”Draw an Engineer”

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“Draw an Engineer” (Work in Progress, Diversity)

Abstract

America is falling behind in terms of educational success on the international stage [1]. Institutions across the US have noted that to strengthen our next generation of thinkers, a focus on improving the diversity of thought is needed, an issue easily solved by expanding the racial, ethnic, and gender diversity of those working on innovative problems [2]. This is most evidently observed in the science, technology, engineering, and mathematics (STEM) fields where there not only exists an achievement gap but also a large disparity along both the race and gender divide [3], [4].

These gender and race gaps have been partially attributed to the perceptions students have of engineering. While studies have been conducted to quantify these gaps, few focus on assessing the results of the research attempting to improve those perceptions. This paper will outline the effectiveness of an assessment tool in order to measure diverse students’ ability to envision engineers as more than the traditional straight, white, cisgender male.

This study used an arts-based design for a research methodology with a central focus on participants’ illustration of “an engineer”. Alongside the illustrations, students were asked to provide 5 adjectives describing the traits of an engineer and a sentence depicting the participant’s opinion of what an engineer does. The goal was to assess students’ perceptions of engineering prior to participating in an engineering summer camp. These points of data were gathered with a procedure that removed bias by removing any context surrounding the task. The participants of this first study were a group of 36 high school students who identified themselves as men.

The analysis of the study’s first set of participant responses overwhelmingly displayed a male-centered and technologically based interpretation of “an engineer”. Notedly, this interpretation also distinctly excludes a conversation or illustration of race for most depictions submitted. The extended analysis to be explored is if this exclusion was due to the medium the participants used in their illustration. This further analysis will also seek to determine whether participants were depicting themselves as engineers, or if, even with an increasingly diverse STEM population, the illustrations continue to be significantly representative of men.

The continued study will: (1) refine the procedure and method used to gather the illustrations to give a more complete picture of the participant’s view of engineers, and (2) expand the number of illustrations analyzed to give a more generalized description of how the participants view the engineering profession, and (3) use that more generalized description to assess whether attempting to reframe engineering as a white male-dominated field has improved the perceptions of the next generation of STEM students.

Keywords: *precollege, drawing, art, dimensions of diversity, engineering*

Divisions: precollege, minorities

Introduction

Who can be an engineer? This question has been asked by students, researchers, practicing engineers, and now, this research team at the University of Cincinnati. However, as the Removing Obstacles for STEM Excellence (R.O.S.E) lab holds more than 15 intersecting identities, this paper seeks to understand the ability to determine how diverse role models have an impact on perceived identity. The outreach department of the R.O.S.E lab has offered a wide range of summer camps to help offer examples of a variety of identities in an outside-the-classroom experience of what engineering is. Our goal is to improve the United States' standing in the international stage of education, while also justifying the need to produce a diverse engineering future workforce. A personal determination amongst our diverse lab to help bring other similarly diverse individuals into the world of engineering, confirmation of the efforts in improving the diversity of thought within our institutions is required [2].

Traditionally, engineers and STEM professionals have been viewed by students as white, able-bodied men with college degrees [5]. Women, non-binary persons, and racially and ethnical minorities, having been barred from higher learning for hundreds of years, are now making progress in terms of representation [6]. The fact remains that there is a large gender and race gap in the field of Engineering [7]. Worldwide, efforts have been made to attempt to see how engineering perceptions affect students' decisions to go into STEM [8]. To help students, specifically students who have been historically denied access, it is significant to teach them the foundational concepts of engineering. This is accomplished through first understanding their perception about this field, ideally increasing the number of talented students pursuing engineering as their future career [9], [10], [11]. Holistically understanding engineering perception and what characters define it from students' perspectives can help to recruit and retain more diversity in this field, providing a stronger background of knowledge and experience to succeed [12].

This study was conducted to offer a fresh perspective on the ongoing efforts to diversify the engineering field, focusing specifically on evaluating precollege students' perceptions of engineering. We introduce a novel assessment method that revolves around creatively capturing participants' engineering perceptions that aligns with current explorations. Throughout this study, and in the subsequent research article, we employ the term arts-based to denote a methodology centered on gathering participants' own artistic expressions as data points to explicate their experiences related to engineers and the field of engineering.

Arts-based research offers a novel approach to inquiry, utilizing creative methods to delve into complex phenomena. This qualitative study adopts an arts-based design, drawing on the rich tradition of participatory arts-based research [13]. By embracing this approach, we aim to provide a more dynamic exploration of engineering concepts within our research. The decision to employ an arts-based design was motivated by the desire for a participatory approach that could accommodate the diverse linguistic backgrounds of participants, aligning with the growing need for inclusivity in educational research. Additionally, the egalitarian nature of arts-based research, as highlighted by Brown [14], played a pivotal role in shaping our methodological choice, facilitating a more inclusive and accessible research process.

Methodology

During the summer of 2023, at the University of Cincinnati, 48 students attended the Men of Color high school engineering camp. This camp involved work with students who identified as being African American/Black Asian, Hispanic/Latinx, and/or mixed races. The majority of participants self-identified as Black and only one student as white. These students were immersed in a week-long experience wherein they toured campus facilities, spoke with industry professionals, toured local engineering companies, and completed hands-on STEM and communication activities. The week culminated in a final presentation on Friday where families, partners, and staff were invited to view capstone presentations where participants presented their vision of a prompt: The Future of Engineering.

At the beginning of the weeklong immersion, students participated in a creative pre-camp drawing activity (completed the morning of Day One) and a post camp drawing activity (completed in the afternoon of Day Five). The use of innovative methods can improve the understanding of complex information and one of these creative methods is art-based research [15]. In the STEM field, researchers used art-based research for the first time to uncover engineering students' identities as engineers [16]. Using art-based research helps people cope with their life circumstances [17]. Some researchers like Knight & Cunningham [18] and Kearn and his colleagues [19] used the Draw an Engineer Test which was our inspiration to design a similar procedure to conduct this research to see how our students draw an engineer before starting their camp.

Of the 48 students, 36 took part in the activity. While we strived for a 100% completion rate, our numbers do not match perfectly due to several factors, including but not limited to the following:

- Absent, tardy, or early release students.
- Students stepping out of the room during the activity.
- Students who were distracted or talked with friends rather than completing the activity.
- Lack of even distribution of art supplies.

The summarized procedure was as follows: Students were asked to complete a drawing of an engineer, along with five descriptive words and a sentence describing what an engineer does. An emphasis was placed on giving no other instructions being given during design as an effort to decrease bias or expectation. Participants knowing the 'goal' of the activity would affect the reliability of the drawings collected. Students were given access to colored pencils as well as any writing utensils they had brought with them for the camp. They were given five minutes before drawings were collected. As mentioned above, a second activity as a post-test was then conducted a week later. These papers were then analyzed by the team over the course of the next few months.

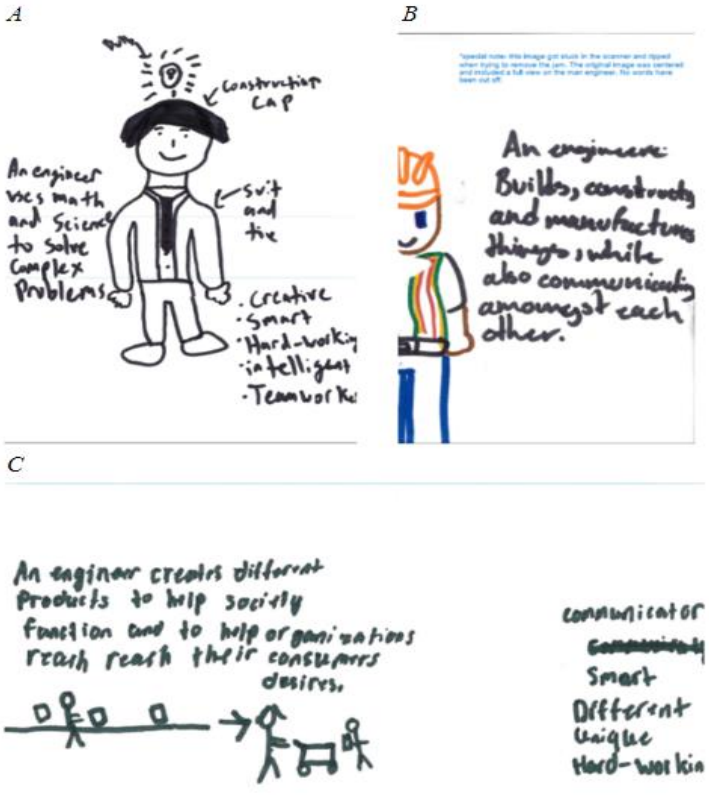
Findings

Two definitions emerged from the student's drawings and how they described *who is an engineer?:* (1) a traditional definition, where included in their expressions are phrases and concepts like *creating something new*, *smart*, and *using math and science knowledge to solve problems*, and (2) what the researchers will call a fundamental definition of engineering,

including expressions like *creativity* or *creative*, *teamwork,* and *communicator*. The reasoning behind the term fundamental due to the researchers' beliefs that the depictions of engineering incorporate the skills of an engineer at is most basic level. Without these skills, even the *smartest* or most skilled in mathematics and science would struggle. In the participant responses, many of these essential engineering expressions were accompanied by a description of engineering as making a difference, using phrases such as *an engineer creates different products to help society* in Figure 1C or *communicating amongst each other* in Figure 1B. In addition to the array of adjectives and descriptions, participants also expressed their view of engineering without a need to depict any specific person or identity. Instead, some of these expressions involved drawing the different characteristics that embodied an engineer without a person.

The more traditional definition of engineering often involved depictions of an engineer as a person who wears a suit and tie in his job environment (Figure 1A) and/or engineering as a field that focuses on specific productive tasks like *an engineer is a person who designs, builds, or maintains engines* or *an engineer is a builder and smart*. It's important to note that at times, both the traditional and fundamental definitions of engineering could be seen in a single participant's expression, also seen in Figure 1A.

Figure 1



Note. (A) Drawing 21 of 36, (B) Drawing 10 of 36, and (C) Drawing 22 of 36

At this point in time, the researchers were unable to draw a conclusion as to whether this group of young men's drawings envisioned themselves as engineers or other engineers as men. Further investigation of this will be postponed until there is time to examine a full range of camps where students are separated by gender.

Discussion

Students' perceptions of engineering and their beliefs about this profession can significantly affect their decision to choose a STEM-based degree and career path [18]. The researchers' investigation into participants' attitudes identified a split between a more traditional definition or a fundamental definition of engineering as a field. The students expressed their belief that engineering needs creativity, intelligence, and complex math and science knowledge. The outcome of this initial analysis was outlining a new way to define and categorize the student's perception of engineering. However, this study has not confirmed that the work has shaken the lack of diversity in the expressions of engineers themselves. So far, this study has interestingly shown that both traditional and fundamental definitions emphasize collaboration, communication, and social effect. This dual perspective illustrates the evolving nature of how pre-college students perceive and describe the meaning of engineering. These discussion points have driven the redevelopment and refocus of the program. With the continued study including the entirety of participants who attended the many different camps, the data gathered will help reshape the work done in shifting the perception of engineering. The future progress of this study will see participants balance their expectations of what is required with the usefulness of social skills such as teamwork and interaction with others as crucial personalities that an engineer needs to have and learn. Ideally, this focus on the skills required to be an engineer will show an increase in the diversity of expression of what an engineer looks like. The desire of the team is to use the completed analysis and findings to help construct a model for building a more inclusive idea of engineering without distinctly focusing on "an engineer". Moreover, this similar focus on tasks and responsibilities of engineers has led some students to observe engineering as a diverse field in which anyone can be an engineer as long as they have the desire and fundamental skills.

From our initial findings, there is still a need to work on students' perceptions about engineering and try to teach them the nature of engineering. The design of the camp will also change to reflect the need for shifting student perceptions from the traditional to a more fundamental definition of engineering. As this was the first execution of this study and activity, a lot of improvement areas have been noted, especially surrounding the materials and time given to the participants. An effort was made to remove as much bias from the activity as possible, though this may have affected the quality of the expressions received. There may also be a better way to remove the tendency for students to assume or guess what is expected from them. These changes could potentially improve the following iterations to the activity, providing more improved expressions to compare with the data that we have already gathered. The proposed enhancements made to the activity could assist in shifting their definition of engineering throughout the week's camp and help to show engineering from an incongruent perspective, affecting their decision to choose engineering as a career while also as better preparing these future engineers for the trials that come.

Conclusion

The core belief behind this paper's creation was to provide a measure of how well the lab's summer camps were affecting the students' perception of qualified representatives in a field they aspire to join at a pre-college level from the Men of Color engineering camp. Researchers asked participants to draw an engineer and define who is an engineer with 5 adjectives as a pre-test which then evolved further with the results of this study. With the evolution of the study's process came the expansion of the initial art-based design, which was used to analyze students' creative expressions of engineering and engineers. These gathered expressions have shown the researchers a shift to a new definition of engineering, one without the need to have traits or identities of what has typically been thought of as successful. The main takeaway from this initial study is a need to address the researcher's own assumption that looking for "untraditional" expressions of engineering within the participant's art is limited only to a similarly "traditional" form of diversity. The researchers continue this project to expand the answer to who can be an engineer and will analyze the rest of the camps that were run in the summer of 2023, hoping to continue to see this positive trend.

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