Journal of Pre-College Engineering Education Research (J-PEER)

Volume 13 | Issue 2 Article 6

2023

The Effects of Engineering Summer Camps on Middle and High School Students’ Engineering Interest and Identity Formation: A Multi-methods Study

Timothy Robinson
University of Nevada, Reno, trobinson@washoeschools.net

Adam Kirn
University of Nevada, Reno, akirn@unr.edu

Jenny Amos
University of Illinois Urbana Champaign, jamos@illinois.edu

See next page for additional authors

Recommended Citation

Robinson, T., Kirn, A., Amos, J., & Chatterjee, I. (2023). The Effects of Engineering Summer Camps on Middle and High School Students’ Engineering Interest and Identity Formation: A Multi-methods Study. *Journal of Pre-College Engineering Education Research (J-PEER), 13*(2), Article 6.
https://doi.org/10.7771/2157-9288.1351

The Effects of Engineering Summer Camps on Middle and High School Students' Engineering Interest and Identity Formation: A Multi-methods Study

Abstract

This multi-methods study explores changes in engineering interest and identity of middle and high school students (n = 79) attending introductory-level engineering summer camps at a large western land grant university. Middle school is a critical time when student interest, identity, and subsequently career choice begin to emerge and hence it is important that at this age students are given accurate information about engineering majors in college and future career opportunities in engineering. Data were collected over a period of two years in six summer camps. Three separate populations of middle and high school students participated in the summer camps: (a) Young Women in Engineering camp, (b) First Generation Engineering camp, and (c) Open Enrollment Engineering camp. The study adds to the body of knowledge regarding involvement in informal engineering experiences and the effect on engineering interest and identity for this age group. Pre- and post-surveys as well as focus group interviews indicated a positive change in engineering identity and a strong increase in interest in pursuing engineering majors in college and engineering careers. Four themes emerged from the qualitative data, namely future self as an engineering major and/or engineering professional, enjoyment of camp activities and engineering interest, perceptions and knowledge of engineering, and increase in engineering identity as a result of camp participation in well-structured and purposefully designed activities. Changes implemented in summer camp design based on these themes are discussed.

Keywords

engineering interest, interest triggers, engineering identity, engineering summer camps, middle school, multi-methods

Document Type

Research Article

Cover Page Footnote

This research was funded by the National Science Foundation PFE: RIEF program, grant number 1738141. The Institutional Review Board of the institution has approved all procedures. We thank the College of Engineering outreach staff Meg Fitzgerald, Rebecca Glasgow, Elyse Bozsik, and Claire Parker for conducting the summer camps.

Authors

Timothy Robinson, Adam Kirn, Jenny Amos, and Indira Chatterjee

Available online at http://docs.lib.purdue.edu/jpeer

Journal of Pre-College Engineering Education Research 13:2 (2023) 84–106

The Effects of Engineering Summer Camps on Middle and High School Students' Engineering Interest and Identity Formation: A Multi-methods Study

Timothy Robinson[1], Adam Kirn[1], Jenny Amos[2], and Indira Chatterjee[1]

[1]*University of Nevada, Reno*
[2]*University of Illinois Urbana Champaign*

Abstract

This multi-methods study explores changes in engineering interest and identity of middle and high school students (n = 79) attending introductory-level engineering summer camps at a large western land grant university. Middle school is a critical time when student interest, identity, and subsequently career choice begin to emerge and hence it is important that at this age students are given accurate information about engineering majors in college and future career opportunities in engineering. Data were collected over a period of two years in six summer camps. Three separate populations of middle and high school students participated in the summer camps: (a) Young Women in Engineering camp, (b) First Generation Engineering camp, and (c) Open Enrollment Engineering camp. The study adds to the body of knowledge regarding involvement in informal engineering experiences and the effect on engineering interest and identity for this age group. Pre- and post-surveys as well as focus group interviews indicated a positive change in engineering identity and a strong increase in interest in pursuing engineering majors in college and engineering careers. Four themes emerged from the qualitative data, namely future self as an engineering major and/or engineering professional, enjoyment of camp activities and engineering interest, perceptions and knowledge of engineering, and increase in engineering identity as a result of camp participation in well-structured and purposefully designed activities. Changes implemented in summer camp design based on these themes are discussed.

Keywords: engineering interest, interest triggers, engineering identity, engineering summer camps, middle school, multi-methods

Introduction

A fundamental problem in engineering formation is the insufficient number of students interested in pursuing engineering as a college major and career. Student interest in engineering predicts whether they pursue engineering as a college major and future career (Carnasciali et al., 2013; Hirsch et al., 2007). Lent et al. (1994, p. 79) developed a framework based on Bandura's (1986) general social cognitive theory for understanding three factors that are critical in career development in late adolescents and early adulthood, namely "(1) formation and elaboration of career-relevant interests, (2) selection of academic and career choice options, and (3) performance and persistence in educational and occupational pursuits." They also point out the role that social and economic factors can play in affecting the level and content of career choices. Godwin et al. (2013) have leveraged aspects of these frameworks to validate a new engineering identity framework. This new framework deals with understanding how students perceive themselves as engineers and how these perceptions influence

https://doi.org/10.7771/2157-9288.1351

the choice of engineering as a major and career. Work in engineering role identity (Godwin, 2016) has demonstrated the importance of interest in students' career choices. Middle school is a critical time when student interest, identity, and, subsequently, career choice begin to solidify and hence the population on which studies should focus (Harris Interactive, 2011; Ing, et al. 2014). It is important that at this age students have accurate information about different career opportunities.

It is well known that the United States needs to train a highly skilled, diverse engineering and scientific workforce to maintain global competitiveness (Langdon et al., 2011; National Academy of Engineering, 2008; President's Council of Advisors on Science and Technology, 2012). According to an article in the Monthly Labor Review, there will be a need for one million more science, technology, engineering, and mathematics (STEM) professionals than will be produced in the USA over the next decade at the current rate (Xue & Larson, 2015). The U.S. Bureau of Labor Statistics predicted that the number of STEM jobs will reach more than 9 million between 2012 and 2022 (Vilorio, 2014). The National Academy of Engineering and National Research Council (2009) emphasize the importance of engineering education at the K-12 level. Since states have been slow to adopt the Next Generation Science Standards and to include engineering curricula in their K-12 classrooms (Carr et al., 2012; Moore et al., 2015), many universities with engineering programs have implemented informal STEM outreach programs for students in elementary, middle, and high schools. However, there is a need to better understand the ways these outreach programs influence middle school students' choice of engineering as a major and career. According to a report by Fairweather (2008, p. 6), "Increasing the interest of K-12 students in the sciences rests on university outreach efforts and improved K-12 instruction, not on college teaching."

A literature survey indicates a variety of STEM outreach programs designed for high school and middle school students, many of which focused on female students and underserved and minoritized students (Bottomley & Parry, 2002; Chen et al., 2011; Chu et al., 2019; Clewett & Tran, 2003; Decoito, 2015; Elam et al., 2012; Fralick et al., 2009; Hammack et al., 2015; Hirsch et al., 2011; Hubelbank et al., 2007; Massi et al., 2012; McAfee & Kim, 2007; McCormick et al., 2014; McKinney, 2002; Nadelson & Callahan, 2011; Sinkele & Mupinga, 2011; Tan et al., 2013; Unfried et al., 2014; Weavers et al., 2011; Zurn-Birkhimer & Holloway, 2008). Many universities have put in place outreach programs involving hands-on engineering activities with the goal of increasing interest in engineering and disseminating information regarding engineering education. Cloutier et al. (2018) described a week-long residential summer program for female high school students that resulted in participants gaining a more complete understanding of engineering and engineering disciplines. They found that one of the factors influencing interest in engineering was interest in problem solving and helping people. Interest in engineering also started in participants' middle school or early high school years. Informal out-of-school experiences in science and engineering present good opportunities for students to engage in and develop an interest in pursuing science and engineering in college and further on as a career. Maltese and Tai (2009) have reported that the majority of participants in their study examining experiences that first got them interested in science started even before middle school. Other studies have indicated that early exposure to science (elementary and middle school) has a strong influence on the development of interest in science and hence the choice of college major (Hazari et al., 2010). There is evidence that supports the importance of informal STEM education experiences in early childhood (Dou et al., 2019; National Research Council, 2009). Science identity has been found to be critical to understanding students' career choices (Hazari et al., 2010). The SEEK (Summer Engineering Experience for Kids) program offered by the National Society of Black Engineers has offered engineering experiences for well over 20,000 low-income community youth in grades 3–5 since 2007 (Edwards et al., 2018; Felder et al., 2020) and provides an insight into lessons learned over time, challenges of such programs, and offers strategies for addressing the challenges. However, more needs to be done toward understanding how informal learning experiences are related to identity and career choices.

While there is a lot of research on the subject of how informal science educational experiences affect students' attitudes toward and interest in STEM (Dabney et al., 2011; Dou et al., 2019; Maltese & Tai, 2009; National Research Council, 2009), the number of research studies on how engineering outreach programs affect students' (especially those in middle school) interest in engineering is sparse. In a study focusing on middle school student participation in an engineering summer camp experience, Hammack et al. (2015) found a positive impact on participants' attitudes towards engineering; however, it was not clear as to which of the camp activities contributed to this impact. Godwin et al. (2017) have examined how high school informal science experiences affect the choice of engineering majors in college and showed that these experiences do affect participants' choice in their chosen major, a topic that has not been the focus of many researchers. Several studies, including those by Elam et al. (2012) and Nadelson and Callahan (2011), have shown that engineering summer camps do indeed influence how students view engineering but do not address the topics of interest or identity formation. Although not specific to informal education experiences in engineering, Ing et al. (2014) found that it was important for students to be introduced to engineering in their elementary or middle school years.

The importance of informal education outreach programs like summer camps is clear, yet there is a dearth of research on the factors that contribute toward engineering interest and identity development in middle-school-age students. Specifically, the **objective** of the research described in this paper was to examine if engineering summer camp activities affect engineering interest and identity in middle school students. Three separate populations of middle school students participating in three engineering summer camps organized by the College of Engineering at a western land-grant university were involved in this project: (a) Young Women in Engineering camp, (b) First Generation Engineering camp, and (c) Open Enrollment Engineering camp. The camps were identical in content and were designed to increase understanding of the different fields of engineering. The goal of the summer camps was to give an opportunity for middle and high school students to engage in collaborative, hands-on engineering activities that would give them a proper perception of what engineers do, encourage them to think about engineering as a college major and future career, and give them exposure to the actual engineering industry and engineers at work.

The **research questions** that were addressed in this multi-method study are:

1. How does a week-long engineering summer camp affect middle and high school students' interest in engineering and their identity as engineers and to what extent do these change their perspective on future careers in engineering?
2. Which specific activities in the summer camps lead to a change in identity and interest in engineering?

This project fills in gaps in the literature by examining the development of engineering identity and interest in middle and high school participants of engineering summer camps and sheds light on how these students develop a sense of both professional and personal identification with engineering as a major in college and possible future careers.

Theoretical Framing

For this work, we borrow from two separate but interconnected theories to understand how summer camps influence participants' engineering interests and identities. Specifically, we utilize psychological conceptions and triggers of interest from Hidi and Renninger (2006) alongside the engineering role identity theory from Godwin (2016) to explore the effects of informal summer camp activities. Each of these theories has been connected to key outcomes such as persistence, engagement, deep learning, and choice of engineering, all crucial outcomes to supporting and growing the engineering workforce to meet industrial demands and creating access to the benefits that engineering can provide.

Hidi and Reninger (2006), Krapp (2002), and Krapp et al. (1992) describe interest as a psychological state that is strongly linked to a person's learning and develops when a person interacts with their environment and people involved in the learning experience. Renninger et al. (2015) and Renninger and Hidi (2016) have performed extensive work on the influence of learning experiences, including those in informal settings like STEM summer camps. Specifically, their work on the four-phase model of interest development (Hidi & Renninger, 2006) and the relationship of triggers to engagement and maintaining interest in the early phase of interest development (Renninger & Bachrach, 2015; Renninger et al., 2019) is of great importance to researchers studying the efficacy of informal STEM experiences. Of particular relevance to our work are the two broader classifications of interest—situational and individual interest. Situational interest is interest that is brought on by specific contexts, activities, and interactions while individual interest is an internalized form of interest characterized by the use of positive feelings, stored knowledge, and value (Hidi & Renninger, 2006). While comprised of multiple phases, all phases of interest positively influence attention, goals, and levels of learning (Harakiewicz et al., 2016; Silvia, 2006). Each phase of interest is triggered when something catches the attention of the learner within specific contexts and can be enhanced through interactions with individuals and participation in activities. How interest is triggered and then supported is crucial in helping students move to higher levels of interest development and ultimately to internalized interests that can drive choice.

Both early and late phases of interest can be triggered through hands-on activities, teamwork, challenge, novelty, environment, affect, character identification (e.g., seeing oneself as an engineer), and technology. The work of Renninger et al. (2019) provides a full review of interest triggers. For early phases of interest, these triggers are provided by others while, for those in later stages, the individual can self-derive these triggers (Renninger & Hidi, 2016). By triggering interest, students are likely to seriously engage with disciplinary content like engineering and improve performance (Hidi & Renninger, 2006). While the potential for interest and triggering interest is clear, fewer published works are extending previous findings from psychology generally and from studies focused on science education to engineering, a domain unique unto itself. This is because pre-college students have adequate exposure to science and math topics in the K-12 curriculum but many lack access and exposure to engineering concepts within the K-12 curriculum or school-based programs. Indeed, Lewalter et al. (2021) have shown that out-of-school programs can significantly enhance interest in participants. We use this framing of interest and interest triggers to understand how informal engineering education contexts can support interest development.

In addition to examining interest within the context of engineering, we apply the lens of engineering role identity to understand how camp activities may support the development of engineering identity, a predictor of performance, retention, and major choice (Capobianco et al., 2012, 2015; Godwin, 2016; Godwin & Kirn, 2020). Engineering role identity is comprised of three constructs (i.e., performance/competence, recognition, and interest) and is focused on understanding how individuals come to see themselves as engineers (Godwin, 2016; Godwin et al., 2013). Being able to see oneself as an engineer and develop goals for a future in engineering are crucial steps in helping move students from considering engineering to pursuing engineering. Further, our expanded conceptualization of interest from Hidi and Renninger (2006) provides additional detail on specific activities that may foster identity development as interest is a key predictive construct of engineering identity (Godwin et al., 2013).

Methods

Triangulation is a commonly used procedure for establishing and enhancing the validity of studies where researchers identify convergence among multiple sources of data to come up with themes (Chism et al., 2008; Creswell, 1994). Our use of quantitative surveys and qualitative focus group interviews to assess changes in engineering interest and identity seeks convergence of our results (Greene et al., 1989). There are no definite guidelines for the measurement of interest development and researchers use a variety of individual or a combination of methods (Renninger & Hidi, 2011). As discussed in Renninger and Hidi (2011), researchers have used individual measures including in-depth interviews, pre- and post-surveys, and self-reports or combinations thereof to better understand and provide richer information on the relationship of interest to motivational variables and interest development.

Using methodological guidance provided by Creswell and Miller (2000) and Chism et al. (2008), we implemented a multi-method design incorporating quantitative data gathered from a pre- and post-participant survey and qualitative data gathered from focus group interviews during six separate week-long engineering camps conducted during the summers of 2018 and 2019. To ensure consistency in the multi-method approach, the same members of the research team performed the analysis of the quantitative and qualitative data. This research design allowed the triangulation of these two forms of data, allowing the researchers to obtain greater insight (Renninger & Hidi, 2011) into how, and perhaps why, participants' engineering interest and engineering identity were affected through the camp experience.

Participants

Participants included 79 middle and high school students ranging in age from 11 to 17. Demographic information is shown in Table 1. Participants came from as far as 450 miles away with most living within a 30-minute drive of the university campus. Participants attended a university-based week-long summer camp lasting five days that ran from 9:00 a.m. until 3:00 p.m. each day. The summer camp was planned and run by the university's College of Engineering K-12 outreach staff, with engineering faculty and undergraduate/graduate engineering students conducting camp activities. All participants were assigned pseudonyms by the project external evaluator before analysis of the collected data (qualitative and quantitative) was conducted by the researchers.

Setting

Three week-long camp sessions were held during both Years 1 and 2 of the study for a total of six sessions. The three sessions during each year of the study were comprised of: (a) Young Women in Engineering camp, open to women-

Table 1
Camp demographics.

Camp	Enrolled campers	Project participants[a]	Gender		Ethnicity/first generation								
			M	F	H	C	A	AA	NH/PI	NA	MR	FG	N
Year 1 2018													
Young Women	20	12		12		6	3			1		1	
Open Enroll.	25	18	15	3	2	11	3					2	
First Gen.	17	17	12	5	7	4	1	4	1			14	
Total Year 1	62	47	27	20	9	21	7	4	1	1		17	
Year 2 2019													
Young Women	11	10		10	2	6	1	1				1	
Open Enroll.	12	11	6	5	1	9	1						
First Gen.	11	11	7	4	6	2					2	6	1
Total Year 2	34	32	13	19	9	17	2	1			2	7	1

Note. H, Hispanic; C, Caucasian; A, Asian; AA, African American; NH/PI, Native Hawaiian/Pacific Islander; NA, Native American; MR, multi-racial; FG, first generation; N, none of the above.

[a]Data for some participants were not included in the research due to the following reasons: (1) non-consent (7); (2) participant absence during one or more days of camp (11).

https://doi.org/10.7771/2157-9288.1351

identifying students, (b) First Generation Engineering camp, open to first-generation/low-income students (all on College of Engineering scholarships), and (c) Open Enrollment Engineering camp, open to any student, All camps were identical in content and overall structure. All camps intended to provide an introduction to engineering through which participants engaged in activities across many fields of engineering. No comparative analysis was done among the three camps as the goal of the study was to examine the effects of the camp broadly. This broad analysis helped us better shape camp activities and provided guidance to our outreach team, a goal of the larger project. The Young Women in Engineering camp had a luncheon with professional women engineers from the local community as well as university engineering faculty and the First Generation Engineering camp had a session by university staff on specific university resources geared toward first-generation and low-income students. The hands-on engineering activities lasted anywhere from one to three hours and had participants working in pairs or small groups. These activities were conducted in campus engineering laboratories, preceded by short, lecture-style introductions to the field of engineering relevant to the activity and conducted by an engineering faculty member or graduate student associated with the laboratory. Two field trips were held, one to the Makerspace located in the campus engineering library and the other to a large automotive manufacturing company, both of which included a tour and hands-on activities conducted by engineering library staff and company engineers, respectively.

Based on researcher observations during Year 1, changes were made to the hands-on part of some of the activities and presentation structure of each activity in Year 2. The researchers also noticed and pointed out to the camp staff that the engineering design process (EDP) was absent in many of the camp activities. This resulted in the addition of the EDP as a central focus of all the activities for Year 2 camps. Engineering laboratory notebooks were also introduced during the second year of the research project. These notebooks were used to document data, record ideas, and reflect on each activity. The observations were used by the research team to shape camp activities and as reflective memos to help guide interview prompts with participants. Observations were not used during analysis.

Additionally, during Year 1, feedback from participants during the focus groups was used to shorten the length of the informational lectures before each activity and to better align the presentations with the related hands-on activities. Another change that was implemented was that the locations at which camp activities were conducted were moved from a general multipurpose-style room to engineering laboratories specific to the field of engineering relating to the activity. For example, the robotics activity was moved from a general computer laboratory to a computer laboratory space used by engineering students, complete with robotics testing stations. Lastly, based on focus group feedback, a few of the activities were replaced with activities that were believed to be more engaging and relevant to the participants. For the purposes of this paper, we are including the Year 2 camp schedule (see Appendix A).

Data Collection and Analysis

Information about the research project was included in each camper's registration packet. All campers were notified that participation in the research project was voluntary and the Principal Investigator's contact details were provided to help answer questions parents/guardians or participants might have. Parental/guardian consent was obtained for each participant as per Institutional Review Board (IRB) guidelines. During the second year of the research project, a research team member was present during the first morning drop-off and registration check-in to answer questions or provide clarification to parents and campers about participation in the research project. This resulted in 100% consent to participate in the research project for Year 2. All procedures were approved by the University's IRB office.

Qualitative Data

Qualitative data were collected by focus group interviews. The research team constructed a focus group protocol that was utilized to ask groups of five to six participants specific questions (see Appendix B) related to engineering interest and identity, and about the camp activities. All qualitative data were analyzed using NVivo software where a codebook was created. Using a method of creating a codebook suggested by DeCuir-Gunby et al. (2011), Creswell (2002), and Saldaña (2016), the codes were formulated based upon literature on engineering interest and engineering identity formation. This allowed the research team to construct a codebook specifically identifying data that were relevant to answering the research questions. A team coding process was used in which two of the research team members met on a weekly basis to review data and agree on which code(s) fit. Discussion as to which code to assign to participants' quotes and development of new codes led to consensus and allowed the research team to better understand the data and how it could be used to answer the research questions. Table 2 shows the codes developed, their definitions, and the number of participant quotes under each code. We have cross-coded and some quotes received more than one code. Most of the cross-coding occurred for the codes "Excitement about an activity or camp in general" and "Change in interest based on activity" and for the codes "Engineering identity" and "Change in identity based upon activity" and was based on discussions by the coding team and agreement that a quote belonged in both codes.

Table 2
Codes, descriptions, and frequencies.

Code name	Code description	Frequency
Camp experience	Participant comments about what they enjoyed or didn't enjoy about the overall camp experience.	26
Collaboration, communication, and teamwork	Participant discusses importance of working as a team including such skills as collaboration and communication.	23
Definition of engineering	Participant states a defining characteristic of engineers or the field of engineering.	67
Excitement about an activity or camp in general	Participant shows excitement about an activity with or without specifically stating a reference to engineering. They may also show excitement about the camp overall.	96
Future		
Connection of major in college to future career	Participant makes a connection between what an engineering major studies in college and their future career or work they may end up doing.	7
Future career	Participant talks about their future plans and the type of work they would like to do.	33
Major in college	Participant talks about a possible major in college either specifically or as a response to a question.	79
Identity		
Change in identity based upon activity	Participant has a change in their identity based upon an activity or experience during the camp.	74
Engineering identity	Participant articulates how they and/or others see them as engineers	82
No engineering identity	Participant states an identity-based comment that is not engineering specific but rather a different field or profession.	6
Non-engineering identity	Participant states an identity-based comment that is not engineering specific but rather a different field or profession	32
Interest		
Activity led to disinterest	Participant discusses an activity that they found uninteresting.	67
Change in interest based upon activity	Participant has a change in their interest based upon an activity or experience during the camp.	122
Engineering interest	Participant shows an interest in engineering. Excitement about some aspect of engineering.	50
No engineering interest	Participant specifically states they are not interested in engineering.	7
New understanding of engineering	Participant has a new insight or idea about the profession of engineering as a possible result of the camp experience.	124
Perceived outcomes of the camp	Participant expresses a possible outcome for their future due to the camp experience, e.g., classes, camps, working with a family member on a project.	76
Principles of STEM	Participant discusses some concept or idea relating to STEM disciplines.	18
Reason for being at camp	Participant discusses why they are here at the camp, and who signed them up or encouraged them to sign up.	28
Student suggestion for activity improvement	Participant suggests how to improve an activity, or a general aspect of the camp experience.	68
Use of engineering design process (EDP)	Participant talks about the process of designing and refining beyond just the mentioning of EDP.	33
Who can be an engineer	Participant discusses their perceptions or beliefs about who can be an engineer based upon camp or outside influences such as media, family, etc.	38

Quantitative Data

Quantitative data were collected using an online survey that was a slightly modified version of the Friday Institute's S-STEM survey which measures student attitudes toward STEM disciplines (Faber et al., 2013; Friday Institute for Educational Innovation, 2012; Unfried et al., 2015). The language in a few of the survey items was changed to be more readable and clearer to middle school students. Additionally, questions around careers that were located within the "science," "math," and "engineering" subsections of the S-STEM survey were moved to their own subset that we called "careers." The reasons for changing the survey were twofold: (a) to help us see if the camp experience led to any specific changes to the participants' attitudes toward a career in one of the STEM disciplines and (b) to acquire quantitative data that might be useful in triangulating findings within the qualitative data. Prior to using the survey with participants within the research study, the survey was piloted within two separate sixth-grade public school classrooms. The sixth-grade classrooms were chosen for the pilot as that age group would represent our youngest participants. These students then participated in a brief discussion about parts of the survey that seemed confusing to them. Students responded well to the survey with an overall positive take on the readability and their level of understanding of each question. Construct validity was addressed with two of the research team members who are experts in engineering interest and identity formation.

On the first and last day of each camp, participants took the modified survey using the Qualtrics survey software. SPSS was used to perform all the quantitative analysis. Normality tests (Shapiro–Wilks) were conducted on the participants' pre- and post-survey data which were found to be negatively skewed and significantly non-normal. A nonparametric Wilcoxon rank sum test was conducted comparing differences for each survey item on the pre- and post-surveys. Additionally, survey results were summed. This allowed us to compare all 79 participants' pre-test to post-test scores using a Wilcoxon signed-rank test. Lastly, we also compared the Year 1 mean difference in total summed scores to the Year 2 mean difference in total summed scores using a Mann–Whitney U test.

Results

Qualitative

Using the focus group data, four related themes emerged from analysis of the qualitative data that were connected closely to the research questions and related to engineering interest and identity. Under each theme we list some example quotes. The table in Appendix C illustrates more quotes related to the themes.

Theme 1: Change in future self as an engineering major and/or engineering professional

The first theme that emerged from the qualitative data was that of "Future self as an engineering major and/or engineering professional." This theme resulted from answers given by participants to the focus group questions: "So you just talked about different activities that made you feel excited. What field of engineering do you think those activities represent as far as what you would study in college?" and "Are you interested in studying these engineering majors in college?" In this theme, participants articulate their desire to pursue an engineering major in college or engineering career.

April, who was one of the younger participants in the camp and wanted to be a doctor or nuclear physicist, articulated her added interest in biomedical engineering after acquiring more knowledge about the field via the activity that involved cooling down a baby's body experiencing hyperthermia. She said:

> When I'm older, I either want to be a doctor, some type of engineer, or a nuclear physicist. That one's kind of a way from the rest of the things that I said. But the biomedical engineering one was really interesting to me. To learn how like the body systems have to cool down and they can't get above a certain temperature. Otherwise they "poof."

Hannah was made aware of the environmental aspects related to mechanical engineering on the field trip to a major automotive manufacturing company. She was really inspired by the enthusiasm of the engineers who spoke to the participants and worked with them on a hands-on activity where they built and tested a basic electric motor. She said:

> I like the mechanical. Same as Celine, like the [a major automotive manufacturing company]. And I got really interested when they said it never got boring. And they were really engaging that it's really fun to have a job there. And it's also environmental, because they're helping the environment with cars.

Participants from all the camps made comments related to their desire to take classes and participate in extracurricular activities related to engineering. For example, Celine said the following after the field trip to the major automotive manufacturing company:

> I'd definitely say yes on that mechanical. That [a major automotive manufacturing company] totally got me hooked. It was really cool to learn all about electric vehicles, there are so many things we can do to help. And new ways to create cars to be more efficient and help the environment. So, I would definitely take more classes, or consider taking classes in mechanical engineering, electrical and industrial.

Many focus group quotes related to what engineers actually did. Kendall's goal was to study at one of the well-known universities in her state. She already seemed to know she wanted to pursue civil engineering in college and said that the camp had opened her eyes to other fields of engineering and that various types of engineers worked in teams. She commented:

> I wasn't sure before this camp which I kind of wanted to lean more towards to, whether it was civil or environmental, but I realized that they're very close and connected, and how I don't have to decide that just yet. But I do think I want to explore both in college, and maybe before college. Just to see which one I get more of a feel for.

https://doi.org/10.7771/2157-9288.1351

Across the quotes in these themes, we see that the camp activities were effective in either maintaining or progressing participants' interests. Being able to see oneself doing engineering in the future and having an interest in doing so may represent their well-developed individual interests. For some students, the camp activities reinforced their existing individual interests in a specific engineering discipline while others had interest emerge in a few disciplinary contexts.

Theme 2: Enjoyment of camp activities and triggers that increased engineering interest

The second theme to emerge is what we term "Enjoyment of camp activities and triggers that increased engineering interest." This theme resulted from answers given by participants to the focus group questions: "Which of the camp activities, if any, increased your interest in engineering?" and "Which camp activities made you feel excited or engaged?" This theme is backed by quotes articulated by participants referring to liking/enjoying certain hands-on camp activities, interacting with engineering students and faculty, and visiting engineering laboratories and a large automotive manufacturing company. Participants also specifically stated that they were interested in the camp activities. Table 3 lists all the camp activities and potential triggers identified (Renninger et al., 2019). Table 4 lists the codes associated with the potential triggers identified in Table 3, and the frequency of mentions of the corresponding camp activities during the focus group interviews.

While it was not possible to identify the frequency of triggers associated with the camp activities (i.e., the number of participants whose quotes could be associated with a certain trigger), it can be said with certainty that the following activities were of high, medium, and low impact on the participants' engineering interest based on the data shown in Tables 3 and 4. Included in the data are those of participants who said that they enjoyed all activities. High-impact ($>$ 25 mentions) activities included a rocket activity, a field trip to a large automotive manufacturing company, and an electrical engineering activity. Medium-impact (15–24 mentions) activities included a tour of the engineering library, makerspace, and a related activity, a biomedical engineering activity, and an activity called mining the environment. Low-impact ($<$ 15 mentions) activities included a chemical engineering activity, a civil engineering activity, a tour of the robotics laboratory and related activity, and an unmanned autonomous systems activity. These results on impact of camp activities lead us to believe that many of the activities could be improved in especially hands-on content, challenge, novelty, and environment.

Celine, who came to the camp thinking it would be mainly math and science, had this to say (her comment got a lot of vigorous nods from other participants) after the field trip to a large automotive manufacturing company that included a hands-on activity of building and testing a basic electric motor:

> I would definitely say [a large automotive manufacturing company]. When we first did the survey [referring to the quantitative pre-survey], I really felt like I wanted to have one of the jobs like that. But then after [a large automotive manufacturing company] I was like "That would be really cool if I worked on that or if I can do that in the future." And I didn't know that was a possibility.

Table 3
Potential triggers identified through camp activity.

	Potential trigger identified							
Activity	**Hands-on activity*** **	**Teamwork** **	**Challenge**	**Novelty**	**Environment**	**Affect**	**Character identification**	**Technology**
Automotive manufacturing plant	X			X	X	X	X	X
Rocket	X	X	X			X	X	
Biomedical	X		X	X			X	
Chemical engineering	X							
Civil engineering	X	X					X	
Engineering library and makerspace	X		X	X	X	X		X
Electrical engineering	X		X	X	X		X	
Mining the environment		X			X			
Unmanned autonomous systems	X			X		X	X	X
Robotics lab tour and activity	X		X	X	X	X	X	X

Table 4
Codes associated with the potential triggers identified in Table 3, and the frequency of mentions of corresponding camp activities during focus group interviews.

	Code				
Activity	**Excitement about an activity or camp in general[a]**	**Change in interest based upon activity**	**Engineering interest**	**Camp experience**	**Collaboration, communication, and teamwork[b]**
Automotive manufacturing plant	32	24	4	2	0
Rocket	53	16	0	3	1
Biomedical	17	11	0	1	0
Chemical engineering	11	12	0	0	0
Civil engineering	10	6	0	0	0
Engineering library, makerspace, and related activity	22	20	3	2	0
Electrical engineering	25	26	2	0	0
Mining the environment	18	31	0	0	5
Unmanned autonomous systems	10	8	0	0	0
Robotics lab tour and activity	12	22	6	1	0

[a]While some participants mentioned specific activities and how they enjoyed the hands-on aspect, others said that they in general enjoyed all the hands-on activities of the camp.
[b]While many participants mentioned how they enjoyed working in teams and realized that engineering was a field where teams were critical to the success of a project, besides the mining the environment activity, there was really no actual mention of any particular activity with respect to teamwork.

Aurora had this to say about how the visit to [large automotive manufacturing company] piqued her interest in the motor building and testing activity:

> Probably the motor that we did at [large automotive manufacturing company]. That was kind of interesting to see, because I never thought you could do it with just a battery, a magnet and some wire. That was very experiencing for me.

Ada expressed how she enjoyed the concrete mixing activity and the visit to the engineering library makerspace since it gave a feel for how she could mix art and engineering. She had this to say:

> I liked when we made the concrete, just because it was very interesting with the civil engineering just how the different things that go into making it, and then trying to figure out how strong it is using different types of equations and stuff like that. And I liked the library because I like doing art and introducing other subjects to engineering was what we were doing with an artistic perspective.

Likewise, Julie liked the fact that they could use their creativity and freedom in designing their bottle rockets:

> And we were able to make our own fins, which I thought was cool. Because I felt like I was in charge of what I was doing, even though they were telling you what to do. Because you know we can't really do what you want with a laser cutter. But the bottle rockets as well because we were able to design our own bottle rockets. He gave us complete freedom on that. And I felt like I was doing my own thing, and not anyone else's.

Jerry articulated his enjoyment of several activities:

> I agree with Timothy on the makerspace in the engineering library. That was one of the highlights of the camp for me and the bottle rockets was the most fun, truly hands on activity for me in a sense because we did it in partners and we got to test it out in three different fields, counting the egg drop. Then I enjoyed the electrical and I enjoyed the [large automotive manufacturing company] tour. I really wish that we got more time at [large automotive manufacturing company] because it really intrigued me.

Throughout this theme, participants highlighted the different ways camp activities triggered their interests. Specifically, the designed camp activities utilized multiple triggers of interest (e.g., hands-on activities, technology, and teamwork) and these triggers were noted by participants across the different camps as influencing their interests in different engineering disciplines. Because of the widespread triggering of interest, we can infer that these triggers work regardless of the phase of interest the participant is in.

Theme 3: Change in perceptions and knowledge of engineering foster interest and build engineering identity

The third theme centered around participant perceptions of what engineers actually do and if this perception had changed since participating in the camp. This theme resulted from answers given by participants to the focus group questions; "What do you think engineers do?" and "Has this changed since the start of camp?" Kaylee said: "I guess before I just didn't know that there were so many different types of engineering. So now that I'm experiencing all types of them, it broadened my experience and everything."

Clark, a budding aerospace engineer, had this to say:

> How do I put this? I just kind of thought an engineer does mathematical equations and then shoots a rocket off. Now I kind of realize that they do a whole lot more, there are a whole lot of more different types of engineers. I thought before that there was a civil engineer, and aerospace engineer. That those were what engineers were. I didn't realize that there were much more and totally different types of engineers, that there were so many different types of engineers and they all kind of merge.

Roger, who during the focus group articulated his interest in robotics, commented: "I just feel like I understand how engineers work or do things, especially the process that we learned about since day one and I feel like I know how they proceed with doing certain tasks now."

We would like to point out that the "process" he was referring to was the EDP that was discussed on day one of the camp and reiterated every day of the camp thereafter. Julian, who was going into eighth grade and always wanted to become a mechanical engineer since he enjoyed hearing about his uncle's mechanical engineer job, agreed with Roger and commented:

> Roger pretty much covered it. I always knew that engineers could go and work in any field, pretty much math, a little like the environment, civil, all that stuff. But since coming here I have a greater understanding of truly how they do it in each field.

Across this theme, we see evolution in the definitions of what an engineer is and does from participants. Providing participants with more nuanced conceptualizations of what engineers do and how they work can help them both create pathways for self-derived interest triggers and on which to build their engineering identities. Both of these aspects can foster sustained interest in engineering.

Theme 4: Increase in engineering identity as a result of participation in well-structured and purposefully designed camp activities

The fourth theme emerged as participants talked about how they had acquired a better understanding of engineering by participation in the camp and could actually see themselves as future engineers (i.e., engineering identity). Activities actually enhanced several participants' desire to learn more about and understand engineering fields they had already wanted to pursue. Participants also commented on how their understanding of who could become an engineer changed (i.e., caused a change in their engineering identity) and that camp activities made them feel more like an engineer. Some common threads that were mentioned are: (a) the hands-on engagement in activities that were fun and mostly team-based and (b) the camp staff who made them feel like engineers and feel like they were performing engineering tasks. These common threads positively enhanced participants' ideas about engineering and engineers that they had pre-camp. Some activities appeared more than others under this theme: electrical engineering, biomedical engineering, civil engineering, rockets, and mining the environment. This theme resulted from comments made by participants to focus group questions, "Has your perception changed since the camp started of who can be an engineer?" and "Are there activities in the camp that made you feel most like an engineer?" Participants discussed how the activities resulted in them wanting even more to be a certain type of engineer. For example, Asher, who already had wanted to be an electrical engineer, said that the electrical engineering activity where participants built a breadboard for a speaker increased his desire to learn more about what electrical engineers do and his wanting to do more of that field. He said: "It's going to impact me because I'm going to work more in how

https://doi.org/10.7771/2157-9288.1351

electrical engineers work and what they do. So, I'll research that more so it'll impact me because I'll probably be wanting to do electrical engineering more."

In addition, when asked if they could see themselves as an engineer, at least 90% of the participants responded "Yes." Asher also commented on how the camp had changed his perspective on who could become an engineer. He said:

> I wasn't thinking a lot of people can be engineers because I didn't know there were so many different types of engineers. So, the more types the more different types of people who have different likes and dislikes could go to different ones.

Josh, a high school student, already knew he wanted to be a computer engineer. He felt his interest in this field and engineering identity were definitely reinforced by the visit to the robotics laboratory. In this laboratory, the professor and his graduate students had a very lively demonstration on how several large and small robots worked, as well as a coding activity later in a computer laboratory. He commented:

> Well for me it's sort of weird because I already know what I want to be. I want to be a computer engineer and when I saw the robots it made me more interested because they had them coding to make the robots do something. And so it made me more interested in what I want to do.

Kendall added that her views on how she thought engineering had something to offer for most people had changed:

> I don't think I thought a specific type of person, but now I realize that there's something for everyone. Because there are so many different types of fields, and you can do so many things within a field, anyone can find something that's for them.

An interesting quote is from Celine, a vocal focus group participant, who really enjoyed being in an all-women camp that allowed her to see that women could have careers in engineering and beat the stereotype of engineering being a male-dominated field. She said:

> I've always been really big on women's rights and stuff, so I've always known that there should be more women. But I've always focused on it. Whenever I think of an engineer, I think of workers for some reason. Like in manufacturing stuff or in the labs, finding out what could work and what couldn't. After this it's totally helped me see women can do so many more things than people think, and I can totally see them running a new manufacturing facility for engineering and stuff.

Related to this theme, when participants were asked who signed them up for the camps, most of them referred to a family member or teacher who apparently recognized engineering identity in the participant. Recognition is an important aspect of engineering identity (Godwin et al., 2013). In addition, as Hidi and Renninger (2006) point out, interaction between a person and individuals such as teachers strongly supports interest development. Stella said:

> In my science and biology class my teacher, I was always ahead of the rest of my class. I would always finish early and there were a few days where I didn't have any work at all because I finished the previous day, and she saw that I was really interested in science and biology. So she actually called me up to the front of the room and talked to me when I was not doing anything and told me about the camp, and told me I should sign up. It'd be a good opportunity to learn about things that what I could possibly do with my future.

Across the camp activities and even the processes of signing up for the camps, we see that the participants expanded their definitions of who could be an engineer. Expanding the definitions of who can be an engineer and what kind of work engineers do is crucial to countering societal stereotypes about the discipline. Further, we see enhancement of existing aspirational identities as participants' interests were further triggered and developed as part of camp activities.

Quantitative

A few changes were made to the S-STEM survey prior to our initial administration, and Cronbach's alpha was calculated for each subset of questions to ensure reliability of the modified participant survey. Year 1 (n = 47) and Year 2 (n = 32) results can be found in Table 5.

Table 5
Cronbach's alpha for question subsets of survey instrument.

Subset of questions	2018 Pre-test (n = 47)	2018 Post-test (n = 47)	2019 Pre-test (n = 32)	2019 Post-test (n = 32)
Math	0.793	0.839	0.722	0.574
Science	0.784	0.720	0.647	0.635
Engineering	0.836	0.830	0.769	0.815
Career	0.696	0.742	0.772	0.631
Future	0.777	0.732	0.500	0.562

Table 6
Participant total summed score for survey.

	Pre-test				Post-test						
N	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	*z*	*p*	*r*
79	80	145	119.71	14.62	87	150	122.54	13.81	−2.61	0.009	0.29

Note. Minimum total score possible: 31. Maximum total score possible: 155.

Table 7
Comparison of Year 1 to Year 2 differences in means (pre-test to post-test).

2018 (Year 1)			2019 (Year 2)			Mann–Whitney U	
n	Mean rank	Mean difference	*n*	Mean rank	Mean difference	*z*(df)	p
47	35.51	0.91	32	46.59	5.66	−2.110(77)	0.035

The survey responses of all 79 participants from both years were compared using a Wilcoxon signed rank test. When summing all the survey items together for each participant and then comparing participants' pre-test scores with their post-test scores, we found that there was a significant ($z = -2.61$, $p = 0.009$) increase in their total mean scores as measured by the survey (Table 6). Effect size was calculated using a normal approximation z to r ($r = z\sqrt{N}$ and found to be 0.29, a small to medium effect size (Field, 2013).

We then compared the mean difference of the total survey score of the 47 participants from Year 1 with that of the 32 Year 2 participants to determine if there were differences between the two years of the program. Levene's test for equal variances was performed at 0.683 and was not significant indicating equal variances between the two groups could be assumed. Using a Mann–Whitney U test we found a significant difference (z – 2.110, $p = 0.035$) between the Year 1 and Year 2 mean ranks. Year 2 participants had an average increase in their total scores of 5.66 points from their pre-test to their post-test as compared with the Year 1 participants who had an average increase of 0.91 total points (Table 7).

Discussion

Our study has focused on triggering of interest and not on maintaining interest as the camps were only one-week long. However, the camps made an impact on participants' future plans in engineering (e.g., major and career plans) in that they wanted to explore engineering more. The camps made participants realize how diverse engineering was, gave them confidence to study engineering, and all the activities contributed to how their knowledge increased about many engineering fields. The quantitative and qualitative results of the project answer Research Question 1 and support Lent et al.'s (1996) findings that informal experiences like engineering summer camps provide an environment that fosters interest (either pre-existing or created by participation in the camp activities). Further, our findings suggest that summer camps can produce a positive change in participants' engineering identities with them expressing a desire to pursue engineering in college and/or an engineering career. Many hands-on experiences, identified by the qualitative data analysis, during the camps led to a positive change in participants' engineering interest and identity. Participant comments in the focus groups that supported these outcomes came from all the camps and lead to the answer to Research Question 2 which seeks to find out which specific activities in the summer camps result in a change in identity and interest in engineering.

Findings from Theme 1 (change in future self as an engineering major and/or engineering professional) relate to Research Question 1 with regard to how a week-long engineering summer camp can influence interest in engineering, identity as an engineer, and perspectives on future careers in engineering. The purposefully designed and meaningful camp experiences involved hands-on activities in various engineering fields and included a field trip to a large automotive manufacturing company and visits to university laboratories. The experiences led to participants being instilled with knowledge about engineering and participants articulating their desire to take engineering-related classes in high school, and participate in engineering-related clubs. In addition, these experiences helped participants visualize themselves as future engineering majors in college as well as engineering professionals, and this in turn helped contribute towards a developing engineering identity in the participants. Results reported by Hammack et al. (2015) indicated likewise that participants' knowledge about engineering and what engineers did increased as a result of the summer camp. However, they indicated that it was not clear as to which components (i.e., hands-on activities, interaction with engineers, or combination) contributed to this increase in knowledge. Likewise, similar to our results, Weavers et al. (2011) indicated that the middle school girls in their camp exhibited an increase in knowledge of engineering and goal to pursue engineering careers. We extended these findings by highlighting that it is not one interest trigger or activity that furthers these perceptions of the future but rather the interconnected combinations of activities and triggers (Renninger et al., 2016). The participant quotes show that by engaging in these purposefully planned engineering activities during a week-long summer camp these middle and high school students' perceptions as to what engineers do has changed and how they see themselves as possible engineering majors in their near future.

With respect to Theme 2 (enjoyment of camp activities and triggers that increased engineering interest), we observed positive evidence from the qualitative data that participants' enjoyment of camp activities triggered an increase in engineering interest. These findings support Research Question 2 by defining "enjoyment" as an activity characteristic that leads to changes in identity and interest in participants. Overall, participants liked those activities that were hands-on, team-based, and required active involvement. They also came away with a better understanding of how the engineering world works in that solutions to problems are created in a dynamic team situation. The field trips to a large automotive manufacturing company and university engineering laboratories, where participants interacted with engineers, faculty, and graduate students, were a highlight and helped support the camp activities and further strengthened participants' engineering interest and identity. Many expressed the desire to participate in more engineering-related experiences with this new or increased interest, a sign that participants have and wish to continue to leverage individual interests (Hidi & Renninger, 2006). Although there were some camp activities mentioned more frequently by participants as being more interesting, all of the activities were mentioned during the focus groups by at least one participant as being interesting and that they enjoyed them. As a result of participation in these activities, participants wanted to explore more the associated fields of engineering that the activities were meant to highlight or represent. They could see themselves doing this in the future. Again, the field trips helped with this perception.

Additionally, camp participants connected different fields of engineering to their current interests in future professions that were not associated with engineering. Camp participants were made more aware of the different types of engineering and began to see themselves as engineers. Results reported by Elam et al. (2012) agreed with our results in that the most popular activities were the collaborative, hands-on ones as well as those where the participants interacted with engineers. Ortiz et al. (2018) also reported that group projects were enjoyed by campers and these projects challenged them to think as a team and to be creative. Clewett and Tran (2003) state that activities like industry tours, interaction with engineering students and engineers, and teamwork in their engineering summer camp led to an increase in engineering interest. Our findings are supported by literature, and demonstrate that to effectively support and develop interest in a domain like engineering, it is necessary to leverage multiple triggers of interest across activities (Renninger et al., 2016).

In Theme 3 (change in perceptions and knowledge of engineering foster interest and build engineering identity), we indicate that participation in the camps gave a better understanding of the various fields of engineering and of what engineers actually did in their jobs, dispelling stereotypical views and the limited knowledge that participants had before participation in the camp. Theme 3 aligns with Research Question 1 by showing the extent of possible changes in career perspectives that can be seen in a one-week camp experience. Students came in with the perception that engineers built and improved things and made the world a better place but left with a deeper understanding of engineering and of what engineers do, similar to that reported by Hammack et al. (2015). The camps also strengthened their understanding about the importance of creativity and communication in engineering as well. Besides participants acquiring a better understanding about the many different fields of engineering, their perception about what engineers actually do changed as a result of camp activities. This is supported by the many focus group comments from participants about their new understanding of engineering and what engineers really do, especially that engineers work in collaborative teams and use the EDP to solve societal problems. Other studies that have indicated that informal engineering activities in summer camps have a positive effect on participants' perceptions and attitudes toward engineering are those by Elam et al. (2012), Nadelson and Callahan (2011), and Chen et al. (2011). We observed positive evidence that many camp participants were made more aware of the wide variety of choices available for engineering majors and careers due to knowledge acquired during camp activities, specifically with respect to which engineering field(s) was/were relevant to the activities. This result agrees with that reported by Ortiz et al. (2018) who concluded that camp activities did have a positive impact on how campers perceived

https://doi.org/10.7771/2157-9288.1351

STEM careers. In addition, our qualitative data showed that when participants started the camp they had a very narrow and limited understanding of different fields of engineering, and about engineering as a viable major and career. However, at the end of the camp their knowledge about different fields of engineering was increased and this in turn increased their engineering interest and helped them establish an engineering identity.

Conclusions under Theme 4 (increase in engineering identity as a result of participation in well-structured and purposefully designed camp activities) were directly related to Research Question 2 by defining several characteristics that lead to changes in identity and interest in participants. Findings from this theme demonstrated that camp activities that were hands-on, conducted in a laboratory setting, where they worked in teams, had the opportunity to be creative, and experience freedom of design, made them feel most like engineers (Elam et al., 2012; Ortiz et al., 2018). The interest in pursuing engineering as a career was enhanced by the field trip to a large automotive manufacturing company. In addition, excitement with respect to their jobs shown by engineers who interacted with the participants added to participants' interest in engineering. Seeing that different types of people could be engineers and the options of so many fields contributed to their engineering identity and reinforced the fact that they themselves could become engineers. Some camp participants knew a little about more commonly well-known engineering fields such as civil or electrical engineering but appreciated the newly acquired knowledge about other fields of engineering because of camp participation. They became more aware of the diversity of engineering disciplines and that because of this diversity there were more college major and career options available to them based upon their interests than they might have thought before the camp experience. This in turn helped establish in them an engineering identity. Additionally, the teamwork aspect of the camp appealed to most participants. Especially when they realized that most engineers worked in teams with a variety of people, this seemed to enhance their engineering identity. These findings also support predictive pathways in engineering role identity models that identity is fostered by student interest (Godwin et al., 2013). Here, we extend these findings to show that triggering interest in environments such as informal summer camps can lead to the development or refinement of engineering identities.

Interestingly, an important outcome under Theme 4 was that many participants in one of the Young Women's camps had comments to make on how being in an all-women camp and seeing so many female engineers on their field trip, as well as amongst camp instructors and counselors, really reinforced their belief that engineering was for them. The engineering identity of participants in the Young Women's camp was definitely reinforced by the field trip to a large automotive manufacturing company. Hirsch et al. (2011) reported a similar finding about women participants in their summer camp. Another important result was that most participants shared with the interviewers that it was their family (usually mothers) or teachers who recognized them as potential engineers and signed them up for the camps. This observation agrees with Sahin et al. (2017) who found that parental attitudes toward STEM-related activities were a strong predictor of high school students' interest in science as well as with Godwin et al. (2013) who state that recognition predicts development of an engineering identity.

Overall, the quantitative data collected through the use of the survey instrument show a positive and significant impact of participation by middle and high school students in the camp experience. When looking first at the overall differences in participants' mean scores of their pre-test and post-test scores, it is clear that their attitudes toward STEM disciplines increased in a positive manner as a result of participating in the camp. Additionally, when looking at the difference between the average scores on the survey from Year 1 participants compared to Year 2 participants, the Year 2 participants had a significant increase in their mean scores. The Year 2 participants increased their post-test scores by five times that of their Year 1 peers. We believe this to be a result of the changes that were implemented to the camp between the Year 1 and Year 2 sessions such as the inclusion of the EDP into the activities, more emphasis on having the activities take place in real working engineering laboratories, and less time devoted to lectures and more time devoted to learning through the hands-on activities themselves. These quantitative findings further support Theme 4 qualitative findings that hands-on activities enhance identity and interest.

The individual items on the survey also show some promising results. The item that stood out the most is "I am good at engineering." In both years, participants' belief that they are good at engineering increased because of participation in the engineering camp. This should not be a surprise as the focus of the camp was an introduction to engineering. However, this is exciting in that it indicated that the camp changed participants' perceptions and self-belief in their ability to pursue and understand different engineering disciplines. The fact that this item had the highest increase between the pre-test mean and post-test mean for both years is promising as it shows increases in engineering performance/competence (a key predictor of engineering role identity; Godwin et al., 2013) are possible through short-term interventions like summer camps.

When taken together, we see shifts in identity and motivation (i.e., interest) through the summer camp programs. Previous work in engineering education has shown that students who have both are likely to pick an engineering major and undertake actions that support learning in engineering (Godwin & Kirn, 2020; Kirn & Benson, 2018; Nelson et al., 2015). Additionally, students who make plans to pursue something in the future are more likely to be motivated by relevant tasks, in this case engineering tasks (Kirn & Benson, 2018). While the changes in identity, interest, and perceptions of the future are not surprising after a short-term intervention like the summer camps (Rosenzweig & Wigfield, 2016), the combined

https://doi.org/10.7771/2157-9288.1351

results help to generate optimism about students' potential pursuit of engineering. However, additional work is needed to understand if the results found in this study are short-term, like many other interventions (e.g., Rosenzweig & Wigfield, 2016), or if they are more long-lasting due to the influence on multiple constructs.

The call for more research exploring engineering identity formation in the middle school years is clear within the literature (Capobianco et al., 2012). The results of our study add to our understanding of how middle and high school students develop their engineering interest and identity as engineers. Specifically, we have examined if informal experiences like engineering summer camps influence engineering interest and identity of the camp participants. Additionally, while many single-gender camps have been shown to have impact, there are few outreach activities limited to first-generation students across gender and race categories. We believe that these camps could warrant further use as they provide benefits to a broader, high-need population. The summer camps strive to spark interest in engineering and enrich participants' knowledge of various fields of engineering via engaging, hands-on activities taught by engineering students and faculty.

Limitations

This study has some limitations. The first limitation is that for some of the quantitative analysis we had a small sample size when aggregating data into smaller subsections of the population. We felt it was still relevant to share those results with the understanding that power was not met on the subpopulations according to each camp type. Second, this study was conducted on a population of participants who either self-selected to participate in the camp experience or were encouraged to attend by a family member or teacher who recognized the participant as possibly enjoying an engineering camp experience. This could point to a positive bias by the participants when it comes to engineering interest. It is also important to note that what is measured and presented in this paper is interest, but the interest measured could be the result of focused attention on the topic at the time of the survey. Since our study involved summer camps that were only a week long, it is not possible to comment on whether the potential triggers impacted maintaining interest. However, from the results obtained by analyzing the codes entitled "Future" (Table 2), it appears that the camps had an impact on the future plans of the participants in exploring engineering further as a college major and career. Additionally, we were not able to conduct follow-up studies in the months following the study to determine any sustained impact.

Further, in examining the demographic data as suggested by Pawley (2017), a few things should be noted. First, the study encompasses almost a 50/50 percent split of males to females over the two years. Second, when comparing demographic data of the study to the most recent demographic data of the county-wide school district data we see that our study does not match the public-school-aged demographics. Our white population is slightly higher and our Hispanic population is lower. These caveats are important to note since past research has shown that while student samples can be valid, student samples can also be inaccurate predictors of how significantly the issue in question will affect a broader population sample (Pawley, 2017; Rosenzweig & Wigfield, 2016). To gain a higher pragmatic validation, the study will need to be repeated with the target populations.

Conclusions

In this work we sought to understand how participating in engineering summer camps influenced participants' interests for and identification with engineering. Results show that camp activities were effective in triggering students' engineering interests, even when students came in with no or pre-existing interests. Further, results highlight that camp activities can maintain and bolster student interests, potentially pushing them to higher developmental levels of interest. Our findings also show that by supporting participant interest camp activities were also able to bolster participants' identifications with engineering. Combined, these results highlight that when summer camps are designed intentionally (e.g., through the use of interest-triggering activities) they can support participants' engineering interest and identity development.

Acknowledgements

This research was funded by the National Science Foundation PFE: RIEF program, grant number 1738141. The Institutional Review Board of the institution has approved all procedures. We thank the College of Engineering outreach staff Meg Fitzgerald, Rebecca Glasgow, Elyse Bozsik, and Claire Parker for conducting the summer camps.

Author Bios

Tim Robinson is a middle school science teacher in the Washoe County School District. E-mail: trobinson@washoeschools.net

Adam Kirn is an associate professor of engineering education in electrical and biomedical engineering at the University of Nevada, Reno (Reno, NV). Dr. Kirn researches diversity, equity, inclusion, future-oriented motivations, and engineering identity. E-mail: akirn@unr.edu

Jenny Amos is a Teaching Professor of Bioengineering and Medicine at the University of Illinois Urbana-Champaign. Dr. Amos researches assessment in engineering and medical education as well as impacts of K-12 STEM outreach. E-mail: jamos@illinois.edu

Indira Chatterjee is the Associate Dean of Engineering and Professor of Electrical and Biomedical Engineering at the University of Nevada, Reno. Her areas of research are bioelectromagnetics, as well as impact of informal outreach programs, and programs geared towards academically talented engineering students with financial need on engineering identity and success. E-mail: indira@unr.edu

References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.

Bottomley, L. J., & Parry, E. A. (2002, June 16–19). *Engineering alive: A summer engineering camp for middle school students and teachers* [Paper presentation]. 2002 ASEE Annual Conference & Exposition, Montreal, Canada. https://doi.org/10.18260/1-2--10112

Capobianco, B. M., French, B. F., & Diefes-Dux, H. A. (2012). Engineering identity development among pre-adolescent learners. *Journal of Engineering Education*, *101*(4), 698–716. https://doi.org/10.1002/j.2168-9830.2012.tb01125.x

Capobianco, B. M., Yu, J. H., & French, B. F. (2015). Effects of engineering design-based science on elementary school science students' engineering identity development across gender and grade. *Research in Science Education*, *45*(2), 275–292. https://doi.org/10.1007/s11165-014-9422-1

Carnasciali, M. I., Thompson, A. E., & Thomas, T. J. (2013, June 23–26). *Factors influencing students' choice of engineering major* [Paper presentation]. 2013 Annual ASEE Conference & Exposition, Atlanta, GA. https://doi.org/10.18260/1-2--19601

Carr, R. L., Bennett IV, L. D., & Strobel, J. (2012). Engineering in the K-12 STEM standards of the 50 U.S. states: An analysis of presence and extent. *Journal of Engineering Education*, *101*(3), 539–564. https://doi.org/10.1002/j.2168-9830.2012.tb00061.x

Chen, K. C., Schlemer, L. T., Smith, H. S., & Fredeen, T. (2011, June 26–29). *Evolving a summer engineering camp through assessment* [Paper presentation]. 2011 Annual ASEE Conference & Exposition, Vancouver, Canada. https://doi.org/ 10.18260/1-2--17939

Chism, N. V. N., Douglas, E., & Hilson Jr, W. J. (2008) *Qualitative research basics: A guide for engineering educators.* Rigorous research in engineering education. NSF DUE-0341127. https://eer.engin.umich.edu/wp-content/uploads/sites/443/2019/08/Chism-Douglas-Hilson-Qualitative-Research-Basics-A-Guide-for-Engineering-Educators.pdf

Chu, L., Sampson, V., & Todd, L. H. (2019). Argument-driven engineering in middle school science: An exploratory study of changes in engineering identity over an academic year. *Journal of Pre-College Engineering Education Research*, *9*(2), Article 6, 72–84. https://doi.org/10.7771/2157-9288.1249

Clewett, M., & Tran, H. D. (2003). Macro analog to MEMS: A program to teach 8th and 9th grade students science and engineering. *Journal of STEM Education*, *4*(3), 1–7. https://www.jstem.org/jstem/index.php/JSTEM/article/view/1099/954

Cloutier, A., Yew, G., Gupta, S., Dissanayake, K., Monaco, P., Mengel, S., & Morse, A. (2018). Modification and assessment of a residential summer program for high school women. *Journal of Pre-College Engineering Education Research*, *8*(2), Article 2, 10–21. https://doi.org/10.7771/2157-9288.1193

Creswell, J. W. (1994). *Research design: Qualitative and quantitative approaches.* SAGE Publications.

Creswell J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Merrill-Pearson Education.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, *39*(3), 126–130. https://www.jstor.org/stable/1477543

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2011). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education*, *2*(1), 63–79. https://doi.org/10.1080/21548455.2011.629455

Decoito, I. (2015, January 3–6). *Exploring middle school students' attitudes and interest in technology, engineering and mathematics subjects* [Paper presentation]. 2015 Hawaii University International Conference, Honolulu, HI. https://huichawaii.org/assets/decoito,-isha2-_-2015-steam-huic.pdf

DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2011). Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field Methods*, *23*(2), 136–155. https://doi.org/10.1177/1525822X10388468

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education*, *103*(3), 623–637. https://doi.org/10.1002/sce.21499

Edwards, C. D., Lee, W. C., Knight, D. B., Reid, K. W., Fletcher, T. L., & Meeropol, G. (2018, April 29–May 2). *Maximizing accessibility: Providing summer engineering experiences for racially, ethnically, and economically underrepresented youth* [Paper presentation]. 2018 CoNECD: The Collaborative Network for Engineering and Computing Diversity Conference, Crystal City, VA. https://peer.asee.org/29552

Elam, M. E., Donham, B. L., & Solomon, S. R. (2012). An engineering summer program for underrepresented students from rural school districts. *Journal of STEM Education*, *13*(2), 35–44. https://www.jstem.org/jstem/index.php/JSTEM/article/download/1619/1437

Faber, M., Unfried, A., Wiebe, E. N., Corn J., & Townsend, J. (2013, June 23–26). *Student attitudes toward STEM: The development of upper elementary school and middle/high school student surveys* [Paper presentation]. 2013 ASEE Annual Conference & Exposition, Atlanta, GA. https://doi.org/10.18260/1-2--22479

Fairweather, J. S. (2008). *Linking evidence and promising practices in science, technology, engineering and mathematics (STEM) undergraduate education: A status report for the National Academies National Research Council Board of Science Education* [Paper presentation]. National Research Council's Workshop on Linking Evidence to Promising Practices in STEM Undergraduate Education, Washington, DC. http://www7.nationalacademies.org/bose/Fairweather_CommissionedPaper.pdf

Felder, A. E., Kotche, M., & Hoda, A. (2020, June 20–24). *Development and implementation of a bioengineering module for NSBE SEEK* [Paper presentation]. 2020 ASEE Virtual Conference. https://doi.org/10.18260/1-2--35531

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. SAGE Publications.

Fralick, B., Kearn, J., & Thompson, S. (2009) How middle schoolers draw engineers and scientists. *Journal of Science Education and Technology*, *18*(1), 63–70. https://doi.org/10.1007/s10956-008-9133-3

Friday Institute for Educational Innovation. (2012). *Middle and High School STEM-Student Survey*. https://csedresearch.org/wp-content/uploads/Instruments/STEM/PDF/MISO_S-STEM_MiddleHigh_09-20-12_PUBLIC.pdf

Godwin, A. (2016, June 26–29). *The development of a measure of engineering identity* [Paper presentation]. 2016 Annual ASEE Conference & Exposition, New Orleans, LA. https://doi.org/10.18260/p.26122

Godwin, A., & Kirn, A. (2020). Identity-based motivation: Connections between first-year students' engineering role identities and future-time perspectives. *Journal of Engineering Education*, *109*(3), 362–383. https://doi.org/10.1002/jee.20324

Godwin, A., Potvin, G., & Hazari, Z. (2013, June 23–26). *The development of critical engineering agency, identity, and the impact on engineering career choices* [Paper presentation]. 2013 ASEE Annual Conference & Exposition Proceedings, Atlanta, GA https://doi.org/10.18260/1-2--22569

Godwin, A., Sonnert, G., & Sadler, P. M. (2017). Disciplinary differences in out-of-school high school science experiences and influence on students' engineering choices. *Journal of Pre-College Engineering Education Research*, *6*(2), Article 2, 25–38. https://doi.org/10.7771/2157-9288.1131

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255–274. https://doi.org/10.2307/1163620

Hammack, R., Ivey, T. A., Utley, J., & High, K. A. (2015). Effect of an engineering camp on students' perceptions of engineering and technology. *Journal of Pre-College Engineering Education Research*, *5*(2), Article 2. https://doi.org/10.7771/2157-9288.1102

Harakiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Behavioral and Brain Sciences*, *3*(2), 220–227. https://doi.org/10.1177/2372732216655542

Harris Interactive. (2011). *STEM perceptions: Student & parent study*. https://news.microsoft.com/download/archived/presskits/citizenship/docs/STEMPerceptionsReport.pdf

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978–1003. https://doi.org/10.1002/tea.20363

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4

Hirsch, L. S., Berliner-Heyman, S., Cano, R., Kimmel, H., Carpinelli, J. (2011, October 12–15). *Middle school girls' perceptions of engineers before and after a female only summer enrichment program* [Paper presentation]. 2011 IEEE Frontiers in Education Conference, Rapid City, SD. https://doi.org/10.1109/FIE.2011.6142990

Hirsch, L. S., Carpinelli, J. D., Kimmel, H., Rockland R., & Bloom, J. (2007, October 10–13). *The differential effects of pre-engineering curricula on middle school students' attitudes to and knowledge of engineering careers* [Paper presentation]. 2007 IEEE Frontiers in Education Conference, Milwaukee, WI. https://doi.org/10.1109/FIE.2007.4417918

Hubelbank, J., Demetry, C., Nicholson, S. E., Blaisdell, S., Quinn, P., Rosenthal, E., & Sontgerath, S. (2007, June 24–27). *Long-term effects of a middle school engineering outreach program for girls: A controlled study* [Paper presentation]. 2007 ASEE Annual Conference & Exposition, Honolulu, HI. https://doi.org/10.18260/1-2--2098.

Ing, M., Aschbacher, P. R., & Tsai, S. M. (2014). Gender differences in the consistency of middle school students' interest in engineering and science careers. *Journal of Pre-College Engineering Education Research*, *4*(2), Article 2. https://doi.org/10.7771/2157-9288.1090

Kirn, A., & Benson, L. (2018). Engineering students' perceptions of problem solving and their future. *Journal of Engineering Education*, *107*(1), 87–112. https://doi.org/10.1002/jee.20190

Krapp, A (2002). An educational-psychological theory of interest and its relation to SDT. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 405–427). University of Rochester Press.

Krapp, A., Hidi, S., & Renninger, K. A. (1992). Interest, learning, and development. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 3–25). Lawrence Erlbaum Associates.

Langdon D, McKittrick, G, Beede, D, Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future (ESA Issue Brief No. 03-11)*. U.S. Department of Commerce, Economics and Statistics Administration. https://files.eric.ed.gov/fulltext/ED522129.pdf

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., & Hackett, G. (1996). Career development from a social cognitive perspective. In D. Brown, L. Brooks, & Associates (Eds.), *Career choice and development*, (3rd ed., pp. 373–422), Jossey-Bass.

Lewalter, D., Gegenfurtner, A., & Renninger, K. A. (2021). Out-of-school programs and interest: Design considerations based on a meta-analysis. *Educational Research Review*, *34*, 1–18. https://doi.org/10.1016/j.edurev.2021.100406

Maltese, A. V., & Tai, R. H. (2009). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), 669–685. https://doi.org/10.1080/09500690902792385

Massi, L., Reilly, C. H., Johnson, D., & Castner, L. (2012, June 10–13). *Expanding your horizons: The impact of a one-day STEM conference on middle school girls' and parents' attitude toward STEM careers* [Paper presentation]. 2012 ASEE Annual Conference & Exposition, San Antonio, TX. https://doi.org/10.18260/1-2--21364

McAfee, L. & Kim, A. (2007, June 24–27). *Successful pre-college summer programs* [Paper presentation]. 2007 Annual ASEE Conference & Exposition, Honolulu, HI. https://doi.org/10.18260/1-2--2792

McCormick, J. R., Talbert-Hatch, T. L., & Feldhaus, C. (2014, June 15–18). *Increasing female participation in engineering: Evaluating POWER summer camp* [Paper presentation]. 2014 ASEE Annual Conference & Exposition, Indianapolis, IN. https://doi.org/10.18260/1-2--20626

McKinney, R. T. (2002). *An evaluation of the effectiveness of the summer technology and engineering preview at Stout (Steps) on the perceptions of females in technology of seventh grade girls* [Master's thesis, University of Wisconsin-Stout]. UW-Stout Masters Thesis Collection, Plan B. http://www.uwstout.edu/lib/thesis/2002/2002mckinneyry.pdf

Moore, T. J., Tank, K. M., Glancy, A. W., & Kersten, J. A. (2015). NGSS and the landscape of engineering in K-12 state science standards. *Journal of Research in Science Teaching*, *52*(3), 296–318. https://doi.org/10.1002/tea.21199

Nadelson, L. S., & Callahan, J. M. (2011). A comparison of two engineering outreach programs for adolescents. *Journal of STEM Education*, *12*(1), 43–54. https://scholarworks.boisestate.edu/cgi/viewcontent.cgi?article=1097&context=mse_facpubs

National Academy of Engineering. (2008). *Changing the conversation: Messages for improving public understanding of engineering*. The National Academies Press. https://doi.org/10.17226/12187

National Academy of Engineering, & National Research Council. (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. The National Academies Press. https://doi.org/10.17226/12635

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. The National Academies Press. https://doi.org/10.17226/12190

Nelson, K. G., Shell, D. F., Husman, J., Fishman, E. J., & Soh, L. K. (2015). Motivational and self-regulated learning profiles of students taking a foundational engineering course. *Journal of Engineering Education*, *104*(1), 74–100. https://doi.org/10.1002/jee.20066

Ortiz, A. M., Amaya, L. R., Warshauer, H. K., Torres, S. G., & Scanlon, E. (2018). They choose to attend academic summer camps? A mixed methods study exploring the impact of a NASA academic summer pre-engineering camp on middle school students in a Latino community. *Journal of Pre-College Engineering Education Research*, *8*(2), Article 3, 22–30. https://doi.org/10.7771/2157-9288.1196

Pawley, A. L. (2017). Shifting the "default": The case for making diversity the expected condition for engineering education and making expected condition for engineering education and making whiteness and maleness visible. *Journal of Engineering Education*, *106*(4), 531–533. https://doi.org/10.1002/jee.20181

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and mathematics*. http://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports

Renninger, K. A., & Bachrach, J. E. (2015). Studying triggers for interest and engagement using observational methods. *Educational Psychologist*, *50*(1), 58–69. https://doi.org/10.1080/00461520.2014.999920

Renninger, K. A., Bachrach, J. E., & Hidi, S. E. (2019). Triggering and maintaining interest in early phases of interest development. *Learning, Culture and Social Interaction*, *23*, 1–17. https://doi.org/10.1016/j.lcsi.2018.11.007

Renninger, K. A., & Hidi, S. E. (2011). Revisiting and conceptualization, measurement, and generalization of interest. *Educational Psychologist*, *46*(3), 168–184. https://doi.org/10.1080/00461520.2011.587723

Renninger, K. A., & Hidi, S. E. (2016). *The power of interest for motivation and engagement*. Routledge.

Renninger, K. A., Nieswandt, M., & Hidi, S. E. (2015). *Interest in mathematics and science learning*. American Educational Research Association.

Rosenzweig, E. Q. & Wigfield, A. (2016). STEM motivation interventions for adolescents: A promising start, but further to go. *Educational Psychologist*, *51*(2), 146–163 https://doi.org/10.1080/00461520.2016.1154792

Sahin, A., Ekmekci, A., & Waxman, H. C. (2017). The relationships among high school STEM learning experiences, expectations and mathematics and science efficacy and the likelihood of majoring in STEM in college. *International Journal of Science Education*, *39*(11), 1549–1573. https://doi.org/10.1080/09500693.2017.1341067

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). SAGE Publishing.

Silvia, P. J. (2006). *Exploring the psychology of interest*. Oxford University Press.

Sinkele, C. N., & Mupinga, D. M. (2011). The effectiveness of engineering workshops in attracting females into engineering fields: A review of the literature. *The Clearing House*, *84*(1), 37–42. https://doi.org/10.1080/00098655.2010.496812

Tan, E., Barton A. C, Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching*, *50*(10), 1143–1179. https://doi.org/10.1002/tea.21123

Unfried, A., Faber, M., Stanhope, D., & Wiebe, E. (2015). The development and validation of a measure of student attitudes toward science, technology, mathematics, and engineering. *Journal of Psychoeducational Assessment*, *33*(7), 622–639. https://doi.org/10.1177/0734282915571160

Unfried, A., Faber, M., & Wiebe, E. (2014). *Gender and student attitudes toward science, technology, engineering, and mathematics*. The Friday Institute for Educational Innovation at North Carolina State University.

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly*. https://www.bls.gov/ooq

Weavers, L. K., Bautista, D. T., Williams, M. E., Moses, M. D., Marron, C. A., & La Rue, G. P. (2011). Assessing an engineering day camp for middle-school girls. *Journal of Professional Issues in Engineering Education and Practice*, *137*(3), 127–134. https://doi.org/10.1061/(asce)ei.1943-5541.0000046

Xue, Y., & Larson, R. C. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly Labor Review*. U.S. Bureau of Labor Statistics. https://doi.org/10.21916/mlr.2015.14

Zurn-Birkhimer, S., & Holloway, B. (2008, June 8–10). *A summer camp program to introduce girls to opportunities in engineering* [Paper presentation]. 2008 Women in Engineering Program Advocates Network Annual Meeting, St. Louis, MO. https://journals.psu.edu/wepan/article/view/58512

Appendix A

First Generation Engineering camp 2019 schedule

July 8–12

	Monday *July 8th*	**Tuesday** *July 9th*	**Wednesday** *July 10th*	**Thursday** *July 11th*	**Friday** *July 12th*
9:00	**Registration & Welcome**	**Bottle Rocket**			
		Presentation			
	Initial survey		**Environmental**		**Intro to UAS**
9:30	**Intro to Engineering**		**Engineering- Mining the**		
		Engineering Library	**Environment Activity**	**Field Trip**	
10:00	**Chemical/Materials**	Tour			
	Instasnow activity	Design fins			
10:30		Laser cut fins	**Bottle Rocket Refresher**		**VEX Robotics Activity**
			Presentation & Rocket		
11:00			**Building Activity**		
	Tie Dye T-shirts				
11:30					**Robotics Lab Tour**
		Lunch	Lunch		
12:00					
		Buffer time			Lunch
12:30	Lunch		**Launch Bottle Rockets**		
		Electrical Engineering			**Final survey**
1:00		**Presentation &**			
		Activity			
	Civil Engineering			**Focus Groups**	**Prepare PowerPoint**
1:30	**Presentation &**			Activity 1:	**Presentation for**
				Programmer says	
	Activity		**Parachutes for Bottle**	Activity 2: Foil boats	**Parents' Reception**
2:00		**Biomedical**	**Rockets & Debrief**		
		Engineering			
		Presentation &			
		Activity			
2:30					**Parents' Reception**

Appendix B

Focus group questions

1. What do you think engineers do?
   a. Has this changed since the start of camp? If so how?
2. Which of the camp activities, if any, increased your interest in engineering?
   a. Which camp activities made you feel excited or engaged?
      i. Why those activities and what made them stand out to you?
      ii. What field of engineering do you think this activity represents as far as a major in college?
      iii. **Are you interested in studying this engineering major in college? If so, what makes it interesting to you? If not, then why?**
   b. Were there specific activities that you were disinterested in while doing them?
      i. (If lectures, which specific ones and why?)
      ii. (Be sure to ask why if specific activities are mentioned.)
3. What are the things you enjoyed the most about the camp experience?
4. Has your perception of who can be an engineer changed from the beginning of camp? In what ways?
5. Which camp activity or activities made you feel most like an engineer? Why?
   a. In what way? How so?
   b. Which field of engineering is that related to?
   c. Can you see yourself as an engineer? Why?
6. As a result of the camp, are you now thinking about future classes that you might be more interested in taking? Which ones?
7. How about other activities such as school clubs or other summer camps?
8. Did this camp make you more inclined to study engineering in college?
9. How did you find out about the camp? Was it your decision or someone else's to sign up?
10. Do you have any suggestions for improving the camp experience?

Appendix C

Table showing themes and quotes supporting these themes

Theme	Quotes	Notes
Future self as an engineering major and/or engineering professional	Bruce said: Maybe I would love to take classes in some mechanical, because we went to [a major automotive manufacturing company] today. I saw those two robots assembling it, and it would be really cool to build some robots of my own and go onto the future making AIs, artificial intelligence.	Participants from all the camps made comments related to their desire to take classes and participate in extra-curricular activities related to engineering.
	Josh said: So since I want to be a computer engineer and I forgot her name but she's a computer scientist here so I talked to her about what I can do to prepare myself for college and she said to take a lot of math so next year I'm going to be taking physics and calculus to prepare myself.	
	Hannah said: At our school we have a STEM lab. And it's 3D printers and computers. There are these Nintendo switches and stuff. And there's also a model club at lunchtime, so maybe I will consider doing that.	
	Celine said: Probably I signed up to do STEM. We really don't hear back until the beginning of August. But I really want to do a STEM club, because it's pretty much all of this at school. And that's bonus. And I don't really know if I would do camps after school or clubs, because I have a lot of sports. So, it's hard for me to be there after school, because I also have to go up into practice in [small town]. And we don't have that many clubs but if we did and I was open to it I would definitely do more STEM lab or clubs, or stuff to do with engineering.	
	Peter said: First, I wanted be like chemistry and stuff, but now i want to be a mechanical engineer and an electrical engineer, so I could get my hands in wires and stuff.	Peter was a Hispanic participant who came to the camp interested in chemistry. He expressed enjoying the electrical engineering activity where participants put together a breadboard for a speaker.
	Kirk said: I feel like with a little more knowledge of what is happening…because I still don't really understand that much, but I have a little bit more knowledge which will back me up in the future and help me in the long run.	Kirk was one of the younger participants in the First-Generation camp and felt his knowledge about engineering had increased as a result of the camp.
	Martha said: Maybe I can get STEM classes to see how it has math, science and engineering, and it can be fun. She also had this to say: It helps me think about what I want to do. I have options in life, you don't have to be a teacher, if you want to you can be an engineer and can work in a field that in you can have another job. When you get older you can always think about those two jobs and what kind of job or career you want to have.	Martha was an African American participant whose family recognized her as a future engineer, not only gained an understanding of the importance of mathematics and science towards a degree in engineering, but also the fact that engineering could be an option for her as a career.
	Jerry said: I always knew that engineers could go and work in any field, pretty much math, a little like the environment, civil, all that stuff. But since coming here I have a greater understanding of truly how they do it in each field.	Jerry had an uncle who was a mechanical engineer and said he now understood more about engineering fields.
	Alina said: I think it made me lean towards other fields of engineering, instead of just because I didn't like chemical engineering but I like biomedical now.	
Enjoyment of camp activities and engineering interest	Celine said: I would probably say either the engineering part of it, like making the design or finding out the interior of it or how it could work better. I thought that was really cool, because I didn't know we had a [large automotive manufacturing company] near [city] and then when I found out I was like, I could actually do that when I grow up and that would be really cool if I did.	
	Tyler said: I liked the part where we, especially our group, innovated with the nose of our rocket, so it wouldn't break on the first crash. I really liked the rocket activity.	He also liked the part where he and his group could be innovative in designing their rocket.
	Josh said: When we went to the library and saw the virtual reality and robots because they (reference to the library staff) were talking about how computer engineers have a part in making that, it made me really excited thinking I'm going to be able to do that.	He knew he wanted to be a computer engineer was very excited about what he would be able to do in the field of computer science and engineering after the visit to the makerspace in the engineering library. His excitement is sensed in his remark.

Continued on next page

Appendix C. *Continued*

Theme	Quotes	Notes
	Josh said: I like that we did the hands-on things, like the circuits for the electrical engineering. So, you sort of got a taste of what they do.	He also enjoyed the hands-on aspect of the electrical engineering activity where they put together components on a breadboard to design a speaker.
	Kaylee said: I also enjoyed that we were given the ability to create everything that we've been creating. We were given constraints, but after that we were able to do whatever we wanted.	She enjoyed being creative and working with the given constraints.
	Ivanna said: The activity where we got to build a tower because then you could see where you went wrong and how your structure was failing in different parts. And what you could have done to make it better.	She on the other hand found the tower building activity where they tested their final product on an earthquake shake table (an activity that caused a lot of excitement amongst the campers) interesting and educational because her team could observe where the tower structure failed, as evidenced by her comment.
	Otis said: I thought the engineering library in general was pretty interesting. It just opened my eyes that there's so many different things that you can create synthetically. Like you can create something like a car part using a 3D printer, and that's really interesting.	He enjoyed the makerspace.
Perceptions and knowledge of engineering	Kendall said: I'd say similar to Kaylee, how doing the activities that I was previously interested in, or in the fields that I was interested in, kind of encouraged me to explore more, and realize that there's so many things that I can do within there. I think that's really interesting.	
	Aaron said: That helped open my eyes to how engineering is a lot more diverse than what most people think and just opened my eyes and makes me more intrigued and make me want to do more in the engineering field.	
	Alexa said: I liked getting to learn more about engineering because I had a totally different perspective, and getting to know which field I would like if I did go into engineering.	Alexa enjoyed learning about different fields of engineering.
	Mark said: I recognized that it takes a lot of different people working together, like at the mining project, the environmental engineer, the manager, the miner, the refiner, and the waste manager, and they all had to manage the mine to make it a clean mine.	Mark commented on how he had learned that teamwork was important.
	Fabian said: In all the different types of engineering, I notice how they all come together. For example, you've got your software engineer who made the software and then they go to the mechanical engineers and the electrical engineers to make the robot. I want to be able to pursue all types of fields that will let me combine all those elements into one.	
Increase in engineering identity as a result of participation in well-structured and purposefully designed camp activities	Alexa said: For me the one that made me feel most like an engineer would probably be the electrical, because that was one where we were actually, making something, testing it, and if that didn't work then we would go through and try to see if we did something wrong.	
	Will said: When I am out of college and thinking about what job I want to do, I might think more about being an engineer, because this was a really fun camp. I'll probably do UAS camp next year. It was a good experience.	He implied that the camp had affected his engineering identity in a positive way.
	Matt said: It only made me want to do it more. From everything, we've learned so far this week, all I keep thinking is how do I pursue all these and bring them together.	This theme is further enhanced by comments like these.
	Julie said: When you think of engineering, the person you think of is a man. And I have never really thought of a girl being an engineer before. I know there's camps and stuff like this, where girls are engineers. But the first thing that pops into your head is a man. So I liked how they're able to develop the fact that women can be engineers too.	
	Aurora said: When I first started getting interested in engineering, I always felt like I couldn't because girls aren't allowed to, because society makes you think that. That girls shouldn't be in that kind of field. But then because my mom's brother is an engineer, she said that he said we need more women in the engineering field. So that's kind of what boosted up my confidence of being an engineer. And so, I asked my mom to find the camps and stuff about engineering.	

Continued on next page

Appendix C. *Continued*

Theme	Quotes	Notes
	Aurora said: I thought that was amazing that there are not only men, but there was a majority of women there. Annabelle said: When I first came here I expected to see a lot of males on campus and when I went into all the different labs I saw a lot of women were teaching. In the circuits lab, there was a woman there who seemed to know a lot more than a couple of the guys that were doing it.	The field trip to a large automotive manufacturing company led to related comments like this. She followed this up by saying how she saw so many women engineers at [large automotive manufacturing company]. One of the highlights for her was the industry tour that left her wanting to work there and seeing herself as potentially working there. In addition, seeing women engineers in the university laboratories and those who were helping run the camp activities, definitely boosted the participants' identity in the Young Women's camp as evidenced by.
	Kaden said: I came because my mom knew I liked building and stuff, and she knew that I liked engineering, so she brought home this packet. And I said I'll give it a try because I have nothing else to do really. Maria said: Well my mom works here and she's like science is your best class you're doing more of it over the summer like you're doing this. And I was like okay…I guess.	

https://doi.org/10.7771/2157-9288.1351