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"Nevertheless, she persisted:" Women thrive when they experience the joy of doing engineering in a climate for inclusion

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ABSTRACT

CONTEXT
For the last 40 years, the aggregate number of women receiving bachelor's degrees in engineering in the US has remained stuck at approximately 20%. Research into this "disappointing state of affairs" has established that "the [educational] institutions in which women sought inclusion are themselves gendered, raced and classed" (Borrego, 2011; Riley et al., 2015; Tonso, 2007).

PURPOSE
Our focus is ***women students who thrive*** in undergraduate engineering student project teams. We need to learn more about how they describe becoming an engineer, about how women come to think of themselves as engineers and about how they perform their engineering selves, and how others come to identify them as engineers (Tonso, 2006).

METHODS
We are guided by a feminist, activist, and interpretive lens. Our multi-case study method, i.e., three semi-structured interviews and photovoice, offers two advantages: 1) the knowledge generated by case studies is concrete and context dependent (Case and Light, 2011); 2) case studies are useful in the heuristic identification of new variables and potential hypotheses (George and Bennett, 2005).

ACTUAL OUTCOMES
Our preliminary results suggest these women find joy in their experience of developing and applying engineering expertise to real, tangible, and challenging problems. They find knowing-about and knowing-how exciting, self-rewarding and self-defining. Further, these women work to transform the culture or ways of participating in project teams. This transforming not only facilitates knowing-about and knowing-how; but also it creates an environment in which women can claim their expertise, their identity as engineers, and have those expertise and identities affirmed by others.

CONCLUSIONS
If we aim to transform our gendered, raced, classed institutions, we need to learn more about women who thrive within those institutions. We need to learn more about the joy of doing engineering that these women experience. We also need to learn more about how they create an "integration-and-learning perspective" for themselves (Ely and Thomas, 2001) and a "climate for inclusion" within those project teams (Nishii, 2012), a perspective and climate that fosters the joy of doing engineering.

KEYWORDS
Female, Project Teams, and Undergraduate Engineering Education.

Introduction

For at least the last 40 years and despite all the well-intentioned efforts, the aggregate number of women receiving bachelor's degrees in engineering in the US has remained stuck at approximately 20% (Beddoes and Borrego, 2011). Sadly, the research that has been done seeking to foster women's increasing participation has used limited rationales, e.g., the pipeline theoretical framework and inadequate theories, including only a few types of participants' roles in only a few types of settings (Beddoes and Borrego, 2011). Such research has been characterized as lacking diversity, e.g., ignoring intersectionality theory, overwhelmingly quantitative, homogeneous, and standardized (Riley et al, 2015). Although it has established that the educational institutions in which women are seeking inclusion are themselves gendered, raced, and classed, the aforementioned research has had little impact on implementing change within those same institutions. Indeed, it may have created a negative discourse regarding engineering education, often associated with deficit thinking (Valencia, 1997); and thereby actually deterred women from viewing engineering as a viable educational and career option.

Our research is distinctive in focus and methodology. Our focus is undergraduate women who are thriving in engineering student project teams and our methodology attends to small numbers in order to learn from small numbers (Pawley, 2013). In order to achieve the goal of more women engineers and to provide a more inclusive and welcoming engineering community, we need to learn more about women's experiences becoming engineers (Tonso, 2007; Tonso, 2014). We need to learn more about why, in our case, women are thriving and how they come to think of themselves as engineers. And, we need to learn more about how women perform their engineering selves, and how others come to identify them as engineers (Tonso, 2006). In this paper, we present the early results of our research. Our aims are two-folded: 1) to facilitate our own reflection on what we are learning and hoping to learn, and 2) to share what we are learning with wide-ranging audiences in order to garner critical review.

Methods

In our approach to learn more, we are guided by a feminist, activist and interpretive lens, one that is grounded in women's experience, gives voice to those women whose experience is sometimes hidden, and encourages emancipatory praxis (Olesen, 1994). Such a perspective is often referred to as standpoint epistemology. According to Sprague (2016), standpoint epistemology argues that all knowledge is constructed from a particular position and that what the knower can see is shaped by the location from which that knower's inquiry begins.

We have adopted a multiple, layered qualitative case study design to learn more about a specific, bounded system – women who are thriving in undergraduate engineering student project teams (Stake, 2005). Engineering student project teams are extracurricular teams that work towards a competition, a service project, or for a client. To date, there is very little research on such teams and what research does exist has not explored gender. Rather the research tends to focus on generalized access (Foor et al., 2013); active, experiential learning (Sirinterlikci and Kerzmann (2011); professionalization of the undergraduate experience (Bland et al, 2016); and the ways project teams can enhance the traditional curriculum (Sulzbach, 2007). In addition, we are investigating these women at three different institutions: a private college of engineering located in the northeast, a state college of engineering located in the Midwest, and a designated MSI state college of engineering in the West. Each institution represents a case, and we expect commonalities and differences in women's experience across these cases. Within each institution, each woman undergraduate student stands as a unit of analysis. Similarly, we expect to observe commonalities and differences across the experiences of these undergraduate women.

Thriving is a term that we choose to describe the experiences of these women undergraduates and our approach has much in common with a relatively new movement: positive psychology and human thriving. Positive psychology represents a "shift from an

emphasis on pathology toward positive human functioning" (Brown et al., 2017). We too understand our research to represent a shift – one from a disempowering discourse and toward an alternative, more positive discourse of empowerment. Such a different discourse highlights terms often used in reference to "thriving" – development and performance (Lerner, Dowling and Anderson, 2019), motivation (Benson and Scales, 2009) challenge and resilience (Beltmen, Mansfield and Price, 2011, Epel, McEwen and Ickovics, 1998; O'Leary and Ickovics, 1995), and trust and support (Liu and Bern-Klug, 2013). In particular, positive psychology suggests that we look for personal enablers and contextual enablers, factors related to the individual and the environment respectively that encourage thriving (Brown et al., 2017).

We use a critical sampling strategy (Creswell, 2016), i.e., we select participants purposefully using the following criteria: a) undergraduate women who have participated in engineering project teams for 2-3 years and, if possible, are in leadership positions; b) participants who consider themselves to have had positive experiences on project teams (certainly not only positive experiences); and c) participants who are willing to share those experiences. In effect, these criteria serve as our beginning understanding of thriving. We attempt to include women from all three types of project teams: competition, service, and client- serving. We expect a total sample size of 25-35 students.

As a research team, we are keenly aware that the predominate number of women engineers identify as racially white and may benefit from privileges associated with particular sociopolitical spaces. Because we are devoted to diversifying the pathways into engineering, we have and will continue to include participants who may not benefit from such privileges and identify and recruit women of color or women who are minoritized through their nationality, age, language, and social class among others. As we progress with our research, critical sampling will allow us to be cognizant of and responsive to these socially constructed and fluid categories. In addition, we have adopted the integrative model of intersectionality (not yet relevant to the results reported in this paper): one that considers each of a person's subordinate identities to interact holistically, suggesting that people experience these identities as one (Crenshaw, Gotanda, Peller and Thomas, 1995). This perspective will lead us to create a sub-codebook for women of color or other women occupying minoritized spaces separate yet still included within the overall codebook for those who identify as white. We have and will continue to recruit a majority of women of color from at least two of the institutions.

Each participant is asked to agree to a sequence of three interviews: a life history interview, individual learning journey interview, and a photovoice interview. The researchers convene regularly as a team to ensure transparency, consistency, and triangulation in the interview sequence for project quality purposes. Each interview is inductively analyzed using NVivo software for coding and qualitative analysis. The results reported here emerged from that coding and qualitative analysis of preliminary data. Our research approach gives voice to the volunteer participants and adheres to standpoint epistemology. First, case studies and the interviews in sequence focus on the participants lives as they define them. Critical sampling across three different institutions both acknowledges the partiality of any one participant's experience, not only initiating and maintaining a dialogue across difference, but also necessitating that dialogue. The sequence of interviews empowers these women to tell their stories of thriving and claim their identities as engineers. We believe that through claiming their engineering identities, women will feel empowered and powerful. Finally, emancipatory praxis will not result from calling out institutions as "gendered, raced and classed" (Tonso, 2007). Emancipatory praxis is more likely to result when those who suffer bias, can claim to thrive, can claim to be doing engineering, and being engineers in an environment that accepts them as engineers. In what follows, we report the early findings observed mostly at one institution and from the first two types of interview data. PhotoVoice interviews are scheduled to occur in fall, delayed due to COVID circumstances. The photovoice interviews reported here were conducted as preliminary research.

Results and Discussion

Family, Gender Socialization and School

The women seem to have been members of families in which the parents were involved in their children's lives, but not so involved as to direct those lives. They were generally encouraged to explore new experiences and were supported, both with parental time and resources. The families were gendered in that there were understood male and female roles. As girls, they were aware of those roles. However, the roles did not seem to serve as a prohibition. They were allowed, even encouraged, to assume alternative roles. There were gender differences among siblings, and those differences were both tolerated and celebrated. Finally, failure was not only permitted, but it was also often understood to offer an opportunity for "getting better." Outside of the family, their gender socialization was what one might expect. Again, there were understood male and female roles. However, unlike in the family, assuming alternative roles sometimes came with consequences. Indeed, what seemed most disturbing to these women were the limitations that these gendered roles placed on them, e.g., girls are not interested in understanding how things work; or how those limitations were assumed by others to be true, e.g., girls are not good at math. The women we interviewed experienced both kinds of role limitations. And, while all the women growing up were comfortable in their normative gendered roles, they also bristled, some less and some more, when they experienced those limitations.

School represented an opportunity to explore interests, to learn by doing new things – less in relation to the standard curriculum and more in terms of what might be considered extra-curricular activities, e.g., clubs or competitions. There was always "something to do." And doing these somethings allowed them to explore, to better understand their capabilities and interests, to gain confidence, to develop greater self-efficacy and a sense of belonging in relation to their peers. This seemed quite important for positive identity formation. It was also important that what they explored was challenging and required a commitment. It was sometimes the case that the challenge and required commitment were actually more engaging than the activities themselves. Those engagements that endured often became identity-defining. The women we interviewed seemed "ready" for project teams. They were aware of the potential biases and the consequences, and they were familiar with an extra-curricular commitment. Indeed, they understood that, while challenging, both the experiences and the results of those experiences could be very positive personally.

Gendered Institutional and Project Team Context

In this study, new project team members are generally assigned by existing team members to one of a number of sub-teams. Each sub-team has a team lead. New members understand that they are to follow the directives of that team lead. The structure of the teams and sub-teams is hierarchical and typically based on seniority, but even more so on technical expertise. These two criteria are often related – those with seniority tend to have more technical expertise. However, technical expertise is very highly valued. The women in our interview cohort often reported identifying senior members evidencing expertise as "models." And while senior members may be identified as models, these women experienced little in the way of "top-down" mentorship. Also, they were expected to commit themselves to the work and to the team. If this commitment required sacrifice, e.g., little sleep, no social life, and/or ignoring other academic responsibilities, so be it. Apparent from the required commitment, project teams are very demanding. Self-directed learning or collaborative learning among team members is typical. The culture of the teams is very results- and goal-oriented. Members who cannot deliver those results or fail to meet goals sometimes leave the team. When members do leave, continuing team members are understanding, yet accommodations are rarely made to keep team members involved. Within the teams there is a clear acknowledgement of their interdependence, and an almost palpable fear of "letting others down." That interdependence contributed to the commitment that the women we

interviewed felt toward the project team. A dedication to realizing results, to developing the necessary skills and expertise, to supporting the efforts of the other team members were recurring topics among the women we interviewed. There are some additional indications in the early data that suggest differences across institutions concerning, for example, how valued technical expertise are relative to the value of social engagement, i.e., "friendship." That there may be differences only confirms the importance of selecting different institutions with differing ways offering students project team experiences.

Unfortunately, project teams appear just as gendered, racist, and classist as the institutions in which they are housed. All the women interviewees reported direct and/or indirect experiences of gender bias. Instances of direct gender biases tend to be face-threatening challenges of their expertise or of their authority – of their becoming engineers – as team or sub-team leaders. The value placed on expertise and seniority, both clearly related to authority, in project teams suggests that these challenges are formidable. Instances of indirect gender bias tend to dismiss or at least neutralize gender, e.g., "I don't think of you as a girl." Also, it is not unusual for these women to have to respond to feminine stereotypes: experiencing pressure to be cooperative rather than competitive and be carefully assertive rather than aggressive.

The project teams, as these women described them, seem to resemble, or at least evince features of other "masculinist contest cultures" or MCCs (Berdahl, Cooper, Glick, Livingston and Williams, 2018) . Berdahl et al (2018) describe such cultures as containing "toxic masculinity." They identify four specific member features: 1) show no weakness; 2) emphasize success above all else; 3) display strength and endurance; and 4) always compete. While we are not suggesting that project teams are either extreme or even typical examples of MCCs or that the level of toxicity does not vary across teams, e.g., the more "technical teams" tend to be more toxic than the "service" teams; still there is certainly evidence of MCCs. That the teams are results- and goal-oriented does not in itself suggest masculinist contest culture, except when that orientation leads to face-threatening challenges of team members. Nor do displays of strength or endurance suggest MCCs, except when those displays require draconian sacrifices in other areas of team members' lives.

We are not far along enough in our research to suggest with confidence how perceptions of gender may be complicated by race and class. Because we are focused on women who thrive in project teams, we are also unclear if women who left project teams, did so because of gender, race or class biases (although it is not unreasonable to assume that some women did leave because of those biases). However, it is the case that the women project team members that we interviewed strongly resisted, even openly defied instances of gender bias. They were unwilling to allow experiences of gender bias to compromise their membership and leadership within project teams. Of course, that resistance or defiance also came with consequences, often those women were "masculinized." This masculinization itself suggests what is often true of MCCs – that power and the ability to wield power is associated with manhood.

Women project team members seemed most likely to experience gender bias when they assumed leadership roles on the teams. The leadership models these women identified for themselves often were not the ones that they had experienced or were currently present in team leadership. In other words, while these women were/are not aware of MCCs, many were/are aware that the project teams that they were participating in displayed features typical of MCCs. Consequently, they reported wanting to change the ways that leadership was enacted. They reported learning what needed to change from what they understood to be the problematic behaviour of prior leadership. The changes that they wanted to make, and had some success making, when they assumed leadership positions were to facilitate new member growth and development, to encourage mentorship by creating more feedback opportunities for team and sub-team members, to develop training protocols, to delegate more responsibility and accountability among members, to foster reflective and supportive responses to mistakes and failures, and to emphasize communality. We believe that these

women, women who are thriving, wanted to create what might fairly be characterized as an alternative culture, an “integration and learning culture” (Ely and Thomas, 2001) or a “climate for inclusion” (Nishii, 2012). Indeed, some clearly wanted and hoped to offer a style of leadership that could become a much-needed alternative to those features of a masculinist contest culture already present in project teams.

While our research team was clear-eyed about what we might discover about undergraduate student project teams, we were still hopeful that we might learn of a culture unlike the academic engineering educational culture described by Tonso (2007). We were hopeful because of the increasing numbers of women members. We were hopeful because those women were assuming leadership roles at least equal to that of men. We were hopeful because of their whole-hearted enthusiasm for project teams. Consequently, we asked ourselves and our interviewees – “Given their experience(s) of indirect and direct gender bias, why did they persist? Our research has not yet matured enough for solid answers, but the women we have interviewed so far have offered us two possible answers, both of which constitute ***two experiences of agency***: 1) the “joy of doing engineering” (Goldberg and Summerville, 2014) and 2) the genuine satisfaction that can be derived from participating in, even helping to create a “climate for inclusion” (Nishii, 2012).

Joy of doing engineering

Perhaps, the single most important experience these women have while participating in project teams is the joy of doing engineering. According to Goldberg and Sommerville (2014), joy is the first pillar of engineering educational transformation. They note that that joy is a result of overcoming complexity, seeing theory applied to real-life, and learning together. Our early results suggest that these women are thriving because they experience joy in developing and applying engineering expertise, in developing “declarative knowledge” and “procedural knowledge” (Bereiter and Scardamalia, 1993) or, as the philosopher Gilbert Ryle (1949) refers to them, *knowing-about* and *knowing-how* to respond to real, tangible, and challenging problems. They reported knowing-about and knowing-how as exciting, self-rewarding and self-defining

Based on their descriptions of themselves and others in their project teams, we believe that this joy emerges in three phases: the apprentice phase, the artisan phase, and the expert phase. All three phases involve both knowing-about and knowing-how but at different levels of performance. The first phase begins when they are introduced to knowing-about as novice team most directly as sub-team members. They begin to learn relevant knowledge or knowing-about for the purpose of developing procedural knowledge or knowing-how to address a particular problem, or realize a particular aim. The artisan or second phase begins when they start to see problems from more than a single perspective, alternative pathways to realizing a certain aim. Knowing-how in this phase facilitates a more advanced, more specialized knowing-about. It is during this second phase primarily that they begin to understand themselves not only as engineers, but also as certain kinds of engineers. It is during this second phase that they begin to recognize and affirm specific disciplinary interests. Finally, in the third or expert phase, they begin to self-monitor their application, to change strategies, when necessary, to make “educated guesses.” It is in this third phase that they begin to internalize discipline-specific norms and thereby routinize the use of discipline-specific tools. Knowing-about and knowing-how are fused, each supporting the continued growth of the other. It is in this phase that they can facilitate the learning and doing for others through mentorship.

These three phases align somewhat roughly but still in ways discernable with the components of expertise articulated by Bereiter and Scardamalia (1993). They maintain that expertise is not a “thing” but rather a developmental process. Expertise is not the possession of an individual, rather the result of situated social action and interaction. Expertise involves constant and progressive problem-solving encouraging the development of “active wisdom” or cultivating new ways to both frame and solve increasingly complex problems. And finally,

expertise is not itself a goal. Rather expertise, as a developmental process that involves others in constant and progressive problem-solving, serves goals apart from or outside of itself.

Experiencing the joy of doing engineering are personal and contextual enablers of thriving. The stories these women tell culminates with them claiming their identity as engineers. We believe these women's stories suggest an important pathway toward a genuine engineering educational transformation. The joy of doing engineering constitutes the first of the two experiences of agency.

A Climate for Inclusion

In a seminal article on diversity perspectives among groups in the workplace, Ely and Thomas (2001) identified one especially effective perspective, the "integration-and-learning perspective," that seemed to yield "sustainable performance gains attributable to diversity." According to this perspective, the different experiences, skill sets, and insights developed by members of various cultural identity groups can and do serve to change "the way people do and experience work – in a manner that makes diversity a resource for learning" (Ely and Thomas, 2001). Two of the outcomes of an integration-and-learning perspective are: 1) that participants place "a high value on process" and 2) that they share a "deep commitment to educating and learning from each other" (Ely and Thomas, 2001) .

Building on their work, Lisa Nishii (2012) introduced the construct "climate for inclusion," and investigated possible features and benefits for gender-diverse groups in the workplace. She identified three important features of an inclusive culture: 1) fairly implemented practices or the equitable distribution of resources both material and personal; 2) the integration of differences or encouraging complex perceptions of others and acknowledging ever-present variability; and 3) democratic decision-making or challenging dominant points of view and understanding those challenges as "value-enhancing propositions" (Nishii, 2012) . The two most relevant benefits were that within a climate for inclusion, relationship and task conflict in gender-diverse groups was significantly reduced. Even more importantly, the negative association between relationship conflict and work satisfaction (the more conflict, the less satisfaction) seemed to disappear. These two benefits suggest that within a climate for inclusion conflict is not understood as confrontation, but rather more like educating and learning from each other and part of the process. Further, when understood in this way, relationship conflict did not impact work satisfaction.

The project teams that the women initially joined, based their own descriptions, did not very often promote an integration-and-learning perspective, nor did they facilitate a climate for inclusion. And, even if the project teams were not full-blown MCCs, they at least exhibited features of MCCs. However, learning from the problematic behaviour of past leadership, these women, when they became leaders, changed project team culture to some extent. The above reported changes – including facilitating new member growth and development, encouraging mentorship by creating more feedback opportunities for team and sub-team members, developing training protocols, delegating more responsibility and accountability among members, fostering reflective and supportive responses to mistakes and failures, and emphasizing communality – all could be listed as practices suggestive of an integration-and-learning perspective and of a climate for inclusion.

Working to facilitate an integration-and-learning perspective and a climate for inclusion serve, like the joy of doing engineering, as personal and contextual enablers for thriving and the second experience of agency. The stories these women tell reveals them as engineers within a community of engineers, recognized by each other as engineers, empowering each other to become better engineers. We believe these women's stories suggest something important about that environment and how that environment might foster the joy of doing engineering. Again, if our aim is a genuine transformation of engineering education to something more

inclusive, then encouraging the integration-and-learning perspective and a climate for inclusion might offer us a pathway.

Conclusions

Our distinctive focus and methodology allow us to identify the situated instances of all the terms highlighted in positive psychology and human thriving: development and performance, motivation, challenge and resilience, trust and support. It allows us to locate these abstractions in the particulars of these women engineers' experience. It allows us to see and understand these women as they see and understand themselves. However, it also allows us to get to know, at least a little, some very amazing women. And it suggests that if we are truly interested in transformation, then the pathway forward is to make doing engineering and being an engineer more joyful and to encourage both project teams and undergraduate engineering education to adopt an integration-and-learning perspective within the context of a climate for inclusion.

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