

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

CONTEXT

For the last 40 years, the aggregate number of women receiving bachelor 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 their “processes of becoming an engineer” (Tonso, 2007; 2014), about how women come to think of themselves as engineers and perform their engineering selves, and about 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 interviews (semi-structured and photovoice) and documents, 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). We attend to “small numbers” in order to “learn from small numbers” (Riley et al., 2015; Pawley, 2013).

OUTCOMES

Our results suggest these women find joy in their experience of developing and applying engineering expertise, knowing-about and knowing-how in response to real, tangible and challenging problems. They find knowing-about and -how exciting, self-rewarding and self-defining. Further, these women also work to transform the culture or ways of participating in project teams. This transforming not only facilitates knowing-about and knowing-how; but it also 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 hope 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” (Goldberg and Sommerville, 2014) that these women experience. We also need to learn more about how they create for themselves an “integration-and-learning perspective” (Ely & Thomas, 2001) and a “climate for inclusion” (Nishii, 2012) within those project teams, a perspective and climate that fosters the joy of doing engineering.

KEYWORDS

Gender, Project Teams, Engineering Education

Introduction

For at least the last 40 years and despite all of the well-intentioned efforts, the aggregate number of women receiving bachelor degrees in engineering in the US has remained stuck at approximately 20% (Beddoes & Borrego, 2011). The available research has primarily used a limited rationale and inadequate theories, and included only a few types of participants' roles in only a few types of settings (Beddoes & Borrego, 2011; Pawley et al., 2016). Such research has been characterized as lacking diversity, e.g., ignoring intersectionality theory, overwhelmingly quantitative, homogeneous and standardized. Although 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 (Riley et al., 2014; Tonso, 2007). It may also have created a negative discourse regarding engineering education and thereby actually deterred women from viewing engineering as a viable educational and career option.

Our research is distinctive in focus and in 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 (Riley et al., 2014; Pawley, 2013). To achieve the goal of having more women engineers and a more inclusive and welcoming engineering community, we need to learn more about the processes of becoming an engineer (Tonso, 2007; 2014). We need to learn more about why, in our case, these women are thriving and how they come to think of themselves as engineers. And, we need to learn more about how these women perform their engineering selves, and how others come to identify them as engineers (Tonso, 2006).

Method

We are guided by a feminist, activist and interpretive lens, grounded in women's experience; it 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, and 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 (Sprague, 2016).

We have adopted a multiple, layered qualitative case study design in order 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, service project, or for a client. The three institutions included in this study are: 1) private college of engineering located in the northeast, 2) a state college of engineering located in the Midwest, and 3) a designated HSI state college of engineering in the West. Each institution represents a case and, within each institution, each woman undergraduate student stands as a unit of analysis. Such a design allows us to observe the commonalities and the differences both across undergraduate women students and across institutions.

Our research approach aligns with positive psychology and human thriving. Positive psychology represents a "shift from an emphasis on pathology toward positive human functioning" (Brown et al., 2017, 167). We are interested in changing the negative discourse that permeates discussions of women's participation in engineering for an alternative, more positive discourse of empowerment. Such an alternative discourse highlights terms often used in reference to

thriving – development and performance (Lerner et al., 2019), motivation (Benson & Scales, 2009) challenge and resilience (Beltman et al., 2011), and trust and support (Liu & 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 on 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. We attempt to include a sample size of 25-35 women students from all three types of project teams: competition, service and client- serving.

As a research team, we are keenly aware that the predominate number of women engineers identify as racially white. Because we are devoted to diversifying the pathways into engineering and the engineering workforce, we have and will continue to identify and recruit women of color or women who occupy other minoritized sociopolitical spaces, e.g., nationality, age, lingual, social class in every possible way. Our critical sampling approach allows us be cognizant of and responsive to these socially constructed and fluid categories. In addition, we have adopted the integrative model of intersectionality: one that considers each of a person's subordinate identities to interact holistically, suggesting that people experience these identities as one (Crenshaw et al., 1995). This perspective leads us to create a sub-codebook for women of color or other women occupying minoritized spaces separate from 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 two of the institutions. In addition, two of the PIs are women of color. We consulted with the Institutional Review Boards (IRBs) of the participating institutions prior to contacting volunteers to confirm that we adhere to all appropriate IRB protocols.

Each participant is being asked to agree to a sequence of three interviews: life history (Goodson and Sikes, 2001), individual learning journey (Adriansen, 2012), and photovoice (Latz, 2017). The researchers at each site are expected to carry out and track the progress of the project, i.e., data collection, analyses, project journaling, as well as convene regularly as a team to ensure transparency, consistency, and triangulation for project quality purposes. Each interview is inductively analyzed using the NVivo qualitative data management and analysis software.

We argue that 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 everyday life as everyday actors know it. Critical sampling across institutions 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, that is, their competencies and expertise as engineers. We believe that the more that women can claim their identities, the more they will feel empowered and powerful. Finally, emancipatory praxis will not result from calling out institutions as "gendered, raced and classed" (Riley et al., 2014; Tonso, 2007). Emancipatory praxis is more likely to result when those who suffer from gender, race and class bias, can claim to thrive, doing engineering, and being engineers in an environment that accepts them as engineers. In what follows, we report the early findings observed mostly from the first two types of interview data. PhotoVoice interviews are scheduled to occur in fall, delayed due to

COVID circumstances. The photovoice data are reported here were from our preliminary research.

Results And Discussion

Family, Gender Socialization and School

Overall, the women participants' parents were involved in their children's lives, but not so involved as to direct those lives. The participants were 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 often understood to offer an opportunity for "getting better," and there was tangible parental support for getting better. The women understood that even when they experienced difficulties elsewhere, there would always be acceptance and reassurance at home.

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 participants 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, and 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 or did 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.

Few of these women, at least before college, thought of engineering as a career choice. Their decision to pursue an engineering education was made after matriculation. For most, they learned about undergraduate project teams either on campus visits or shortly after they arrived on campus. Once they learned about project teams, they were not only interested, but also quite determined to participate.

Gendered institutional and project team context

At all of the institutions included in this research, new project team members are generally assigned 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 very 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, and particularly senior members with expertise, as “models.” And while senior members may be identified as models, these women experienced little in the way of “top-down” mentorship. Something many of them, once established in the teams, sought to change. Also, they, and this is true of all members, were expected to commit themselves to the work and to the team. Often this commitment meant sacrifice, e.g., little sleep, no social life, and/or ignoring other academic responsibilities.

Apparent from the required commitment, project teams are very demanding. There is an unwavering expectation that all members will do whatever work needs to be done, to do so well, and on time. 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 rarely are there accommodations made to keep team members involved. Within the teams and between the sub-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 indications in the 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, the project teams appear just as gendered, perhaps racist, and classist as well, as the institutions in which they are housed. All of the women interviewees have 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: be cooperative rather than competitive, be 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 et al., 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 little sleep, no social life and/or ignoring other academic responsibilities.

Currently (at the time of writing this paper), 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 bias (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 and discriminations 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 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 from the problematic behavior of prior leadership that they and other team members had experienced. 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 argue 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 & Thomas, 2001) or a “climate for inclusion” (Nishii, 2012). For some, they clearly noted wanting and hoping to offer a style of leadership that could become a much needed balance 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, their assuming leadership roles, and their seemingly whole-hearted enthusiasm for project teams. Consequently, we asked ourselves and our interviewees – “Given the presence of those features of MCCs noted above, 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: 1) the “joy of doing engineering” (Goldberg & Summerville, 2014) and 2) the genuine satisfaction that can be derived from participating, 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 & 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 first phase begins when they are introduced to knowing-about as novice team members. They begin to transform that relevant knowledge or knowing-about, into usable knowledge that they can apply to a solution. The second phase begins when they start to see problems from more than a single perspective. They learn to use and appreciate established knowledge systems in engineering. They begin to engage in knowing-how. 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 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 of others.

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 procession 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 in 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. That pathway, regardless of the many obstacles and difficulties, is to facilitate the joy of doing engineering.

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 & 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 & 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 employment 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 important, 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 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 they were not full-blown MCCs, then they at least exhibited features of MCCs. However, learning from the prior and problematic behavior of past leadership, these women, when they became leaders, changed project team culture. The above reported changes (e.g., facilitating new member growth and development, encouraging mentorship by creating more feedback opportunities for team and sub-team members, etc.) could be listed as behaviors 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. The experience these women share reveals them as engineers within a community of engineers, recognized by others as engineers, and as empowering others to become better engineers. That experience suggests 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 has allowed us to identify the situated instances of the terms highlighted in positive psychology and human thriving: development and performance, motivation, challenge and resilience, trust and support. It allowed us to locate these abstractions in the particulars of these women engineers’ experience. It has allowed us to see and understand these women as they see and understand themselves. However, it also allowed 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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