# Career Pathways (Work in Progress)

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# Connecting Middle School Students' Personal Interests, Self-efficacy, and Perceptions of Engineering to Develop a Desire to Pursue Engineering Career Pathways (Work in Progress)


## Abstract

With the increased exposure to science, technology, engineering, and mathematics (STEM) through activities in-school and out-of-school K-12 learning environments and representation in media outlets, students who attend our summer engineering intervention tend to articulate a more holistic understanding of the role of engineers within society. However, despite this increased exposure and a diverse understanding, students from diverse backgrounds (e.g., racially/ethnically diverse and women) still pursue engineering career pathways at disproportionately lower rates than their peers. Research suggests that the disproportionately low rates may result in students disengaging with STEM careers like engineering as they progress through middle school and high school. Therefore, to contribute to research exploring the gap between exposure and enrollment in engineering programs, this work in progress paper intends to explore the relationship between middle school students' perceptions of engineering, their interests, and self-efficacy to better understand how an out-of-school engineering intervention may influence their engineering career aspirations.

This paper uses a concurrent mixed-method, case-study approach, to analyze participants' survey and interview data to understand how middle school students' interests and perceptions of engineering are influenced by an out-of-school engineering experience and influences their career beliefs. Using a Holland's theory of career choice, the preliminary analysis of this data helped us identify student cases that demonstrate the complex relationships between students' changing perceptions of engineering, their interests, and beliefs about their future career. This paper shares two cases that represents the eighty-six percent of student profiles from the makerspace experience: (1) students with initial low interests and self-efficacy who demonstrate high situational interests; and (2) students with high interests and uncertain self-efficacy who demonstrate improved fit between their perceptions and personal interests during the camp experience. The findings from this work will inform the development of engineering-focused curriculum and programs intended for out-of-school engineering learning experiences that supports middle school students making personally meaningful connections to the engineering activity and the discipline in the future.


## Introduction

With significant investments of money and resources targeted at improving the participation of racial, ethnic, socioeconomic, gender, and/or ability diverse students in engineering across the educational continuum, some national reports suggest engagement with science, technology, engineering, and math (STEM) must begin earlier in students' educational journey [1-2]. As a result, STEM interventions are continually being developed, modified and sustained throughout the K-12 educational ecosystem. Through consistent early engagement, the engineering community hopes to stimulate and foster interests, attitudes, beliefs, perceptions, and improve their self-efficacy to support students with diverse social identities in considering and pursuing engineering as a future career pathway. Despite the current efforts in K-12 educational settings, the participation and retention of diverse students in undergraduate engineering programs remains dismal [3].

To improve the participation and retention of diverse students in undergraduate engineering programs, more K-12 school curriculums include STEM content. Due to disparities in access for students from diverse racial, ethnic, and socioeconomic backgrounds to STEM curriculums in K-12 schools, out-of-school STEM programs are an important pathway for increased student engagement [4]. By engaging students in out-of-school engineering experiences, the engineering education community hopes to increase students' interests in pursuing careers in engineering by arousing excitement through their engagement with engineering activities [5-9]. Research suggest that two primary factors for diverse students limited engagement with engineering as a future profession is their narrow conception of engineering careers and their decreasing interests in core subjects like math and science as they progress through middle school [5-6]. For example, students' perceptions of engineering are often shaped by stereotypes perpetuated through public messaging (e.g. media) [10]. These stereotypes include, but are not limited to, the image of engineers as fixers or builders, male, and nerds [10]. As a result, students who do not see themselves represented by this image of engineering may feel as if they do not belong in the profession. In addition, students' interest act as motivators for continuous engagement [11]. If students are unable to make meaningful connections to the profession than their sustained engagement will often dissipate [10-11]. Although students will respond to engineering interventions in a variety of ways, we believe that students' engagement with engineering interventions may not improve alignment between students' perceptions of engineering and their interests resulting in students' situational excitement that is not sustained in their career pursuits [12].

As a result, this work in progress paper focus on the participation of students in middle school ($6^{th}$-$8^{th}$ grade) in a summer makerspace experience designed to introduce them to engineering to understand how middle school students' interests and perceptions of engineering are influenced by an out-of-school engineering experience and influences their career beliefs. We build on our previous work of utilizing interest-based framework to design engineering challenges to broaden participation and the development of a survey instrument to measure students' personal interests and their perceptions of engineering to identify students' likelihood of pursuing a career in engineering [12-14]. We used Holland's theory of career choice as the theoretical foundation for the survey instrument to understands students' perceptions of their interests and the engineering discipline along the following six dimensions: realistic, investigative, artistic, social, enterprising, and conventional [15]. We piloted the survey instrument with $3^{rd}$ – $5^{th}$ grade students at an engineering summer camp, where we aggregated the findings to identify global trends. The data suggested that gaps existed between students' interests and their perceptions of engineering, which could be contributing to their disengagement with engineering career pathways [12]. However, we were unable to draw conclusion about why these gaps existed. To address this limitation of the previous studies, we initiated this study to explore why gaps between students' interests and perceptions of engineering exists, how they influence students' self-efficacy, and career beliefs. In this work in progress paper, we present two student cases that represents the eighty-six percent of student participants in the camp experience. By presenting these cases, we want to illuminate the diversity of student perspectives that an out-of-school learning experience must accommodate to support the goals of broadening participation in STEM disciplines like engineering.

**Theoretical Framework**

The theoretical foundation of the survey instruments used in this study to measure the relationship between students' personal interest and perceptions of engineering is Holland's theory of career choice. Holland's theory of career choice utilizes six personality dimensions - realistic, investigative, artistic, social, enterprising, and conventional (RIASEC) to connect personalities to career choices [15]. The connection between personality and career choices described by Holland's theory of career choice was derived from observations of people engaging in different occupational settings. Based on Holland's theory of career choice, historical perceptions of engineering are skewed toward investigative and realistic, however due to the integrated nature of today's engineering landscape these roles are shifting to require equal emphasis on personality dimensions previously overlooked (e.g. social).

As K-12 engineering interventions seek to provide engagement opportunities that promote a sociotechnical understanding of engineering, it is becoming increasingly important to evaluate the effectiveness of interventions. We propose that effectiveness for supporting students' future engagement with engineering can be measured by differentiating between their situational and personal interests. In these theoretical underpinnings, situational interests relate to general engagement, whereas, personal interests can influence their choices [11]. In addition, if we are able to build a students' personal interests through our engineering intervention, they are more likely to have continued engagement with the discipline [11]. As students continue their engagement with the discipline they begin to develop their self-efficacy, which will impact the career paths students perceive as achievable [16]. By using the theoretical underpinning of career choice, personal interests, and self-efficacy, we are able to explore how engineering interventions influence students' engineering career aspirations.

**Methods**

This study used a concurrent mixed-method approach to explore the relationship between students' personal interests, perceptions of engineering, self-efficacy and their engineering career aspirations. In the study, we use concurrent triangulation design to attempt to confirm or corroborate our findings within the study [17]. Through this approach, we wanted to gain an in-depth understanding of students' mindsets as it relates to future careers in engineering by conducting exploratory interviews about students' survey responses through their subsequent engagement in the engineering intervention. To meet the study goals, we administered pre-survey to identify students' interest. Student interest items were adapted from O*NET Mini Interest Profiler [18]. On this survey, students identified how likely they were to engage in a variety of activities that we mapped to components of Holland's theory of career choice. For example, a survey item mapped to realistic component is building things. Other examples of survey items included engaging in experiments, doing arts and crafts, and helping others. A pre- and post- surveys to understands students' perceptions of engineering that include three additional 5-point Likert-scaled statements related to students' current beliefs and career aspirations to all consenting students[1]. The perception survey asked students to rate how much

[1] Consenting students implies parent consent in addition to student assent.

they think an engineer engages in twenty-four different items. These items were also mapped to Holland's theory of career choice and included items like helping people, design or build, working with others, and more. At the end of the perceptions of engineering surveys, students were asked to identify their level of agreement with the following statements (1) *I like engineering*, (2) *Engineering is exciting to me,* and (3) *I believe I can become an engineer.* Using student reported levels of agreement to the three questions at the end of the perception of engineering surveys, we interviewed students who reported a strong agreement or a strong disagreement with all three statements and students who identified a strong agreement with statement 1 and 2, but a weak agreement with statement 3 at the beginning, middle, and end of camp. To determine the fit between students' interests and their perceptions of engineering, we calculated correlations between their interests and perceptions. All interviews were recorded and audio transcribed verbatim to ensure accuracy of the student narratives. At the conclusion of the 10-day intervention, the research team created vignettes, known in this document as student profiles with assigned pseudonyms, from the collected qualitative and quantitative data.

*Engineering Intervention*
The summer engineering intervention is embedded within a free five-week summer camp created for children ages 8-14 (3rd-8th grades) from families whose incomes are at or below the federal poverty line. Each day approximately students arrive on the campus of a large Midwestern university where they participate in 40-minute activity stations. These stations include activities in STEM (Science, Technology, Engineering, and Mathematics), financial literacy, dance, art, videography, photography, judo, nutrition, swimming, career development, service learning, and other special events. During the STEM station, campers work in small teams (2-4 students) to complete four different engineering design challenges developed and facilitated by our research staff.

*Participants*
During the summer, 137 students in grades 6th-8th (ages 11-14) participated in the 10-day summer engineering intervention, only 64 students consented to participate in the study and had completed pre- and post- surveys. Of the remaining 64 students, 67.2% identified as non-White (1.6% American Indian/Alaskan Native, 10.9% Asian, 23.4 % Black, 10.9% Two or more races, and 1.6% Other) and 32.8% as White. Although we are reporting the aggregated camp demographics to provide transparency of the camp context, we do not intend to suggest that students' social identities are singular contributing factor for differences in the presented student profiles or that the profiles chosen in this paper are representative of all students with similar backgrounds across any context. However, we would be remiss if we did not acknowledge that students' identities could be one many factors influencing their experience in addition to the findings of this study. Using the interview selection process identified in the methods, we concluded the study with 21 student profiles with all the quantitative and qualitative data components complete out of the 64 members of the consenting population. The final participant pool comprised of student profiles from 11 females and 10 males.

*Data Analysis*
The research team began by writing student profiles that included a brief description of the student (e.g. pseudonym, age, gender, race, etc.), any previous experience with engineering, a

description of their survey responses, and their identified career aspirations from interviews. Next, we analyzed the fit between students' interests and perceptions of engineering at the beginning and end of the intervention. Next, we included any changes students identified in their interviews throughout the intervention. And lastly, we described the connections students made between the makerspace experience and their career aspirations.

Once the student profiles were complete, the research team reviewed all of the student profiles overall several weeks and discussed interpretations of the data at weekly research meetings. In these weekly meetings, we began deductively coding student profiles to identify themes as they relate to fit between personal interests, perceptions, self-efficacy, and students' career aspiration. This coding process is currently in process and is not represented in this paper. However, during our initial analysis processes, we noticed that the expectations of engineering intervention to improve interests, attitudes, beliefs, perceptions, and self-efficacy placed a significant burden on the intervention design. As a result, we are sharing two cases to demonstrate the student negotiations that occur during the engineering camp experience and how these negotiations influence the relationship between their interests, self-efficacy, and career aspirations.

**Results**

The results section highlights two different student profiles demonstrate the complex negotiations occurring with the context of engineering interventions by students. The two student profiles represent eighty-six percent of the twenty-one student profiles, we created. These profiles are as follows:

(1) Joseph: A $6^{th}$ male student with limited interests in engineering and low self-efficacy at the beginning of the intervention (Figure 2). Over the course of the intervention, Joseph demonstrates an increase in situational interests and self-efficacy with disjointed relationship between his personal interests and perceptions of engineering (Figure 1).; and

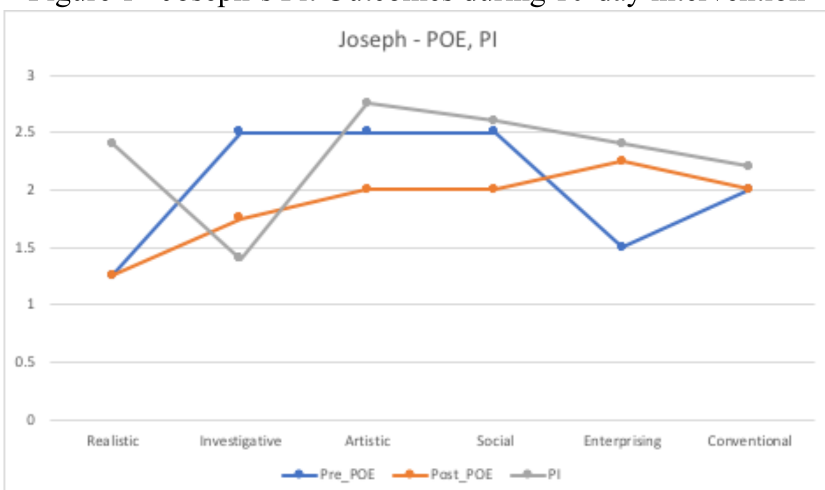
(2) Jessica: A $6^{th}$ grade female student with an initially reported high interest in engineering and some uncertainty in her reported self-efficacy (Figure 4). Over the course of the intervention, Jessica's interests and self-efficacy does not change, but her student profile demonstrates an increased alignment in her perceptions of engineering with her personal interests (Figure 3).

*Joseph*

At the beginning of intervention, Joseph reported that he believed engineers personality profiles according to Holland's [7] theory of career choice was investigative, artistic, and social (Figure 1). He identified that his personal interest aligned with artistic, social, and enterprising traits in decreasing order. In addition, Joseph reported he did not like engineering nor was engineering exciting for him, which we identify as elements of the potential for situational interests during the intervention (Figure 2). When asked about why self-beliefs and aspirations were rated lower, Joseph mentioned did not believe that he could become an engineer because he "wasn't a good listener" and did not have any "mechanic skills". These statements are an example of Joseph's low self-efficacy and personal interests as he begins to eliminate the possibility of becoming an engineer because he believes it requires skills beyond his recognized capabilities. This aligns ideas presented by Bandura, Barbaranelli, Vittorio Caprara, and Pastorelli [16] that students will eliminate future career possibilities when they believe the occupation is beyond their current ability. When asked about his future career aspirations, Joseph acknowledged that he didn't know but a professional athlete may be an option.

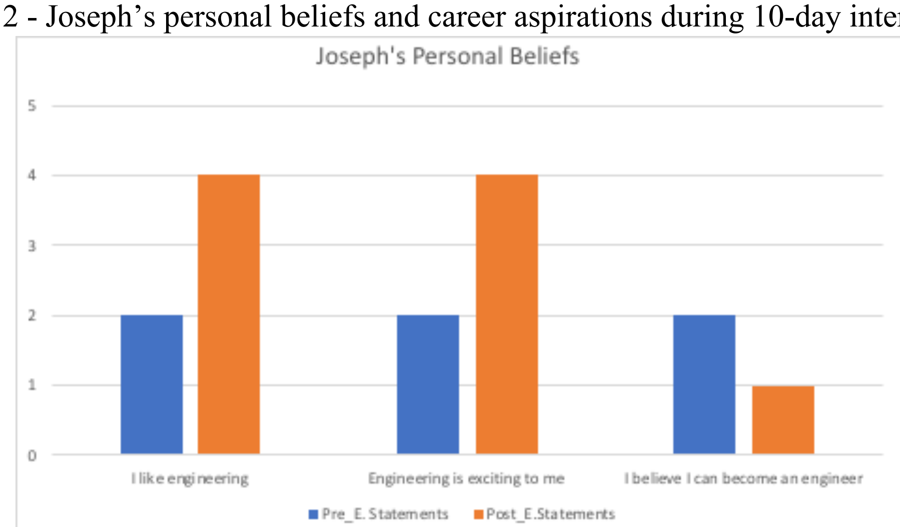
As Joseph engaged with different team members in 5 different engineering design challenges over the 10-day period his perceptions and self-efficacy began shifting. As seen in Figure 1, Joseph's perceptions of engineering decreased in the traits initially identified. Joseph explained that his decreased perception was a result of a change in his perceived level of difficulty. Due Joseph becoming more confident in his abilities to engage in the skills of an engineer, by the end of camp, Joseph states "I can [become an engineer], but I just don't want to waste time." This statement is a direct reflection of the mismatch in Joseph's personal interests with his pre- and post- perceptions of what a career in engineering may entail (Figure 1).

Figure 1 - Joseph's Fit Outcomes during 10-day intervention




In addition, elements of Joseph's situational interest increased while his personal interests decreased over the course of the intervention (Figure 2).

Figure 2 - Joseph's personal beliefs and career aspirations during 10-day intervention



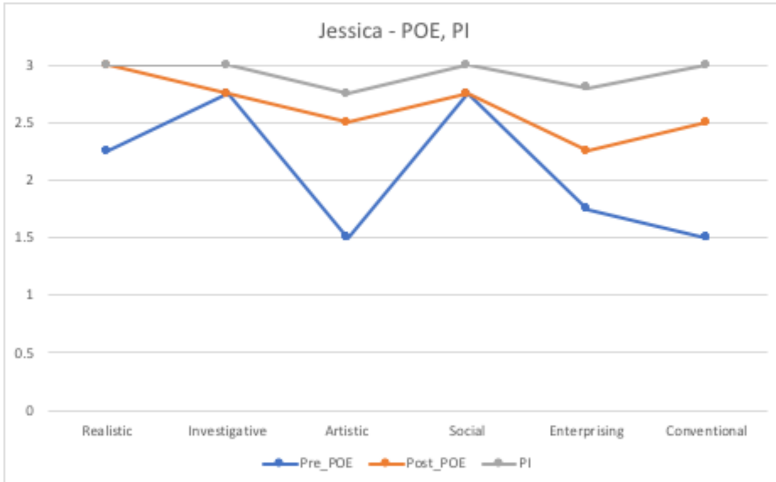
*Jessica*
At the beginning of the intervention, Jessica reported that she believed engineers personality profiles according to Holland's theory of career choice is realistic, investigating, and social [15]. However, she does not initially believe that engineers are artistic, enterprising, or conventional. In addition, she reported that she had some previous exposure to engineering seemed to like it and think it was exciting (Figure 3).

Figure 3 - Jessica's personal beliefs and career aspirations during 10-day intervention


At the start of the intervention, Jessica wanted to become a doctor and was not certain if engineering is something she would like to pursue. Jessica's initial profile represents a student with high situational interest and some uncertainty about her self-efficacy and personal interests. Given the developmental age levels of uncertainty is expected. Our hope is that the engineering intervention will promote continued engagement in the future.

As Jessica completed the five design challenges with different team members, Jessica's interests and excitement for engineering did not change. Jessica states "...like engineering is exciting for me and that's true because you get to design things to like help people for fun and see what they do…". Then, Jessica continues "...but [I'm] unsure if I want to become an engineer". This uncertainty remains present in Jessica's responses to the interests' statement. However, the most interesting aspect of Jessica's profile is the outcomes of the survey instruments (Figure 4). As represented by Figure 4, Jessica's perceptions of engineering at the end of camp (orange line) began to shift to a similar shape as her personal interests (grey line). Based on Jessica's engagement over the course of the intervention and these outcomes, it is highly likely that Jessica will continue to engage with engineering and similar disciplines in the future [11].

Figure 4 - Jessica's Fit Outcomes during 10-day intervention




**Discussion**

The two cases presented in this study demonstrate the complex negotiations students engage with during engineering inventions. During their engagement in engineering interventions, students are building their conceptual and practical skills along with reconciling how the activity aligns with their current interests. In this reconciliation process, students, like Joseph and Jessica, begin to make preliminary career choices that may result in continued engagement with activities related to the occupation or disengagement. These decisions during middle school may influence course selection, extra-curricular engagement, and future aspirations. They have the potential in a single interaction to transform a students' future career trajectory.

In the case of Joseph, the engagement with our engineering intervention did not align with his personal interests. Although his self-efficacy increased and he could see himself as an engineer, engineering was not a potential career of interests. We acknowledge that these decisions are fluid and can change at any moment, but with this example as curriculum designers and researchers we must begin to reflect on the intervention design. The current intervention is situated in constructing prototypes, which Joseph does not associate with his artistic personal interests. As a result, our team should evaluate ways to incorporate various artistic modes within the engineering design to support students with interests like Joseph. On the other hand, Jessica initially reported high interests in engineering with some uncertainties about her self-efficacy and future aspirations. Although these factors did not significantly change, we witnessed Jessica's perception of engineering begin to align more closely with her personal interests. In this scenario, curriculum developers and researchers should explore how this transition is occurring to determine ways to foster this for more students.

By continuing the analysis of this work, we intend to identify practical ways shifts in the intervention design can support a diverse student population by enhancing their self-efficacy through engagement in with their personal interests.

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