

**Proposal for a New Course in Computer Science and System Engineering: Advanced Design
Techniques**

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On my honor as a University student, I have neither given nor received unauthorized aid on this
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Abstract

The University of Virginia is slowly transitioning to a new computer science curriculum. However, there is a lack of courses that prepare students for their internship experience, which is a major stepping stone for a professional career in software development. Those few computer science courses that do prepare students have a specific focus on developing a project as a team of software developers. The proposed course, Advanced Design Techniques, will introduce a new course that can simulate an internship experience for students that will work closely with colleagues with other expertise outside of software development. The course will be a special topics elective course for both computer science and system engineering that will encourage students to work and communicate in an interdisciplinary team while exploring the process of brainstorming and designing that most computer science courses gloss over.

1. Introduction

As of 2022, after the transition and implementation of the new computer science (CS) curriculum, the University of Virginia (UVA) offers one required course in the computer science curriculum focused on group project and simulation of real-world work experience. However, this is only true for undergraduate students pursuing a Bachelor of Science in Computer Science (BSCS). On the other hand, students who are pursuing a Bachelor of Arts in Computer Science (BACS) are not required to take this course [1]. Under the old curriculum, this course, “CS 3240: Advanced Software Development Techniques,” prepares students for internship experience through hands-on group project with an

emphasis on the Scrum agile methodologies [2]. With the new curriculum, the class remains with some slight changes to its prerequisites and contents; however, overall, the course structure and focus on Scrum agile method should remain the same. This course is considered by many CS students as one of the most useful and relevant courses that prepares students for internship and industry. However, by the nature of the project, this experience is not as applicable for students working for a non-software development company. The proposed course aims to supplement and provide students with a different simulation of internship experience.

2. Related Works

Companies are shifting away from plan-driven methods, like the Waterfall model [9]. In fact, about 83% of companies that adopted agile methods are using Scrum or its hybrid forms [4]. Even though a course focusing on one of these agile software development methods would provide a lot of great experience for students, it is heavily focused on development within a team of software developers. While this is a common scenario at a software development company, as stated above, many students would receive internships at other companies with only one or two software developers working closely with professionals of other fields. There is a need to provide students an opportunity to work within an interdisciplinary team.

To address this lack of collaboration between computer science students and students of other majors, there are many classes across the University of Virginia School of Engineering and Applied Science (SEAS), even within the CS department

itself, that can be analyzed to determine how to best implement a class with a half semester-long group project that encourages a diversity in students' expertise or majors for every group.

2.1 UVA Computer Science Special Topics Course

CS 4501/6501: Engineering Interactive Technologies has been offered for multiple semesters over the past couple of years. The Spring 2022 syllabus will be used, as well as the undergraduate offering of the course (CS 4501). The course is lecture-style with basic to intermediate Arduino labs and assignments, followed by a half-semester long group project. The labs serve as hands-on learning experience for the microcontrollers that will be used extensively for the final project. The second half of the semester has students working together to build a user interface with the usage of Arduino encouraged.

While not having much diversity in students' majors, the utilization of the Arduino microcontroller and the nature of a large group project split up the group dynamic into the "electrical" team and the "coding" team. Even though it is a small distinction, students now have two sub-groups that depend on each other. This means that students in different sub-groups would develop different expertise in either "electrical" or "coding" part of the project that needs to be sufficiently communicated among one another.

2.2 UVA System Engineering Special Topics Course

In the fall of 2019, a special topics elective course, "SYS 3501/ENGR 1624: Human-Centered Product Design," was last offered by Professor Bailey. This course was structured rather differently as compared to other courses with a semester-long group project. Professor Bailey had an ambitious goal of forming teams of 5-6 students, consisting of first-year students, system engineers, and students from the School of Architecture or Department of Art. This is why the class was also offered as ENGR 1624: Introduction to Engineering, a general requirement for the SEAS, to add at least one first-year for every team. With the expertise of the students ranging from architecture to computer science, the project's scale was also larger than other classes: designing and building a life-size prototype that is mentally and

physically engaging for first- and fourth-grade students from the local Clark Elementary School.

Almost half of the semester was spent on brainstorming the project. This is a completely different pace compared to CS 3240: Advanced Software Development Techniques, where the project ideas were basically pre-generated for students to choose. Similarly, in CS 4501: Engineering Interactive Technologies, the ideas were generated by the students; however, only about 2 days were spent on finalizing the idea for each group. This is a common trend that effective brainstorming is not taught much in computer science. On the other hand, Human-Centered Product Design was structured with a "Fall Break Retreat," where students would spend their fall break continuously brainstorming with feedback from the elementary students as well as utilizing concepts like problem immersion. Most teams went through multiple iterations of their prototype concepts and prototype construction did not start until after fall break.

There were also workshops of Arduino, wood-working, 3D-printing, and laser-cutting in which each member of the group would choose one of the four workshops and sharpen their skills. This allows first-year engineers to learn and contribute their own "expertise" to the team, almost like an intern. In the second half of the semester, each member would work to build the prototype in multiple interconnected sub-groups: general prototype structure, wiring, coding, numerous moving mechanisms, etc. This fosters communications between all the students in the group to ensure that every sub-group would be able to seamlessly combine into the final prototype.

2.3 Comparison and Analysis of Syllabi

While one course is very much focused on a group project with interdisciplinary team and the other has the group project as a way to assess students' knowledge from the course, there are still some connections between the two courses. Both of their projects have a physical deliverable, ranging from a life-size prototype to some simple Arduino circuit, with heavy coding elements. Comparing the above two courses with two other elective courses in the CS Department with half semester-long projects, both CS 4750: Database Systems [6] and CS 3205: HCI in Software Development [7] share the same weakness

as CS 3240: having the project being mainly software developers working with software developers. All of these courses also all have digital or software deliverables. Therefore, having a physical deliverable with coding elements would be the best way for a group project to encourage students to have different expertise and learn from each other through proper communication.

3. Course Design

The goal of the proposed course, “Advanced Design Techniques”, is to introduce students to brainstorming and designing strategies through hands-on labs and a half semester-long group project. This course would be designed to improve student ability to navigate a design process and communicate in an interdisciplinary design team composed of students with different skills. The course design is influenced by the syllabi of the Human-Centered Product Design course and the Engineering Interactive Technologies course.

The course will be designed for a biweekly meeting of 75 minutes each. The course will be split up into halves: lectures and labs for the first half and group project for the second half. With the course being rather hands-on, grades will be based on labs and project deliverables.

The first four weeks would be going over some of the assigned course reading: *The Design of Everyday Things* (Norman, 1988) and doing labs which serve as workshops for students [10]. On the first meeting each week, the course would focus the understanding of problem immersion. For example, how does a person know whether a door needs to be pushed or pulled? The design of the handle, the hinge of the door, and much more minute aspects of design. The students learn to put themselves in the user perspectives to solve problems that might appear to be obvious to the designers (the students). On the second meeting each week, the students would do a partner lab with 2 Arduino labs and a 3D printing lab. The last meeting of the fourth week will be a day off with options of the students going to either the wood shop to learn woodworking or to the laser-cutting workshop over the weekends.

After these four weeks, the class would transition to the group project where the students be randomly assigned to teams with a diversity of majors and years. The brainstorming phase can start and the users will be introduced, either elementary students from Clark or other students at UVA. The goal is to design a fun, physically, and mentally engaging activity for the users. All the teams will brainstorm at least five ideas and slowly narrow it down by the start of week six where the ideas can be sent to the users to get their feedback. Teams can start prototyping and send if their ideas are realistic and technically possible. After receiving user feedback on week seven, teams will use that to brainstorm more ideas based on the foundation that they have established over the past couple weeks. Then, they will again narrow it down to one final idea and continue working until the end of the semester. There will be a presentation or a showcase of the prototype to the user and the students can write a reflection paper based on what they have learned.

4. Course Procedure

The course is to be delivered in a classroom with access to a maker space for both lectures, labs, and projects, which are in different buildings like Rice, Mechanical Engineering, Wilson, etc. It is to be administered similarly to in-person courses at the University of Virginia, preferably twice a week for 75 minutes to allow for more continuous time to spend on the final project.

There are about four weeks of planned lectures and labs for the first half of the semester. The second half of the semester consists of mainly project work time. The course does not have any prerequisite and should be considered as a special topics elective course for both computer science and system engineering, similarly to the way CS/ECE 3501: Embedded Computing and Robotics was set up by Prof. Dugan [8]. With some endorsement of the class to students in both the School of Engineering and Applied Sciences as well as the School of Architecture, there would be a high chance of the roster containing students with different skillsets.

There will be multiple channels of communication ranging from UVA Collab to Discord. Since the class

is almost required to be in-person because of the nature of prototyping a physical deliverable, UVA Collab will serve as a database of lecture and lab information. Discord will be similar to the set-up of CS 3240 which just serves as a quick form of communication between students, instructor, and teacher assistants.

5. Conclusion

The proposed course, Advanced Design Techniques, was designed to fill the weakness of courses like CS 3240: Advanced Software Development Techniques in providing students an opportunity to gain experience similar to that of their internship at non-software development companies. With the analysis of various syllabi of special topics elective courses, the weakness was determined to be the lack of physical deliverables and the lack of diversity in students' majors and skillsets. With the introduction of more dimensions to the project, both physical and digital, as well as students with a diversity of skills aside from software development, the course can serve as another course that simulates a different internship experience while teaching students effective designing and communication skills.

6. Future Work

The current deliverable only gives a rough summary of the course schedule for the entire semester. The labs serve as opportunities for students to develop their own skills and bring different expertise to their design team. The first Arduino lab should introduce basic concepts through LEDs and buttons. The second Arduino lab can introduce more intermediate concepts with sensors and IMU. Other labs like woodworking and laser cutting should allow students to use the machinery and construct a small physical deliverable. While the content of the course has been roughly laid out, more work is needed for a semester-long course.

References

- [1] "CS Undergraduate Curriculum Transition Plan" University of Virginia School of Engineering and Applied Science, [Online]. <https://engineering.virginia.edu/cs-undergraduate-curriculum-transition-plan>.
- [2] Mcburney, Will. (Spring 2021). *CS 3240: Advanced Software Development Techniques* [Syllabus]. University of Virginia.
- [3] Bailey, Reid. (Fall 2019). *SYS 3501/ENGR 1624: Human-Centered Product Design* [Syllabus]. University of Virginia School of Engineering and Applied Science.
- [4] Petrova, Sandra. Adopting Agile: The Latest Reports about the Popular Mindset. Adeva. <https://adevait.com/blog/remote-work>.
- [5] Heo, Seongkook. (Spring 2022). *CS 4501: Engineering Interactive Technologies* [Syllabus]. University of Virginia.
- [6] Praphamontripong, Upsorn. (Spring 2022). *CS 4750: Database Systems* [Syllabus]. University of Virginia.
- [7] Apostolellis, Panagiotis. (Spring 2022). *CS 3205: HCI in Software Development* [Syllabus]. University of Virginia.
- [8] Dugan, Joanne. (Spring 2019). *CS/ECE 3501: Embedded Computing & Robotics I* [Syllabus]. University of Virginia School of Engineering and Applied Science.
- [9] Bhandiwad, Achyut & Vijayalakshmi, M. & Pandey, Abhinav & Nagesh, Preetham & Mellikeri, Kartik. (2018). Transition from conventional to Agile process model An Experience Report.
- [10] Norman, D. (1988). *The Design of Everyday Things*. Basic Books.