Cyber War is not Gender War - Experiences of Creating a Productive Heterogeneous Environment in Cyber Security Research

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Abstract

While degree enrollments continue to see an increase in female enrollment, there remains a distinct gender gap in STEM disciplines [1]. In particular, the Technology and Computing space have always struggled to recruit and retain women. A similar trend is seen in employment, where approximately 25% of computing jobs are held by women [2]. Within Brigham Young University's Information Technology program, we have struggled to achieve 10% female enrollment. This is unfortunate, as it is the universal opinion of our own faculty, supported by both internal and external research data that gender balance enables peak productivity. It is thus extremely unfortunate that elements of society are still struggling with mistaken gender stereotypes, and that this, coupled with occasional misogyny can dissuade young women from pursuing a career in computing. While this may not be the only cause, it is unacceptable.

We have found (in line with other research) that strong faculty mentorship is an important factor in recruiting and retaining women in technology computing disciplines. This paper thus describes the approaches implemented by a cybersecurity research group of over 20 students in achieving a 2:3 female to male participation ratio within a program of less than 10% female enrollment. There have been significant immediate and long-term benefits to establishing this ratio in a research group. These include a measurable increase in research productivity from both genders, peer-to-peer mentoring, and a more complete perspective into the significance and impact of research overall. In the past four years, female students have participated in both pedagogical and technical research conferences, obtained research funding and developed entire courses. One particular effect of significance has been an increase in direct, targeted recruitment of women into the program — and subsequently from the program by employers. We anecdotally note also that women in cybersecurity command a higher average placement wage than men, although regret that to date, this data is not statistically significant due to insufficient data samples.

Introduction

At the beginning of 2015, Intel announced a $300 million diversity initiative intended to give full representation to women within their company by 2020 [3]. Intel stated that its plan is to "hire differently and tie executive pay to performance on the issue [4]." Full representation in this context means that Intel's aims to reflect the amount of women who have the skills and aptitude to take on technical jobs at prestigious companies and everywhere [5]. Many other tech companies (e.g. Microsoft, Google) understand the value of having a diverse workplace and are looking for ways to balance the genders in an already male dominated field. Despite this, the U.S. Department of Labor predicts that by 2018 technology jobs will continue to increase in the

United States, but only 61% of the openings will be filled and only 29% will be female applicants [6]. While there is a desire in the tech industry to recruit more women, women today represent just 18% of computing and information science degrees awarded (this represents a decline from 35% in 1985[6].) Both engineering and computer science topics have the lowest female enrollment of all disciplines with the latter showing a significant decline since the 1980's[7]. There appears to be a great imbalance of women actually having interest, let alone accomplishing degrees. At the second annual Women in Cybersecurity (WiCyS) conference held in Atlanta, GA it was revealed that women represent just 10% of the cybersecurity workforce.

Though the societal norm may not present this fact so avidly, women in cybersecurity bring talents and skills that not only complement the stereotypical characteristics of men, but bring new perspective and opportunities to the entire workforce. Each gender typically approach situations and problems differently, and may often employ different tactics to achieve a desired solution. A combination of these two different approaches allows companies and teams to analyze more solutions for a given problem. Indeed, current research supports the claim that an even gender split helps organizations reach peak performance. The Credit Suisse Research Institute reported that over a period of six years, companies with a gender-diverse environment outperformed a dominantly male environment by 26 percent [8]. Gender imbalance is detrimental to the cybersecurity field and prevents the industry from achieving peak performance and inhibits innovation.

Faulty recruitment procedures and the inability to retain the interest of women in cybersecurity are two key issues that need to be addressed. In post-secondary education, only 60 percent of women retain their interest in STEM fields compared to the 80 percent of men [9]. Efforts that are being pursued to increase female retention, though varying in success, include: earlier recruitment aimed at high school students; creating opportunities to involve students in research; mentoring; and developing technical communities specifically for women. Within the Cyber Security Research Lab (CSRL) at BYU we have addressed these issues and have found a high success rate.

Approach & Methodology

The Cyber Security Research Lab (CSRL) is not the first group to attempt to diversify its numbers. By evaluating and examining the methodologies and results of current known studies [10,11], a holistic approach was followed which has shown a significant improvement. Through the study *Increasing Participation of Women in Cyber Security* [10], an ASEE paper in 2012, researchers at Mississippi State University approached women at a young age and encouraged them to nurture a continual interest in cybersecurity. The researchers implemented a three phase approach to recruiting and retaining females:

- Phase one: a free "summer camp for high school juniors and seniors." Its purpose was to teach participants about Information Assurance. By cultivating this kind of awareness within high school students, it creates an early interest and understanding.
- Phase two: undergraduate research in cybersecurity through a program named "Research Experience for Undergraduates." The program was tailored for women studying any major related to information assurance (i.e. computer science) and allowed them to gain involvement and firsthand experience regarding the subject.
- Phase three: focused on creating internship opportunities for sophomores seeking to gain experience. Sophomores attended the Scholarship For Service (SFS) job fair and were educated about career prospects in the cybersecurity field. This phase allowed sophomores to gain motivation, revitalize interest, and eventually obtain their desired career.

One of the most important aspects of the three phase approach is that it facilitated a cycle of mentorship in which the mentee eventually became the mentor. Additionally, the method included exceptional teachers, opportunities for experience, the chance for women to start early in cybersecurity, and a supportive environment that encouraged women to pursue STEM fields. Despite insufficient data regarding this method, it is substantial progress towards successfully recruiting and retaining women in cybersecurity.

The research project *Computer Clubs for Girls* also showed promise [11]. Created in England, *Computer Clubs for Girls* is an all-girl environment aimed to motivate young girls (ages 10 – 14) to pursue interest in information technology. The club intended to accomplish its goal by tailoring the subject matter to the girls' interests (e.g. fashion, music). Assumed to be successful, the evaluation results completed in July 2013 varied from the objective. Many of the girls reported not being persuaded to foster a continual interest in IT as a career. The factors that contributed to such a result were a lack of technical depth and an excessively narrow perspective that was mainly geared towards "girly girl" interests. The primary aim of *Computer Clubs for Girls* was impressive, but it was not implemented with effective methods. The sacrifice of information about what IT entails, different fields, and failure to include all types of girls created a misrepresentation of IT.

In contrast to these prior studies, the CSRL at BYU has attempted to cultivate a gender-balanced environment rather than an all-female program. By adapting proven approaches that have shown success to a mixed-gender environment, the CSRL has shown an increase in student research publications, class performance, and cybersecurity competitions. Though the research environment contains a large male population, it does not cause any discouragement for women as the environment is equal and unbiased. Students are encouraged to socially interact, ask questions, and seek mentorship in research projects and class work. Likewise, students are constantly given opportunities to discover and attend conferences, competitions, and social

events. The CSRL's steady flow of research projects and events allow students to join together as a learning community and explore their interests while simultaneously being mentored and teaching others. Since 2011, the ratio of female to male students has risen from 1:4 to 2:3. This growth has been accompanied by a similar growth in publications and competitions. Additionally, the parent program of this laboratory — Information Technology has, in the last year, seen a rise in female enrollment as a direct result of the CSRL.

Implementation

The CSRL implemented concepts provided by the above-mentioned studies and implemented its own three phase program:

- Recruitment
- Mentoring
- Mixed Groups

Through this process, the CSRL has managed to create its own cycle similar to the researchers at Mississippi. While a lot of the focus is on increasing the female participation, the secondary goal is to create a mixed gender environment for more productivity.

Recruitment

Recruitment focuses on two goals: Combating social ideas (e.g. females are not as technically capable as men, women should not be invested in a career, women lack skills for technical fields, etc.) that are deterring females from being interested or feeling like they are incapable, and increasing awareness that cybersecurity exists as a career path for women. We have found that with very few exceptions, technical programs (including those at BYU) have been built from the ground up by men. The result of this is that many methods being used to teach, recruit, and retain revolve around a male oriented thought process. Having women participate in curriculum development, career fairs, marketing, and recruitment can enact positive change towards encouraging girls in their early years and onwards as they evaluate potential career paths. Having women reach out to bring others in when they're young can help stir up their interest in cyber security. It give these young women role models and mentors to look up to and help boost their confidence by having interaction with successful women in the field.

It has been our own experience that the majority of women that have joined the cybersecurity field came from other technical fields that they felt unsatisfied with, and through recruitment activities gained awareness of this option of study. 70% of women in the CSRL describe meeting another female student at a campus major fair as a key factor in their decision to enroll in IT (later emphasizing in cybersecurity). Yet some women are also recruited directly into the program. Though it can be difficult to recruit women unless they have a pre-affinity for technology, the CSRL has made it a goal to focus on informing unaware women of what cybersecurity entails and the opportunities therein.

Mentoring

According to *The Center for Women and Information Technology*, mentoring is "a relationship where one person invests time and effort in enhancing another person's growth, knowledge, and skills" so that they may reach "greater productivity or achievement in the future" [12]. Mentorship is an exceptionally effective method that is important for both the mentor and the mentee as learning usually occurs on both ends.

The CSRL implements mentorship by consistently providing equal opportunities for involvement regardless of the amount of experience an individual may have, or which gender they might be. New students meet regularly with a faculty mentor, but are also encouraged to seek peer mentors. Almost immediately, mentees are given opportunities to work with their mentors in helping other students in difficult or confusing topics. We have found that this approach of co-mentoring by mentor and mentee increases confidence and promotes a strong learning environment. In a combination of tutoring and supportive projects that perk student interest, the CSRL promotes a healthy and effective method of mentorship where all students are both mentor, and mentee.

Mixed groups

The final phase focuses on giving experience as a community by mixing research groups in both gender and ability. This works alongside mentorship efforts and includes research and the creation of Red/Blue teams and student clubs. Students are encouraged to discuss new ideas and taught how to determine a project's feasibility as a group. Some projects thus far have included developing new cybersecurity learning modules, teaching foundational principles using malware, or wireless sniffing using autonomous drones. Every project is open to and welcomes any curious student willing to participate in the research — from freshman to graduate. Many women are not aware of what a career in cybersecurity can lead to or all the possibilities it holds, hence promoting this information is an excellent recruitment strategy.

By utilizing these 3 phases, it was hoped that recruitment and retention would be increased and held until the ideal environment could be formed.

Findings

The methods the CSRL has utilized in the recruitment process are word of mouth, social events, major or career fairs, and physical advertisement. These recruitment methods tend to be successful in soliciting interest as in the case of one woman actively involved in the CSRL. She specifically came upon the cybersecurity field through the BYU major fair where CSRL faculty and students working the IT booth were distributing flyers concerning the benefits for women in technology. She developed more interest in introductory courses and declared the major.
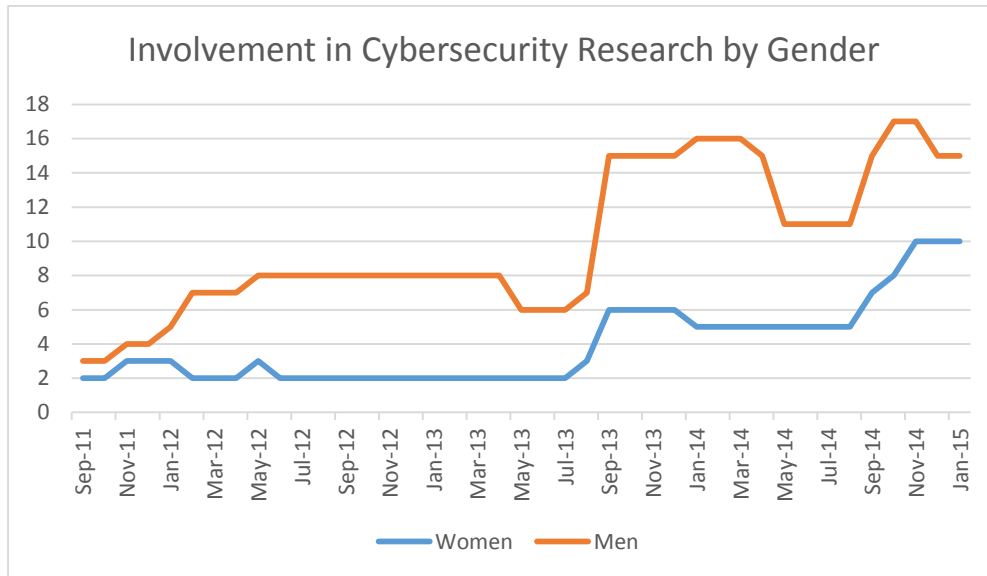
Figure 1 - Cybersecurity Research Participation by Gender at X (Institution)

From the mentoring provided in the CSRL it was noticed that women were more inclined to stay in the major. The CSRL provided a safe environment for women to feel a part of something and gain a better vision of what their future career could look like. There are currently 25 students actively involved in the Cyber Security Research Lab, 10 female and 15 male giving the CSRL an impressing 2:3 female to male ratio (Figure 1) in a major where women make up only 10% of current students (Figure 2). The CSRL has also to publish 18 papers 5 of which were lead-authored by female students and is working on publishing more. Women within the CSRL report that participating in the lab has helped to retain their interest in cybersecurity as well as the IT program. One woman described her experience in the following quote:

> *"Seeing what people could actually do and seeing the things we were learning (or would learn) applied in real life was amazing."*

Another female student commented on the social environment, describing it as a:

> *"Community that allows mentorship, to grow interests as a group" and "promotes research into interests you don't get to do in class".*

A female major from another computing discipline commented on the CSRL environment in the quote below:

> *"It is so relaxed and inviting, it makes me consider switching majors."*

For these and other women, they have felt that involvement and opportunities presented in the CSRL have allowed them to better see and understand the application of cybersecurity.
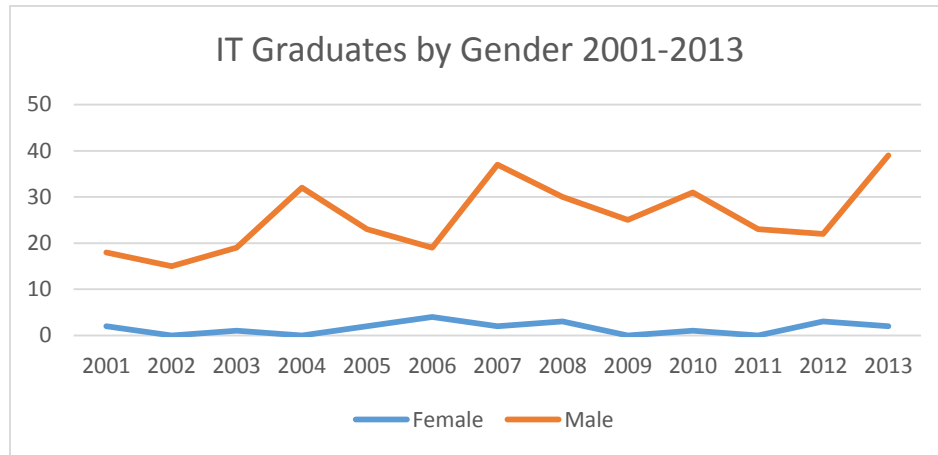
IT Graduates by Gender 2001-2013

Figure 2 - IT Graduates by Gender

Despite the reported retention benefits, there are also women who reported that they would have pursued their interest in cybersecurity without mentoring or targeted recruitment. However, in these instances, the women had specific predeterminations and interests within the cybersecurity field either developed from a young age, cultivated in high school years, or attributed to their own mentality and lifestyle. One woman described how she decided to take programming classes in high school and was around men who applauded her for doing so, thus preventing any inclinations of inferiority. This was incorporated into mentoring methods in an effort to create similar mentalities that women are equally capable in technical fields. Mentoring did not solidify interest for these particular women, nor was it the key to retention for all women in the CSRL; however, mentoring was a catalyst for gaining experience, building teamwork, expanding interest, and strengthening knowledge within cybersecurity. This shows building confidence at a young age and continuing through mentoring can help with retention methods as well as recruitment efforts.

Through the CSRL, there has been significant evidence of how women and men working together is beneficial. During a recent Collegiate Cyber-Defense Competition (CCDC), the CSRL competed with a four person team consisting of three male students and one female student. At the time this was very unusual, with most competing teams being all-male. One competitor was overheard to inquire why a team would "waste" a spot with a girl. Yet, the team ended up winning the competition in spite of the doubt that was shown by other contestants. The following year, new rules were set in place requiring every team to have at least one female participant. In this contest, a BYU CSRL team comprising of two women and two men went on to win the competition by almost double the points of the second place competitor — including an all-male team of cybersecurity professionals. It is clear that there are benefits that accompany men and women working together. Through equal representation there can be improvements in the work field as it provides new insights and new ways to approach a problem.

Consequently, in order to improve the number of women involved in cybersecurity, there is a requirement for an expansion of internal communities that are welcoming to all personalities, encourage social interaction, promote exploration, and continue to fight stereotypes that try to curtail the technical capabilities of each gender. The ability to find a community where one feels welcome to question and develop talents undoubtedly promotes retention, especially for women when taking on the challenges of a male dominated technical field.

What does this all mean? It means that women coming into cybersecurity, when involved in a mentorship program and instilled with a confident mentality, will have greater success in the field and an easier time navigating obstacles. It also allows for women, who are both new to the major and have never dealt with computers before, to feel comfortable and obtain a support system. For incoming women, having someone to rely on and lean on in this major is crucial and makes all the difference. This method of mentoring has not only significantly helped with the retention of women but has profited the recruitment process as well. As these methods have been implemented, a self-sustaining effect has been observed. As women make their way through these phases they in turn become the recruiters and mentors to their peers.

Conclusion

Women are vitally important to the progression of technology and cybersecurity. Production, performance, and innovation not only increase but thrive when cultured in a gender diverse environment. Mixed-gender environments have been shown to lead to greater productivity. In order to produce these environments, recruitment, retention and experience methods needed to be combined into a solution to fix this imbalance. Through targeted recruitment efforts, mentoring, and mixed-group environments, this imbalance has been growing smaller and smaller in the cybersecurity research environment created at BYU. Providing communities and environments that are open to all thought processes and personalities will allow the future of technology fields to grow and improve dramatically. Though it may be a traditionally male-dominated field, the methods expounded upon here will inform more women of the opportunities in the cybersecurity field. These methods when implemented will allow women to feel confident and excited in pursuing technical fields. Thus, through the presentation of mentorships and communities this engagement will be cultivated. Over time, the cycle will perpetuate until an imbalance no longer exists, and we theorize that both productivity and innovation will peak.

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