Improving Computer Science Curriculum through Cooperative Education

The Role of Sociocultural Dynamics and Relations in Computer Science Education and Industry

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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

As the world evolves technologically, computer science (CS) careers are in high demand. According to the U.S. Bureau of Labor Statistics (2022), computer and information technology employment is projected to grow 25% between 2021 and 2031. Following this trend, more students are choosing to earn CS degrees. Growing 12.1% from 2019, more than 53,000 CS degrees were awarded in 2020 alone (Data USA, 2022). Traditionally, the task of managing the transition between universities and the computer science industry falls largely on students. While universities may attempt to create a CS curriculum that provides students with necessary algorithms and tools, the CS industry is constantly changing and the skills provided by these classes fail to aid students in preparing for their future careers and do not always meet the needs of current and future employers.

To address the technical shortcomings of the current CS curriculum at the University of Virginia (UVA), I will propose the development of a cooperative education program. Many universities, such as Northeastern and Georgia Tech, have cooperative education programs. These cooperative education programs, which are also referred to as co-ops, combine classroom-based education with practical work experience, allowing students to learn by using academic knowledge in practical settings (Huggins, 2010). Currently, UVA does not have a co-op program. I believe that students should have the option to apply their academic skills to real life applications, allowing them to explore relevant skills and discover how compatible they are with being a computer scientist.

In order to ensure the success of the new program I am proposing, it is necessary to consider social factors that normal CS curriculum fail to incorporate. A successful program would need to correctly acknowledge the difficulties of onboarding at a new job and provide support for students of varying experience levels (Salguero, Griswold, Alvarado & Porter, 2021). Due to the diverse background of students, there should be a mandatory co-op preparation course that covers essential topics such as resume workshops, career exploration, interviewing skills, and professional conduct in the workplace. Employers and administrators will need to communicate throughout, outlining expectations and progress, as well. I will analyze some current failures of diversity and mental health considerations of CS programs and co-ops, in the hopes of mitigating these issues in the new co-op program.

Technical Project Proposal

This past summer, I became a software engineer intern for Amazon's Seller Fulfillment Services team. Over the course of 12 weeks, I received a project requirement relevant to the team's functionality, created a design document proposing my solutions, then worked with my mentor and manager to implement my idea.

While I knew myself to be a good programmer and problem solver, I found it difficult at first to transition to interacting with a complex system. Schools are often guilty of providing more theoretical knowledge than practical experience (Exter, 2014). I found this to be true upon starting my Amazon internship as I struggled to adjust. When it's an internship, there is already not a lot of time being spent working with a company, so even taking 2 to 3 weeks is a lot to successfully onboard and become familiar with the system. That's not to say that my CS classes

at UVA left me completely clueless. Of course all the CS classes I had taken up to this point provided me with a strong foundation in being familiar with common programming languages (Python and Java) and problem solving skills. My advanced software development class had taught me how to collaborate on a project in a group and code in an agile environment, a kind of software development practice used by many companies including Amazon. Additionally, concepts I learned from my algorithms and data structure class were useful when completing the technical interviews while going through the recruitment in the first place.

The most difficult part of the internship for me was not creating or implementing a new product design, but rather processing a lot of new information given to me and quickly adapting to a completely new system that does not have good documentation. Due to the many services and millions of users of Amazon, the code base I was working with was massive and any code I wrote would have to be scalable to a larger platform through numerous testing systems. While this makes sense, this was not something that I had been prepared for and knew nothing about, even theoretically. This is not a new experience however; Begel and Simon (2008) similarly found that although new graduates typically have proficient coding skills and are taught programming languages extensively in their curriculum, new hires' technical skills, such as testing, debugging, and revision control system, are often lacking.

As mentioned above, there were some gaps in my knowledge of both hard and soft skills that inhibited the progress I made while working on my internship. If I had known more about the application process, how to conduct myself, and what to expect from the workplace, I would have been able to adjust to working at Amazon faster and been more efficient in my time interning there. As said by a co-op participant in a study by Exter (2014), "An ideal program

would bring existing large-scale real-world applications and infrastructures into the curriculum. Current traditional college degrees have a tendency to teach students how to ride a tricycle. This doesn't teach them how to work on a busted jalopy rigged with a car bomb." I believe that the CS classes in their current form do not adequately prepare students for the software engineering workplace.

The CS program at UVA would benefit from the creation of a co-op program and mandatory co-op classes. It is necessary to integrate soft skills into CS curricula, allowing CS programs to provide and encourage experiential learning opportunities to teach students to connect and collaborate with others (Stepanova, Weaver, Lahey, Alexander & Hammond, 2022). The classes, taught by the co-op faculty, will prepare students for interviews, facilitate career exploration, practice interviews with students, and teach them the necessary soft skills required by employers. Communication will be important as well, as employer expectations of the cooperative education experience are often independent of those of the academic institution (Huggins, 2010), and students should be communicating with employers and administration to ensure they are on track and their needs are met.

STS Project Proposal

The University of Ottawa conducted a study of ten co-op students, interviewing these students during the academic semester and job search process preceding a work experience, during the work experience, and during a subsequent academic semester (Milley, 2016). Milley found that the motivations behind students' decisions to join a co-op program were, for some, more of a necessity than a preference. Concerns about labor market outcomes and personal finances were more pronounced for mature students and those from small towns and rural areas,

those from minority groups, and those who experienced difficult economic circumstances. During academic semesters leading up to work experiences, they attend preparatory workshops, write résumés and covering letters, apply for jobs, and go to job interviews. At work, students saw co-op work experiences complementing the technical nature of their accumulation of soft skills. By engaging in this process, co-op students were able to market, exchange, and accumulate their human capital, networking themselves and their skills to the university and the workplace. However, despite the skills gained, students wanted more of a balance between sociocultural and economic contributions to the system.

When discussing integration of a co-op program to CS curricula, previous research considers the benefits of the 3 parties at the core of every cooperative education experience: the student, the employer, and the academic institution (Huggins, 2010). While these are essential, they fail to consider beyond just these main technical actors at the center of a co-op program, leaving out other important social and cultural actors. If we only focus on the technical relationship between the students, employers, and the academic institution, then we will not have a full understanding as to the failures of the University of Ottawa co-op program, which is essential to understanding how a co-op program should be developed to create the most successful and beneficial program for all parties involved.

I argue that the lack of technical skills of the students in the co-op program, lack of preparation from the academic institution and lack of support from the employers were not the only reasons for the students' failures and difficulties during their work terms, and thinking so would fail to account for the power dynamics between employers, administrators, and students and the patterns of social relations in workplaces. For example, many students noted that their

skill development and progress were directly affected by their experience with the power dynamics in the workplace, even going as far as suggesting the university spend time teaching students what their rights are and how to advocate for themselves in those difficult situations (CITATION MILLEY). Similarly, a student struggled to communicate challenges to her male co-workers, with her co-op administrator advising to focus on "people skills", when the problem at hand was due to gendered power dynamics. This translated to both on campus and at work. With the group of women students in her academic program she could be communicative through asking direct questions, but with the male students she found that she needed to be tactical and reserved to avoid "big confrontations." This dynamic created a roundabout way of learning and diminished the size of her potential learning network.

Estimates suggest that women and immigrants are less likely than their peers to have success in the labor market (Wyonch, 2020). Researchers from the same study found that participation in a co-op program is beneficial for successful transition to the labor market for new graduates in terms of income, full-time employment, and occupational relevance to their field of study, which coincides with the motivations of the students in the Ottawa study. In addition to assisting with financial burdens by allowing students to make money, co-ops can help set up underrepresented students who might not have the opportunities and connections that majority students do, driving the demand for support for these groups. These positive career outcomes suggest a promising pathway to broaden participation and diversity in the engineering profession. However, underrepresented minority students are less likely to participate in co-ops than white students, even when controlling for other demographic and academic motivating factors (Johnson & Main, 2019). This prevents underrepresented students from potentially benefiting from co-ops for professional mentorship opportunities and socialization to equalize

the field. Thus, I argue that it is important to understand how to best serve and cater to these students with the co-op program, so that they don't have to have the same experience as the students in Ottawa.

To frame my analysis of the creation of the co-op program, I will draw on the science, technology, and society (STS) concept of Actor-Network Theory (ANT), which claims that technology is produced by network builders and the how and why can be traced back by examining the actors in the network, to examine certain aspects of how co-ops can be improved by analyzing how all of the actors interact as a whole to accomplish a goal (Cressman, 2009), by considering social and economic factors, rather than just the technical program. To support my argument, I will utilize evidence from articles with data pertaining to mental health in the workplace, dealing with equal representation, and overall experience from underrepresented minority students.

Conclusion

In my technical report, I hope to create a co-op program which can be adopted by the CS program at UVA, better preparing students for the workplace by providing them with more experience, allowing them to be aware of the social conditions of joining a new software engineer job. These social conditions are skills that are not expressly said by employees, but are important for a functional workplace, and would be learned while still in school through a co-op. In order to help me create a more comprehensive program, I also would like to gain some understanding from my STS research into how to incorporate the priorities and concerns of underrepresented social groups, by examining some current failures of diversity and mental

health considerations of CS programs and co-ops. With this additional knowledge, I hope to resolve these issues in the new co-op program, creating a more diverse workplace in the software engineering industry.

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