The University of Virginia's CS Curriculum: A Proposed "Path Program" to Prepare Graduates for Specific Industry Careers

A Technical Report submitted to the Department of Computer Science

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Alexandra Martin
Spring, 2023

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

Briana Morrison, Computer Science

The University of Virginia's CS Curriculum: A Proposed "Path Program" to Prepare Graduates for Specific Industry Careers

CS4991 Capstone Report, 2023

Alexandra Martin
Computer Science
The University of Virginia
School of Engineering and Applied Science
Charlottesville, Virginia USA
adm8mwh@virginia.edu

ABSTRACT

Although many CS graduates from the UVA will go into industry, only a few classes actually provide graduates with skills like conflict resolution, prioritizing equity, and working with diverse clients which they need to be an effective engineer. To improve the CS curriculum, I propose adding a mandatory "path" that each graduate can choose. This path would be composed of elective classes related to the specific field, in addition to a 3-credit class which would govern their capstone. I propose analyzing the electives offered to B.S computer students in the last three years, surveying students to understand their industry fields of interest, and studying course curriculums to design a capstone program could be formed that accurately prepares graduates to be successful in their chosen field. After doing this research, I would be prepared to create 5-7 individual "field paths" that match student interests. The university would have to find business professionals and/or professors with a vested interest to head the program and capstone class. Additionally, CS administrators would need to decide when to launch the program.

1. INTRODUCTION

The majority of CS graduates at UVA will go into industry, pursuing roles in software engineering, data analysis, and product management. Although the fundamental skills developed in universal CS classes like Algorithms, Data Structures, and Computer Architecture are undoubtedly essential to the development of a competent engineer, a more well-rounded educational experience could be created.

UVA offers a Bachelor of Science in Computer Science within the School of Engineering and Applied Sciences. Among the multitude of mandatory classes required for the degree, only four of the classes are in the department of Science Technology Society (STS), which focuses on a number of topics related to ethics and social issues.

Outside of this sequence of classes, prospective engineers at UVA receive minimal applied experience about fields they are interested in. An attempt at this is made in requiring at least five CS elective classes in order to graduate with a degree in CS. These electives include classes like Databases, Introduction to Cybersecurity, Defense of the Dark Arts, and Networks. While these courses do provide exposure to industry experiences and practices, there is currently no linear, methodical required approach to these courses that would allow students to receive comprehensive exposure. For example, a student could choose to take a Databases course and Cybersecurity course as part of their elective sequence. A student could also elect to take Cybersecurity, Networks, Defense Against the Dark Arts, and pursue a

capstone related to improving firewalls for small companies. While both elective sequences are allowed under the Bachelor of Science in Computer Science requirements, the latter is much more effective in providing aspiring students insight into what an industry career in a specified field would look like.

2. RELATED WORKS

Analyzing the curriculums of various universities across the United States illuminates the idea that incorporating more real-world project experiences related to CS fields like Systems Engineering, Testing, Data Analysis, and Software Engineering is becoming increasingly popular in the undergraduate curriculum. A basic glance at the University of Delaware's CS website will demonstrate the breadth of concentrations they offer for those pursuing a Bachelor's of Science in Computer Science. In contrast to \ UVA's CS program where students take the same classes as their peers, with differences only in the electives offered, the University of Delaware requires that students follow a common plan in their first two years to allow them to become comfortable with different areas of the field before choosing an area of focus at the end of their second year (University of Delaware, 2020). The concentrations range from Artificial Intelligence and Robotics and Systems and Network.

In a study exploring industry needs and how to better prepare CS students for a successful career, Simmons (2020) surveyed several CS graduates who currently work in the workforce and compiled their responses. When asked what undergraduates students needed in their curriculum to better prepare them for working in project teams, the students noted that significant group project skills, good communication, time forecasting, and how to ask the right questions were some of the most prominent skills used on the job. Additionally, former students said that "gathering and eliciting customer requirements is very desirable skill set for computer science graduates" (Simmons, 2020, p. 35).

As demonstrated in this survey, employers look for a wide range of technical and "soft skills," wanting graduates who will be able to make a significant impact in their company by practicing cultural competency and solid communication skills. My proposal builds on these related works to add to the existing CS curriculum a proper, sequential program that will give students exposure the soft and technical skills needed to be successful in their intended fields.

3. PROPOSED DESIGN

Below is an overview of the proposed design of the pathways program for the CS program at the University of Virginia, including a review of the system architecture, list of requirements, and potential challenges and solutions.

3.1 Review of System Architecture

To graduate with a Bachelor of Science in Computer Science, students must complete a series of fundamental CS courses, including Introduction to Computer Science, Theory of Computation, and Digital Logic Design. In the following years of their studies, students will also complete five "upper-level courses," which are considered to be more intensive, such as Operation Systems and Computer Architecture. These required courses are coupled with mandatory Applied Math Courses, five CS-specific elective courses values 3000 and above, and five elective courses that are non-STEM related.

In their final year of enrollment, students must complete a Capstone – this can be in the form of an independent study, thesis paper (such as this), or formal project with a professor. While many students choose to continue their

preexisting research in their final years, there are no requirements or specific constraints for what this research requires.

3.2 Requirements

Below, I give a summary of the current needs of the student and how the current system (CS curriculum) is lacking in providing for these needs.

3.2.1 Client Needs

After graduation, many CS graduates from the engineering school will choose to pursue careers in industry in the hope of achieving a substantial salary. Many jobs require or prefer some existing work experience related to the field, which could range from an internship, project work, or research.

3.2.2 System Limitations

The current curriculum, however, does not provide students with the opportunity to focus on a specific field of CS and develop the skills necessary to gain an early career position. While achieving a well-rounded, general education in CS is definitely beneficial, the current work force is more likely to offer jobs to students who have already developed great prowess in one field. This is beneficial for the company that a graduate chooses in that it decreases the cost and time spent on training new employees, and is also beneficial for the employee with greater foundational knowledge, who could have the potential to accelerate their career progression.

3.3 Key Components

Below, I give the specific details of the pathways programs, including the requirements that each student must complete and the specific components of each track.

3.3.1 Specifications

This pathways program consists of 5 different concentrations, each of which will culminate in a capstone seminar with other fourth years in their major. This seminar group will guide their capstone project and promote more complete, substantive theses in the CS departments.

The five different concentrations within the pathways program and the classes needed to complete these concentrations will be:

1. Cybersecurity
    - CS 3710–Introduction to Cybersecurity
    - CS 4760–Network Security
    - CS 4630–Defense Against the Dark Arts
    - CS 3240–Advanced Software Development
2. Data Analysis
    - CS 4750–Databases
    - DS 1002–Programming For Data Science
    - DS 2002–Data Science Systems
3. Machine Learning and AI
    - CS 4710–Artificial Intelligence
    - CS 4774–Machine Learning
    - APMA 3080–Linear Algebra
4. Web Development
    - CS 4710–Artificial Intelligence
    - CS 4610–Programming Languages for Web Applications
    - CS 4720–Mobile App Development
    - CS 3240–Advanced Software Development

3.3.2 Challenges

Some expected challenges with the pathways program come with the variance in CS courses offered from semester to semester. Because the presence of many courses is dependent on the availability of staff, it may be difficult for students to complete their concentration if there is a smaller staff presence if the CS department in a particular semester. Further, it could be difficult to find professors with the time to oversee a weekly intensive capstone course.

3.3.3 Solutions

A potential solution to the challenge with the capstone course is to find a group of professors who are already doing existing research on a topic related to the concentration. Professors who are more knowledgeable about their topic through research would be better equipped to guide students through a capstone project, and the preparation for the class would be largely informed by the professor's existing work, decreasing the time commitment.

4. ANTICIPATED OUTCOMES

A major expected outcome of this new pathways program is more career opportunities and a 10% increase in the range of pay that CS graduates are offered following graduation. After completing various projects setting them up for internships and possessing various skills from a sequence of CS courses related to a specific field, students will be sought after by companies in need of students with exposure to the work they will be doing.

A second major outcome is more centered, higher-quality final capstone projects from fourth-year students. Although the current capstone structure does yield some successful projects, many students spend a large amount of time during the semester lacking direction on a concrete topic and finding themselves scrambling at the last minute to complete their thesis. This pathways program will provide students with an idea of what their capstone will look like in their third year, allowing them to develop a more structured and expansive capstone.

5. CONCLUSION

The proposed pathways project presented here will significantly enhance and elevate the experience of CS students at UVA. For years, the CS department has been plagued with generic, unrelated classes required for graduation. With the increased competition of the workforce due the decline in economy combined with the competition of other CS curriculum at universities across America, it is necessary for UVA to make changes in their curriculums that will create lucrative opportunities for prepared employees. This program is a great step forward in propelling the program to where it needs to be, while providing students with experiences to a related field which will elevate and expand their experiences.

6. FUTURE WORK

Those interested in carrying out these ideas to fruition should work to ensure that the courses integrated into the program will be offered consistently throughout the year so that students will be able to complete it. Additionally, cohorts of professors who are interested in mentoring and guiding students in a particular subject matter should work to create a curriculum that provides students with the necessary information and background to be successful in a capstone project.

REFERENCES

University of Delaware, 2020. B.S. in Computer Science. https://www.cis.udel.edu/academics/undergraduate-programs/bscs/.

Simmons, Chris B. & Simmons, Lakisha L., 2010. "Gaps in the computer science curriculum: An exploratory study of industry professionals". *Journal of Computing Sciences in Colleges*, 25(5). p. 60-65.