2018 ASEE ANNUAL CONFERENCE & EXPOSITION
JUNE 24–27, 2018
SALT PALACE CONVENTION CENTER
SALT LAKE CITY, UT

Paper ID #22914

Investigating the Fit Between Students' Personal Interests and Their Perceptions of Engineering in a National Society of Black Engineers (NSBE) Precollege Summer Workshop (Fundamental Research)

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Introduction

Concern over the underrepresentation of women and certain minority populations in engineering has been a concern for the last few decades. Government agencies, non-profit organizations, and private companies have invested significant money and resources to address this concern (Committee on Equal Opportunities in Science and Engineering (CEOSE), 2017; Gibbin & Davis, 2002); however, the numbers of women and underrepresented minorities participating in engineering remains dismal (National Science Foundation & National Center for Science and Engineering Statistics, 2017). Much of this money has been invested in pre-college engineering education programs aimed at introducing students to engineering with the goal of improving their interests, attitudes, knowledge, beliefs, perceptions, etc. of engineering. Research and evaluation efforts connected to these interventions have shown promising results, yet matriculation into engineering undergraduate programs continues to lag.

The psychology of interests provides a useful distinction between situational interests and personal interests (Krapp, Hidi, & Renninger, 1992). Situational interests relate to the interestingness of the social or nonsocial environment that evokes engagement for an individual. Personal interests relate to one's personal characteristics that influence their choices to engage in a particular social or nonsocial environment. Personal interests are more likely to predict prolonged and persistent engagement (Renninger, Hidi, & Krapp, 1992), while situational interests may be fleeting given the temporary nature of certain situations. Our hypothesis is that pre-college engineering outreach interventions measuring change in students' engineering interests may be primarily measuring their change in situational interests. The engineering intervention may have been fun and engaging, at least as compared to the alternative (e.g., silent reading time, mathematics worksheets, etc.). However, these engineering interventions may not be sufficiently appealing to students' personal interests and resulting in a sustained, persistent pursuit of engineering.

This paper presents pilot results from administering the Fit of Personal Interests and Perceptions of Engineering Survey (F-PIPES) across 16 National Society of Black Engineers (NSBE) Summer Engineering Experience for Kids (SEEK) workshop sites as part of a larger project. The pilot included a survey of the 3rd-5th grade students' personal interests as mapped to the six dimensions of interests in Holland's Career Theory (1997)—realistic, investigative, artistic, social, enterprising, and conventional. The students then took a survey administered at the end of the 3-week engineering workshop measuring their perceptions of engineering as it maps to those same six dimensions. This framework was applied in a previous interview study of students participating in engineering activities revealing that students' personal interests were more concentrated toward the social dimensions, and that after participating in broad, holistic engineering activities the students perceived engineering as a more socially-related endeavor (M. M. Hynes, Joslyn, Hira, Holly, & Jubelt, 2016). This provided the impetus to develop the survey instrument.

Methods

The participants recruited for the study reported here were participating in a larger multi-institution study. This study includes the pre-surveys of students personal interests (36 items) from an interest profiler instrument used by the Bureau of Labor Statistics (Rounds, Ming, Cao, Song, & Lewis, 2016) followed by a post-intervention survey of their perceptions of engineering (24 items). The surveys were administered via paper and pencil and each item was read aloud by the instructors of the camp experience. Survey results were entered into a spreadsheet where students were assigned numbers removing any personal identification.

Participants

Participants for this study were recruited from NSBE SEEK camps taking place in 16 cities across the United States. Approximately 3000 8-11 year-old students took part in these camps, with approximately 1000 consenting to participating in the project's research. From that pool, 715 students completed in full the interests survey and 635 completed the perceptions survey in full. The racial/cultural ethnicity identification of the students participating breaks down as: 82.2% African American or Black, 5.9% Multiracial (including Black), 6.5% Hispanic/Latin@, 1.7% White, 1.6% Asian, and 1.8% Other. The gender of participating students broke down as 55% female, 45% male, which included one all girls camp.

Engineering Intervention

The NSBE SEEK camps are three weeks long and students take part in a different unit for each camp. The units all follow the same framework where students can take place in one of three competitions that are held on the Friday of each of the three weeks. The competitions fall into the categories of a design competition, an artistic competition, and a presentation competition. NSBE SEEK has nine different curricular units that all involve the development of some sort of hands-on artifact. Each camp site experiences 3 of these units. The units range from developing a remote-controlled machine to a catapult to fragrances to coding a snap-circuit rover. The daily activities focus on learning related mathematics and science concepts and then engaging in the engineering design process to develop the artifact. The final days of each week are preparation for the competition where the artifact will compete against other groups across the site, and sub-teams will be judged on artistic and oral presentations.

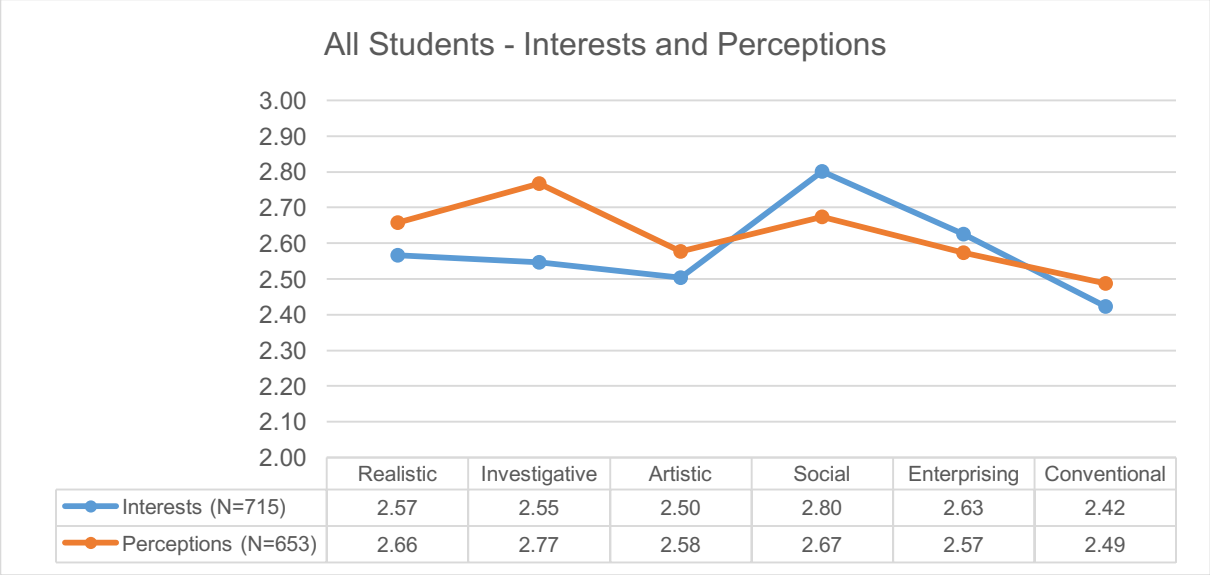
Data Analysis

The data were analyzed in excel where the means of each of the six interest dimensions were calculated for the different demographics analyzed. Likewise, the means were calculated for the perceptions of engineering items for each of the six dimensions.

Results

The F-PIPES instrument measures students' personal interest profiles and their perceptions of engineering along six interest dimensions—realistic, investigative, artistic, social, enterprising, and conventional. Briefly those are defined as:

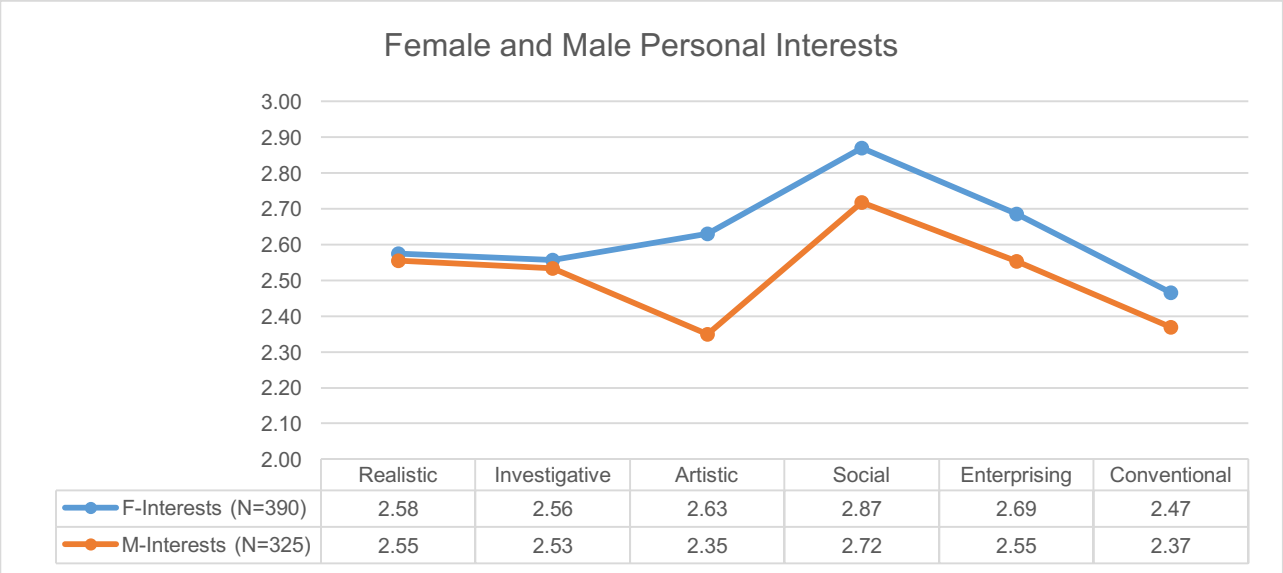
Realistic – hands-on doing, building, creating, fixing, etc.
Investigative – analytical thinking, mathematics/science, figuring things out
Artistic – creative thinking, making art, making music, etc.
Social – helping people, teaching others, thinking of society
Enterprising – business-minded, persuading others, entrepreneurial
Conventional – data organization, following rules, systematic processes



	Realistic	Investigative	Artistic	Social	Enterprising	Conventional
Interests (N=715)	2.57	2.55	2.50	2.80	2.63	2.42
Perceptions (N=653)	2.66	2.77	2.58	2.67	2.57	2.49

Figure 1: Personal interests and perceptions of engineering for all IRB approved students who completed all survey responses

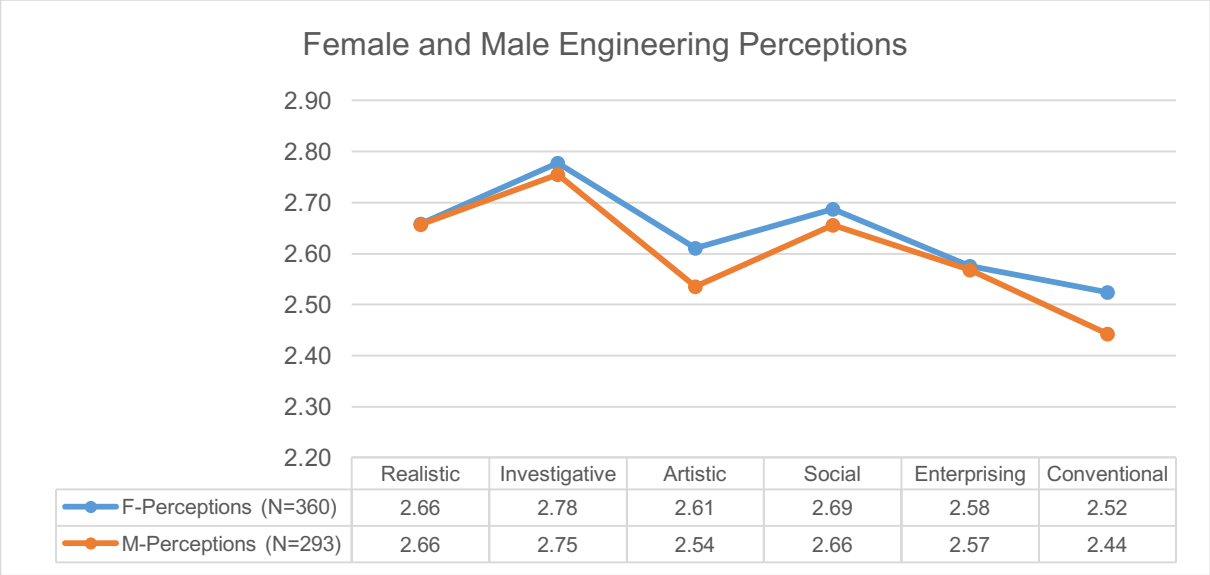
Figure 1 displays the results for all students where we had complete data and consenting parents/students. In looking at the results, there are some distinct gaps between students' interests and their perceptions of engineering. In particular, we see students viewing engineering as realistic and investigative, but they do not have as high interests in those dimensions. On the other hand, we see students with high interest in the social dimension, but the engineering perception does not quite rate as highly. It is important to remember that we only did the perceptions of engineering as a post-survey. There may have been movement up or down in any of these over the course of the 3-week SEEK camps, which would be more telling for what the program really impacts. Pre- and post- administration for the survey is planned for the 2018 camps. The figures presented below break things down by gender.



	Realistic	Investigative	Artistic	Social	Enterprising	Conventional
F-Interests (N=390)	2.58	2.56	2.63	2.87	2.69	2.47
M-Interests (N=325)	2.55	2.53	2.35	2.72	2.55	2.37

Figure 2: Interests profiles of female and male students according to Holland's dimensions.

Figure 2 displays the interest profiles for all female and male students. Clearly, the female students have higher interests in artistic and social dimensions as well as slight higher in enterprising and conventional. The differences for all four of these differences is significant at the $p<.01$ level. At the end of this document, there are a few recommendations or things to think about with respect to these results. It is also important to note that for both male and female students the interests in the social dimension is the highest pointing to an opportunity to ensure that engineering activities highlight the social nature of engineering. Many engineering interventions center on a hands-on design task that is highly engaging for students (highlighting the realistic and investigative dimensions), but these results point to the need to make sure those tasks also relate to the humanistic aspects of engineering (M. Hynes & Swenson, 2013).



	Realistic	Investigative	Artistic	Social	Enterprising	Conventional
F-Perceptions (N=360)	2.66	2.78	2.61	2.69	2.58	2.52
M-Perceptions (N=293)	2.66	2.75	2.54	2.66	2.57	2.44

Figure 3: Female and male engineering perceptions according to Hollands six dimensions

Figure 3 displays the male and female students' perceptions of engineering after participation in the SEEK camp. It is quite interesting and somewhat promising that the perceptions of engineering were relatively consistent between female and male students. This may point to a consistent message and experience in the SEEK camp. Again, this is speculative as we do not know what, if any, change occurred over the 3 weeks. It is also promising that the social dimension rates relatively highly as that is the dimension of highest interest among students. The NSBE SEEK experience does try to emphasize that engineers help people and they have chants and other messaging highlighting these ideals.

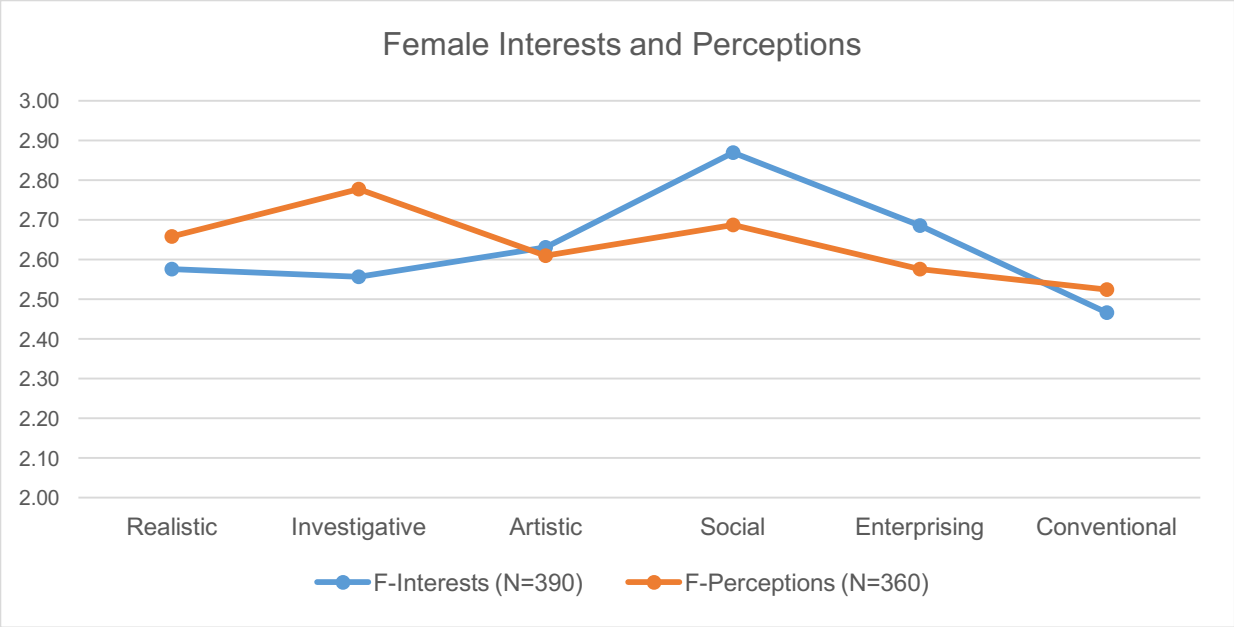


Figure 4: Female interests and perceptions of engineering

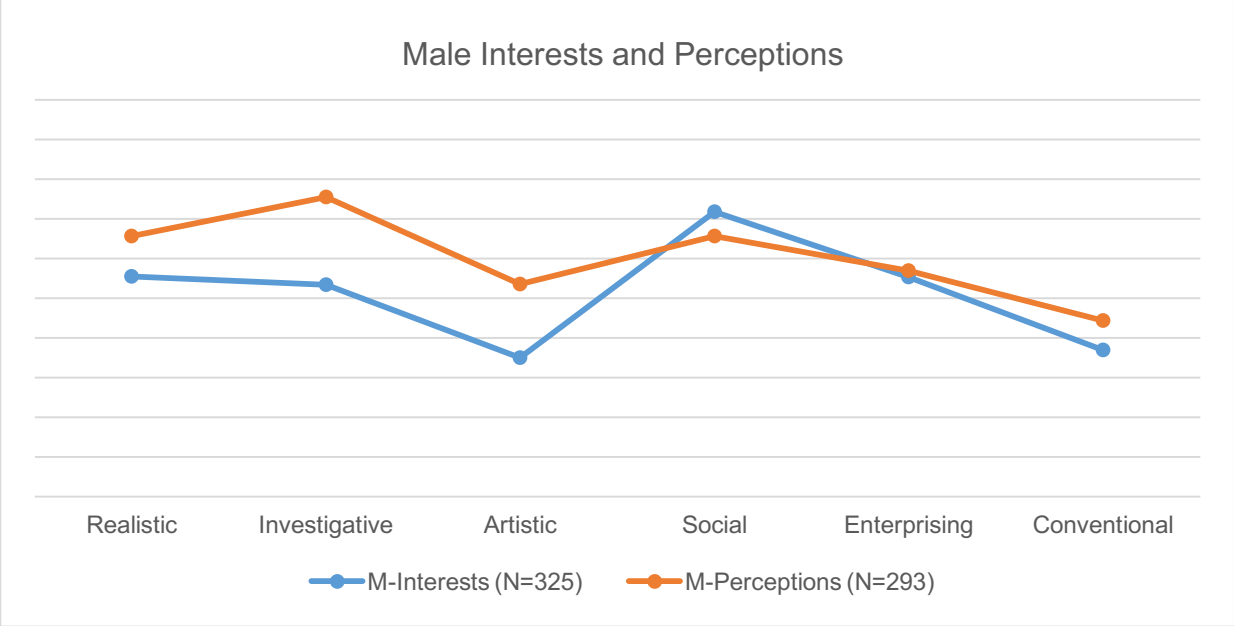


Figure 5: Male interests and perceptions of engineering

Figures 4 and 5 allow us to see how the students' interests and perceptions align according to gender. The figures highlight how the differences in male and female interests create gaps with their perceptions. Common to both male and female particpants was the higher perceptions of engineering as realistic and investigative as compared to their interests in those dimensions (significantly different at $p<.01$). Engineering is certainly a domain that emphasizes those dimensions (see Department of Labor and National Center for O*NET Development's database

https://www.onetonline.org/), which may point to an opportunity to think about integrating those aspects of the engineering task in artistic (especially for female students) or social contexts. For example, an activity might include analyzing data that students collect from people (maybe they gather data from their peers, the mentors, etc.). These gaps could also point to students' lower self-efficacy in those dimensions that with continued exposure and practice could increase over time and become better aligned. For example, an activity might include analyzing data that students collect from people (maybe they gather data from their peers, the mentors, etc.).

The results also highlight differences between female and male interests. This could be helpful in thinking about the value of the single-gender sites or maybe exploring the possibility of single-gender classes within a co-ed site. In a female-only site it appears that emphasizing the social, artistic, and enterprising dimensions of engineering would be beneficial, while an all-male class may want to emphasize the social more and artistic less.

These results coupled with the observations, other surveys and knowledge assessments may shed light on additional opportunities to tweak the curriculum and programming for the students as well as the training for the mentors.

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