Prospectus

Confidence in Computing: A Career Preparatory Course for Undergraduate Computer Science Students
(Technical Topic)

Bridging the Gender Gap in Undergraduate Computing Programs: A Sociotechnical Approach
(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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Introduction

Computing majors drop out of their program or change concentrations at some of the highest rates of any college major, especially those in their first or second year of study. Efforts to improve retention in the field typically focus on addressing issues of self-efficacy, prior experience, and outcome expectations, as these are the strongest predictors of academic persistence in any course of study. For our capstone project, we are delivering a 1-credit course aimed at first-year and second-year computing students with relatively low indicators in these areas. The course focuses on exposing students to common industry tools and practices, with the hopes of raising students' self-efficacy and experience level and, thereby, retention. The course also requires students to complete three professional development activities, with the goal of improving outcome expectations as well as general feelings of confidence and belonging.

Sense of belonging is another important indicator for academic persistence and retention. Most computing students report that they feel welcome in computing. For underrepresented groups like women, however, feelings of exclusion from a predominantly male culture may play a significant role in their choice to leave the computing field or to begin to study it at all. There is a severe gender imbalance in computer science, both academically (in K-12 and higher education) as well as in industry. However, most efforts to correct this imbalance focus on early exposure to computing concepts, as opposed to improving women's experiences in computing programs. The STS research thesis will examine women in computing from a social constructivist perspective, analyzing the social group's relationship to computer science education and investigating methods to improve their sense of belonging and retention in the field.

Technical Topic

Computer science curricula in universities encompass a broad range of topics, including the theoretical foundations of the field as well as practical applications of computer programming and software engineering. In a recent survey of computer science undergraduates (n=7659) at various Ph.D. awarding institutions, respondents generally indicated satisfaction with the computing program at their school, and would recommend computing courses to friends (Computing Research Association, 2019). Despite satisfaction with computing programs, research indicates that coursework is not a primary motivation for continual study of computer science. In one study, researchers employ Social Cognitive Career Theory (SCCT) - a psychology framework concerned with how educational and professional choices are made - to examine the reasons why students choose to pursue computer science. They identify four primary motivations: prior experience, social support, self-efficacy, and outcome expectations (Alshahrani & Wood, 2018). Self-efficacy, defined by Bandura in 1986, is “people’s judgments of their capabilities to produce designated levels of performance.”

Furthermore, many students don’t form a professional identity from their coursework. Instead, they cite other factors like social connections to computing, computing-related activities, and professional development opportunities as influential to their identity as computing professionals. Students also mentioned that identities form in their second or third year of study (Kapoor & Gardner-Mccune, 2019). Given this information, a supplementary course in the first or second year of computer science curricula, with a focus on professional development, may benefit computing students - especially those with low self-efficacy and outcome expectations who do not seek these experiences on their own.

With the assistance of Professors Tom Horton and Jacob Somervell of UVA and UVA-Wise, respectively, a team of seven undergraduate TAs and I are delivering such a course: “Tools of the Trade” (TotT). TotT is a 1-credit course focused on teaching industry practices that may not relate directly to technical skills already incorporated into the undergraduate curriculum. This includes career guidance advice like resume writing and creating a LinkedIn page, as well as tutorials and guided activities for using industry tools like GitHub or Integrated Development Environments (IDEs). Students are also required to complete three professional development activities, examples of which include attending a career fair or hackathon. The course is aimed at first-year and second-year computing majors who have likely not yet developed a professional identity in computer science, and would generally show low confidence in their ability to succeed in the field, with the goal of helping students improve in these areas. This was accomplished by selectively admitting students to the course, based on the criteria that they took no AP classes in high school and have not completed an internship. Of the team of student instructors, Andrew Ni, Mara Hart, and I form the core research group that will answer the research question: What are the effects of a career preparatory course in increasing the self-efficacy and career expectations of computer science students who prior to undergraduate studies have relatively low self-efficacy, career expectations, and computing experience?

To measure improvements in self-efficacy and career expectations, as well as determine which factors of the course were responsible for any such change, we plan to employ two metrics. The first is a pre and post survey, comprised of questions which specifically measure self-perceptions of computing ability as well as relevant background information. We will track general trends as well as individual responses to answer questions about quantitative changes in self-efficacy and career expectations. Second, after obtaining approval from the Institutional Review Board (IRB), we will conduct interviews with several students to gain insight as to which features of the course had the greatest impact on these criteria. By the end of this project, we hope to have a good understanding of how this career preparatory course affects students' confidence in computing, as well as ideas for how to improve this course for future semesters.

STS Topic

Computer science is one of the fastest-growing and most lucrative fields to study today. In 2019, the median pay for a computer industry professional was $122,840, and the Bureau of Labor Statistics (2020) predicts an industry growth of 15% in the next decade. However, when examining K-12 education or university program enrollment in computing studies, one takeaway is clear: computer science is a male-dominated field. According to data from College Board (2020), of the 70,580 students who took the 2020 AP Computer Science A exam, only 25% were female. Moreover, despite there being significantly more female students taking AP exams than male students - nearly 1.5 million versus 1.1 million, respectively - the proportion of male AP students taking the AP Computer Science A exam outnumbered the proportion of female AP students by a factor of 4 (College Board, 2020).

This gender discrepancy in computing studies continues into university and beyond. In a 2017 survey of Ph.D. awarding institutions, the Computing Research Association reported that introductory courses for computing majors at public universities had a median female enrollment of 21%; for upper level computing courses, this figure drops to 15%. The National Science Foundation (2015) reports that only 18% of all computer science bachelor's degrees awarded are earned by women. Interestingly, this phenomenon of low female participation in computing studies does not extend to other STEM fields. The share of computer science bachelor's degrees awarded to women has declined from 27% in 2000, despite increases in numbers of science and engineering degrees awarded to women in the same period (National Science Foundation, 2015). In one study, over 77% of women (compared to 45% of men) who initially declared a computer science major eventually left STEM altogether, the highest rate of any STEM field (Ferrare & Lee, 2014).

Looking back at Alshahrani et al. (2018), discrepancies between men and women choosing to study computing may be heavily influenced by a lack of prior experience, social support, self-efficacy, or outcome expectations in women. They cite Taylor and Mounfield (1994), who found that prior experience in computing strongly correlates with female undergraduate success in a computer science major. Given the overwhelmingly male makeup of high school computing courses, women may simply not have enough exposure to the subject to choose it as a field of study. Lack of prior exposure may impact self-perceptions of computing skill and amplify feelings of low confidence and self-efficacy in women (He & Freeman, 2010). However, even when women performed equally to men in computing tasks, they indicated lower levels of confidence in self-assessments (Liberatore & Wagner, 2020). This is significant, Alshahrani et al. (2018) point out, as "most people are attracted to, and pursue, tasks and fields in which they are confident."

Additionally, perceptions of computer science as "nerdy" with little social connection to computing beyond these stereotypes makes women significantly less interested in majoring in computer science than men (Cheryan, Plaut, Handron, & Hudson, 2013). Cheryan et al. (2013) argue that stereotypical perceptions of computer scientists as "lacking interpersonal skills and being singularly focused on computers" are "incompatible with the female gender role." This raises an interesting point about women's sense of belonging in computing. Blaney and Stout (2017) found that women rated their self-efficacy and sense of belonging in computing significantly lower than men (especially so among first-generation college groups). This is important as even when controlling for self-efficacy, a sense of belonging forms a powerful predictor for academic persistence in STEM fields (Lewis et al., 2017).

Such feelings of exclusivity may arise from existing gender imbalances in computing courses. But they may be exacerbated by other aspects of undergraduate computing programs. For example, company recruiting sessions are an important resource for undergraduate students looking for careers or professional development experiences (i.e. internships) in the computing industry. Wynn and Correll (2018) examined these recruiting sessions and found that certain common themes create a culture of female exclusion. Gendered references, overt stereotyping, and gender-imbalanced presenter roles were key factors, they argue, in reinforcing an environment that is alienating to women and lessening women's interest in technology careers.

Sense of belonging can be better understood as an influence toward continued academic persistence in computing from the perspective of the Social Construction of Technology (SCOT) framework. SCOT, developed by Pinch and Bijker in 1984, asserts that various social groups have unique values regarding particular technologies, or "interpretative flexibility." Furthermore, it is a result of these social groups' relationships with a particular technology that allows that technology to reach a stable state, or "closure." Given the historical absence of women in computing, it may be that computer science as a culture has reached such closure, without the contribution of women as a relevant social group. Garcia and Scott (2016) explore these ideas by applying the lens of intersectional feminist science to SCOT, examining efforts to close the gap in graduating women of color in STEM fields, and how they have fallen short due to their focus on technical acuity and general disregard for the social relationship between technology and its users. They then offer the counterexample of CompuGirls, a "culturally relevant" technology program that teaches girls of color from under-resourced schools how to use technology to approach their intersectional identities, and critically examine technology as a socially shaped artifact. This program reflects other efforts to increase the interpretative flexibility of computer science, such as at Stanford, who introduced "bridge" programs for women and other underrepresented groups to expose them to the many applications of computer science beyond programming. Notably, these bridge programs resulted in significantly high retention rates (Roberts, Kassianidou, & Irani, 2002). By approaching the gender gap in computer science from a sociotechnical perspective, we can explore the educational improvements that can be made to increase the interpretative flexibility of the field, aiding women's sense of belonging and ultimately retention.

Next Steps

For my technical project, we plan to refine our data collection methods between now and the following semester, so we can obtain clear results on the TotT course's impact on students' self-efficacy and outcome expectations. Additionally, we will have a completed public curriculum published on YouTube for any undergraduate student to learn and benefit from. For my STS thesis, I will investigate various improvements that can be made to the computer science curriculum to increase women's sense of belonging and ultimately improve retention. I will mainly focus on existing literature on other universities' efforts to address this issue. I plan to discuss these suggestions with a focus group of female computing students, comparing them with their current experiences in their undergraduate program. The conclusions I draw in the STS thesis will hopefully prove beneficial to the course design of TotT, and further improve feelings of self-confidence, self-efficacy, and retention among students in the computing program.

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