Engineering Gender Identities of Women in a Service-Learning Context

Danielle Corple
Brian Lamb School of Communication
Purdue University
West Lafayette, IN, USA
mcdona51@purdue.edu

Megan Kenny Feister
Communication
California State University Channel Islands,
Camarillo, CA, USA
megan.kennyfeister@csuci.edu

Carla B. Zoltowski
School of Electrical and Computer Engineering
Purdue University
West Lafayette, IN, USA
cbz@purdue.edu

Patrice M. Buzzanell
Communication
University of South Florida
Tampa, FL, USA
pmbuzzanell@usf.edu

***Abstract*— This Research Work in Progress Paper explores the identities of women engineers within the EPICS Program at Purdue University. This study builds on previous research on engineering cultures and identities in which women often have to minimize or alter feminine aspects of their identities in order to fit in and be perceived as competent. However, engineering service-learning contexts have an opportunity to provide an environment that challenges traditional engineering cultures, values, and identities with its focus on societal impact and integration of human-centered design processes. Furthermore, service-learning programs like EPICS and community-driven organizations like Engineers Without Borders (EWB) are typically more gender-balanced in contrast to significant underrepresentation of women in traditional disciplines like electrical and mechanical engineering. Empirical research is needed to determine the role of gender in such engineering contexts that may hinder or aid expressions of gender and identity. Using an ethnographic case study approach to examine video-recorded observations and in-depth interviews, we explore the social identities of three women engineers within the EPICS engineering service learning program. In this work-in-progress paper, we provide a brief summary of the literature related to engineering culture and identity, and describe the engineering service-learning context, methods and preliminary findings of the study, as well as directions for future research.**

Keywords— Service-learning; Diversity & Inclusion in Engineering

I. Introduction

This study builds on previous research on engineering cultures and identities where technical competence is considered paramount so that women often have to minimize or alter feminine aspects of their identities in order to fit in and be perceived as competent. For example, Faulkner found that many women engineers experience gender in/authenticity whereby engineering is considered to be a 'gender authentic' option for men and 'gender inauthentic' option for women [1]. The subsequent normative dynamics cause women to face an"in/visibility paradox" wherein their gender is highly visible yet they are invisible as engineers [2, 3]. Women engineers' invisibility as engineers requires them to work extra hard to prove their ability to be taken seriously as 'real engineers'. According to Faulkner, "Most women engineers I met have experienced being invisible as engineers on the job – classically when they are mistaken for the secretary by outsiders" [3 p. 174]. Faulkner also found that their visibility as women often brought contradictory expectations: "Women engineers are expected to 'blend in' but, at the same time, not to behave like men in certain areas. The dividing lines are often only obvious when crossed" [3 p. 180]. A tendency of the engineering culture to be dualistic in nature, as well as the significant underrepresentation of women in engineering also contribute to this in/visibility paradox.

However, engineering service-learning contexts have an opportunity to challenge traditional engineering dualisms and mindsets with its focus on societal impact and integration of human-centered design processes. Furthermore, service-learning programs like EPICS and community-driven organizations like Engineers Without Borders (EWB) have attracted proportionally more women than are represented in traditional disciplines like mechanical and electrical engineering [4-11]. Our study begins to explore if the service-learning context and the higher representation of women provide an opportunity for women to overcome the in/visibility paradox. Using an ethnographic case study approach, this project uses video-recorded observations and in-depth interviews over the course of multiple semesters to examine the social identities of three women engineers within the EPICS program at Purdue University. In this paper, we provide a brief summary of the literature related to engineering culture and identity, and describe the engineering service-learning context of EPICS, methods and preliminary findings of the study, as well as directions for future research.

II. Engineering Culture and Identities

The challenges facing engineering education, especially those related to diversity, go beyond developing knowledge and skills and include perceptions of engineering practice and engineering identity. Perceptions of engineering identity are related to perceptions about the nature of engineering practice, as summarized by Stevens et al. [12, p. 126]: "If we are interested in a full understanding of professional engineering, we must attend not just to what people learn and know but also to who they are and what is their place in the world among their

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consociates as engineers, both within their local professional networks and within social life more broadly."

Furthermore, students' experiences of engineering within their undergraduate education shape their understanding of the nature of the work done by engineers, the skills and knowledge that are valued and needed in engineering, and whether these things align with their personal identity and values. Instead of taking a heterogenereous view of engineering, where the social and technical are inextricably tied up together, "there is a tendency among engineers to define "real" engineering in terms of the technical "nuts and bolts" and scientific and mathematical labor, thereby locating the social aspects of heterogeneneous engineering outside of "real" engineering (cf. [13])." ([12], p. 127). Godfrey found that in addition to making this distinction, there is a "devaluing of content or subject areas that were seen as 'easy' or 'soft'" [14, p. 442].

These common dualisms are often extended to create dualistic identities for men and women engineers [3] where engineering is considered an authentic profession for men, and inauthentic for women. Furthermore, Faulkner found in her fieldwork observations of engineering workplace cultures, that the "the largest cultural group will tend to set the tone in any workplace culture, leaving the minority group(s) to adapt and 'fit in'" [2, p. 182], making the everyday interactions more difficult for women (and other underrepresented groups) to build working relationships with colleagues [2]. All these aspects contribute to 'in/visibility paradox' [3], wherein women engineers downplay traditionally 'feminine' aspects of their identity or appearance in order to 'fit in' with dominant male culture and male colleagues [2,3], but yet at the same time are expected to maintain their femininity in other ways. Thus, "through numerous subtle and not so subtle dynamics, women engineers are perceived, and can feel themselves, to be not quite 'real engineers' or 'real women'. Men engineers belong more 'naturally' on both fronts, while women have to do additional identity work on both fronts if they are to secure their membership in the community of practice, and so stay and progress in engineering" [3, p. 181]. Faulkner's findings align with those of a study by Hatmaker of engineering practice in six firms in the US where "The women in this study described experiencing workplace interactions that conferred a status based on being a woman rather than an engineer. These interactions marginalized their professional identity and overly validated their gender identity" [15, p. 386].

III. Social Identity Theory

A great deal of literature informs how we understand how engineering identity is developed. Social identity theory describes how the culture of an organization can influence how individuals construct their identities and behaviors to align with certain group norms [16]. According to Anderson [17], "While Wenger does not specifically discuss engineers, his discussion of individual and social elements of identity development within professional communities of practice applies to engineers: how an engineer 'experiences her job, how she interprets her position, what she understands about what she does, doesn't know and doesn't try to know – all of these are neither simply individual choices nor the result of belonging to the social category (cf. [18])' of engineer" [17 p. 156]. Instead, they are interconnected. For example, Tonso found that campus culture impacted social interactions and shaped how students understood engineering identity [19]. Self-categorization and social identity theory also suggest how individuals and organizations differentiate what an engineer is from what it is not, and modify their identities and behaviors as a result [16]. According to the theory, individuals develop identity 'prototypes,' that "cognitively represent the defining and stereotypical attributes of groups … often in the form of representations of exemplary members (actual group members who best embody the group) or ideal types (an abstraction of group features)" [16 p. 123]. These prototypes "then show what the group values and serve to distinguish the ways of doing and thinking of one group from another" [17]. Then, through a process called depersonalization, individuals begin to align their behavior and attitudes to match the 'in-group' (dominant group) prototype. As a result, members develop new or altered identities based on their particular social group, such as 'engineer,' 'athlete,' or 'sorority girl.'

However, it is important to note that conceptions of 'in-group' and associated norms are highly context-dependent and largely constructed in opposition to whichever outgroup is contextually salient. Thus, for example, if engineering in-group prototypes are gendered masculine, the out-group engineering prototypes are likely gendered feminine. Therefore, engineering education contexts that present alternative prototypical members have an opportunity for new understandings of ideal or exemplary engineers to emerge within that context. Thus, this project applies the principles of social identity theory to examine the prototypical engineering identities within a nontraditional engineering environment, a service learning undergraduate engineering program. However, since the context-dependency of social identity theory also suggests that one's cognitive representation of the in-group prototype is primarily born out of one's immediate group context, our study is situated within a specific project team.

IV. Service-learning Context

In recent years, many engineering education programs have incorporated service-learning, community engagement, and/or learning through service projects as curricular or co-curricular undergraduate experiences. Aligned with literature, these programs demonstrate higher percentages of women than what is typically represented in the discipline [4-11]. Furthermore, given the nature of the design challenges in these programs, service-learning programs often utilize design process models such as human-centered design that prioritize different knowledge sources and more integrated socio-technical understandings of engineering than traditional, technology-centered design processes found in many engineering design courses. For example, the most comprehensive category from Zoltowski, Oakes, and Cardella's phenomenographic study of human-centered design [20], Empathic Design, was characterized by a very broad and integrated understanding of the stakeholders and the social, cultural, political, technical and ethical issues associated with the design. We argue that the service-learning context presents an opportunity for female engineers to exercise more than purely technical competence, making it an important site for examining how women engineers

make sense of and enact their identities as both women and engineers.

V. Methods

This study is part of a larger, longitudinal study which explored how student design teams negotiate design and ethical decision-making in diverse teams [21, 22]. This specific study employs an ethnographic case study approach to examine how organizational norms produce social identities within this service-learning context. It draws upon observations and interviews of undergraduate students on a design team in a service learning engineering program. We have specifically attended to dynamics related to gender in observing students' interactions. Observations of these students' interactions allow us to examine how members establish in-group norms and how others attempt to align themselves with these norms in order to gain acceptance. Additionally, the interviews provide insight into the way team members make sense of their relationships with their teammates related to ethics and design and are useful for explicating how identity is constructed within these environments.

A. Participants

The participants in this study are members of a multidisciplinary engineering design team nested within the EPICS Program at Purdue. Students enrolled in EPICS work together to design and deliver a product to their community partner, the end user. Students in EPICS historically come from approximately 50 majors and include first-year through senior students. They also assume a variety of roles such as Design Leads (students who oversee all aspects of the product design), Webmasters (students who manage the team's website), or Project Managers (those who manage the project resources and timelines for multiple design teams). Students often participate in EPICS multiple semesters throughout their undergraduate education at Purdue.

The target of this preliminary study is a team that is working on a device for people who are blind. This particular design team was chosen for this study because of the significant number of students who participated on the team for multiple semesters, although a limitation is the low proportion of women within the team for multiple semesters. This study examines this team across the course of three consecutive semesters. The total number of participants is 17, with 14 men (82%) and three women (18%) participating on this project team over the course of three semesters. Three of the team members were of Asian/Pacific Islander descent (18%), and the rest of the team were Caucasian (82%). The team was comprised of a variety of engineering majors, including electrical, mechanical, chemical, biomedical, and nuclear engineering. During the course of the study, the design team primarily was engaged in conceptual and detailed design tasks.

B. Data Collection

This qualitative case study draws on observations and interviews of these students on the design team over the course of three semesters. After obtaining IRB approval, the second author observed weekly lab meetings throughout the 2014-2015 academic year, taking extensive field notes, and videotaping the social interactions. At the end of each semester, she also conducted in-depth, semi-structured interviews with all of the students. The interview protocol probed students' perceptions of the cultures of their teams, team processes, their relationships with other teammates, significant design decisions, and their understandings of ethics and design. Sample questions include: "Describe your team interactions as a whole.", "How would you define design or design work?", and "How would you define ethics?" In addition, students were asked to discuss their answers on a social network survey they completed twice during the semester during the interview. In this survey, the students ranked their teammates on Likert-type scales across seven relations: Q1. I work with this person regularly (e.g. every class meeting; sometimes outside of class time), Q2. I can I can rely on this person to complete a task he or she agreed to do, Q3. I would feel comfortable sharing my personal problems and difficulties with this person, Q4. I can rely on this person to have the technical competence needed to get the task done, Q5 I can rely on this person to have the project/ EPICS knowledge needed to get the task done (non-technical), Q6. I would go to this person if I had a serious ethical concern about the project, Q7. I consider this person a friend. While the survey data are not included in this analysis, the qualitative interviews include conversations about the survey responses. The interview protocol remained consistent throughout the three semesters so we were able to trace the development of social identities as the participants moved through the program.

C. Data Analysis

The interviews were transcribed and de-identified; pseudonyms were assigned to each team member. The transcripts and field notes were then coded using thematic analysis by the second author. Following Adler and Adler's approach to observation, in this process, the second author identified gender as one of the "elements of the setting that have emerged as theoretically and/or empirically essential" [23, p. 381]. In order to more specifically examine the role of culture in gender and identity, the first author engaged in systematic observations of the video recordings of the design team lab meetings. She observed 20 hours of video and recorded 83 pages of observational notes, paying particular attention to gender in social interaction. In addition, she engaged in selective coding of the interview transcripts, applying a social identity theory lens to these codes [24]. Given the interpretive nature of this process, she discussed the emerging themes with the second author, engaging in "dialogical intersubjectivity" as a means to verify the findings [25].

Preliminary Findings

The three women on the project team constructed their social identities within this context in different ways. Devika is a freshman engineering student on a team with older male engineering students, who have all participated in EPICS before. As a result, Devika is placed in the out-group from the outset by her fellow team members and eventually by herself. Early in the semester, she demonstrates an eagerness to discuss her academic and extracurricular life with her upperclassmen teammates. Not only does she want to learn technical skills, but she describes wanting to establish friendships with them. However, as her male teammates signal their disinterest in developing personal relationships, Devika shifts from focusing on these relationships

to focusing exclusively on the task at hand. Devika appears to recognize that gaining acceptance with the in-group requires her to demonstrate technical proficiency and distance herself from her focus on relationships and associated femininity. Through this process of depersonalization, she is successful in achieving acceptance in the in-group, as evidenced by her team members' praise of her technical skills and dedication to the project. For example, her teammate, Doug, praises her in his interview, stating, "You know, it's such a technical project, and there's so much to take in, and she just kind of dealt with it amazingly and was immediately throwing out ideas that were, you know, useful to us."

Diane's experience also reinforces the centrality of task orientation and technical proficiency in gaining acceptance to the engineer in-group. Diane is a freshman engineer and the only new member to her EPICS team. Although her team included a senior woman engineering student, Diane was also positioned in the out-group from the beginning because she did not "jump right in". Rather than strive to develop technical skills, Diane was discouraged from contributing to the team due to the highly technical nature of the design project. She recognized this as well, as she explains to the interviewer,

R: ... sometimes it's not that beneficial to the project to sit down with me and spend hours explaining it to me.

I: Oh, yeah, yeah, yeah.

R: I'm like, it's probably better if they just do it, and then I'll do like some menial task that I can do.

As a result, over time she began to demonstrate less task orientation and technical proficiency, and therefore never succeeded in joining the team's in-group.

As a senior mechanical engineering major and long-time EPICS member, Danielle's case is the most complex. She has proven her technical prowess and dedication to the project as one of its founding members; however, the observations and interviews indicate that Danielle's in-group status becomes jeopardized when she does not actively demonstrate her technical skills or task orientation. In addition, when she displays traits, behaviors, or roles, such as the more administrative Project Manager, that are considered stereotypically feminine, her in-group status becomes even more fragile. For example, Danielle's teammate Danny contrasts her work as a Project Manager versus her technical work as part of her Senior Design project, "There's not all that much to do as a Project Manager. Yeah, that was really, really cool because she [pause] it was like in her domain. I was able to see her technical expertise every time she asked me a question or I asked her a question, and she was leading her six-person team. So I enjoyed it." In addition, Danielle's identity is clearly gendered feminine as her teammates refer to her as "Mom." So as her team members simultaneously show respect for Danielle as well as dismiss her non-technical skills and interests, they evidence conflicting attitudes regarding her in-group status. Danielle's precarious belonging to the in-group demonstrates the persistence of the traditionally masculine, task oriented engineer prototype.

VI. Discussion and Future Work

Although the identities of these three women cannot be reduced to their in-group/out-group status, social identity theory does provide a useful interpretive framework for understanding how they align themselves with the prototypical engineering identity within their service learning context. For example, although she is a first-year engineering student on an all-male project team, Devika is able to gain membership as part of the in-group because they view her as technically competent and task-oriented. However, because Diane, also a first-year engineering student on a male dominated team, is unable to demonstrate technical skill or project commitment, she never achieves membership with the in-group. As a result, she disengages from the team, and eventually, the EPICS program altogether. Finally, although Danielle, a senior mechanical engineering major, has participated in EPICS all four years, it is only through her demonstration of technical skills and project dedication, that she aligns with the prototypical engineer. However, by identifying with 'culturally' feminine Project Manager role, she identifies with the out-group as well, creating a fragile sense of belonging within the gendered masculine engineering in-group.

The experiences of these three women provide insights for considering how deeply entrenched cultures can persist despite the opportunities afforded by contexts that challenge these cultures, such as service-learning programs. Faulkner's finding that relative numbers of women and men do impact the culture of an organization [3] provides a possible explanation as women were a significant minority on this team, with only three women compared to 14 men. For future work, we plan to examine a team that is gender-balanced and/or where women are in the majority, to understand whether the experiences are similar. This will also help us probe whether the specific team culture which is created by not only the team members, but the faculty and teaching assistants associated with the program, created a more inclusive culture, which was a second factor identified by Faulkner that contributed to overcoming the 'in/visibility paradox' [3]. Although the overall culture of the program promotes more integrated socio-technical understandings of engineering, and supports more inclusive disciplinary membership, the impact on creating specific team cultures is not known. However, it seems that this context provides a space for women engineers to work through facets of their identities in meaningful ways. Future work will endeavor to continue exploring the musing of Faulkner that "Perhaps the most significant sign of change to emerge from [her] own work is that young women engineers are challenging the notion that you can't be a 'real woman' and a 'real engineer'" [3 p. 185].

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