# Board 124: Influencing Student Engineering Interest and Identity: A Study Investigating the Effect of Engineering Summer Camps on Middle and High School Students (Work in Progress)

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Indira Chatterjee received her M.S. in Physics from Case Western Reserve University, Cleveland, Ohio in 1977 and Ph.D. in Electrical Engineering from the University of Utah, Salt Lake City, Utah in 1981. Indira is Associate Dean of Engineering and Professor of Electrical and Biomedical Engineering at the University of Nevada, Reno. As Associate Dean she oversees undergraduate and graduate education in the college including assessment, accreditation, recruitment, retention and advising. She also coordinates efforts to expand the research productivity of the College of Engineering. This includes promoting and facilitating industry-college partnerships, identifying and monitoring opportunities for competitive research grants, apprising faculty of research opportunities and providing coordination and leadership for forming research teams as needed to respond to these opportunities. She serves as chair of the College of Engineering curriculum committee and is a member of the university curriculum committee. Indira has been a faculty member at the University of Nevada, Reno since 1988. As Professor of Electrical and Biomedical Engineering she has been actively involved in funded research. She has been primary mentor to several graduate students who are well placed in industry and academics. Her research areas include: Numerical and experimental bioelectromagnetics, RF/microwave/millimeter wave dosimetry, high intensity electronanopulse clinical applications, antenna design, and electrical properties of materials. Over the past 30 years she has brought in over $6 million in research funding from the National Science Foundation, Air Force Office of Scientific Research, Johns Hopkins University, National Institutes of Health, Environmental Protection Agency, Department of Energy and private industry. She is a senior member of the IEEE, a member of the IEEE MTT-10 committee, and a member of the ASEE, Bioelectromagnetics Society and Society of Women Engineers. She serves on the editorial board of the Bioelectromagnetics Society.

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## Introduction

The need for qualified STEM trained people is 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]. However, an insufficient number of college students are pursuing degrees in engineering. Therefore, creating and recruiting interested future college students, especially females and ethnically diverse students, is of high importance [1] One way to foster student enrollment in engineering 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]. To meet the demand for more engineers, we sought to understand how summer camps, five days in length, influenced student interest in engineering and engineering identity.

Building engineering interest in middle and high school, 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 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 and awareness of the engineering disciplines [7]. To understand how university summer camps influence interest in engineering, 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

Although studies have looked at various types of summer camp or outreach programs few have looked at how these summer camp experiences help build middle and high school participants' identity and interests in pursuing engineering as a college major. One study showed that over 80% of the 885 participants,$7^{th}$ and $8^{th}$ grade students, majored in a STEM discipline in college [8]. Another study looking at high school female engineering camp participants found that the majority, 65.1%, of past camp participants chose engineering majors over other majors [9]. Furthermore, participants were more likely to attend the university hosting the camp than other universities [9].

When it comes to student interest in pursuing engineering disciplines one reason students do not enter university engineering programs is a lack of understanding of the work engineers perform [10]. This ties directly into what Lent et al. [11] suggested in their social cognitive career theory in that people need experiences to build their interests. Lent et al. propose that one's experiences can lead to building interest in a subject of study through the building of self-efficacy. However, one cannot build self-efficacy without the chance to experience new things. Furthermore, Seymour and Hewitt [12] discuss one reason that many STEM majors switch to

non-STEM related majors is due to a lack of interest in the discipline. Their participants claim that they originally did not understand what the STEM 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 [10]. We define interest in the context of this study as whether the campers enjoyed the activities sufficiently that they want to do more of these types of activities in the future. Perhaps even as engineering students in college due in some part to the experiences and knowledge about engineering gained from participation in these camps.

Erik Erickson [13] first popularized the idea of personal identity and identity formation in adolescence and even went so far as to say that the main goal of adolescence is to find one's identity. A person must decide who they will become and that is based upon a number of aspects including past experiences and future life choices. 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 when it comes to how they see themselves and 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 [14, 15]. 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 whether these campers can see themselves becoming engineers in the future and did the camp reinforce or create this identity. Although the work of Hazari et al. [15] 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. [14] specifically looked at engineering identity and using a regression model found 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. We wanted to further this line of research and look specifically at how an engineering camp experience affects campers' interest and identity in Engineering disciplines as a result of participation in a five-day engineering summer camp.

**Methods**

Fifty-five 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 several hands-on activities meant to introduce them to multiple engineering disciplines. These activities were facilitated by engineering students, professors, and alumni. 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 local engineer and electrical engineering alumnus as well as electrical engineering 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. This survey, which took approximately ten minutes to complete, was a slightly modified version of the Friday Institute's S-STEM survey [16] which has been shown to be a valid instrument for understanding student attitudes for different STEM disciplines. Second, focus group interviews related to attitudes and interests in engineering were conducted. The focus group protocol and questions were created by the team of researchers to address specific topics around the research questions including student interest and identity around engineering tasks. 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 [17].

The pre-test survey was given electronically during the first thirty minutes on the first day of the camp. The posttest survey was given electronically 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 each and lasted about twenty-five minutes each one led by a member of the research team with a second team member recording participants' comments. During each focus group session, participants were encouraged to share their responses to the following questions:

1. What do you think engineers do?
    a. Has this changed since the start of camp?
2. Were there specific activities that increased your interest in engineering?
    a. What activities in the camp made you feel excited or engaged?
        i. Which ones?
        ii. Why those activities and what made them stand out to you?
        iii. Would you want to study this [activities] in college?
        iv. What are the things you enjoyed the most about the camp experience?
    b. Were there specific activities that you were disinterested in while doing them?
3. Which activity or activities made you feel most like an engineer? Why?
    a. In what way?
    b. Would you want to study this [activities] in college?
4. Has your perception of who can be an engineer changed from the beginning of camp? In what ways?
5. How will what you learned during this camp impact you as you move forward in life?
    a. Has the camp influenced possible future classes you might take or after-school activities? In what way?
    b. Did this camp make you more inclined to study engineering in college?

All focus groups were videotaped for transcription purposes. NVivo software (QSR International, Melbourne, Australia) was used to analyze the focus group data. Two members of the research team met together to review and analyze all focus group transcripts over a period of three months looking for commonalities and themes within the data.

**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. 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. More detailed analysis of the quantitative data is planned in which comparisons between groups will be investigated to see if differences between the camps exist.

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 emerged 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 paper, we discuss themes 1 and 2 only, dealing with interest formation in detail below.

Camp participants found activities that took place in actual engineering spaces such as engineering labs or in the engineering library more interesting than those that were held in the common room. After visiting a robotics lab and coding robots, one camper 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. Another camper said this about the factory tour, "Yes, I feel like when we went to Tesla (battery factory) that definitely peaked my interest in engineering."

The participants also discussed the activities in which they were disinterested in during the camp experience. Far and away the portion of the camp they found little interest in 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. One camper said, “Most of the lectures we listened to were really boring.” In fact, another camper 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 a really long time 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,” and other such hints as to show student boredom and disinterest.

**Discussion and Future Work**

Much was gained by the participants throughout the camp experience. The data from the focus groups support this claim and 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 [13 - 15]. Participant comments during the focus group interviews support that there were activities they participated in which their interest in engineering increased. 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 developed new interests in engineering that they did not even know they had before the camp. During the focus group, participants expressed how they will make future 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 has been shown can lead to the formation of identity, many students, especially first-generation college students, may miss out on a productive career in engineering. Therefore, it makes sense that these opportunities should 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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