122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Paper ID #11763

Inclusion or Exclusion? The Impact of the Intersection of Team Culture and Student Identity and Pathway on Team Diversity

Dr. Deborah A. Trytten, University of Oklahoma

Dr. Deborah A. Trytten is an Associate Professor of Computer Science and Womens' and Gender Studies at the University of Oklahoma. Her main research focus is diversity in engineering education and introductory software engineering education.

Dr. Rui Pan, University of Oklahoma
Ms. Cindy E Foor, University of Oklahoma

Cindy E. Foor is the Associate Director/Research Associate for the Research Institute for STEM Education (RISE) at the University of Oklahoma. Her contribution to the multi-disciplinary team lies in qualitative methodologies, cultural theory and the belief that outliers offer great insight into the workings of power. Her research interests include cultural theory, the cultural/historical construction of women's identities and roles in past and present societies, and most recently, equity issues surrounding gender and underrepresented populations in engineering education. She can be contacted at cynthia.e.foor-1@ou.edu.

Dr. Randa L. Shehab, University of Oklahoma

Dr. Randa L. Shehab is a professor and the Director of the School of Industrial and Systems Engineering at the University of Oklahoma. She was recently appointed as Director of the Sooner Engineering Education Center dedicated to engineering education related initiatives and research focused on building diversity and enhancing the educational experience for all engineering students. Dr. Shehab teaches undergraduate and graduate level courses in ergonomics, work methods, experimental design, and statistical analysis. Her current research is with the Research Institute for STEM Education, a multi-disciplinary research group investigating factors related to equity and diversity in engineering student populations.

Dr. Susan E. Walden, University of Oklahoma

Dr. Susan E. Walden is the founding Director of the Research Institute for STEM Education (RISE) and an associate research professor in the Dean's office of the College of Engineering (CoE). She is also a founding member of the Sooner Engineering Education (SEED) Center.

Inclusion or Exclusion? The Impact of the Intersection of Team Culture, Student Identity and Pathway on Team Diversity

Abstract

Student, Experiential-Learning, Engineering Competition Teams (SELECT) provide an opportunity for engineering students to practice technical and professional engineering skills. Tremendous academic and financial resources are dedicated to SELECT teams, both from institutions of higher education and from companies that sponsor and support these competitions. Female and minority students constitute a disproportionately small percentage of engineering undergraduates participating in SELECT. This paper stems from a multiple year research project identifying and explaining factors that contribute to cultures of inclusion or exclusion among varied SELECT (NSF DUE STEM Talent Expansion Program #1068453).

We use a case study framework to examine the pathways of two female students: Alice and Sarah as they entered Competition Team A, a SELECT. These students came from high schools with similar socio-economics and academic programs. Both Alice and Sarah had a personal connection to an engineer, strong mathematical skills, and high self-efficacy in engineering. We examine how the intersection of race/ethnicity, gender, and socio-economic status with Team A's culture lead to Alice becoming a team leader, while Sarah eventually abandoned Team A. The comparison between the experiences of these students will show engineering educators and industry supporters of SELECT the sometimes invisible barriers to team participation that inhibit groups of students (e.g. women, racial/ethnic minorities, students with socio-economic disadvantages) from gaining the full benefits of participation in SELECT. By making these barriers visible, we hope to show how educational institutions and companies can work together to make team participation more broadly available. We conclude with suggestions for making SELECT participation more equitable.

1.0 Introduction

Industry and academia collaborate to provide Student, Experiential-Learning, Engineering Competition Teams (SELECT) in many engineering fields. An example of a SELECT is the Formula SAE Series, from SAE International (formerly the Society of Automotive Engineers). The SAE International website lists six companies that provide parts for free and an additional company that offers teams a 30% discount from retail on parts.[1] In addition to supplying parts, industry representatives are involved in designing the parameters of competitions, judging competitions, and providing both financial and technical support for individual teams.[2] Similar competitions include Design/Build/Fly from the American Institute of Aeronautics and Astronautics (AIAA), the Concrete Canoe and Student Steel Bridge Competitions sponsored by the American Society of Civil Engineers, and the Chem-E-Car competition sponsored by the American Institute of Chemical Engineers. Some competitions include a hundred or more teams and represent a significant collaboration between colleges and industry. Many students, people in industry and academia see broad benefits from SELECT.[2-5]

This collaboration between industry and academia is beneficial to students, colleges, and industry. Students gain engineering design experience beyond what is offered in the curriculum,

additional experience working in teams, and practice performing professional presentations. Students also may gain hands-on experience with tools, specific materials and software. Colleges get competition teams that they can promote and market to prospective students and donors, and benefit from producing some graduates that may be better prepared to be engineers. Participating industries get an opportunity to meet promising engineering students to recruit to their workforce and can encourage the next generation of engineers to become familiar with their products.

Many competition teams are similar to the teams pictured in Figure 1, with little visible diversity in gender or race/ethnicity. SELECT generally do not have requirements for team diversity, with the exception of the ASCE Concrete Canoe and ASME Human Powered Vehicle Challenge competitions where the rules penalize teams that lack female competitors. As both industry and academia are committed to equal opportunity, this situation is discordant.

Figure 1: The Design/Build/Fly team from Cornell University is shown in the left.[6] The Formula SAE Team from the University of Oklahoma is shown on the right.[7]

As part of a larger research study, we've been examining how the culture of SELECT impacts the participation of members of groups that are underrepresented in engineering. In this work, we will use a case study methodology[8] to examine the experiences of two female students, Alice and Sarah, who wished to participate in Competition Team A (CTA). CTA has traditionally been composed mostly of students from engineering discipline A at Midwestern University (MU). The artifact that CTA develops comes from a field and industry that is currently dominated by white men.[9] The specific goal of each competition changes every year, requiring a substantial new engineering effort. Although CTA focuses on an artifact that requires extensive skills from engineering discipline A (Alice's major), there is a significant component (subsystem S) that requires skills from discipline S (Sarah's major). And as is the case in most engineering projects, a multi-disciplinary approach to developing the artifact would be beneficial.

Alice and Sarah present an interesting perspective because they were both excellent candidates to participate in SELECT but had vastly different team experiences. Alice was ultimately successful in integrating into the team, going on to lead the team. Sarah attempted to integrate into the team unsuccessfully. This paper will examine their backgrounds and experiences and show how factors such as their engineering pathway, socio-economics, race, and gender entered into their ability to gain the benefits of the team experience. The stories of these students show otherwise invisible barriers to participation in SELECT.

The research question that we address in this paper is:

How do members of under-represented groups' identities and pathways intersect with SELECT culture to facilitate or encumber participation in SELECT?

The structure of the paper is as follows. The next section will describe the research methodology. The Results section will present two separate narratives of Sarah's and Alice's engineering experiences as they pertain to team competition. The Discussion section will compare and contrast Sarah's and Alice's experiences and interpret those experiences, including placing these experiences in the context of the literature. The final section will draw conclusions.

2.0 Methodology

This manuscript uses data from a large research project using qualitative and quantitative research methodologies and an interpretive framework to examine how the culture of SELECT impacts the participation of members of underrepresented groups. We have used a critical cultural theory lens to examine this data. This lens recognizes that culture is engineered by people with power for their own benefit with the unknowing agreement of those who are less powerful.[10] While we recognize individual agency of students as being essential to college-level success in any field, our focus is on examining how institutions (in this case universities, companies that support SELECT, and organizations who run SELECT) advantage some students at the expense of others. This lens allows our research recommendations to focus on how institutions can be more equitable, instead of focusing on how students with limited power can exercise agency within inequitable institutions.

During this larger project that surrounds this research, we performed semi-structured interviews of both SELECT participants and non-participants at an institution and at national and regional SELECT competition events. Participants also filled out brief questionnaires that describe their family, educational pathway and funding, and job/internship experiences. We also performed ethnographic observations at a variety of SELECT competitions around the country. Additional data came from organizations that support SELECT, competition rules, SELECT websites, and public data sources. These data have been analyzed with a variety of qualitative research methodologies and units of analysis, including individual teams, comparisons between teams, and individuals on teams, as appropriate for the selected research questions.[11-14]

One advantage of qualitative research methodologies is that researchers routinely take advantage of unexpected opportunities that arise during and after the collection of research data.[15] In this case, we interviewed two strikingly similar female students who joined the same SELECT within a short time frame, but had drastically different outcomes from the competition team experience. One student was from a racial/ethnic group that was underrepresented in engineering and the other was white. Given the low participation of women and racial/ethnic minorities in SELECT, this distinction was a fortunate occurrence.

We will use a case study methodology to examine the experiences of these two female engineering students as they tried to integrate into CTA. Case study methodology is appropriate for this research question because the answer depends upon a deep interpretive understanding of how the student pathways intertwine with student identities (especially gender, race/ethnicity, socio-economic status), the culture of engineering, U.S. culture, and the culture of CTA. In

addition, a case study methodology is appropriate when the number of participants is small, as it is in this case.

We use the following conventions when we quote research participants. When interviewer and participant statements are both given, the participant's statement will be preceded by a "*P:*" and the interviewer by an "*I:*". If it is unclear which participant is speaking, her name is put before her words (e.g. "*Alice:*"). Words quoted and in italics without these prefixes are from the participant. We added square brackets around words that were not said by the participant, but were added to include necessary context or conceal information that might identify the participants. Verbal ticks, such as repetition of words, are removed. Ellipses (…) are used to indicate that words or sentences are removed. The (L) notation indicates that the participant laughed.

We have gone to great lengths to protect the identities of the participants. This protection is necessary because our agreement with the Institutional Review Board requires us to conceal the identity of research participants in publications. Alice's role as captain of CTA, and Sarah's identity as a woman of color make them more visible than most engineering students. In addition to using pseudonyms, we have concealed their academic institution, their majors, Sarah's race/ethnicity, and their SELECT. In a few places, we have concealed personal data that could lead to the identification of the participants by substituting similar information without changing the fundamental meanings. When presenting data about the demographics of their high schools, we have presented approximate values instead of exact values to prevent re-identification of the participants' high schools.

3.0 Results

We present each participant's story chronologically, first Alice and then Sarah. We start with a summary of relevant parts of the participant's childhood and family life. We then present her high school experience, college experience including CTA, self-perceptions she shared with us, and how the participant views her future in engineering. Comparisons between participants and situating their experiences in the engineering education literature will be the focus of the Discussion section.

3.1 Alice

Alice grew up in a two parent family. Her father had some college and her mother had completed high school. Both Alice and her parents are white. Alice was generally given large amounts of time as a young child to occupy herself: "*When I was really little…, we played outside a lot. So it was always fun for me and my sister to go out and find random stuff and do something with it.*" Alice's father would not let her use tools out of concern for her safety. Alice was inspired to pursue engineering by a popular movie where engineering played a critical role.

Alice's high school was a rural fringe school with around 300 students, in a state adjacent to Midwestern University's (MU) state. It was predominantly white, with slightly more than 10% non-white students. About half of the students had free and reduced price lunch provided.[16]

Alice dislikes being inactive and strives to fill every minute with organized activity. In high school, Alice played many sports and participated in band. She graduated as valedictorian of her high school. Alice had a transformational math teacher, who taught her to love mathematics. She had AP opportunities in calculus, chemistry and physics.

Although our interview did not address social class directly, we infer that Alice is from a middle class background. Her heavy involvement in a multitude of extracurricular activities is typical of the over-scheduled middle class child.[17] And although she described the financial strain of college as "*a nightmare*", her day to day decision making appears to be unaffected by monetary concerns. Her funding of college was from government loans, scholarships and awards, avenues that are typically most accessible to students from the middle class. She had no government or university grants and no personal or family loans, as would be typical of a student who was poor or working class.

Alice had a male high school friend who came to MU to study engineering discipline A. She came to campus on a tour during her senior year in high school. Her tour guide was a student in engineering discipline A and introduced her to CTA. When she first arrived at MU, Alice participated in a bridge program designed for new engineering students who were members of underrepresented groups. She found this program to be highly beneficial to her academic progress:

> *[The bridge program] was the best decision I made coming to school. I met some of my best friends. We actually went to class, so like we had calculus and chemistry and we could feel how it was going to be in college, which was great for me because my biggest fear was not being prepared… Me and my friend just breezed through the classes. So it was a nice relief. And then we had activities and got to know a group of people…*

Alice met the CTA team leads in her sophomore year in college. Alice came to her first CTA team meeting directly from field hockey practice. She was later told that her messy appearance impressed the team. To integrate into the team, Alice shadowed more experienced team members and helped when she could. In her junior year, Alice participated on a subsystem team and shadowed the project manager to prepare herself for the role she wanted in her senior year. At the end of her junior year, just before the competition, Alice took over some managerial responsibilities when the previous project manager proved inept. She began actively recruiting majors from discipline A to assure that the team would have a sufficient number of seniors from discipline A in her senior year to be able to use CTA as a capstone experience. In the end, the leadership of CTA was populated by Alice's close friends from discipline A.

CTA leadership positions in Alice's senior year were settled in the back room. Alice successfully negotiated for the project manager position by convincing her male competitor for the role that he would be more satisfied with the more technical role of technical lead. During the year, Alice increased her power as the team leader by reaching an understanding with the technical lead that in cases where the two leaders did not agree, her opinion would prevail. The rationale given for this agreement was avoiding conflict between the two leaders.

In the project manager role, Alice developed a close relationship with the faculty advisor. The faculty advisor trusted her judgments and accepted her recommendations without questioning, a

courtesy that was not extended to male team members who were less willing to show him respect. This relationship with the faculty advisor matured into a research opportunity for Alice: "w*orking on a daily basis with him really, really made a difference."*

A critical incident occurred during Alice's leadership with Brian, the subsystem S lead. Alice told us that Brian's academic and team performance diminished during junior year. Nonetheless, Brian was selected as the subsystem S team lead which meant he would be permitted to do his capstone project with CTA. Concerns about Brian's abilities led the team to put him in the least critical leadership position on the team, in control of subsystem S. Brian proved to be undependable and ultimately was asked to step down by Alice. This forced Brian to find another capstone project, with the full support of the faculty advisor. In essence, Alice made the kind of decision that is usually reserved for faculty: determining another student's academic pathway. Alice's final take on this incident was *"It was very well handled. I was actually surprised how it all worked out."*

The competition the year that Alice was project manager was viewed as successful, with the team placing in the top ten percent at a national competition. This result was higher than the team had placed historically.

Alice made a substantial time commitment to CTA. She reported spending in excess of 40 hours a week on the team, even more during the competition season. Alice also had an engineering internship and was hired by the college as a recruiter. She was also involved in a couple of other student organizations and was a full time engineering student. As the project manager, her job was not tied to the physical artifact that the team was building and could be done at her convenience. Alice seems to use her over-scheduled life to build status[18] and to justify her absence from some building activities attended by many other team members. This absence created a perception among her team members that she was less committed to the team and was a source of friction between Alice and the rest of the team. The mapping of extraordinary time commitments to team loyalty is common among SELECT.[14] A back of the envelope calculation of her time commitments would indicate that she was probably spending less than 40 hours/week on CTA. Nonetheless, her recruitment speech for new recruits to CTA is: "*[Students who participate in CTA] have to be very flexible, because we all have class, we all have work, we all have other things to do...if you have to stay here until two in the morning, you have to stay here until two."*

Alice has several self-perceptions that impact her engineering experience. Alice views her abilities as being primarily managerial, as opposed to technical: "*I am not a technological superstar by any means. I just saw a way I could fit in and slowly got into that."* She rates her technical competence as a seven or eight on a scale of one to ten. Alice sees herself as one of the guys and prefers the company of men: "*I've always grown up around guys. I'm more of a guy person than a girl person… But there are times when you have to step on toes and make the guys realize that [gender/sex] doesn't really matter.*"

Alice's active and continuous participation in many sports, including demanding physical sports like field hockey have shown her that hard work is more important to success than natural talent. This awareness helps Alice avoid the pitfalls of fixed mindset thinking[19] and focuses her efforts

on improving her abilities in a growth mindset. Her sports background has also made her competitive: *"Growing up playing sports has made me a very competitive person."*

Alice's experiences in CTA provided her with outstanding preparation for professional life. Her GPA upon graduation in engineering discipline A was around 3.1. She had lead CTA to success as a project manager, had engineering internships, participated in a variety of student organizations, and done research with the faculty advisor of the competition team.

Alice had very specific and focused career goals, including the desire to work for a particularly prominent and inspirational company. She also knew that while this goal could be realistic in the long term, in the short term she would probably have to work for a less prestigious company to build her credentials before the more prominent company would want to hire her.

> *…Short term [goal] is to find a job that will get me financial stable first because [getting] through college has been a nightmare....I've learned through college that your dream job is probably not going to happen your first time around and so my short term goals are to find the jobs that will eventually get me [to her most desired company]. Now what those are could be anything really and then I want to get my MBA in the next few years so just trying to figure out how all that fits together. I actually have a job offer with a company right now who I know will pay for my MBA but you have to sign a service commitment.*

Alice left college brimming with confidence from her successful leadership of CTA: *"I want to get into management. I do very well at managing people and huge projects, so I want to maybe manage the next big thing."*

3.2 Sarah

Sarah grew up in a two parent home. She and her parents are from a racial/ethnic group that is underrepresented in engineering. Both of Sarah's parents have bachelor degrees. Her mother works as a technician, as did her father who retired after losing his job when his employer closed a plant location. As a child, Sarah helped her dad fix things with tools. Sarah's childhood toys were hand me downs from her sister. A supportive teacher let her play in the classroom with *"all sorts of stuff, little play things, nothing serious"* after school because she knew Sarah's family didn't have much money. Sarah was inspired to pursue engineering by a family friend who was an engineer: *"What he said about [discipline S] engineers is that if they have a problem, they call one in and he works some kind of sorcery and it's fixed. And I wanted to do magic, too."*

Sarah attended a large suburban high school with a diverse student body (around 60% of the students were non-white). More than half of the students received free and reduced price lunches.[16]

Sarah had a great high school mathematics teacher, although her science education suffered: "*My calculus teacher was awesome, I liked her a lot. ...The science program at the time was very limited. Not much beyond the basics.*" During her high school experience Sarah did a service project that supported students in a particularly difficult family situation: *"I made friends with a lot of the bad kids. I came from a poor family."* Sarah dabbled in extracurricular activities briefly. She ultimately had to give up these activities to work during her junior year of high school.

Sarah repeatedly refers to her family as poor. Sarah paid for college through grants that are restricted to students of limited socio-economic means. She said she was not sure she would have the money to complete her degree and graduate, although she was only a year from graduation at the time of the interview. She felt frustration with more affluent students who had much given to them and lacked appreciation for their advantages. Sarah also discusses her mother continuously working, her father being retired (not laid off), and does not discuss her family receiving any form of public assistance. Although both of her parents have college degrees, we conclude that her family background is working class or poor.

Sarah took two years off from school before pursuing higher education, making her a nontraditional student. Her first experience in higher education occurred at a community college in a state adjacent to MU. This community college had a large percentage of students of Sarah's race/ethnicity. She became further inspired to pursue engineering by an introduction to engineering course:

> *When I was in community college I hadn't decided what I wanted to do ... and one of my mom's co-workers, he's an engineer... told me I would be a great engineer. I like math and science and so I took an introduction to engineering course at the community college and I fell in love with it.*

Sarah was not recruited to MU, but transferred in as a junior to pursue engineering discipline S. She first heard about CTA during a College of Engineering event designed to introduce new engineering students to the student organizations, including the many SELECT that are available at MU. She was initially interested in CTA because the engineering artifact developed was the one that inspired her to be an engineer as a child. "*I saw the [artifact from the previous year] and talked to people.* " She joined the team with her boyfriend Jeff who also was majoring in discipline S. Jeff is white.

Sarah and Jeff initially felt welcomed by CTA. Sarah was attracted by the opportunity to apply her course work in discipline S to a practical application: "*I really wanted to see something [from discipline S] work, I wanted to know that everything I was learning in all these classes was going to do something.*" Sarah envisioned herself taking on a specific technical role on CTA. Her interest in subsystem S was driven by the specific mission of CTA that year, which was unusually highly weighted toward discipline S.

Sarah and Jeff attended weekly CTA meetings for about two months. While they initially felt welcome, they were never able to socially integrate into the clique of discipline A majors that ran the team. Sarah explained:

> *They were all really nice and welcoming but they all knew each other and a big problem I felt was and this is silly, this is not discrimination based on color or ethnicity, it was based on engineering field. It's like if you aren't discipline A...*
> *I: You aren't in the in group kind of?*
> *P: Yeah.*

Sarah and Jeff attended weekend workdays, but were sometimes excluded:

> *Sometimes [we] would show up on Saturdays, … and [a team leader] would be like 'oh, we don't need you after all.' We were like 'Okay, we're here. We want to do something*

but you don't need us after all?' After all what? After you got everybody else doing something?'

In spite of the weekend frustrations, Jeff in collaboration with Brian, the team lead for subsystem S, developed a design and prototype for the subsystem. Then, Brian was removed from his leadership role by Alice. Sarah explains that Brian was removed from the leadership role "*for personal reasons.*" The new team lead, who replaced Brian, used the design that Brian and Jeff had developed without giving Jeff credit.

[Jeff] basically ended up giving the mock-up to the [new team lead] and told him what he did and the guy rebuilt it and never got back to [Jeff] about it. [Jeff] tried emailing him a couple of times but he never heard back. He never invited [Jeff] to participate in the new construction. He never asked for anything else. … the new [subsystem lead] didn't want anything to do with us ... he didn't want to be the leader of a team, he just wanted to do it himself...

Neither Sarah nor Jeff sought any remedy for this, like going to Alice (who was the project manager) or the faculty advisor. Sarah and Jeff would have had some difficulty going to the faculty advisor since Sarah incorrectly identified a staff technician as the faculty advisor for CTA. Sarah and Jeff eventually both left the team. Sarah reports that people who were on the team sometimes socially sanctioned her: "*Like I'll say hi and sometimes they'll wave but they won't even acknowledge your existence half the time.*" Shortly before her interview, someone on CTA invited Jeff to another CTA meeting. Sarah interpreted this as an inadequate recognition of his contribution, but was nonetheless pleased that he had been personally invited. Sarah was not personally invited. The evening after her interview Jeff was supposed to attend this meeting.

Sarah and Jeff still both strongly want to participate in a SELECT: *"[Jeff] wants to try [joining CTA] again. And he's right, there are all different captains and different people in charge this semester and he feels that with different people working on the project it will be different with the way things happen.*" Sarah remains optimistic:

I think I am going to try again. … I like the idea of doing something like that. I know for my capstone I will have something completely different to do and I understand that for a lot of these students it is their capstone,…I feel like I want to give the new team a try because it's not the new people it was the people who were around before.

Sarah also considers joining a different competition team, although this new team is dominated by majors in a different engineering discipline. A friend analyzed this idea:

'[joining a different team] is what you should not try doing.' (L) He says he tried it and he said 'I know [students in discipline A] do [CTA] but I thought [this other team] would be cool but most of the guys there don't want to work with you if you are not [in another engineering discipline].'

Sarah places most of the blame for the social structure of CTA on the fact that students in discipline A use it for a capstone project:

I think where [CTA] got lost is that they don't look at it as fun, they look at is as a homework assignment…It is their capstone but I mean...you are volunteering to do this so I assume you would like or enjoy this. They didn't seem like they were having any fun. I understand it is a lot of work, but I thought that was the idea. I mean I hope when I have

a job that I also have fun. I became an engineer because I want to go to work to play kind of thing.

Sarah had an engineering internship, where she worked 20 hours a week. She was a member of a technically focused sorority at MU. She did not report any research experience at the time of her interview. Sarah did not rejoin CTA or any other SELECT and graduated with an engineering degree in discipline S and around 3.4 GPA.

Sarah has high self-efficacy and perceives herself to be highly technically proficient: "*I'd give myself an 8 right now [on a scale of 1 to 10 in technical proficiency] and at the end of this [class I am currently taking] I would probably say a 10. (L)*" She is proud of being intelligent and academically capable, and feels strongly competitive towards the male students in her classes:

Like in our [class] we are going to have a competition and I will be honest, I am determined to beat all the guys. I: So you are competitive! P: Yeah, I guess I have to say in sports I was never very competitive when I played sports but with the engineering stuff I do get a little competitive. I'm not so much the person that wants to get done first, I just want to get done the best.

Although she sees herself as personable, Sarah struggles with introversion and reports that joining groups is generally difficult for her: *"Yes, I am a very private person. … I: So getting out and doing all this stuff is not by nature something that you are typically comfortable with? P: Yes, I am making myself do it and I am finding that I actually enjoy it."* Sarah tells us that Jeff is also an introvert. Sarah's CTA experience interfered with the process of Sarah becoming more outgoing: "*CTA kind of shut that down a little bit.*"

Sarah's professional ambitions include getting a masters degree and finding a job overseas in her field. She lists several companies where she might want to work that recruit locally in engineering discipline S, but was not focused on any company or specific future pathway at the time of her interview. For example, she hadn't selected a country to work in yet and most of the companies she listed are based in the U.S.

4.0 Discussion

Alice and Sarah were both outstanding candidates to participate in SELECT. They were surprisingly similar in many dimensions. Both Alice and Sarah came from two parent homes. They are both female, and hence members of a group that is underrepresented in engineering. They both described similar academic offerings at their high schools, although Sarah talked about her high school's programs in somewhat more negative terms. They both had solid high school preparation in mathematics and had inspirational mathematics teachers. Both women felt less prepared in science. Both women were inspired to become an engineer by a friend who was in engineering, although Alice's inspiration was a near age peer and Sarah's inspiration was older. Both Alice and Sarah were generally good students in both high school and college. Alice's academics were stronger than Sarah's in high school, as demonstrated by being her high school's valedictorian. However, Sarah's GPA was higher than Alice's in college. Neither Alice nor Sarah was recruited to MU. Both women had a deep passion for engineering. In short, both Alice and Sarah were students who were likely to succeed in engineering when they started at

MU. Neither reported any loss of interest or uncertainty about their choice of engineering in general or their discipline. Both women finished engineering degrees at MU.

There are differences between Alice and Sarah's backgrounds prior to college. Alice and Sarah are of different race/ethnicity and social-economic status. Alice is white and Sarah is from a racial/ethnic group that is underrepresented in engineering. Based on our earlier analysis, Alice is from a middle class family and Sarah is from a poor or working class family, although Sarah's parents had higher levels of education than Alice's. Sarah did not directly address how her family's socio-economic status impacted her pathway into engineering. However, Sarah gave up extra-curricular activities in high school in order to work. She is a nontraditional student who worked two years before starting college and began her education at a community college instead of a comprehensive university like MU. It is likely that this pathway was dictated, at least in part, by financial necessity. Alice's pathway into MU engineering was more direct. Alice went from high school to a summer bridge program to being an engineering major at MU.

Sarah attributes her inability to integrate into CTA almost exclusively to her academic major. However, Alice told us she valued engineers from discipline S: *"Alice: But the main majors we get are [discipline A] and [discipline X] and then we also get some [discipline S] because we do have to deal with [discipline S] systems... So they always help out.*" This would indicate that Sarah's disciplinary expertise should have been welcomed by CTA under Alice's leadership.

Sarah perceived and Alice indirectly acknowledged that the CTA students from discipline A formed a clique. Alice had strategically recruited discipline A majors to assure that there would be a sufficient number of discipline A majors on the team so she could use the team for her capstone experience. Discipline A's capstone would not meet capstone requirements for other engineering disciplines at MU. This gave CTA a convenient justification to marginalize people from other majors, even people with engineering expertise CTA needed. In addition, pre-existing relationships, like those developed during shared disciplinary coursework, have been shown to be directly associated with higher initial group performance in teams with interdependent roles.[20] By recruiting majors from discipline A, Alice probably formed a team that was initially more harmonious and productive. From an academic perspective, CTA's cliquishness cost them a valuable opportunity to work with students from other engineering disciplines, an experience so important that it is required for engineering accreditation.[21]

CTA's cliquishness may have been Sarah's explanation for her difficulty integrating into CTA, but complicated social interactions are rarely one dimensional. When Sarah was directly asked if she felt her gender or race/ethnicity had disadvantaged her on CTA, she said no. However, Sarah may not recognize how systems of oppression intersect for a socio-economically disadvantaged female member of a racial/ethnic minority, a topic that is not part of traditional engineering curricula. An examination of Sarah's academic transcript showed that her coursework contained no classes where this type of cultural competence would typically be developed. The core curriculum requirements at MU require that students study culture from a non-western perspective, but do not require understanding diversity in the U.S. Sarah met the culture requirement at MU by taking a class on international music.

Members of under-represented groups are faced with the burden of determining whether unpleasant interactions are the result of their group membership on a daily basis. This burden can be exhausting and is part of the social taxation of members of under-represented groups. Some people avoid this taxation by simply deciding that their membership in an underrepresented group doesn't matter in the absence of blantent acts of discrimination. This behavior permits members of underrepresented groups to go on about their day-to-day work and ignore many incidents of bias (called micro-aggressions[22]) that come with underrepresentation. Ignoring micro-aggressions also restores the illusion of control in the presence of even minor forms of social ostracism.[23]

In addition, one of the most treasured myths of U.S. culture is the hegemonic myth of a meritocracy: anyone can achieve greatness if they just work hard enough. This myth effectively places the blame for failure on individuals, instead of on inequities in the system. We believe the interplay of multiple factors (called intersectionality[24]), including race/ethnicity, gender, socio-economic status and Team A's culture influenced Sarah's ability to integrate into CTA in ways that were not visible to her.

Sarah's path to acceptance in CTA should have been easier than Alice's, because CTA had an example of a successful woman engineer who had already integrated into the team: Alice. Alice never mentioned Sarah in her interview. Sarah had tried to make friends with Alice, but Alice was not receptive.

> *[Alice] was one of the people I felt like was happy with the way her friends were kind of thing. She was fine with the status quo. I attempted to like talk to her and befriend her but it didn't really work. ... And this isn't meant to be mean to her but she seems to like the attention of boys more, if that makes sense. She's one of those girls who say they make friends with boys better.*

Alice may have had an easier time integrating into the team because her gender expression contained elements that are more typically male. Alice's athleticism, especially her choice of physically demanding sports like field hockey, may have made her more acceptable in CTA's male dominated team culture. We know that her physical appearance at her first CTA meeting (disheveled from sports practice) had initially impressed the team. Alice is also openly and directly competitive:

> *I like to compete in all areas. One thing I have noticed, I used to think I had to be number one. I had to be the best at everything. I was valedictorian, I was super competitive with this one guy in school, we fought it out to the very end to see who was going to be first.*

Alice attributes this to her background in sports. Alice also makes use of violent references in speech, "*guys who know me know not to ever make me mad because I could probably hurt them (L),"* a typical male communication pattern.[25]

Alice, as a team leader, openly and repeatedly stated her preference for working with men: "*It was all boys, so that was fun."* She seemed to be uninterested in team diversity. When we asked her how many non-white males were on her team, she responded: "*That is a good question, I've never noticed. We actually didn't have any [non-white males]."* When we further asked her thoughts on why there are not many women on the team, she said: "*I don't actually know why that is."* Alice's ideas for increasing gender diversity of SELECT were naïve. When asked if she

thought the gendered participation on the team would be different if a different artifact were built, Alice agreed and suggested building an equally (if not more) masculine artifact. She was unaware that other SELECT at MU had more women because the rules for their competitions required diversity. Being a woman does not automatically imbue a person with a critical eye for gender-related issues and gender diversity. Having a woman on a team, even in a leadership position, isn't necessarily going to create an environment that is welcoming to other women.

A particularly interesting issue is why Sarah and Jeff did not exercise more personal agency when they perceived his design to have been stolen. There is a simple answer available: CTA was a clique and Sarah was an introvert. While simple answers may be preferred in engineering, very few elements of social interaction are simple. The answer to this question may involve gender, race/ethnicity and socio-economics in ways that Sarah had not considered.

Sarah's high school was more diverse than MU and her high school friends were from a variety of racial/ethnic backgrounds. When she moved to the state where MU is located, she felt conspicuous: "*When I lived in [a large city with a significant population of people of Sarah's race/ethnicity], I was a [person of color] in a sea of [people of color]. Here it's like you can see me, everybody else is [of a different skin color] and you can pick me out in a room kind of thing.*" The feeling of being different from everyone can lead members of underrepresented groups to retreat from the perpetual spotlight that can arise from being visibly different from the majority.

> *Also, I personally don't know why more [people of Sarah's race/ethnicity] aren't doing, or [people of another underrepresented race/ethnicity] or anybody aren't doing it. I think, well, part of it is probably because, well, it's a vicious cycle. There aren't very many in there so therefore nobody wants to join. I don't see somebody else in there that can represent me so I don't want to be there. The hard thing is finding the one that is willing to go in there and be like "I can do this." .*

The fact that Sarah was both a woman and a racial/ethnic minority may have exacerbated her feelings of isolation. She describes being isolated by gender in discipline S: "*I am only one of four females in my classes out of about 45 total students*." Although she didn't tell us how many people in her discipline were from her racial/ethnic group, institutional statistics indicate that about 20% of women in the College of Engineering at MU were from her racial/ethnic group.[26] It therefore is possible that she was the only woman of her race/ethnicity in her classes in discipline S. She does tell us how she feels about being a woman in discipline S:

> *At first it was kind of tough, it was very weird to walk in the class. I think the first thing I noticed was I was one of the only girls. The very first class I walked into [at MU], or panted into because I was running late, I looked in and I saw the professor setting up and I looked up and there was only three girls.*

Sarah acknowledges that being new to MU also silenced her:

> *I: If this year you run up against the same barrier… would you feel comfortable saying anything to anybody?*
> *Sarah: I probably would feel more comfortable now than I did then. Last year I was still new. It was my second semester at [MU]…I still hadn't made a whole lot of friends...and*

it was actually my first semester that I was going to do something… other than go to class and do my homework.

Sarah was new to MU as a junior because she had transferred from a community college. While she did not share her rationale for this pathway, lesser expense is a common reason for students to attend community college instead of a comprehensive institution. In other words, Sarah's newness to MU may have been related to her family's socio-economic status. Being a transfer student also cut the time for Sarah to integrate into CTA to half the time Alice had.

I: Do you think being transfer students impacted your experience? If you had started at [MU], even though you are [in discipline S], do you think it might have been different? Sarah: Yeah, I think so, I think so. All of these people, they have been going to school here together since they were freshman. Some of them lived in the dorm together as freshman, they have a community. As a transfer student coming into this community it is a little different. I think that is why it was hard for me my first semester because I plopped myself into a different community. Everybody knew each other. Plopped right down into upper level classes and everybody was like, who is this girl?

Sarah's experience as a member of a working class family may have caused her to see authority figures, like the faculty advisor, as arbitrary and unapproachable. Parents in working class and poor families tend to enforce rigid rules with strict discipline in a harsh and unforgiving environment.[15] Children from working class and poor families therefore have substantially less experience using negotiation to alter their environment to suit their preferences. Sarah tells us about a technician that she has mistaken for the faculty advisor of the team: "*I: Do you know who the faculty advisor is for [CTA]? P: I think his name is [Barry]. We didn't talk to him much and it seemed like … he talked to the people who had been around and it was hard to confront him.*"

In Alice's middle class world, parents and authority figures are approachable and negotiation of the more malleable environment is often expected and welcomed.[17] Alice's high school and college experience with myriad organizations gave her ample opportunity to build confidence in her negotiating skills. Alice demonstrated this confidence when she convinced a rival for a leadership role that he really wanted to do something else, and convinced him that when they disagreed that she would be declared to be right. She also convinced a faculty member to let her make an academic decision impacting another student. Because engineers value Alice's self-efficacy and negotiation skills, her socio-economic privilege gives her unearned advantages.

With less socio-economic privilege, Sarah struggled to learn how to fit into the team. She tried to follow the informal rules she knew, such as stopping by for weekend work days and coming to meetings. These are the same strategies that Alice used to integrate into CTA successfully. But when Sarah was rejected, she was unable to negotiate a situation where she could participate in SELECT. We know that Sarah devoted considerable thought to this process since she reports researching other SELECT teams at MU and asking advice from friends on possible strategies for integrating into other SELECT teams.

An alternate lens to view Alice's and Sarah's stories through is provided by the accrual of advantages.[27] Just as those with more economic capital are better able to increase their economic resources (*e.g.* through investment, by lobbying congress for favorable taxation laws), those with

more social[28] and cultural capital from the dominant culture are better able to gain additional social and cultural capital from the dominant culture. Alice is a master at leveraging her advantages. Alice's sex gained her admittance to a bridge program that allowed her to transition to college seamlessly. She used negotiating skills honed from her middle class upbringing to gain prestigious positions of leadership on CTA. She used her leadership position on CTA to build a strong relationship with the faculty advisor, resulting in a research assistantship. And every step of the way, her resume and desirability for employment, and opportunity to gain additional advantages are growing. Sarah also leveraged her smaller set of advantages quite successfully. For example, she used a community college to move to a comprehensive university. But because she started out so far behind Alice, especially in socio-economics, she hit a glass ceiling with CTA.

5.0 Recommendations for Change

Both industry and colleges invest substantial resources in SELECT. Their hope is that many students will gain experience in real world multi-disciplinary engineering, leadership, and management, and be better prepared to be good engineers for industry. For students like Alice, this ambitious goal was achieved to some degree, although her leadership and management skills were not sufficient to facilitate Sarah's and Jeff 's integration into and perceptions of equity in CTA. People like Sarah are marginalized, in spite of being interested, having relevant skills, and putting in the effort to participate.

It is unlikely that either academia or industry intentionally designed SELECT experiences to exclude members of under-represented groups. They may have, however, designed many SELECT experiences without considering whether they would be equitable. The design of every competitive event design includes:

- Size/complexity of the artifact
- Size of a team necessary to successfully build the artifact
- Amount of money necessary to build the artifact and transport it to the competition site
- Expense of competition venue
- Composition of the teams (majors, memberships in national organization, gender/race/ethnic/socio-economic diversity)
- Timeline of competition
- Rules of competition

Each one of these competition design elements can influence how many and which students are able to participate. For example, when artifacts are large and expensive, the number of schools that can afford to field teams will decrease. And of course the better funded schools will be able to field teams when lesser funded schools (*e.g.* historically black colleges and universities, Hispanic serving institutions, community colleges) will not. So once again, advantages will accumulate.

When a unique or expensive venue like a race track or an airfield is required for the competition instead of less specialized facilities, the number of competitions will be limited. This requirement thus precludes a more cost effective and possibly more inclusive multi-layered strategy such as multiple regional competitions or qualifying events. More events, spread around

the country would allow more teams to participate. Regional competitions will also lower travel costs. This structure is especially beneficial since travel costs are often borne by students.

Few SELECT have rules that require participation of members of under-represented groups. One exception is the ASCE Concrete Canoe competition, which requires 50% female participants. All participants are required to be majoring in engineering and have contributed to the design and construction of the canoe during the current academic year.[29] We infer that the purpose of requiring sex diversity is likely to equalize differences in body weight and upper body strength between males and females (*e.g.* if a paddler is injured they must be replaced by another paddler of the same sex and if there is not a paddler of the same sex available, the injured paddler must sit in the boat). This competition does not require diversity in any other dimension.

Many competitions have rules requiring participants to be student members of the organizing technical society. This rule may discourage participation by students from multiple disciplines, since if students are members of any technical society, it probably is the one in their own discipline.

One way for SELECT to increase participation of members of under-represented racial and ethnic groups would be to actively encourage more Minority Serving Institutions (MSI) to participate. For example, only 2 of the 10 top HBCUs with engineering programs field SELECT, and even at these institutions the student participants are predominantly white. Many MSIs have proportionately higher percentages of first generation college students and students with socio-economical disadvantages. Scholarships to the institution to help defray some of the costs of team participation, offers of technical mentorship or other types of support (*e.g.* equipment) might be effective in encouraging these schools to participate in more SELECT competitions.

Competitions could also offer, require or reward participation by faculty advisors, mentors, and participants in training on leadership, management, and especially diversity. No matter how thoughtfully the competition is structured, most of the daily dramas of SELECT team membership will be resolved locally, either by a faculty advisor or a student team leader. Alice thought that firing Brian had worked out surprisingly well—but was unaware that his firing cost Sarah her opportunity with CTA. Giving critical team members training to be effective and inclusive leaders should be beneficial. Management training might also help student teams to avoid the unreasonable time commitments that come from poor time management. Teams could be helped with time management if a competition required periodic checks of sufficient progress over a longer period of time rather than a single competitive event. A successful approach for this kind of training has been described.[30]

Competition designs should attend to scope and scale. Large artifacts require large spaces to build, more expensive parts, and much more time. Space and money are more available at more affluent institutions, again allowing advantages to accrue. Time is also an important consideration. Many students from socio-economically disadvantaged backgrounds (a category that includes members of underrepresented racial/ethnic groups more often than white students) will have to work to afford higher education. Projects that require large amounts of time will more likely exclude socio-economically disadvantaged students—particularly from the more time consuming and yet rewarding leadership roles. This exclusion is exacerbated when teams

interpret commitment to the team to mean spending unreasonably large amounts of time on it.[14] Time consuming projects may also preclude participation by many women due to a wide variety of care taking activities, especially child rearing.

On the academic side, coupling SELECT participation in its current form with engineering capstone courses is another way to allow advantages to accrue to the already privileged. For example CTA spent around $15,000 on their artifact and competition. This money came from discipline A's department, the College of Engineering, various university administrators and other university sources as well as private donations. It is unlikely that all other capstone teams in discipline A were provided with this type of financial support for their capstone projects. Other challenges for combining SELECT and capstone projects have also been discussed.[31] An interesting variation of having multiple capstone teams from a single institution compete internally on an industry supplied project may avoid these problems.[32]

In addition to the diversity, management and leadership training discussed above, faculty advisors need to provide active, daily oversight of their teams. Faculty should actively coach leadership and management skill development. These recommendations are challenging in an environment where SELECT mentorship may be undervalued and not recognized as an intense teaching activity.

We encourage organizations that sponsor SELECT, and the companies/industries/academic institutions that support them, to engage people with expertise in diversity to help them identify exclusionary elements of their competition. Of particular value would be people with academic training or experience in critical cultural analysis. Sponsoring organizations need to realize that having an isolated woman or a member of an underrepresented racial/ethnic group on the organizing committee will not ensure getting good advice on diversity. Neither Alice nor Sarah, for example, demonstrated understanding of inclusiveness or the kind of cultural competency necessary to design competitions that are more equitable.

Acknowledgment

The authors gratefully acknowledge the funding that makes this work possible from the National Science Foundation's Directorate of Undergraduate Education's STEM Talent Expansion Program Grant No. DUE-1068453. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Bibiliography

1. SAE International. *Formula SAE (R) Series--Michigan.* 2015 [cited 2015 1/15]; Available from: http://www.sae.org/servlets/competitionSponsor?OBJECT=CompetitionSponsor&PROD_GRP_CODE=STUD&PAGE=supplierListPage&OBJECT_TYPE=CompetitionSponsor&COMP_GEN_NUM=null&COMP_CODE=FSAE.

2. Molen, G.M. *Benefit of Student Participation in Advanced Vehicle Technology Competitions*. in *2010 ASEE Annual Conference and Exposition*. 2010. Louisville, KY, United States: American Society for Engineering Education.

3. Orlandella, M. and T. Zeigler. *Student Team Competitions: A Path to Creativity and Problem Solving in Civil Enginering Technology*. in *2002 ASEE Annual Conference and Exposition*. 2002. Montreal, Canada: American Society for Engineering Education.

4. Radu, M., et al., *Design Competitions: A Practical Approach to Improving Students' Hardware and Software Skills*, in *2009 ASEE Annual Conference & Exposition*. 2009. Austin, Texas, United States:American Society of Engineering Education.

5. Rencis, J., *The Formula SAE Racecar Project at WPI*, in *2000 ASEE Annual Conference and Exposition*. 2000. St. Louis, Missouri, United States: American Society of Engineering Education.

6. *Cornell Design Build Fly*. 2015 [cited 2015 1/15]; Available from: http://www.engineering.cornell.edu/academics/undergraduate/special_programs/student_teams/teams/human.cfm.

7. 2013 Sooner Racing Team. *University of Oklahoma Formula SAE*. 2013 [cited 2015 1/15]; Available from: http://sae.ou.edu/SRT_2014/team.html.

8. Cresswell, J.W., *Qualitative Inquiry & Research Design*. 2013, Sage Publications, LTD: London, England.

9. Landivar, L.C., *Disparities in STEM Employment by Sex, Race, and Hispanic Origin*, in *American Community Survey Reports*. 2013, United States Department of Commerce.

10. Bordieu, P. and J.C. Passeron, *Reproduction in Education, Society, and Culture*. 1990, London, England: Sage Publications, LTD.

11. Pan, R., et al., *Building Diversity in Engineering Competition Teams by Modeling Industry Best-Practice*, in *2015 ASEE Annual Conference & Exposition*. 2015. Seattle, Washington, United States: American Society of Engineering Education.

12. Walden, S.E., et al. *Leadership, Management, and Diversity: Missed Opportunities within Student Design Competition Teams*. in *2015 ASEE Annual Conference and Exposition*. 2015. Seattle, Washington, United States: American Society of Engineering Education.

13. Foor, C., et al., *'We weren't intentionally excluding them...just old habits': Women, (Lack of) Interest and an engineering student competition team*, in *IEEE Frontiers in Education Conference*. 2013. Oklahoma City, Oklahoma, United States: Institute of Electrical and Electronics Engineers.

14. Foor, C., et al., *'You choose between TEAMA, good grades, and a girfriend--you get to choose two!' How a culture of exclusion is constructed and maintained in an engineering design competition team*, in *2013 ASEE Annual Conference & Exposition*. 2013. Atlanta, Georgia, United States: American Society for Engineering Education.

15. Borrego, M., P.E. Douglas, and C.T. Amelink, *Quantitative, Qualitative, and Mixed Research Methods.* Journal of Engineering Education, 2009. **98**(1): p. 53-66.

16. United States Department of Education. *National Center for Education Statistics*. 2014 [cited 2014 October 7]; Available from: http://nces.ed.gov/globallocator.

17. Lareau, A., *Unequal Childhoods: Class, Race, and Family Life*. 2011, University of California Press: Los Angeles, California.

18. Schulte, B., *Overwhelmed: Work, Love and Play When No One Has the Time*. 2014, New York, New York: Sarah Crichton Books, Farrar, Straus and Girous.

19. Dweck, C., *Can Personality be Changed? The Role of Beliefs in Personality and Change.* Current Directions in Psychological Science, 2008. **17**(6): p. 391-394.

20. Parise, S. and K. Rollag, *Emergent Network Structure and Initial Group Performance: The Moderating Role of Pre-existing Relationships.* Journal of Organizational Behavior, 2010(31): p. 877-897.

21. Engineering Accreditation Commission, *Criteria for Accrediting Engineering Programs*. 2014, ABET, Inc.

22. Su, D.W., *Microaggressions in Everyday Life: Race, Gender, and Sexual Orientation*. 2010, Hoboken, New Jersey: John Wiley & Sons.

23. Williams, K. and A. Carter-Sowell, *Marginalization Through Social Ostracism: Effects of Being Ignored and Excluded*, in *Coping with Minority Status: Responses to Exclusion and Inclusion*, F. Butera and J. Levine, Editors. 2009, Cambridge: London, England.

24. Strayhorn, T., *Living at the Intersections: Social Identities and Black Collegians*. 2013, Charlotte, North Carolina: Information Age Publishing.

25. Tonso, K.L., *The Impact of Cultural Norms on Women*. Journal of Engineering Education, 1996. **85**(3): p. 217-225.

26. Unidentified University. *Factbook*. 2014; Available from: URL concealed to protect participant anonymity.

27. DiPrete, T. and G. Eirich, *Cumulative Advantage as a Mechanism for Inequality: A Review of Theoretical and Empirical Developments.* Annual Review of Sociology, 2006. **32**: p. 271-297.

28. Halpern, D., *Social Capital*. 2005, Cambridge, England: Polity Press.

29. American Society of Civil Engineers, *2015 American Society of Civil Engineers National Concrete Canoe Competition Rules and Regulations*. 2015.

30. Gershenson, J., *How to Engineer a Winning Competiton Project: Lessons Learned from the Human Powered Vehicle Challenge*, in *2006 American Society of Engineering Education Annual Conference & Exposition*. 2006. Chicago, Illinois, United States: American Society of Engineering Education.

31. Aller, B., et al., *Industry-sponsored Design Competition: Opportunities and Challenges for a Capstone Senior Design Project*, in *2006 ASEE Annual Conference and Exposition*. 2006. Chicago, Illinois, United States: American Society for Engineering Education.

32. Blust, R. and D. Myszka. *Merging Design Competition and Industry Sponsored Projects*. in *2005 ASEE Annual Conference and Exposition*. 2005. Portland, Oregon, United States: American Society for Engineering Education.