CS curriculum missing substance that benefits students' Employment

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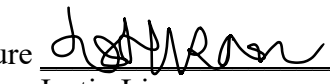
Signature  Date 05/07/2022
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Introduction

"An investment in knowledge always pays the best interest" – Benjamin Franklin.

In today's society, going to higher education is often seen as the next step in pursuing employment and making a higher income. Millions of students each year invest tens of thousands of dollars to acquire a degree that will say they are qualified for the workforce(*Computer and Information Technology Occupations: Occupational Outlook Handbook 2021)*. But what if even after spending that much money, students are not getting the applicable knowledge needed to get hired and succeed in their respective fields?

For computer science students, there is a gatekeeper that they will certainly face. This gatekeeper is the technical interview. The technical interview is like an audition a musician would have to do to join an orchestra. But while auditioning, the musician has to speak aloud about what he or she is thinking to the interviewer. This is what people in the computer science field must do almost every time they apply for a job. Unfortunately, undergraduate students are often not prepared for the technical interview. In my capstone and technical, I go over what can be done and offer a solution to address how students in higher education are not exposed to the technical interview, even though it is something they absolutely will face.

In this STS research paper, I address other shortcoming of the computer science undergraduate curriculum. The CS undergraduate curriculum at this moment in time needs more of what students need to succeed in their future career. This includes how to manage a situation

where ethics is an issue, soft skills that will be needed in general, and how to generally be a better employee. These are the issues computer science undergraduates currently face.

Literature review

The computer science curriculum has long been researched, ranging research topics from how to get more prospective students to major in computer science to making the curriculum more applicable towards employment (Weaver 2010 & Garousi et al. 2020). In recent years, there has been emphasizes on post-graduation and employment aspects of the computer science curriculum. Topics include what employers are satisfied or dissatisfied with, what they look for from graduates and what graduates are lacking, etc.

Weaver shows that there have been efforts to change to the computer science curriculum to get a desired outcome. The outcome that Weaver wanted to come from his research was an increase in enrollment of computer science major in undergraduate. Weaver's research was split into 4 core parts where he looked at the state of the computer science curriculum, how job posting promoted themselves, get input from those involved such as enrolled students and prospective students, and finally using what was discovered to come up with a potential curriculum that might make prospective students more likely to major in computer science. I am also looking to change the computer science curriculum for a desired outcome, where students are more prepared for the workforce post-graduation.

Garousi et al. looks at other studies on improving this issue and consolidating their findings on what needs to be done and what is needed. Their review discusses what are the most important skills that have the most gap between industry and higher education, discussing whether hard skills are enough, and discussion of how the authors are applying their findings to

their own roles as educators. This paper shows that educator has have responsibility to their students in what they do post-graduation. The paper focuses mainly on the industry perspective as they interview hiring managers/directors for their input on their entry-level hiring process. Asking students for their input could have provided more insight on what exactly is lacking. Getting involved the most affected actors is crucial when coming up with a new idea.

At Stanford University and Harvard University, there are courses that teach students applicable knowledge and situations they will most likely face in their future career (Grosz et al. 2019 & Stanford University 2020). The CS 9: Problem-Solving for the CS Technical interview course at Stanford University is an ideal starting line for what this paper envisions. The course teaches students about the technical interview; something that the students will almost certainly face as they begin their job hunt after graduation. This paper seeks to prepare undergraduate students for the job force and make the transition as smooth as possible. Harvard University and Stanford University both are trying to address situations students might face via courses that teach about ethics, where Harvard is evaluating a pilot program and Stanford has the course CS182: Ethics, Public Policy, and Technological Change (Stanford University 2020 & Grosz et al. 2020). These courses teach their students the implications of their work and how damaging and detrimental they can be, regardless of whether the results were intentional or not. Stanford's course is co-taught by Jeremy Weinstein, a professor of political science, and Mehran Sahami, a professor of computer science (Stanford University 2020). Harvard's approach is to embed ethics into all courses so that there is not an increase of courses to be taken while also meeting the "student demand for learning about ethics and the potential societal impact of their work as well as for acquiring computer science technical competencies" (Grosz et al. 2020 pg 1). These two approaches in teaching their students ethics are not part of the standard computer science

curriculum. The courses discussed are what this research paper has in mind to help students be better prepared for their future career.

Many papers have concluded that computer science students need to have some sort of way to develop their non-technical skills, also known as soft skills. This is because these skills are highly valued and sought after by employers and can determine how successful an employee will be. This relationship is even more prevalent in the computer science field where communication and problem solving are essential to completing the job. Carter and Gorousi et al. discuss how important soft skills are and how pure technical skills are not enough to succeed in the field of computer science. With non-technical skills being so important, this paper intends to include the improvement of these skills to better prepare students.

Burke et al. discusses the differences between a traditional four-year higher education and coding boot camps in terms of cost and time. A coding boot camp on average is $12,147 and 10-12 weeks, while a four-year education is on average $98,440 (Burke et al. 2018). With boot camps having a focus on employment, according to Burke et al., hiring managers have a "general favorable perspective of coding boot camp hires" in terms of soft skills. Additionally, in the discussion section, boot camps are discussed as the alternative training ground for software development industry." This suggests that higher education is not providing everything it could be to its students, despite the time and cost of it.

Methodology

For this paper, I interviewed past University of Virginia computer science students who have graduated recently to get their input on the proposed solution to the computer science curriculum. In the figure below, I have the questions I asked and the responses of the three

software engineers; all of whom have been working a little less than a year at well-known companies. The reason I wanted their input is because having experienced what the current computer science curriculum had to offer, I wanted to know if there is anything they wished they had been exposed to in undergraduate that could have prepared them for what they are currently doing in their day-to-day career. By knowing what they would have liked to have been exposed to, I will have a better idea of what exactly should be improved on.

College	SWE 1	SWE 2	SWE 3
Works for…	***Amazon***	**Capital One**	**Appian**
Do you think there should be an ethics course geared specifically for computer science?	Yes, worthwhile course, because we don't work with the implication of our code	Yes, especially relevant in data science and analytics. Maybe even have its own department	Yes, because it's something not important until it comes up. Should be incorporated early
How important are soft skills in your day-to-day career?	**Very important, most of the job even. Not as much coding as identifying things that need to be done**	**Really important, good to have so you can show what you have accomplished**	**Important, the skills that I find valuable are conflict resolution, communication, and presentation**
Scale 1-10, with 10 being the most important, what would you give soft skill?	8 or 9	8	10
Are there any classes you would have liked to have had before our current job?	**Classes that taught skills that can scale to industry, there should be a healthy selection of applicable courses**	**Courses that teach technical/current industry, prepare for real-world, soft skills. Essentially, expose to real-world applications**	**Soft skills in general, maybe have a course that allow students to co-op. Basically, give students exposure to real-world stuff**
Parting comments	**When applying to jobs, starting out can be really hard. It's a number's game.**	**Not a whole change to the curriculum, but professors should realize that students need experience and help students get the knowledge they need to get jobs**	**A little too much theory. What's important is how you think after taking a class.**

Rearch Findings

The primary motivator for this research topic was my expectations that the undergraduate computer science curriculums to prepare me for the work force. All my life, I was told to get good grades to get into college, so I did. I was told go to college if I want a well-paying job, so I did. But now that I'm nearing graduation, I am not convinced that undergraduate computer science has really prepared me for the promised job I was told over and over since childhood. Though I am stuffed with knowledge, not all the knowledge I have been stuffed with will not be applicable to any future career path I may choose. For a computer science curriculum to address the expectation of those who go to college to get a job, it must include development of skills that will help students succeed in the future. In the proposed CS curriculum, there are three major pillars that it should revolve around.

The first pillar is exposing students to real world applications and experiences. Many colleges and universities that teach computer science often "focus on theoretical and technical computer science topics as well as mathematical foundations" (Garousi et al. 2020). According to Garousi et al., this "causes a discrepancy between the skills learned from a [software engineering] university education and those needed in SE employment". Based on my own experiences and of those my peers, there does feel to be some lack of connection to what might be need in employment and the contents of certain courses. In figure 1, there was the same sentiment in those I interviewed. Foster et al. pushes for a curriculum that prepares for a "cloud-first" future. There are many other papers that also lament over the disconnect between higher education and industry and offer guidance of what to do.

Students need to know the skills that they will apply in the future. Exposure to real-world skills is crucial for a smooth transition into the computer science workforce. The significance of

adding real world skills to a CS curriculum is that employers will gain a more qualified employee and will not need to spend as many resources getting the new hire up to speed. Students also benefit by becoming more employable and gain the confidence in applying for jobs. Bruke et al. states that there is a shortage of software engineers, but Gorousi et al. suggests that instead of a shortage of software engineers, there is a shortage of "well-studied, experience engineers with a formal and deep understanding of software engineering".

In addition to knowing the skills, students also need real-world experience. The reason most students apply for internships is to gain experience and show that they have experience on their resumes so that acquiring future jobs is easier. My capstone is a subset of this CS curriculum, where it would expose students to the technical interview. Once past the technical interview, students will learn new skills and gain experience in their internship. But expecting the company to teach students everything is unreasonable. Internships are often a student's first exposure to real world situation, which puts stress and pressure on the student to perform well. By providing students the experience they need, students will boost their confidence and give employers a strong employee.

Ways to incorporate this into a CS curriculum can be having courses arrange co-ops and internship with business partners and sponsors. Co-ops and internships arranged by colleges and universities can be a fantastic way to get students experience while also closing the gap between higher education and industry. These courses should not contribute to credit as all internships are different and cannot be standardized. Higher education should merely provide students the opportunity. As of time of this paper, UVA has a a specific topics course, CS4501: Cybersecurity and Elections, that is arranging to have its students intern with local election offices (Lou's List 2022). This is exactly what I had in mind for a CS curriculum. Unfortunately, this type of

firsthand experience is limited and not guaranteed to here for future students. A post-graduation curriculum would ensure that such a class is permanent, so all students can have the chance to gain experience.

The second pillar needed for this curriculum is students learning and developing the non-technical skills they need to succeed and thrive in the field. In every job description, from intern to senior positions, soft skills are listed as highly recommended. There have been many studies done that on non-technical skills and their important in employment. Burke et al., Carter, and Gorousi et al. all discuss the importance of soft skills in employment. Even though it is so widely known that these skills are needed, the current state of the CS curriculum is not doing much in the way of addressing this demand. According to the Carter, the reason is that students and faculty alike look down upon a course that teaches about soft skills saying that they already have the skills, or it is a waste of time. And yet, employers are constantly saying they need new hires to have these skills. Burke et al. states that while interviewing industry manager/directors, they mentioned soft skills came up twice as much as technical skills. This demonstrates that there is a demand and a need for soft skills in students. A course for soft skills would be required to ensure students meet employers' expectations. The benefits of a required soft skills course would show in the success of the students' post-graduation. Interviewing those who have graduated only recently and have jobs, I can see that having these skills are vital to making a project succeed on time and smoothly. Employer satisfaction would increase, and newly hired students would reap the rewards of being a useful part of the team.

The third and final pillar in this new curriculum is a need for ethics. Ethics is often overlooked when it comes to the computer science curriculum, but there has been a recent trend in some universities of implementing ethics into their curriculum. Ethics is crucial to any

computer science student's education because it offers a new perspective in computer science students often do not consider. The code we create in courses do not have any consequences outside of class. This is not a good mindset when entering the real world where things have lasting consequences. One of the recently graduated software engineers I interviewed sums it up as it's not important until it comes up. In the heat of the moment, those who graduated from higher education should have the mindset of what is the right thing to do and consider those who the choice affects. With the world becoming more digital and online, our choices matter more as everything is becoming more connected. And these choices will be made by current students in future positions.

Understanding the implication of revising a new computer science curriculum with the focus on post-graduation employment is critical. This includes the shaking of the status quo and considering who it affects. Students are the ones this change aims to help, but there are other parties that are affected. If CS curriculums do change to focus on post-graduation and help students get employed, then faculty and industry will also be affected.

Higher education, represented by faculty, would need to change a lot of the current way of teaching. This includes developing new courses, hiring new staff that would suit the needs of the new curriculum, and other logistical issues. This means it would take time to transition. To remedy this, having a pilot program with volunteers would be the first step and edit based on student feedback. Harvard is trying to implement a pilot program called "Embedded Ethics" to integrate ethics into their curriculum (Grosz et al. 2019). Eventually, through trial and error, CS curriculums should be refined to help students get employed and be a model employee. Industry would be affected in getting a new improved generation of graduates who are closer to their needs. This new workforce will be more efficient and productive because the tradeoff for hiring

would be offset by the experience knowledge provided by higher education. A more productive employee means more value to a company, which would have a ripple effect in the economy.

There are also ethical questions that come up from a new curriculum. Soft skills such as communication and problem solving need to have some standard if they are to be taught in a course. The question is who gets to decide those standards and how those standards are decided. Carter states that students and faculty alike do not particularly favor such a course, so is forcing them to take and teach the course respectively ethically acceptable when there could be some subjective bias in what counts as good communication or problem solving?

Even before the development of such a curriculum, higher education is expensive. Those who aren't financially well off would be incentivized to enroll in the hopes of getting a job after graduation. But if they do not have the resources to enroll in the first place, it would be cruel to tempt them. Does creating a higher education curriculum further widen the gap between socioeconomical classes? These unintended consequences show that no matter the technology or idea, there are those who affected.

5. Conclusion

Higher education should help it students become more employable after graduating. The best way to do this is to have a curriculum that prepares them for the real world and give them the skills they need to succeed and thrive. Unfortunately, the current state of the computer science curriculum is not up to scratch when it comes to helping its students becoming employable as possible. Students need to have classes that teach them real world applicable skills that they will bring to the table when they go job hunting. In addition to this, higher education should also provide opportunities for students to gain experience. At the end of the day,

experience trumps all, so having students that have experience before they graduate would be a huge resume booster. To supplement this experience, students should have the non-technical skills to translate their skills to other people and the ethics to use those skills. Courses would be available to teach about these two crucial skills.

This project has the intended consequences of proving the quality of hires coming out of computer science undergraduate. Improving the relevant skill levels and capabilities of students and giving experience to students, so that they are more employable. This has the significance of providing the future with a more capable workforce that can deal with future challenges more easily. Students will also not have to worry about finding a job after graduation as much. The unintended consequences include the transition to the new curriculum and how the socioeconomical gap between those who can afford higher education and those who can't widen.

Future works of this design can branch into many other topics. As mentioned earlier, soft skills can be subjective and does not have a standard. A potential future work can be where exactly is the line between good and bad communication skills. By interviewing those in industry what they consider to be an adequate level. Other future works can be spreading the concept of making students more employable to other departments and majors, what real world skills should be taught in CS curriculum, and how much experience makes a difference when applying to jobs.

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