Influencing Student Engineering Interest and Identity: A Study Investigating the Effect of Engineering Summer Camps on Middle and High School Students (Work in Progress)

Introduction

With an insufficient number of college students pursuing degrees in engineering creating and recruiting interested undergraduate students, especially minority students such as females and ethnically diverse students, is of importance [1]. To address this problem, we sought to understand how week-long summer camps influenced student interest in engineering and engineering identity.

The need for qualified STEM trained people is only on the rise. Economic projections indicate that the United States will need more than one million more STEM graduates than what is currently being produced if the United States is to remain a leader in science and engineering [2,3]. One way to help meet this demand is by generating interest in future college students as they progress through middle and high school. Student interest in engineering at these grade levels has been shown to predict future college majors and possible careers in engineering [4].

Building engineering interest in middle and high school grade levels before students enter college is best achieved by exposing students to engineering related tasks and learning activities[5]. With the adoption of the Next Generation Science Standards by some states, but not all, educators in t now have a framework for implementing and building engineering activities into their classroom experiences [6]. However, there are indications that engineering is underutilized in K-12 settings and therefore universities are supplementing with outreach to introduce students to engineering principles and build interest for and awareness of the engineering disciplines [7]. A mixed-methods design was used to answer the following research questions: 1.) How does a week-long engineering summer camp affect middle and high school students' interest in engineering and their identity as engineers? 2.) Which specific activities in the camps lead to a change in identity and interest in engineering?

Theoretical Framework

When it comes to student interest in pursuing engineering disciplines, Hammack, Ivey, Utley, and High [8] make a case that one reason for students not entering university engineering programs is a lack of understanding on their part as to what type of work engineers actually perform. This ties directly into what Lent et al. [9] suggested in their social cognitive career theory in that people need experiences to build their interests. Furthermore, Seymour and Hewitt [10] discuss one reason that many STEM majors switch to non-STEM related majors is due to a lack of interest in the discipline and that they originally did not have an understanding of what the discipline was all about. A student's prior knowledge is a leading factor as to what type of profession they choose to pursue in college [8].We define interest in the context of this study as did the campers enjoy the activities sufficiently that they want to do more of these types of activities in the future as engineering students in college.

Erik Erickson [11] first popularized the idea of personal identity and identity formation in adolescents and even went so far as to say that the main goal of adolescences is to find ones

identity. A person has to decide who they will become and that is based upon a number of aspects including past experiences and future experiences. This personal identity encompasses many facets of one's self such as gender identity, religious identity, as well as career or vocational identity. The experiences a person has forms their identity as far as how they see themselves as well as how others see them in a social context.

One way to approach identity formation in students is through four dimensions, beliefs about their performance, competence, recognition by others, and interest [12, 13]. It is worth highlighting the role that interest plays in identity formation. Our definition of identity as it relates to this study is based upon are these campers able to see themselves becoming engineers in the future and did the camp reinforce or create this identity. Although the work Hazari et al. [13] conducted was in physics and not an engineering discipline specifically, they did find a strong link between one's physics identity and choosing a career in the physical sciences. Godwin et al. [12] did specifically look at engineering identity and using a regression model did find that STEM identity contributed significantly to a major in engineering. In other words, the more a student sees themselves as a scientist or good at math the more likely they would go onto select a major in engineering. Their study shows the importance of providing experiences in STEM disciplines for future engineering students.

Methods

Fifty-five people campers ranging in ages from 11 to 17 participated in the week-long summer camp experience. The campers were from two western states and attended public schools in either a traditional setting or an online public charter school. Thirteen different schools were represented.

Participants were recruited through classroom visits by staff from the outreach office of the College of Engineering, or by teachers recommending them for the camp. The teachers heard about the camp through email notifications to their work accounts sent by the outreach office of the College of Engineering.

Each of the three week-long engineering summer camps took place over five days at a land-grant university located in the Western United States. The camp was organized and run by the outreach office of the College of Engineering. During the week-long camps participants experienced a number of hands-on activities meant to introduce them to multiple engineering disciplines. These activities were facilitated by engineering graduate students and professors in their respective disciplines. For example, one activity asked participants to work in pairs to build a speaker using a breadboard and component parts. This was facilitated by a professor of electrical engineering and a number of his graduate students. Besides the activities the participants also received tours of the university. Most activities were held in a large common room within one of the engineering buildings. Those activities not held in the common room were held in discipline specific engineering laboratories.

Data were collected in three streams. First through identical pre-test and posttest surveys measuring attitudes and interest in STEM fields. Second, focus group interviews related to attitudes and interests in engineering. The third data collection method was observations of camp

participants during each activity. This paper focuses on the first two data streams. More detailed information on the methods is available in another paper presented at this conference.

The pre-test survey was given during the first thirty minutes on the first day of the camp. The posttest survey was given during the final day of the camp in the afternoon. Normality tests, Shapiro-Wilks, were conducted on the participant's pre and post survey data which was found to be negatively skewed and significantly non-normal. A non-parametric Wilcoxon rank sum test was conducted comparing differences for each survey item on the pre and post surveys. Focus groups consisted of 5 or 6 participants and lasted about twenty-five minutes each. Questions ranged from "Which activity made you feel most like an engineer" to "Were there specific activities that increased your interest in engineering".

Results

After removing 8 participants from the quantitative data analysis due to missing pre or post survey data, 47 remaining campers survey results were compared. Normality assumptions were violated. The initial data from the participant pre and post surveys indicate a positive statistically significant change in three of the survey items (Table 1). The item asking participants about doing well in science ($Z= -3.153$, $p=.002$) and being good at engineering ($Z=3.167$, $p=.002$) (a precursor to identity), both showed a positive significant gain. Interestingly, participants' attitudes towards math tasks ($Z=-2.4$, $p=.016$) were negatively impacted as a result of participation. Admittedly there was little opportunity for students to conduct mathematical analysis during engineering activities. Table 1: Results of Significant Survey Items

	Pre-test Survey			Posttest Survey		
Survey Item	Mean	SE	SD	Mean	SE	SD
I know I can do well in science.	4.21	.118	.806	4.49	.109	.748
I am good at engineering.	3.17	.170	1.167	3.68	.152	1.045
I am good at math.	4.34	.130	.89	3.87	.148	1.013

The focus group responses seem to support the participants' change in attitudes towards science and engineering tasks. Five themes emerge from the focus group data: 1.) growing interest in engineering activities based upon where the activity took place, 2.) little to no interest in lecture-based activities, 3.) increases in participant engineering identity, 4.) new knowledge and understanding around the engineering profession, and 5.) future self. For this work in progress, we discuss the themes 1 and 2 dealing with interest formation in detail below.

One common aspect of the engineering activities that campers found interesting was that they were ones in which took place in actual engineering spaces such as engineering labs or in the engineering library. After visiting a robotics lab and coding robots, Jason mentioned how interested in robotics and coding he was, "When I saw the robots it made me more interested because they had them coding to make the robots do something. And so it kind of made me more interested in what I want to do." Another activity that was mentioned by participants was the tour

of a very large battery storage factory in which they were able to see the production of these batteries as well as large teams of different engineers working together in the manufacturing of the batteries. Danni said this about the factory tour, “Yes, I feel like when we went to (name of company) that definitely peaked my interest in engineering.”

The participants discussed the activities in which they were disinterested during the camp experience. Far and away the portion of the camp they found uninteresting were the parts where invited engineering professors or graduate students came in to discuss their chosen discipline, usually with the use of a PowerPoint presentation. Danni said, “Most of the lectures we listened to were really boring.” In fact, Doug had this to say about the lectures, “I liked that I had all the activities, I just didn't really like the talks, the presentations, because those take really long times and that kind of made me bored.” The observational notes taken during most of the talks did include observations of participants showing disengagement including, “head on the table, surfing on his phone, not looking at the presentation slides,” as other such hints as to show student boredom and disinterest.

Discussion and Future Work

Much was gained by the participants throughout the camp experience. In looking at the data found within the focus group transcripts it is not hard to tie the two themes discussed above to the notion of identity formation and the role interest plays as discussed in the literature [11, 12,13]. These middle and high school students were able to participate in a week-long experience where they developed engineering interests that they at times knew they had, but also in new interests that they did not even know about. During the focus group, participants expressed how they will make choices that will lead them down a new path of discovery, one that might even lead them to an engineering major in college.

The participants were given an opportunity, during an important stage in their life, adolescence, to see if they have an interest in engineering. Data from this ongoing project will be used to make adjustments to the current camp experience. Activities have already been redesigned to take place in working engineering labs with less lecture time and more emphasis on the engineering design process to solve problems. (Discussed in detail in another paper at this conference.)

Without experiences such as these where young adolescents can develop new interests which can lead to the formation of identity during these formative years, many students, especially first-generation college students, may miss out on a productive career in engineering where they can help others and society. Hence, these opportunities need to be extended to a more diverse population of students.

Future work will involve a comprehensive analysis of all data, quantitative and qualitative data gathered from cycle 1 (2018) and cycle 2 (2019). Further changes may also be implemented to camp activities based upon this analysis.

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