CS 4501 Cybersecurity in Elections Curriculum Redesign

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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

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ABSTRACT
The University of Virginia's CS 4501 Cybersecurity course covers election infrastructure and history and can be used to satisfy undergraduate elective requirements but misses an opportunity to ask students to more carefully consider the intentional and unintentional social consequences of the technologies they design. I propose implementing Halpern's Four-part model which can be achieved by designing new learning targets and vocalizing them prior to class, supplementing preexisting lectures with a non-technical analysis and discussion, and hosting Socratic seminars. By implementing Halpern's four pillars of training, the CS 4501 curriculum can bridge the gap between technical events and legislation and sociotechnical analysis. As a result, students will be better equipped to design computer programs—especially those that interact heavily with the public—and make more informed, considerate workplace decisions. As the course ages, the effectiveness of Halpern's Four-part model can be evaluated using written assessments and course evaluations, and it can be remodeled or supplemented accordingly.

1. INTRODUCTION

In order to earn a Bachelors of Science in Computer Science at the University of Virginia, students must complete 15 credits of CS elective courses. Classes that count towards the elective credits span a variety of topics from cloud computing to software testing. One subsection of electives—CS 4501—is a range of special topics in computer science that are usually highly specialized courses with small class sizes requiring instructor permission.

One example of this course is CS 4501 Cybersecurity in Elections taught. According to the syllabus, the purpose of this course is to "understand [the] election system and legislative history of voting in the U.S.," "understand the cultural significance of voting in American democracy, " and "identify threats, vulnerabilities, and attacks in election infrastructures" (Davidson, et al., 2022). While I appreciate the team of professors for including the importance of historic background in this course, in execution, there is a gap of understanding between those historical events and how they continue to shape our voting technologies. This is a result of voting technologies being discussed in the absence of sociotechnical analysis. By not acknowledging the social implications behind technological design, the course is missing an opportunity to educate students on the dangers of the programs they create and risk having them repeat social and political tragedies because of a lack of consideration.

Using Diane Halpern's Four-part model to restructure the course by synthesizing cybersecurity principles alongside the social aspects of election phenomena will enable students to truly understand the political significance of

election hardware and software. The proposed course would ask them to consider how technologies they create could contribute to modern-day cases of disenfranchisement.

2. RELATED WORK

In 1999, Herrmann established the Whole Brain Model and his theory of learning. He describes how humans have naturally dominant structures, and that if these dominant structures can be identified, we can more fully apply our brains to improve learning, retention, and mental ability. The quadrants to consider are (A) upper left which deals with logical and analytical thinking, (B) lower left which deals with sequential thinking and planning, (C) lower right, which deals with interpersonal and emotional thinking, and (D) upper right, which deals with intuitive thinking and synthesis. He argues that after students receive a profile showing their preferred way of thinking, "they are better able to successfully apply not only their understanding of their thinking style, but also their preferred learning, communicating, and problem solving styles, to name a few" (Herrmann, 1999). When considering a course redesign, Hermann's technique benefits students by deepening self-awareness of their most beneficial learning style.

Halpern (1998) provides four key steps to help adults better transfer and engage with their critical thinking skills : (1) conduct a dispositional warm-up to prepare learners, (2) explicitly teach thinking skills, (3) provide problems and arguments to test critical thinking skill transfer, and (4) evaluate students using a metacognitive component to record progress. Halpern's method is perfect for redesigning the CS 4501 Cybersecurity in Elections curriculum because it teaches students to transfer the critical thinking skills they learn in required STS courses—a series of ethical and sociotechnical writing classes—and apply them to the computer programs they are creating.

3. PROPOSED DESIGN

To redesign the CS 4501 curriculum using Halpern's Four-part model, I propose integrating each step of her plan into the course.

3.1 Achieving Part 1 : Warm-Up for Effortful Cognition

To begin an effective warm-up, I would recommend starting each class by directly stating the learning targets for that session to give students a clear and explicit goal. This has been shown to positively impact student understanding and performance on assessment tasks (Fadhil, 2018). In addition to learning targets, I would also recommend asking students to conduct a self-awareness check and considering non-cognitive factors like how much sleep they have gotten, their level of anxiety that day, outside stressors, etc. Recognizing a connection between their physical and mental health and their learning and critical thinking skills can help students evaluate the root of their struggles.

3.2 Achieving Part 2 : Explicit Instruction

This course alongside the required STS curriculum currently satisfies this step. The mission of the STS program is to give students the tools to make "creative, ethical, and inspired contributions" (University of Virginia School of Engineering and Applied Science, 2021). It does so by teaching critical thinking skills beginning with exposing students to a series of sociotechnical and ethical frameworks. Likewise, CS 4501 establishes its topics and readings via the course syllabus and elaborates them further with lecture-style teaching.

3.3 Achieving Part 3 : Provide Opportunities for Critical Skill Transfer

While part 2 has been previously satisfied by the course, it is missing the necessary

components to fulfill part 3. STS classes previously taken by CS 4501 students teach critical thinking skills by evaluating an array of scenarios through a sociotechnical lens. CS 4501 lays out the facts of a variety of scenarios regarding election machinery, instances of disenfranchisement, and security vulnerabilities. The gap to be closed in part 3 is the critical thinking skills learned in STS needs to be transferred to the content of CS 4501 to more deeply consider the social and political causes behind the course's objectives. I would implement this during the lecture-style component of the class. After concluding the lecture, I would recommend the professors selecting 3 of the frameworks with which students are already familiar, use them to develop research questions, and facilitate a class-wide discussion to engage students and allow them to bounce ideas off one another. Class-wide discussions have been shown to cultivate higher thinking skills and help students gauge their own learning (Lam, 2018).

3.4 Achieving Part 4 : Evaluation with a Metacognitive Component

The main purpose of the metacognitive component is to give students experience evaluating their own progress and thought processes instead of only receiving grades based on a professor's evaluation (which is the current method.) To satisfy this part, I would make weekly discussion posts a requirement of the course. The posts would touch on two main parts : (1) the content of the week and further applying to new sociotechnical or ethical frameworks and (2) student evaluation of their performance in class, like their new or deeper understandings, how they developed their opinions and how they evolved during the class discussion, and an assessment of their participation.

4. ANTICIPATED RESULTS

As a result of implenting Halpern's Four-part model for critical thinking transfer in the CS 4501 curriculum, students will be able to take the problem solving and reasoning skills learned in STS and use them to analyze similar disasters and controversies within their own major. Students of the CS department will be better equipped to make controversial workplace decisions and more carefully consider the social and political implications of their seemingly technical work. More generally, the engineering department as a whole can move closer towards its mission statement : "make the world a better place by creating and disseminating knowledge and by preparing engineering leaders to solve global challenges" (University of Virginia School of Engineering and Applied Science, 2021).

5. CONCLUSION

The CS 4501 Cybersecurity and Election offered by the University of Virginia's Computer Science department stands to benefit from a course redesign. Currently, it falls short by not asking students to delve deeper and perform sociotechnical analysis on the social and political elements of the course. I recommend improving the course by implementing Halpern's Four-part model to help students develop and apply their critical thinking skills. By adding a purposeful and directed warm-up, explicit instruction, opportunities to test critical thinking and understanding, and metacognitive evaluation, students have the potential to become more well-rounded and considerate designers.

6. FUTURE WORK

After the initial course redesign, a necessary step to guarantee it is both effective and continuously improving is establishing a feedback and evaluation system. This could be done using an anonymous course evaluation form with questions tailored to the course's content, methods, and instruction techniques.

As opposed to the University's current method of course evaluation which only surveys students at the end of the semester, a new technical project could consider the benefits of having multiple evaluations staggered over time or other methods of assessment beyond anonymous forms.

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