

Board 28: Progress on a Mixed Methods Research Project Studying Interest and Identity of Participants Engaged in Engineering Camp Activities – Methods and Preliminary Results

Dr. Indira Chatterjee, University of Nevada, Reno

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 electro-nanopulse 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.

Tim Robinson, University of Nevada Reno

I am a former elementary and middle public school teacher who is currently pursuing a doctoral degree in STEM Education. My research interests are in the areas of science and engineering education where I look at student interest as well as the use of technology such as digital data collection devices and the impact they have on students' ability to argue scientifically.

Dr. Adam Kirn, University of Nevada, Reno

Adam Kirn is an Assistant Professor of Engineering Education at University of Nevada, Reno. His research focuses on the interactions between engineering cultures, student motivation, and their learning experiences. His projects involve the study of student perceptions, beliefs and attitudes towards becoming engineers, their problem solving processes, and cultural fit. His education includes a B.S. in Biomedical Engineering from Rose-Hulman Institute of Technology, a M.S. in Bioengineering and Ph.D. in Engineering and Science Education from Clemson University.

Dr. Jennifer R Amos, University of Illinois, Urbana-Champaign

Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Teaching Associate Professor in Bioengineering and an Adjunct Associate Professor in Educational Psychology. She received her B.S. in Chemical Engineering at Texas Tech and Ph.D. in Chemical Engineering from University of South Carolina. She completed a Fulbright Program at Ecole Centrale de Lille in France to benchmark and help create a new hybrid masters program combining medicine and engineering and also has led multiple curricular initiative in Bioengineering and the College of Engineering on several NSF funded projects.

Progress on a mixed methods research project studying interest and identity of participants engaged in engineering camp activities: methods and preliminary results

Introduction

There exists a continuing issue in the United States with respect to under-enrollment in engineering majors in college, and hence interest in pursuing an engineering career, especially within underrepresented groups including women [1]. Studies have shown that a strong predictor of students enrolling in engineering college majors and pursuing an engineering career is student interest in engineering at the K-12 level [2, 3]. In addition, it has been shown that a critical time where student interest, identity, and career choices begin to solidify is during middle school years [4, 5] and hence should be the population on which studies should focus. The National Academy of Engineering and National Research Council emphasize the importance of engineering education at the K-12 level [6]. Informal STEM outreach programs have been instituted for students in K-12 by many universities that have engineering programs [7, 8]. Specifically, “Increasing the interest of K-12 students in the sciences rests on university outreach efforts and improved K-12 instruction” [4, p. 6]. There is a need to better understand the ways in which outreach programs like engineering summer camps influence engineering interest and identity in middle school students and subsequent choice of engineering as a major and career.

This paper reports on progress to date of a two-year project that explores interest and identity development of three populations (ages ranging from 11 to 17 years) participating in three separate introductory level engineering summer camps offered by the College of Engineering at the University of Nevada, Reno. The three populations are participants in a (1) Young Women in engineering (all female), (2) a First-Generation (for students who will be the first person in their immediate family to attend college), and (3) an Open Enrollment engineering camp (admits any student who applies on a first-come first-served basis). The research design leverages an existing quantitative survey along with focus groups and observations related to the survey questions. Results and preliminary analysis of the qualitative data collected during the first cycle of summer camps held during summer 2018 are presented and discussed.

Research Design, Methods and Instruments

Guidelines provided by Creswell [9] were followed in developing the research design for this project. The approach is a convergent parallel-mixed methods and the research questions that are being addressed are: (1) How strongly are engineering identity and interest linked to the pursuit of engineering as a major in college and as a possible future career? (2) Which specific activities in the summer camps lead to a change in identity and interest in engineering? (3) To what extent and in what ways do the qualitative participant focus group interviews and observations of participants engaged in camp activities contribute to a comprehensive understanding of the quantitative data obtained via pre- and post-surveys?

Description of summer camps and participants

The engineering content of each of the three camps is the same, designed with the goal of increasing understanding of and sparking interest in different engineering fields and careers. The only difference between the three camps is that the women-focused and first-generation camps involve participation of guest speakers and role-model mentors appropriate for the camp populations. The camp activities include building a speaker using a circuit breadboard, blasting

off bottle rockets designed by the campers, testing gum-drop and toothpick towers on a miniature shake table, learning about environmental concerns in mining, crafting code for a robotics activity and, touring a local engineering company where they interact with engineers. Some of these activities were conducted in university laboratories and some in the engineering conference area that is the location for the summer camps. Activities were led by engineering students and faculty. IRB approved protocols were followed. The total number of participants in the camps during summer 2018 was 62 that included 20 in the Young Women in Engineering camp, 17 in the First Generation camp and 25 in the open-enrollment Introduction to Engineering camp. Seven campers did not have parental consent and we did not have complete data for eight. Hence the total number of participants included in year 1 of the study was 47.

Quantitative Data collection

Quantitative data consists of a pre-survey, administered electronically using Qualtrics, taken by the participants on day 1 of the camp in the Engineering Computer Center. Campers had 15 minutes to fill out the survey and the researchers were present in the room in case the campers had any questions. Survey questions were from the Friday Institute survey [10], an instrument that measures student attitudes towards STEM and has been tested and validated [11]. The survey was also delivered on day 4/5 of the camp (post-survey). Analysis of the data was conducted using SPSS. Results will be discussed in detail in another paper at this conference [12].

Qualitative data collection

Qualitative data consists of in-depth focus group interviews (on day 4/5). A semi-structured focus group interview protocol was developed by the researchers and consisted of open-ended questions relating to identity, interest, and career aspirations, i.e. closely related to the project research questions. Each twenty minute focus group consisted of 5 - 6 participants and was videotaped, transcribed by Rev.com and checked for accuracy by the researchers.

In addition, observations of camp activities during all five days of the summer camp were carried out. A semi-structured checklist and the worksheet for the daily observations of participants involved in camp activities was designed based on guidelines provided in the Individualized Classroom Assessment Scoring System (inCLASS) [13]. Video recordings were made of campers engaged in camp activities.

Qualitative data analysis

A team coding process was adopted where the principal investigator (PI) and graduate student coded as a team in several weekly meetings spanning a period of three months. An open coding process was followed where codes were developed from the transcripts, followed by axial coding where the codes were analyzed to see if there was any connection between the codes [14]. The codebook was developed based on the project research questions and the collected data. Since the objective of the PFE:RIEF program is to train researchers in the field of engineering education research, the PI and graduate student first went through the process of manual coding one of the focus group transcripts following the suggestion of Saldaña [15]. Once they felt comfortable with the process, they took the training offered by NVivo and started using NVivo for coding the remaining focus group transcripts (eleven in all: three each from the Young Women's and First Generation camps and five from the Introduction to Engineering open enrollment camp). A codebook consisting of twelve main codes was developed during first-cycle

coding. Under three of the codes “future”, “interest” and “identity” (that have emerged as themes) there were sub-codes. The analysis of data (focus group participant quotes) that was inserted under these three themes and that directly relate to research question (1) will be presented in another paper at this conference. Seven codes directly related to the research questions, and the remaining codes contained data from the focus group transcripts that were sufficiently interesting that warranted a separate code. In this paper we present a preliminary analysis of data that falls under three emergent themes that are related to research question (2). Some interesting observations are made based on this preliminary analysis. We also discuss some of the changes that will be implemented in the second cycle of summer camps that will be held during the summer of 2019 based on results of the qualitative analysis.

Results

Preliminary analysis of the focus group interview transcripts indicates that there is a positive change in engineering interest and identity of the participants due to the summer camps and the results are presented in another paper at this conference. The results presented here are based on analysis of codes mentioned in the previous section that have led to three emerging themes:

1. *Feelings about autonomy:* A recurring emerging theme was that the standalone PowerPoint presentations were too long, slow and boring sometimes being attributed to the speaker’s level of enthusiasm, length of presentation and disconnect between the presentation and hands-on activity that followed. Sample quotes are “I found at the very first day all the PowerPoint that were super long, I find that kind of boring. You just listen to it”, “I didn’t really like all the PowerPoints and stuff they were telling us. It was super long and it made me kind of tired. And I couldn’t always hear what they were talking about. Or understand it”. The campers definitely enjoyed the hands-on activities more and indicated that if the presentations were combined with a hands-on activity they would have found them more interesting. They also seemed to be more interested in the activities that were not guided but where they got to build something according to some design specifications. They wanted to understand why they were doing what they were doing. Typical quotes were: “So don’t stop the lectures. They’re useful. They helped me remember things that I forgot, but maybe do them a bit faster”, “I was kind of expecting some cool engineering project after the one lecture”, “Like I said, a lot of the activities I didn’t feel like much of an engineer because I felt like we were just being told what to do, which isn’t really what engineers do”. In addition, we observed in some of the focus groups that the campers got involved in a lot of animated discussion about some of the activities (Mining the Environment and the Rocket activity are examples). Activities that did not present a challenge also caused disinterest, or if some activity was hard or did not work.

2. *Collaboration, communication and teamwork:* A second emerging theme was that the camps created an awareness of how engineers work in teams, collaborate and communicate while working on a project. The campers also learnt that it took a lot of people to make things happen in engineering. They seemed to really enjoy this aspect of the camp as it was related to the social aspects of being in a camp and meeting new friends. Although an in-depth comparison between the three populations and among focus groups within a population has not yet been carried out, it was noticed that one of the focus groups in the open enrollment camp seemed to have a good insight into the issue of teamwork compared to one in the first generation camp who said the least on this subject. Sample quotes that lend credence to this theme from the above mentioned open enrollment focus group are: “My perception didn’t change, but 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”, “My perspective changed on it too because, um yeah, I didn’t know that we had to work in teams, like I thought you’d just be like one person doing it, and it would just be kind of easy to do, but it’s not, you need like a team, cause if you only have like a computer scientist then to build a rover, just him working on it, you’d only be able to do the program, but then the rest of it you wouldn’t be able to do so”.

3. Planning and ‘future self’: This theme emerged around camper comments regarding what classes they need to take in the future in order to become engineers. Typical quotes are: “So like you said it is going to make me take some certain classes that could help me. Like, let’s say I wanted to get into robotics. So I would most likely take a class that’s like computer programming and stuff like that”, “Yeah, I definitely think I need to take a different angle on classes I choose in high school”. Another theme that emerged is that some campers were more focused on hands-on activities and wanted to pursue that aspect in the future. Also, we noticed that they were not quite making the connection between activities and a particular field/s of engineering. Campers’ comments indicated that they enjoyed the camp and they spoke about how they learnt about how many different types of engineering fields existed.

Discussion

Three main themes related to research question (2) Which specific activities in the camps lead to a change in identity and interest in engineering? have emerged after analysis to date: 1. Feelings about autonomy, 2. Collaboration, communication and teamwork, 3. Planning and “future self”. Further in-depth analysis is continuing, including analysis of the observational notes.

An important outcome of the preliminary data analysis is some changes in the camp activities. This includes shorter presentations, emphasizing the engineering design process, and a follow-up hands-on activity closely connected to the presentation ending with a “reflection” session (theme 1). The “reflection” session after each activity would be where campers could discuss why a design or approach worked or failed, like in a real engineering environment. We feel that this would contribute towards creating an engineering identity in the participants and that this will lead us to rich qualitative data during the second cycle of camps in summer 2019. In addition, an interesting outcome (theme 2) was that the camps did instill in the campers the connection of words like “teamwork”, “collaboration” and “communication” to engineering. This has been indicated as a necessity in marketing engineering to the public, including K-12 [16]. Finally, an outcome of theme 3 is that we will be giving guidance to the campers on classes they should be considering to be successful in engineering keeping in mind what has been suggested in [16]. We will also reinforce the connection of camp activities to fields of engineering throughout the five days of camp. Future work will focus on understanding which activities and approaches serve to positively foster students’ identities and interests so that we can transfer these findings to other summer camps and informal K-12 education programs.

Acknowledgement

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

References

1. B.L. Yoder. Engineering by the numbers. 2016. <https://www.asee.org/documents/papers-and-publications/publications/college-profiles/16Profile-Front-Section.pdf>.
2. L.S. Hirsch, J.D. Carpinelli, H. Kimmel, R. Rockland and J. Bloom, “The differential effects of pre-engineering curricula on middle school students’ attitudes to and knowledge of engineering careers”, 37th ASEE/IEEE Frontiers in Education Conference Proceedings, October 10-13, 2007, Milwaukee, WI, S2B-18.
3. M-I. Carnasciali, A.E. Thompson and T.J. Thomas, “Factors influencing students’ choice of engineering major”, 120th ASEE Annual Conference & Exposition Proceedings, 2013.
4. J. Fairweather, “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, https://nsf.gov/attachments/117803/public/Xc-Linking_Evidence--Fairweather.pdf
5. STEM Perceptions: Student & Parent study, Harris Interactive, <https://news.microsoft.com/download/archived/presskits/citizenship/docs/STEMPerceptionsReport.pdf>
6. National Academy of Engineering and National Research Council. Engineering in K-12 education: Understanding the status and improving the prospects. Washington DC: National Academies Press. 2009.
7. I. Decoito, “Exploring middle school students’ attitudes and interest in technology, engineering and mathematics subjects”, 2015 Hawaii University International Conference Proceedings, June 13-15, 2015.
8. R. Hammack, T.A. Ivey, J. Utley and K.A. High, “Effect of an engineering camp on students’ perceptions of engineering and technology”, Journal of Pre-College Engineering Education research (J-PEER), Vol. 5, pp. 10- 21, 2015.
9. J. W. Creswell. Research Design. Qualitative, Quantitative and Mixed Methods Approaches. 4th Edition, Sage Publications, Inc. Thousand Oaks, CA, 2014.
10. Friday Institute for Educational Innovation. Student Attitudes toward STEM Survey-Middle and High School Students, Raleigh, NC: Author. 2012
11. A. Unfried, M. Faber and E. Wiebe, “Gender and student attitudes toward Science, Technology, Engineering, and Mathematics”, <http://miso.ncsu.edu/wp-content/uploads/2014/08/AERA-2014-paper-Student-Attitudes-Toward-STEM.pdf>
12. T. Robinson, A.Kirn, J.Amos,and I. Chatterjee, “Influencing Student Engineering Interest and Identity: A study investigating the effect of engineering summer camps on middle and high school students (Work in Progress)”, Proceedings of the 126th Annual ASEE Conference & Exposition, Tampa, June 16 – 19, 2019.
13. J.T. Downer, L.M. Booren, O.K. Lima, A.E. Luckner and R.C. Pianta, “The individualized classroom assessment scoring system (inCLASS): Preliminary reliability and validity of a system for observing preschoolers’ competence in classroom interactions”, Early Childhood Research Q, Vol. 25, 2010, pp. 1 -16.

14. J.T. DeCuir-Gunby, P.L. Marshall and A.W. McCulloch, “Developing and using a codebook for the analysis of interview data: An example from a professional development research project”, *Field Methods*, Vol 23, pp. 136-155, 2011.
15. J. M. Saldaña. *The coding manual for qualitative researchers*, 3rd edition, Sage Publications, Thousand Oaks, CA, 2015
16. *Changing the Conversation*, National Academy of Engineering, The National Academies Press, Washington D.C., 2008