A Proposal for a Modern UVA Computer Science Curriculum Design

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ABSTRACT

While there have been recent efforts to modernize the UVA Computer Science curriculum, it remains outdated and still needs to align with the rapidly evolving technological landscape. I propose splitting up the CS major into five separate disciplines, each with their own separate degree requirements: 1) Software Engineering, for those aspiring to design and develop robust and scalable software solutions 2) Theoretical CS, for those intrigued by the mathematical foundations and theoretical aspects of computation 3) Computer Engineering, for those interested in the hardware-software interface 4) Data Science & Machine Learning, for those drawn to the extraction of insights from vast datasets and 5) Cybersecurity, for those interested in safeguarding digital systems and networks from cyber threats. Students will benefit from a more tailored and specialized education that more closely aligns with their career aspirations. By aligning the CS curriculum with current industry demands, the university can enhance its reputation as a forward-thinking institution.

1. INTRODUCTION

The UVA CS degree is currently broken into two options, one degree which can be earned through the College of Arts and Sciences, and the other through the School of Engineering and Applied Science. While the degrees are similar in terms of the required CS courses, each degree has different core requirements based on the core requirements of the school. The CS degree through the College requires less credits but more diverse courses. On the other hand, the Engineering CS degree has more requirements with core math and science courses, and also requires more CS courses. UVA recently went through a major effort to transition to a "new curriculum." The goals of the curriculum changes were to "reduce duplication and improve flow among the early courses." (Tychonievich & Sherriff, 2022) The new curriculum did a good job addressing the need for a more updated curriculum that had not been changed significantly in over 20 years, and definitely reduced duplication in topics covered across classes.

With over 1400 undergraduate CS majors per year (University of Virginia), CS is one of the largest majors at UVA. Because of this, the University has had to handle many scaling challenges. For example, class registration has become highly competitive, with elective courses filling up extremely soon after registration opens and long waitlists forming. Also, the number of students has grown faster than the number of professors required to support the load, leading to a teacher shortage and a drop in quality, with most classes consisting of

hundreds of students. With the insufficient course offerings, teacher shortage, and surge in demand for the CS degree, the CS student body has become more homogenized. It is more difficult for students to set themselves apart without a project or internship outside of the classroom.

2. RELATED WORKS

One relevant related work includes the paper outlining proposed curriculum modification plan for UVA. Tychonievich and Sherriff (2022) outlined the entire process that they went through in designing and implementing the new curriculum at UVA. This work is particularly relevant to this paper because it outlines the thought process behind the decisions in changing an existing outdated curriculum. It highlights potential constraints that I may not have considered before, like the flexibility of requirements across multiple schools. They also reference curriculum standards that they aimed to follow that span across universities.

There is a movement underway within the ACM community about what should influence curriculum design. They argue that curriculum should be designed to meet a common set of principles rather than a common set of requirements. (Holland-Minkley et. al., 2023) This work is relevant to this paper because it highlights the thought process behind a growing movement to create newer and more modern college CS curriculums.

3. PROPOSAL DESIGN

The proposed redesign of the UVA CS curriculum aims to address the shortcomings of the current structure. This will be done by rearchitecting the major into five distinct disciplines: Software Engineering, Theoretical Computer Science, Computer Engineering, Data Science and Machine Learning, and Cybersecurity. Each discipline will have its own set of degree requirements tailored to provide students with specialized knowledge and skills, in addition to a core set of skills.

3.1 DISCIPLINE DEFINITION

Software Engineering: This discipline focuses on designing and developing robust and scalable software solutions. Coursework will emphasize modern software development techniques, project management, and developing usable software products and services.

Theoretical Computer Science: This discipline focuses on the mathematical foundations and theoretical aspects of computation. Students will study algorithms, complexity theory, formal languages, and computability.

Computer Engineering: This discipline focuses on the hardware and software interface. This includes computer architecture, embedded systems, and operating systems.

Data Science & Machine Learning: This discipline centers on extracting insights from large data sets using statistics and machine learning. This discipline will also be heavily focused on math. Students will learn how to develop predictive models and perform big data analysis.

Cybersecurity: This discipline focuses on learning how to protect digital systems and networks from cybersecurity threats. Students will learn about network security, cryptography, ethical hacking, and prevention mechanisms.

3.2 DEGREE REQUIREMENTS

Each discipline will have its own set of required courses, elective options, and experiential learning opportunities such as internships or capstone projects. The curriculum will be designed to provide a balance of theoretical knowledge and practical skills relevant to each discipline's focus. While each discipline will have its

own set of degree requirements, some courses will fit as a requirement for multiple CS degrees. For example, every degree may require a class on algorithms, or just the Software Engineering and Cybersecurity degrees may require a class on computer networks. Class offerings will be determined by the Computer Science department leaders. Requirements will be determined by the department heads of each individual major.

3.3 FACULTY AND RESOURCES

UVA will need to hire more CS faculty to support more diverse course offerings. Faculty members should be hired with expertise in each discipline. To address the shortage of faculty, UVA should consider hiring more non-PhD candidates. These candidates would often have more relevant experience to the topics that they are teaching as well.

Space constraints would be easier to accommodate because average class size would decrease.

3.4 IMPLEMENTATION PLAN

The implementation of the redesigned curriculum will involve collaboration across departments, schools, and administrators at UVA. This plan will be carried out in two major steps: 1) Expand the breadth of course offerings and hire more faculty to accommodate this expansion. Requirements will be adjusted as necessary to conform to the previous curriculum requirements as well. Along the way, feedback mechanisms will be implemented to ensure no major problems arise. 2) Plan faculty reorganization and institute the curriculum redesign changes. This can either be a gradual process or change immediately after one academic year.

4. RESULTS

I anticipate multiple benefits from implementing this system

4.1 ENGAGEMENT

By offering specialized tracks aligned with students' career aspirations, I anticipate more engagement and motivation among students. By offering a more diverse set of courses that still conform to a set of curriculums, UVA would empower students to pursue areas of interest more deeply, leading to improved academic performance.

4.2 CAREER READINESS

The revamped curriculum will equip graduates with specialized skills and knowledge relevant to their chosen discipline within CS. As a result graduates will be better prepared to enter the workforce or pursue advanced degrees. This would enhance their employability and competitiveness in the job market. This will have several reputational benefits to UVA as well.

4.3 RESOURCE OPTIMIZATION

As mentioned, this change would necessitate hiring additional faculty members with expertise in specific disciplines. While this will likely be challenging, diversifying the faculty pool will improve the quality of the UVA CS course offerings. This implementation would also reduce the class sizes of many electives, fostering closer student-faculty interactions and reducing space capacity constraints.

4.4 INNOVATION AND EXCELLENCE

UVA has the opportunity to set their CS program apart from other Universities. By embracing this new curriculum solution, UVA will be able to attract more top-tier students and faculty by providing opportunities that currently do not exist elsewhere. This change would further solidify its reputation as a leader in CS

education. This new curriculum also would be better for fostering student innovation, equipping students with more domain expertise, giving them the background to discover new solutions.

5. CONCLUSION

In light of these problems, UVA needs to continue to rethink how the CS curriculum is structured. While the transition to the new curriculum is a step in the right direction, it does not address the capacity constraints, the homogeneity of the student body, or even the shortcomings in terms of relevance to modern CS topics. Some courses in the curriculum today have so much material that could be covered that they could be their own independent concentrations or majors. Yet, they stand as mere electives in the curriculum today, with no way for students to use their classes to dive deeper into a topic of interest.

By restructuring the CS major into distinct disciplines tailored to different career paths, my proposal directly addresses the concerns. Offering specialized tracks ensures that students receive education tailored to their interests and aspirations. This not only enhances student engagement and motivation but also better prepares graduates for the workforce or further studies, thus addressing concerns regarding career readiness. By hiring faculty with expertise in each discipline and diversifying the faculty pool, we can improve the quality of course offerings and reduce class sizes, mitigating the issues of teacher shortage and homogeneity within the student body.

6. FUTURE WORK

The most important thing to do is to ensure that the vast majority of the faculty, students, and families are on board with this future direction of the UVA CS department. Without the support of the major stakeholders, it will be difficult to institute these changes.

Additionally, a curriculum transition plan should be formalized, similar to Tychonievich and Sherriff (2022). Moreover, faculty and leadership should start thinking about potential course offerings and recruiting new faculty.

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