Project-based Education: Enhancing the Curriculum for a Competitive Workforce

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ABSTRACT

Currently, computer science students at the University of Virginia have limited experience working with projects that emulate the work they will be expected to do in their careers. In the class that is most like the expected work, CS 3240—Advanced Software Development, students engage in a semester-long project. However, the scope of the project is limited to a university environment, so students only gain a limited understanding of future projects in the real world. To improve students' employability, I propose enhancing their experience with projects that last for the duration of their time at UVA. Early in their program, students would begin work on a project with some entity within the Charlottesville community. Instead of just a semester-long project, this project would start as soon as they decide to pursue a CS major and continue until they graduate. The benefits of this project would be two-fold: students would gain real world experience with clients and their projects could help the Charlottesville community. Implementing a project of this scope would naturally require a trial period to observe the effects and to see how students react to it.

1. INTRODUCTION

UVA's computer science curriculum currently consists largely of courses that teach the necessary content for a student to be considered proficient in computer science. One class, Advanced Software Development, includes a project, and that project is relatively simple, dealing with basic skills**,** such as Python, Django, and HTML, which have somewhat limited applicability in a professional environment. The soft skills used for that project are valuable but are only developed over the course of a single semester.

Further development of these skills is mostly done through summer internships. By extending skills development in their time at UVA, students will have better internship experience and improved job prospects. The optimal way to master the necessary skills would be to have the students work on a project for the duration of their time at UVA.

2. RELATED WORKS

Renz and Meinel (2019) implemented a similar project on a smaller scale than a university, but in collaboration with several industry partners. The approach they modeled adds a project to a more typical curriculum, with the project comprising the latter part of an undergraduate degree. A two semester-long group project is done under the supervision of advisors working with professionals. There are a wide range of projects that students can select.

The group acts as a professional group would, using communication channels like Slack, holding code reviews, and having daily meetings. The industry partner takes the role

of the customer, and the advisors take the role of product owner. Throughout the project, students are surveyed on a variety of topics-to see if the project is beneficial. Students largely liked the project, believing it to be a valuable use of time. Additionally, the experience working with an industry professional and with a group gave them experience that they would not usually develop until after graduation.

Vaz and Quinn (2015) researched employer perceptions of project-based education. Students at the Worchester Polytechnic Institute (WPI) have a project included in their curriculum. The researchers interviewed employers from industry, non-profit organizations, and the military to determine if the project-based curriculum made the students more attractive. According to the employers, it made students easier to train and to integrate into their organization. Even employers that did not know about the curriculum believed that graduates from WPI were well prepared for a professional career. The curriculum at WPI requires two projects to be completed before graduation: an interdisciplinary one in the junior year, and a project related to their major in the senior year. Both projects are done in groups and usually with support from an external sponsor. Additionally, many of these projects are done off-campus, often with community organizations.

3. PROJECT DESIGN

The current curriculum at UVA is a standard computer science curriculum, covering a wide range of CS topics. Students can supplement these courses with internships. The following section details a possible change in curriculum that would focus more on project-based learning. This represents a skeleton for curriculum, and will have to go through changes and specifications before being ready for deployment.

3.1 First Year

UVA engineering students declare their majors at the end of their first year. Before major declaration, the curriculum will remain the same as it currently is. It provides a good general understanding of engineering and coding. By the end of the year, students should be knowledgeable about the basics of programming through the required introductory CS classes. Additionally, they will be exposed to the professional responsibilities of engineers through their STS class. Students that are interested in pursuing CS should also be informed of the project requirement and encouraged to think of possibilities.

By going through this year, students should have a good understanding of how engineers work and have at least some ideas of what project they want to pursue. During the summer of their first year, most students pursue internships to prepare for their career. Students that choose to major in CS would be encouraged to do the same, and to look for opportunities to inspire their projects. Going through this internship will certainly expand students' coding and engineering skills. Students that do not pursue an internship during this time could take future classes to prepare.

3.2 Second Year

After the first year and summer, students should have had built the foundation for their engineering and coding skills. Those that spent the summer at an internship will be especially well-prepared and have more detailed ideas for their projects. During the first semester of the second year, CS students will be required to take a class where they design their projects. This class will work well as a Pass/Fail class. Students will work with the professors and their advisors. An approved project proposal will be necessary to pass this class.

This will also be the time for students to form groups. It is unlikely that a single student can make a successful and meaningful project in their undergraduate career. Additionally, working in groups will better prepare students for their careers, where collaboration is non-negotiable. Students that want to work individually will be allowed to but should be heavily encouraged to find partners. Committing to any project for several years would be difficult, making it necessary to provide external motivation. A good way to do this would be to have the project be in some way tied to the Charlottesville community. UVA is the center of Charlottesville and having projects from the students benefit the community would require students to consider the needs of their clients, a valuable trait that will further help them in their careers. To further encourage this collaboration, a representative of the Charlottesville community should be a part of the project design class and have some say in the approval of the project.

Following the successful completion of the project design class, students will have their projects and groups and be ready to start tackling the work. During the second semester of their second year, students will begin working together and start the project. It may be beneficial to have another Pass/Fail class to help encourage the project and give them a professor with whom they can work. From this semester onward, it would be difficult and unnecessary to micromanage the students. Giving them a professor to turn to for advice should be enough to ensure success with the early stages of the project. So long as sufficient progress is made on the project, students will earn a Pass in the class. This is hard to quantify, but the professor and the group should be able to determine what counts as sufficient.

Over this summer, students typically pursue an additional internship. Students should obviously be free to pursue whatever internship they are interested in but should be encouraged to look for internships that relate to their projects. Doing this would help them with their project, and it would give them more experience in the field they are interested in. They would return from the summer with more ideas on how to improve their project and connections with the industry they want to eventually work with.

3.3 Third and Fourth Years

The project-based curriculum following the second year would be incredibly free-form. Professionals are trusted to operate very independently in their careers, and students at this stage should be trusted to do the same. They should continue to make progress on the project and must submit their work every semester to show adequate headway. Over the summer of their third year, students will once again pursue an internship. This will give them ways to improve the project, and by this stage, the project should be far along enough that they can show it to employees at the company where they intern. Soliciting feedback and advice will enable them to stand out among other interns, depending on the impressiveness of the project. This will further incentivize quality work.

In the first semester of the fourth year, students will continue to work on the project and should be mostly finished by the end of the semester. Starting in the final semester, students should work to implement the project in the Charlottesville community and write a paper on the project to be included in their undergraduate portfolio. By graduation, their project should be up and running.

3.4 Post-Graduation and Early Graduation

After graduation, students will go on to pursue careers in their preferred fields. Surveys should be sent after this to see if they benefit from having such a project in their repertoire. By evaluating their jobs and whether they feel the project was helpful to

gaining employment, improvements can be made to the curriculum.

There is one point of concern when considering this curriculum and that is the possibility of early graduates, those who only take three years to finish the degree. They will have to operate on a different timetable than other students and might have difficulty finding groups to work with. An easy way to rectify this would be to have students provide their plans for graduating early and then have them work with other students that plan to do the same. This way, no project will be left unfinished by graduation. They will also have to work harder to complete the project as they will only have three semesters between approval and graduation. However, this should be enough time to ensure a quality product, perhaps missing some of the bells and whistles that can be added in the fourth year. It will be especially important to solicit information from these students after graduation to ensure that the project requirement is friendly to those with expedited undergraduate careers.

4. ANTICIPATED RESULTS

By implementing this change in the curriculum, CS students at UVA will be better prepared to enter the workforce and Charlottesville will be better served. Overall, implementation of this policy would improve students' coding skills, their soft skills, and give them valuable experience working with clients and on large projects. These skills will make them more employable and benefit the surrounding community.

Project-based learning tends to be viewed favorably throughout most education systems, as seen by its rapid acceptance. While it is not guaranteed that such a curriculum would significantly benefit students at UVA, benefits were observed in other universities. Therefore, it stands to reason that UVA students would also benefit from incorporating projects into its CS curriculum. To ensure that this change benefits students, surveys will be conducted, both from students in the curriculum and alumni to see how it benefits them. From this, modifications can be made. If the change in curriculum shows positive results, as it likely will, the project-based curriculum could be expanded to other majors in the engineering school. If this is done, engineering students at UVA would be even better prepared for their careers than they already are. Alumni would be very desirable and have solid career opportunities.

5. CONCLUSION

To keep up with the rapid pace of the 21st century workforce, the CS curriculum needs to focus on preparing students for the workforce. To do this, UVA should develop a project-based curriculum in which students work on a multi-year project throughout their time at UVA. This project will instill a variety of skills in students, from cooperation and communication to experience working with clients to deliver a finished product. Students will be more prepared for their careers and more desirable to employers.

Project-based learning has been well received by both students and employers where it has been implemented. Much of the design of a project-based curriculum has already been done at several other institutions. Therefore, implementing it at UVA would be a relatively simple affair. After the curriculum is implemented, its effects will need to be observed, and it will need to be updated to suit the needs of students at UVA. By doing this, an advanced curriculum can ensure that UVA stays at the forefront of engineering education.

6. FUTURE WORK

UVA recently went through a change in CS curriculum. This change removed some classes and moved some of the content. The project-based curriculum would not require many updates to this updated curriculum. It

just needs a few simple courses, a closer connection between students and their advisors, and the aforementioned project. There would be a few growing pains, but implementation would not be difficult. Overall, such a curriculum would noticeably benefit students both during their time at UVA and after.

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