Thesis Project Portfolio

The Impact of UVA's Machine Learning Class (CS 4774) on Students: How its Benefits can be Augmented

(Technical Report)

Comparing the Perspectives of Students and Professionals on Machine Learning Pedagogy

(STS Research Paper)

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Suhayla Ahmed

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Machine Learning Pedagogy at UVa and Beyond

"Students deserve great teachers. And teachers deserve the support they need to become great."
-Bill Gates

The importance of pedagogy as a whole in the computer science field is often not emphasized by professionals. This can have detrimental effects on the learning of students, especially as many CS fields are reliant on applying prior knowledge to developing technologies. In the spring, I was inspired by one of my classes - a lecture-based, math-heavy machine learning elective - to look deeper into CS pedagogy. While this certainly was not the first time I paid attention to a professor's teaching style, a lot of my peers and I noticed how difficult it was to comprehend the source material regardless of how many times we would rewatch a lecture. I realized then that I would have to grow more familiar with the learning process if I wanted to continue to grow both during my studies and after graduation. I wanted to find a way to maximize my learning both in and out of the classroom. For my technical project, I took a more in-depth look at the student reviews of UVa's machine learning elective. I also compared the elective to other electives at top universities across the country. My STS research project branched off of this, but rather than being focused on the learning outcomes within machine learning electives, I decided to analyze the discrepancies in perspectives of students and professionals in machine learning. In addition, I analyzed the process of turning from a novice into an expert in a field.

The technical portion of my project was an in-depth review of machine learning electives. Of course, the true case study I had was CS 4774 at UVa. In the most recent semester, students in

interviews detailed that they felt like they did not absorb much of the course material in class and that they felt unprepared for pop quizzes. The course material was highly mathematical, so sometimes a lecture-based teaching style was not effective. However, in past semesters, the class was described to be reasonably hard but recommendable for other students looking to learn about machine learning. After looking at similar machine learning electives at Princeton, University of Illinois-Urbana Champaign, and Georgia Tech, I found the key similarities and differences between these classes. For instance, they all had the same mathematical course overview because of national standards. They also followed a lecture-based teaching style. However, the grade distribution between exams, projects, and other assignments was different. I applied these findings to propose a stronger design of a machine learning class as a whole. One proposed solution was for the professor to start their lectures asking students general questions about real-life applications of machine learning. This would help to bridge the gap between the mathematical coursework and the 'real world'.

For my STS research project, I built upon the prior research from the technical portion to develop an analysis of the novice versus the expert perspective of machine learning. Looking at the differences between student and expert perspectives provides valuable insights into how novices can become experts and how experts can become better equipped to educate novices. The reason why there is a disconnect between what students learn and what professors aim to teach is often due to the fact that professors have been studying their topics for years and hence may have forgotten the feeling of being a beginner. After revisiting the student perspectives from my capstone, I analyzed them using Benner's Theory and found out that novices can feel constricted by certain rules or theoretical knowledge of a skill, causing them to be unable to

move to a more advanced level. The following figure shows the five stages of learning that Benner talks about. With each stage, there are definitions and common ways to reach each level.

Stage	**Definition**	**Knowledge acquisition**
Novice	The learner has had no previous experience	Teach simple concepts/attributes
Advanced beginner	The learner has enough real-world experience to understand themes in rules and guidelines.	Increase assistance and support
Competent	The learner has been on the job two or three years and is able work efficiently	Offer inservice education or opportunities
Proficient	The learner uses pieces of evidence (i.e. maxims) that provide directions to view a situation as a whole.	Use case studies to stimulate critical thinking
Expert	The learner grasps the situation and understands what needs to be accomplished beyond rules, guidelines, and maxims.	Provide opportunities for experts to share their skills and knowledge

Figure 1: Benner's Novice to Expert Theory in a table

In my results, I gained new insights into why these disconnects exist - not only do novices face difficulty trying to adapt to rules, but experts are unable to empathize with the novices since they have let go of such rules since reaching higher skill levels.

Through my work on this project, I was able to take into account an overlooked part of computer science - the pedagogy itself - to also think about the implications of not going through an education truly understanding course material. When classes become a matter of passing or failing rather than augmenting one's knowledge, then that defeats the purpose of an education and can also incite apathetic attitudes towards the idea of schooling. Through my research, I reflected on how important my schooling is in my development as an engineer. I also was able to remember why I am in school in the first place and the irreplaceable skills I gained.