Prospectus

Constructing a Solution Oriented Design Network
(Technical Topic)

The Effectiveness of Women in Engineering Initiative at the University of Washington to Increase Retention Rates of Undergraduate Women in Science and Engineering
(STS Topic)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Sociotechnical Problem

Despite considerable efforts to promote women in STEM, the engineering industry is still heavily dominated by men. In 2018, the U.S. Bureau of Labor Statistics reported that STEM occupations made up 6.3 percent of employment nationally. However, of that percentage only 26 percent were women (*Nonmetropolitan Areas Had over Half a Million STEM Jobs in May 2018*, n.d.). Limited diversity in the development of the STEM workforce has detrimental effects on innovation, creativity, and social relevance (Niler et al., 2020). While there have been many initiatives to promote diversity and inclusion in the workplace, recent studies have examined the longevity and retention of women in the STEM workforce noting that women leave the engineering workforce at a significantly higher rate than men (Dizikes, 2016). The prevailing masculine workplace culture marginalizes women within the company and within teams (Ayre et al., 2013). Team performance evaluations have shown that women experience a lack of self-confidence and acceptance making women more likely to think about leaving STEM workplaces (Cardador & Caza, 2018). These expressions of confidence, or lack thereof, impact interest and passion in technical roles contributing to the switch from engineering to non-engineering roles. Women are seen to transition to more managerial positions relying more on their social skills than technical skills (Bastalich et al., 2007). To address this problem, the technical project we are developing is a design based project network that connects UVA Health and academic system and undergraduate students to develop tangible solutions. This promotes early exposure to collaboration in engineering teams during undergraduate studies to maximize the role of women by honing their unique technical and social strengths.

Although this addresses the technical aspect of overall retention of women in engineering, there are social factors that need to be better understood. Professional socialization

greatly influences women's confidence and ability in the workplace. According to Dimaggio (1992), "professional socialization entails both the mastery of the routine skills and specialized knowledge of the profession as well as match between personal values and those expressed in the profession's culture" (p. 127). The perceived confidence of professionals not only reinforces security in his or her expertise when faced with uncertainty, but also emphasizes the embrace of the roles, values, and identities that are associated with the field (Cech et al., 2011). Undergraduate experiences can promote professional socialization and persistence in the STEM workforce. Furthermore, the influx of undergraduate students into the job market is shaped by these experiences and the skills learned throughout their undergraduate careers. To better understand this issue, the STS research problem will examine the failure of a women's initiative program to increase enrollment and retention of undergraduate women in science and engineering programs. If these problems go unaddressed, there is a risk of more women leaving the engineering profession.

Understanding the technical and social complexities during undergraduate studies provides insight into the level of interest in technical roles and persistence in the engineering industry. To explore these factors, I will analyze the Women in Engineering Initiative at the University of Washington using the Actor-Network Theory framework to understand the actors that influence the program's inability to increase the retention rate of undergraduate women pursuing science and engineering.

Technical Problem[1]

The purpose of undergraduate study is to prepare students for post-graduate success. Undergraduate research has been shown to be a valuable experience, demonstrating an increase

[1] Coauthored by Aidan Houser, Zack Landsman

in breadth of skills, with instruction-based research reporting greater skill gains and research with a presentation component reporting greater oral and written communication skill gains (Lopatto, n.d.). A large part of the success in undergraduate research is attributed to the freedom of direction in research, where students are encouraged to discover how to solve problems. This autonomy allows students to apply their classroom learning to real-world situations and has shown holistic results to prepare for post-graduate plans. Student research experience should be formatted to be an accessible and applicable opportunity for any student's interests. However, we believe the current student research experience is taking a traditional approach, generalizing the experience to all students which causes exclusion of students who do not find interest or meaning in lab-based model research. We argue that an improved approach to research, with personalization based not only on each student involved, but also each project, will create solution-oriented research design opportunities that scope much smaller to directly impact communities in need. The current research model at the University of Virginia has little to no opportunities for students wishing to pursue solution-oriented design projects that provide students with pre-professional experience and visible community impact.

At the University of Virginia, there exist various programs and organizations that promote a career in STEM. These include the Undergraduate Research Network (URN), Undergraduate Student Opportunities in Academic Research (USOAR), Engineers Going Global, and Forge, formally known as HackCville. URN and USOAR facilitate student-faculty interaction in a research-based setting. Engineers Going Global has project-based innovations scoped outside of the immediate UVA community. Lastly, Forge offers lessons and projects in the realm of computer science and UX design. However, none of these programs focus primarily on team design thinking with projects spanning across all disciplines of engineering to produce

innovative solutions that directly impact the UVA community. This limits experience in designing, prototyping, and developing a product, which are important skills to develop before entering the workforce. All students learn engineering principles and skillsets in class, but may not see the real world application in class assignments. When we asked a student majoring in biomedical engineering with career aspirations in medical devices what he felt was lacking from their undergraduate experience he noted, "there are limited resources to seek exposure and hands on experience in a setting that is not research lab-based" **(**Anonymous, personal communication, October 9, 2020**)**. On the other hand, we asked a healthcare professional what limited her interaction with students on projects and she stressed that she had a wealth of projects, but not enough students to work on them (S. Berres, personal communication, October 22, 2020). This lack of transparency between professionals and undergraduate students limits workplace efficacy as well as hinders student experiential learning.

The goal of this technical project is to develop a network between the UVA Health and academic system and engineering undergraduate students that focuses on design based projects, where students are given the opportunity to solve real world problems and receive hands on experience. These design projects can range from constructing medical devices to configuring website user interface to designing collaborative workspaces. We aim to have at least 3 projects with student teams of 4-5 people to develop team-based design thinking, client relations, and product management skills. Under our guidance, we will facilitate client meetings and assist with the engineering design process to formulate feasible solutions. Completion of the project will result in a tangible solution and implementation strategy that students will present to the professionals. We plan to implement this network in the UVA engineering department next

semester and closely track team dynamics and progress through frequent team check-ins, client evaluations, and deliverable benchmarks.

By facilitating the development of this network, we hope that there will be downstream effects, even if subtle or hidden. Focus will be placed on the team dynamic component and enhancement of technical skills since there is potential for meaningful and insightful experiential teamwork learning. It is our desire to deliver solutions that will prepare for socialization into professional careers, which will directly improve workplace efficacy and strengthen career aspirations.

In order to develop the network, we need to test our two biggest assumptions: that healthcare professionals and students not only want this network, but are also actively wanting to participate in our program. To test these assumptions, we will need to interview doctors in the UVA health network to first identify interest and then outline design projects. If we are able to identify three projects then we can present these research options to undergraduate engineering students at UVA, to survey their interest in working on the projects and their overall interest in the network. If we are able to fill the three identified research projects, along with finding a surplus of students interested in network participation, then we will be able to successfully construct the network. From there, we can continue project acquisition and student outreach to grow the network further until growth is self-sustainable by reputation.

STS Problem

The importance of increasing the retention rates of undergraduate women pursuing degrees in science or engineering is related to the pipeline into the STEM workforce. In 1997, the national retention rate for women, calculated as the ratio of students who completed an engineering program to the number of incoming freshman four years earlier, was slightly below

60% (Babco, 1994). Similarly, at the University of Washington the calculated retention rate of women engineering students was about 55% (Brainard & Carlin, 1998). The University of Washington's Women in Engineering (WIE) Initiative, funded by the Alfred P. Sloan Foundation, conducted a six-year longitudinal study of undergraduate women pursuing degrees in science and engineering (Brainard & Carlin, 1998). The objective of this study was to evaluate the effectiveness of WIE's support programs targeted at increasing the enrollment and retention of women in science and engineering. The study reported an increased retention rate from 55% to 72% since the development of the WIE in 1988. While this number indicates an increase in retention, this fails to take into consideration the number of women who switched out of science and engineering and that biological science programs have substantially higher retention rates than engineering programs (National Science Foundation, 2014). Ultimately, the reported retention rate was inflated and depicted WIE's failure to improve the retention rate of undergraduate women pursuing science and engineering.

One actor that suggests the failure of the WIE to increase the retention rate of undergraduate women in science and engineering is the emphasis of mentors offering support to first and second year students, but sidelining third and fourth year students. At the University of Washington, students do not enter the College of Engineering or science departments until their junior year. In an effort to increase enrollment in science and engineering programs, WIE offers a mentoring program that matches students with professionals working in their field of interest. Higher priority is given to first and second year students to increase interest in pursuing one of these fields. While an effort was made to increase enrollment rates, retention rates among third and fourth year students suffered. Of the third and fourth year students, 59% and 63%,

respectively, reported a lack of interest in science and engineering programs, causing students to switch out the program and lowering the retention rate.

Although there was an inadequate number of mentors offering support for upperclassmen leading to lower retention rates, this study overlooks the comprehensive undergraduate experience, in which other actors caused the failure of the WIE program to increase retention. The retention rates of female students at the end of first and second year were 91% and 73%, respectively. Comparatively, at the end of third year the rate was 65% and at the end of fourth year the rate was 59%. If we continue to think that only mentors are responsible for engaging interest in science and engineering programs and subsequent persistence, we won't understand the role other actors play alongside mentors offering support in the WIE's failure. By leaving this issue unresolved, further initiatives to promote women in STEM will be ineffective if actions are not taken to keep women in the profession. Drawing on the Actor-Network Theory, I argue that mentors offering disproportionate support in conjunction with faculty providing inadequate advice and the curriculum affecting academic progress caused the WIE Initiative at the University of Washington to fail in increasing retention of women in science and engineering programs. The Actor-Network Theory considers both human and non-human elements associated together equally as actors within a network (Cressman, 2009). The network builder identifies a goal and the actors needed to accomplish it. In this case, the network is the undergraduate women pursuing science and engineering at the University of Washington and the network builder is the WIE Initiative to increase enrollment and retention of women in these programs. To support my argument that there are both human and non-human actors that contribute to the failure of this network, I will analyze evidence from course evaluations and faculty advising, which will provide information about why women switch out of science and

engineering. Poor curriculum quality and low course grades can exacerbate academic difficulties and discourage students from furthering their careers. The perception of low grades can feed into low confidence and hinder women's ability to make their way through college. Faculty advising can be unsupportive and cause women to feel unaccepted in the program, which can greatly influence retention at the end of fourth year and post graduate degrees when advising is most crucial. Thus, both provide a holistic view of undergraduate studies that the WIE Initiative failed to identify in its attempt to increase retention among women in science and engineering.

Conclusion

The technical report details the development of an engineering design network between the UVA Health and academic systems and undergraduate students to improve the lives and work of professionals as well as encourage innovation and creativity among engineering students. This network focuses on building tangible solutions driven by students' motivation to work in a team environment and apply skills and knowledge acquired from class to a real life application. The configuration of the project teams will place greater emphasis on equivalent technical roles and teamwork to maximize team performance and industry preparedness. The STS research paper will provide further insight into the concept of the Actor-Network Theory by analyzing undergraduate experiences in terms of mentors offering support, faculty providing advising, and the curriculum stilting academic progress. These actors relate to the overall understanding of persistence and retention throughout students' engineering course and into the job market. Without this insight, current initiatives to draw women into the field of STEM will be futile if the technical and social implications of why women end up leaving the engineering pathway are not better understood.

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