Recommendations for UVA CS New Curriculum Enhancement

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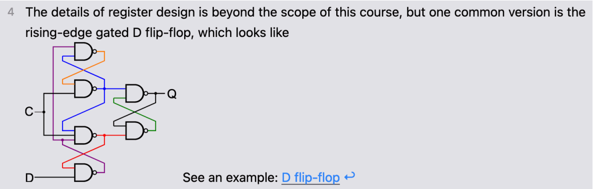
ABSTRACT

The new UVA computer science curriculum places too much emphasis on software engineering and needs to pivot to include more depth in electrical and computer engineering topics and algorithmic proof writing. To achieve a more balanced curriculum, I propose several changes, including removing CS 3240 (Advanced Software Development Techniques/Software Engineering) as a requirement for the B.S. degree, replaced with topics from Digital Logic Design and more algorithms content. I anticipate that these changes will produce CS graduates who are better equipped for work in lower-level systems, or for success in graduate school. To roll out these changes, a similar curriculum overhaul design akin to the original transition plan by Professors Sherriff and Tychonievich should be implemented.

1. INTRODUCTION

UVA's computer science department went through a curriculum overhaul beginning in Fall 2021, in effort to reduce redundant information and align the curriculum more closely with other schools. As part of the first cohort of students graduating after the launch of the new curriculum courses and as a two-time teaching assistant, I propose my thoughts on some of the changes made to the curriculum.

One of the biggest weaknesses in the new computer science curriculum is the lack of depth in digital logic design.

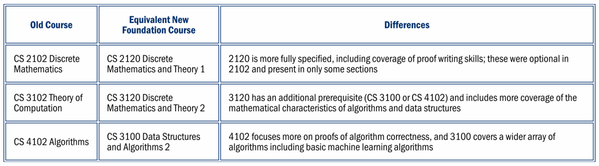


4 The details of register design is beyond the scope of this course, but one common version is the rising-edge gated D flip-flop, which looks like

See an example: D flip-flop ↩

Figure 1: A reading from the "Components of Digital Computers" section of CSO1 in Fall 2022

Figure 1 is a screenshot of a reading from Computer Systems and Organization 1 (CSO 1), which I took in Fall 2022. As the note indicates, "The details of register design is beyond the scope of this course." Not only was it beyond the scope of the course, it is beyond the scope of the entire computer science curriculum at UVA. There is no other place where students learn about lower-level design and the most basic computer architecture. In my opinion, this information is not optional, it should be mandatory for every CS student. Additionally, it is not excluded for its difficulty; it is excluded because there is not enough time for other topics. Instead of having such a strong emphasis on software engineering, UVA computer science should focus on building well-rounded computer scientists with a good foundation in everything from low level to high level design, enabling them to pursue a career within the entire spectrum of computing.



Old Course	Equivalent New Foundation Course	Differences
CS 2102 Discrete Mathematics	CS 2120 Discrete Mathematics and Theory 1	2120 is more fully specified, including coverage of proof writing skills; these were optional in 2102 and present in only some sections
CS 3102 Theory of Computation	CS 3120 Discrete Mathematics and Theory 2	3120 has an additional prerequisite (CS 3100 or CS 4102) and includes more coverage of the mathematical characteristics of algorithms and data structures
CS 4102 Algorithms	CS 3100 Data Structures and Algorithms 2	4102 focuses more on proofs of algorithm correctness, and 3100 covers a wider array of algorithms including basic machine learning algorithms

Figure 2: A table from an old UVA CS advising page, noting changes from old curriculum to new curriculum courses. Accessed via Archive.org's Wayback machine

Looking at the changes from the UVA's original algorithms course (CS 4102) to the newer data structures and algorithms 2 course (DSA2) in figure 2, one can see that depth in algorithmic proof ability is substituted for content in machine learning. In my view, this is problematic. While machine learning may be more popular at the moment, learning this content does not make a more well-rounded computer scientist. As a former teaching assistant for DSA2, I believe the ML material in DSA2 is rather surface level. This material can be learned in the machine learning and artificial intelligence courses offered at UVA as electives, instead. In a fundamental algorithm's course, such as the ones offered by similar prestigious public institutions like Michigan and Berkeley, algorithmic proof writing ability is emphasized and prioritized. Some schools even go beyond this, adding an advanced algorithms course to their curriculum. This same emphasis on algorithmic proof writing ability needs to return to UVA's CS department.

2. RELATED WORKS

The most relevant literature that piqued my interest in improving UVA's computer science education is the original plan Professors Tychonievich and Sherriff crafted to transition from pre-Fall 2021 curriculum to the new curriculum, Fall 2021 and beyond. They cite the main issues with the old curriculum as too much content in the programs and data representation course (CS 2150), as well as an inability to transfer into UVA CS because our old curriculum courses were too unique (Tychonievich and Sherriff, 2022).

While the split from CS 2150 into CS 2100 and CS 2130 was a necessary change, removing ECE/CS 2330 (Digital Logic Design) was not. Computer Systems and Organization 1 (CS 2130) does not cover logic design in depth at all. Students have a blind spot about the way circuits translate into memory, and how memory translates into computing systems. Professors Tychonievich and Sherriff state they surveyed all of the computer science professors at UVA and found general agreement that there was too much information to be included in the foundational CS courses. I agree with this finding but propose prioritizing the curriculum differently.

Perusing Reddit's UVA subreddit reveals similar opinions on our software engineering focus from CS students. In a thread comparing our program with Virginia Tech's, a newly admitted student eager to gauge the quality of our program noticed that "unlike most CS programs, UVA CS doesn't have separate tracks within CS for different areas" (Luv2ski2, 2023). A CS graduate responds with "my biggest gripe with [UVA's] program is it's clearly designed to churn out software devs, with very little opportunity to explore any side tracks" (Kuckucksuhr, 2023). Another student continues the conversation with "they have reworked the CS curriculum recently, so there are more opportunities for electives" but it is "still mostly focused on software devs" (lift_1337, 2023). While one Reddit thread cannot capture the overall opinions on this matter, these responses align with what I've experienced and heard from friends and classmates. UVA's computer science program has a strong emphasis on software development. The curriculum certainly needs some adjustments to even out the courses and align with other top schools.

3. PROPOSAL DESIGN

My proposal for curriculum design includes several key changes. One is to remove CS 3240 (Advanced Software Development Techniques/Software Engineering) as a requirement and instead offer it as an elective rather than a core requirement for the BS CS degree. (The BA degree does not require this course). This change will make room for more foundational content that is missing from the curriculum. When CS 3140 was offered in Fall 2022, there were a few "free" lectures at the end of the term meant to be flexible and cater to student interest. These can be replaced with some of the concepts in CS 3240, for example Agile methodology, verification and validation, software maintenance, or other topics. I do not see a reason for students to have to learn topics like UML design twice.

Additionally, I propose that the UVA CS program introduce more ECE topics into the curriculum. This is to fill gaps in knowledge from transistor level to computer level. This will ensure that UVA computer science graduates are well equipped to tackle lower-level hardware tasks in the workforce. Many computer science problems arise as optimizations to lower-level binary problems. Making this change would give UVA computer science students the background and confidence to succeed in these roles.

Finally, DSA2 should focus more on algorithm correctness, like its predecessor, CS 4102/Algorithms. I propose replacing the machine learning content with more proof correctness, and letting the students learn the ML content with our elective offerings instead.

4. Expected Benefits

If the proposed changes are implemented, UVA computer science majors will be better prepared for roles in areas involving hardware development, embedded systems, and typical lower-level roles. This will not decrease preparedness in entering the workforce for software development at all, since CS 3140 (Software Development Essentials) is already part of the new curriculum. There is so much overlap between CS 3140 and CS 3240 that merging the two courses would not diminish students' knowledge on software engineering.

Another expected benefit from instituting this change is enhanced graduate school preparedness. A stronger emphasis on algorithmic proof writing and foundational CS concepts will equip students for success in graduate-level research and study. Students will feel more comfortable researching lower-level topics with increased digital logic design knowledge, and will be better off reading and writing proofs for more theory and math based computer science topics.

Finally, this will help strengthen the competitiveness of UVA CS graduates. Other top public programs have these suggested improvements in place and have higher CS rankings. With these changes enacted, we can improve our department's standing, attracting more funding for research, more competitive applicants into the school, and a stronger national recognition.

5. CONCLUSION

As part of the first cohort of students graduating with the new curriculum in place, I appreciate the changes our CS department made. It is certainly a major improvement from what it used to be. Just as the professors changed the curriculum in hopes of improving our education, I hope that this proposal will encourage additional improvements for students in the future.

I believe the changes I have discussed, including removing CS 3240 as a requirement, adding more lower-level topics, and more depth in algorithmic proof correctness, will create better computer science graduates. They will be better more prepared for a wider variety of roles in the industry, and will feel more confident to tackle courses and research in graduate school.

6. FUTURE WORK

The insights provided by Professors Tychonievich and Sherriff in their work are invaluable. Their framework for implementing a curriculum change is precisely what I would utilize. Reception of these changes by professors and students needs to be gauged. Since the changes I propose are much smaller than the complete curriculum overhaul in the original transition, I believe they will be rolled out much faster.

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