in Table 2, this study resulted in a significantly higher percentage of drawings with women as engineers than would be anticipated from the literature.

Table 2: DAET gender results across studies

Gender	Capobianco et al. [23] (n=396)	Fralick et al. [22] (n=744)	This study (n=20)
Women	18%	13.3%	50%
Men	58%	48.9%	15%
No discernable gender	24%	8.4%	20%
No people	-	15.3%	15%

We offer three possible explanations for this deviation, each of which will be discussed below:

- Something special about the environment in which this study occurred
- A broader change in pre-college students' conception of engineers
- Outside influences

The Environment

By the nature of the environment, this sample is single-gendered. This may have skewed the results, as some studies have found that pre-college students are more likely to draw someone of their own sex. For example, when asked to draw a generic person, more than 70% of children drew one matching their own sex (e.g., [29], [30]). This trend was found to hold in the DAST for young children; however, as children aged, girls began to draw more male scientists. By age sixteen, girls were found to draw male scientists three times more often than female scientists [31]. Similar trends were found in Capobianco et al.'s [23] study. About 40% of the engineers that first grade girls drew were female and about 30% were male, but when examining the drawings of fifth grade girls, just under 60% drew male engineers and about 30% drew female engineers. Given the age of the participants, previous research suggests it is likely that they would draw male engineers.

The study took place in the context of a Girl Scout troop environment. This may have influenced the participants' conception of engineers for several reasons. First, the national Girl Scout organization recently began a significant focus on STEM opportunities within the organization. This began with the

introduction of the initial round of programs in 2017 [32] and has continued to present day. Additionally, the CEO of GSUSA at the beginning of this study was Sylvia Acevedo, who holds degrees in engineering and worked as an engineer with NASA, prior to her time as Girl Scouts [33]. Ms. Acevedo's previous engineering experiences were widely publicized by the Girl Scouts at the time of her appointment as interim CEO in 2016 [34], when she became permanent CEO in 2017 [35], and again when the initial STEM badges were released (e.g., [36], [37]). These factors may have influenced participants' perception of engineering, as Ms. Acevedo may have acted as a role model. Previous literature indicates that role models can be a critical factor in career selection (e.g., [14], [38]). However, it should be noted that only one participant drew space-related objects (a rover), and none mentioned Ms. Acevedo by name. While the recent focus on STEM opportunities and Ms. Acevedo's background may have influenced the participants, they did not articulate it. Beyond the recent focus on STEM, the Girl Scout environment is highly focused on girls and women in general. Nearly all materials, including promotions, advertisements, and program materials feature girls and women. Additionally, all four troops were led by women. This may predispose participants to draw women within the Girl Scout setting

A Broader Change

It should be noted that this study occurred a significant amount of time after Capobianco et al.'s [23] and Fralick et al.'s [22] studies. In that time, there has been significant growth in the profile of engineering in pre-college education, which may have resulted in these participants having more exposure to diverse engineers than the participants had in previous studies. For example, the Next Generation Science Standards (NGSS) were released in 2013 [6]. These standards seek to integrate engineering into the science curriculum across grade levels. While not all states adopted NGSS, by 2018, 70% of states had either adopted NGSS itself or developed state-specific standards based upon NGSS, including Ohio, where this study occurred [39]. Additionally, toys which seek to market STEM to specifically to girls, such as GoldieBlox [11] have become more prevalent, as are media representations, such as the children's book *Rosie Revere, Engineer* [40], which was published in 2013. In many ways, the landscape of pre-college engineering education looks much different than when previous studies were conducted, and this may explain the differences between this and other data sets.

Additionally, there is evidence that perceptions of STEM professionals are changing. In a recent meta-analysis of five decades of DAST results, Miller and colleagues [31] found that while in the 1960s and 1970s less than 1% of children drew female scientists, in the decades since, the number has risen significantly, with 58% of girls and 13% of boys, on average, drawing female scientists in 2016. However, a search of the extant literature did not result yield any similar meta-analyses or more recent large-scale study using the DAET focused on investigating more recent pre-college student perceptions of engineers.

Outside Influence

While the members of the research team sought to avoid influencing the participants, it is possible that conversations which influenced participants' views occurred without the knowledge of the research team. For example, while the lead author, who conducted the recruitment and interviews, described herself to the participants as "a student trying to understand how kids like you learn about engineering outside of school", in attempts to de-emphasize her position as an engineer, we do not know how the troop leaders or other trusted adults, who knew from study recruitment material that the research team was comprised of engineers, discussed the research team members with participants. Similarly, while members of the research team sought to avoid discussing engineering or what an engineer did before participants completed their DAET and interview, participants may have discussed engineers and engineering with troop leaders, peers, or other trusted adults, leading to a change in perception. Previous research has shown the influence of family (e.g., [41], [42]) and role models ([14], [38]) on career decisions, which may be evident here.

Future Work and Conclusion

The results of gender distribution in the DAET in this study differed significantly from existing literature and throughout our analysis, no clear single reason emerged to explain the deviation from the extant literature. While several possibilities were identified, as discussed above, no one possible explanation seemed to be fully supported by the data. Thus, more work is needed to understand if the study results herald some larger societal change, were caused by outside or environmental factors, or are a result of random chance. These future studies should include a range of participant characteristics, in a wide range of setting (both formal and informal) and should seek to limit the possible impact of "role models". By seeking more data, we may be able to better understand what, if anything, has changed in how our pre-college students perceive engineers and perhaps leverage this information to support efforts to diversify the engineering field.

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