UVA Computer Science Curriculum: Preparing Computer Science Students for the Changing Technical Landscape

Artificial Intelligence in Education: How ChatGPT Can Affect Students' Learning and Comprehension of Subject Material

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

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November 3, 2023

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Introduction

Education has continuously transformed and evolved by adopting and incorporating new innovations in technology. From hornbooks to projectors, and typewriters to laptops, institutions are constantly changing to improve their education system by adopting more effective advancements in technology to enhance students' ability to learn and understand subject material ("The Evolution of Technology in the Classroom", n.d.). My technical capstone and sociotechnical research topic both focus on the advancement of education within schools through the use of technology. In my technical capstone, I analyze the University of Virginia's (UVA) undergraduate computer science curriculum and examine ways to improve the curriculum to produce industry-ready graduates for the workplace. One of the primary challenges graduates face when transitioning from college into the workforce is filling in the gaps in areas that were not covered in their curriculum and understanding how to function effectively as a professional in the workplace. Studies have shown that "there are significant disconnects between students' perceptions of their preparation and employers' expectations of students' preparation," leading to recent graduates having noticeable gaps in their skills after college (Lawrence-Fowler, 2015). My technical capstone will address how to fill the skills gap and better prepare undergraduates for careers in the computer science industry by making strategic changes to the current computer science curriculum at UVA.

My sociotechnical topic addresses artificial intelligence in education, specifically looking at how ChatGPT can affect students' learning and comprehension of subject material. ChatGPT is an artificial intelligence model developed by OpenAI that "is trained on a massive amount of internet text data and is able to generate human-like text" and "has the ability to understand and interpret the meaning of text" (Adeshola and Adepoji, 2023). Given most prompts, ChatGPT can

produce what appears to be a detailed response, although it may not always be accurate. My sociotechnical research will strive to answer the question of whether ChatGPT furthers students' education, or if it inhibits critical-thinking skills that have been historically developed through the completion of assignments through more traditional learning methods.

My technical capstone focuses on how UVA can change their computer science curriculum to better prepare computer science undergraduates for the workforce while my sociotechnical research focuses on a subset of artificial intelligence – ChatGPT – to understand whether it is helping or hindering students' ability to learn. The technical capstone specifically addresses learning in the context of preparing undergraduates for the workforce, such as interviewing skills and common areas of knowledge employers are expecting graduates to have for jobs in the computer science industry, whereas my sociotechnical research focuses on knowledge areas that were learned in grade school, such as subject material for classes and social and critical thinking skills developed during that time. The changing landscape of education affects students' ability to learn and develop necessary skills that will be valuable later in life; understanding the structures and technologies that influence education can maximize students' potential to learn and thrive.

UVA Computer Science Curriculum: Preparing Computer Science Students for the Changing Technical Landscape

The University of Virginia's computer science (CS) curriculum needs to evolve to ensure key skills are aligned with the changing landscape and prepare undergraduate students to become competitive job applicants and innovative contributors and leaders in the computer science

industry. To accomplish this, I propose increasing the number of programming languages students learn, reformatting the curriculum to provide more exposure to specialty areas beyond software development, and including a course to address non-technical skills such as interviewing techniques and networking. With these changes, UVA undergraduate CS students would be well-positioned to pursue internships and enter the competitive workforce. The success of these changes would be measured by establishing a baseline of CS undergraduate alumni, conducting follow-up surveys with students participating in the new program, and evaluating the degree to which the new undergraduate experience prepared them to enter the workforce.

While the UVA CS curriculum does a good job of covering the fundamentals students need to begin their career, students can feel intimidated and unprepared when starting their job search and the interview process. Employers require a variety of skills and abilities due to the ever-changing landscape of technology and business focus areas. At UVA, students learn the basic principles of programming, data structures, algorithms, and computer systems, but they have limited resources for building interview skills or understanding the different computer science specialties. Additionally, UVA students learn to program in Python, Java, C, SQL, and x86 assembly, while some of the more common languages in the workforce are JavaScript, C++, C#, and PHP.

To address these knowledge gaps and better prepare undergraduate UVA CS students for the transition to the workplace, I have proposed changes to the UVA CS curriculum. Specialties in the computer science field can be grouped into four categories: Generalists, Infrastructure and Security, Software Development, and Embedded Systems. Generalists revolve around the basic skills required in a job, such as management, problem solving, and teamwork. The Infrastructure and Security community focuses on cybersecurity and troubleshooting, which involves

addressing faults and vulnerabilities within a computer system. The Software Development community creates software, a program used by a computer, with a team of programmers and stores information in databases. The Embedded Systems community deals with computer memory (Maghsoudi, 2023). Of these four categories, students are only required to take classes related to software engineering, and classes covering other specialty areas are limited and optional as they can only be taken as electives. This can be a disadvantage, as some employers may seek applicants who have a balance of both a broad knowledge base and an in-depth focus in a specialty area. To mitigate this deficiency, I further divided the computer specialties into five categories: Cybersecurity, Software Engineering, Computer Systems, Artificial Intelligence, and Digital Media. In my revised curriculum, all the CS electives are separated into each category, such as Computer Game Design in Digital Media and Network Security in Cybersecurity, and CS majors will be required to take a minimum of one course in any three of the five specialty areas. Additionally, a one-credit Career Readiness Class will be created that will focus on interviewing skills, career fields, networking opportunities, job searching strategies, and resume workshops.

To address a gap in student's exposure to programming languages common in the computer science industry, I recommend changing the programming language that is used in some courses. CS students at UVA learn Python in Introduction to Programming, Java in Data Structures and Algorithms 1 and 2, C and x86 assembly in Computer Systems and Organization 1 and 2, and Java and SQL in Software Development Essentials. To reduce redundancy, I would suggest that students learn C++ in Computer Systems and Organization 2 instead of C since C++ uses C as the basis for its own language. Moreover, I would require that JavaScript is used in

Advanced Software Development since that class typically uses languages that were already taught in their prerequisites.

By making these changes to the UVA CS curriculum, students will have an enhanced awareness of the different computer science specialties they can focus on, have a broader exposure to multiple programming languages that are prevalent in the CS industry, and have confidence that they are fully prepared for interviews to attain internships and full-time jobs.

Artificial Intelligence in Education: How ChatGPT can Affect Students' Learning and Comprehension of Subject Material

I am working on the topic of artificial intelligence in education for my sociotechnical research because I want to understand how ChatGPT can affect students' learning ability and comprehension of subject material. This is important because ChatGPT is an artificial intelligence technology that can answer almost any topic area given the right prompt. Analyzing students' use of ChatGPT for their classes can help determine whether ChatGPT furthers students' education or if it inhibits critical-thinking skills that are regularly developed through them completing assignments on their own.

In a study conducted to determine the most effective strategies for students to learn, it was found that "the lecture/discussion teaching method was the most preferred among students…they have a desire to be somewhat active learners, engaging in discussion rather than passively listening to a lecture" (Carpenter, 2006, p. 18). To actively understand and memorize course material, students often prefer to learn by studying and practicing the concepts they are taught so they can fully understand their importance. Additionally, neuroscientists have found

that when students work on problems that are of the right difficulty – not too challenging or too easy – the brain rewards itself by releasing a naturally occurring chemical in the brain's pleasure system (Willingham, 2021). These two arguments indicate that for students to effectively learn and understand new material, their education must have challenging activities to help them commit the information to memory. If practice problems are too easy, then students' brains are not stimulated, and they may bore of solving simple questions. In contrast, if the work is too difficult, students may lose focus and get frustrated. Having students work on problems that are challenging but solvable will result in them enjoying the homework assignment and having greater satisfaction in its completion. The most effective ways in which humans learn are experience, social interaction, and training (Reynolds and Mason, 2002). Through communication, students can develop a deep analysis and understanding of the topic they are studying by seeing it from different perspectives. The integration of ChatGPT within classrooms may limit social interaction and thus lower the quality of students' learning experience and the development of social skills.

A new application in artificial intelligence, ChatGPT, was introduced by OpenAI in 2022. ChatGPT is "an artificial intelligence-based chatbot…capable of generating cohesive and informative human-like responses to user input" (Lo, 2023). ChatGPT is trained on data from the internet and formulates responses to prompts it is asked, such as answering questions and having conversations. ChatGPT has demonstrated that it can be used to pass multitude of common exams, such as AP exams and tests regularly given in school. With the proliferation of ChatGPT in education, many have questioned whether ChatGPT is helping students learn, since students can use it to understand concepts but also as a crutch to easily get direct answers to their homework, which would not stimulate their brain and help them learn. Students using ChatGPT

can make it "difficult for educators to provide targeted feedback [to students] and develop necessary intervention strategies. Consequently, the educational process becomes less effective and the true purpose of teaching and learning is compromised" (Grassini, 2023). Teachers may not be able to help students understand the topics they struggle with if they are getting their homework answers from ChatGPT. Additionally, students using ChatGPT also introduces the question of academic dishonesty since ChatGPT can complete written assignments and examinations on behalf of students, which can go unnoticed because ChatGPT can bypass most plagiarism detectors, and other tools and algorithms to detect AI-written text are not accurate (Lo, 2023). Students using ChatGPT to complete their homework assignments are not challenging themselves to make learning meaningful, which can make it harder for the student to understand or master the material. Moreover, since ChatGPT is trained on past data, its answers may be inaccurate, leading to the user learning incorrect material.

On the other hand, artificial intelligence like ChatGPT can be used to improve the educational experience. Although "AI seems to reduce cognitive load to a certain extent, effective learning must carry a certain cognitive load" to increase the quality of students' learning, AI can "reduce human teachers' repetitive work, so they have more time to focus on the ontological activities of education" (Zhang et al., 2022, p. 4). Artificial intelligence can grade students' work for teachers so they can instead concentrate on improving the learning experience of students, such as by using the time saved from grading assignments to help students one-on-one. Moreover, artificial intelligence can be used to generate lesson plans that teachers can build off of to present to their class. One study with artificial intelligence utilized Amazon Echo Dot devices in classrooms, which yielded a better learning experience for students since the device assisted them in their learning process as a tool for fast and efficient information. In this study,

students ended up asking their teachers less questions and opted for the virtual assistant (Terzopoulos and Satratzemi, 2019). In reference to examples more specific to ChatGPT, students can use ChatGPT to solicit feedback on their assignments, improve their essays, get explanations for topics they have trouble understanding, and generate practice questions in preparation for exams (Grassini, 2023).

To determine whether ChatGPT is helpful towards students' education, I will conduct interviews with current students. These interviews will help answer the question of: Does ChatGPT improve students' learning and comprehension of subject material? Questions asked during the interview would consist of how often they use ChatGPT, why they use ChatGPT, what classes they use ChatGPT for, and if ChatGPT is used more as a source of understanding and studying concepts or as a source of finding answers to questions. I will also analyze whether the student feels that using ChatGPT in their education has helped them understand their class's content better. If a student states that they have better comprehension of subject material after using ChatGPT, then I can interpret this result to mean that ChatGPT is helping the student learn. Otherwise, if ChatGPT is used more as a gateway to complete assignments, I can reasonably infer that ChatGPT is not helping the student comprehend the material they need to learn.

Conclusion

The technical deliverable of my research will help to improve the UVA CS curriculum by reformatting the curriculum to produce industry-ready graduates. The technical deliverable will detail changes to the current CS curriculum, which will involve the following alterations: adding a Career Readiness class, requiring students to take electives in multiple specialty areas, and changing the primary programming languages used in core classes to expose students to more popular programming languages in the computer science industry. My sociotechnical research

will analyze how ChatGPT, an artificial intelligence program, impacts students' learning ability in regards to comprehension of subject material. My STS deliverable will help to advise teachers and students on whether ChatGPT should be allowed in the classroom and if it is a valid and helpful studying resource for students. This will be shown through detailing ways that ChatGPT can help or hinder students' learning experience. The STS deliverable will additionally help educators better understand how new technologies like ChatGPT affect learning patterns and education, and how new technologies like this can be beneficial, and also harmful to future generations.

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