The Abaclock
(Technical Paper)

Gender Bias in Artificial Intelligence: An Analysis of Man-Made Technology and Its Effects on Women in the Workplace
(STS Paper)

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
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Bachelor of Science in Mechanical Engineering

By
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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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Introduction

The STS research paper draws inspiration from the social construction against women and how such bias can be ingrained within certain technologies. There is a clear connection between my experience as a woman in mechanical engineering and the motivations behind the STS paper. Efforts to close the gender gap in this field remain modest, and current strategies for doing so are proving ineffective (Arefi, 2022). These unsuccessful efforts show a pattern that can be seen through history and why an investigation into this area is necessary. How does the underrepresentation of women in STEM lead to technological bias and further inequalities? How can these themes be tracked through history and through different technologies? These thoughts are inspired by the process of my technical capstone project. As the sole woman in my project group, and one of three women in the entire class, it was easy to ask why this was and what social constructions and deterministic technology made this to be true.

The technical capstone group had a clear vision and motivation for the mechanical engineering project at hand. We decided to make an installation that encapsulated all the technical learning we achieved in the mechanical engineering, electrical engineering, and computer science fields. To demonstrate this engineering mastery, we landed on creating an unconventional clock in the form of an abacus. Our goal was to combine an old mathematical instrument with new mechatronic techniques to create something unique and interesting for the UVA community.

Technical Topic

The motivation for the technical topic is broken down into two parts: demonstrating mastery of mechatronic engineering practices and creating a unique art installation to enhance some part of the UVA community. Despite the numerous hours involved studying the field of

mechanical engineering, there are very few opportunities for undergraduates to demonstrate their knowledge and skills. Lab and course work provide adequate experience when it comes to the theoretical practice of mechanical engineering through simulations and closed experiments. However, such methods of learning often disregard real life variables such as feasibility, reliability, and practicality. A major cause of the lack of open-ended experimentation opportunities is due to online learning during peak COVID lockdown. A study on engineering education during the COVID-19 pandemic stresses concern with the severe lack of hands-on learning and argues that personal engineering kits can allow students to better grasp new technical skills by letting students learn via hands-on trial and error (Asgari et al., 2021, p. 12). Our team's technical advisor utilized such a teaching method by providing extensive kits to each student in the third-year mechatronics course. This technical project will rely on skills learned in that course while also providing an opportunity for us to grow those skills through our own design iterations (Lüder et al., 2020).

The object of this project is to create a mechanical wall clock in the form of an abacus. This clock will integrate mechanical and mechatronics systems that both demonstrate the practical skills of undergraduate mechanical engineers at the University of Virginia while paying homage to the origins of numerical methods.

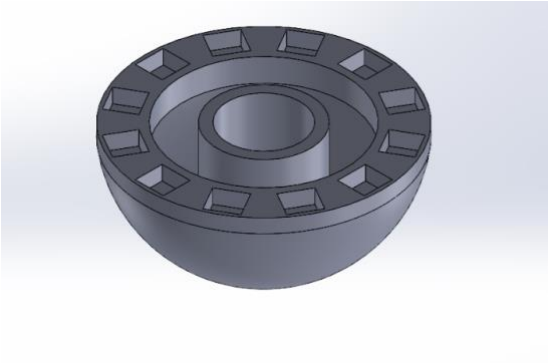

Figure 1: Computer Aided Design (CAD) of half of an Abacus bead with magnet housings (Bauer, 2022)

An abacus is a counting tool that has been used throughout history since before the Arabic numerical system was adopted (Samoly, 2012). This clock will use theoretical knowledge of mechanical, and electrical engineering systems to physically display the time of day in the form of a number on an abacus. The design will consist of beads lined with magnets that travel along linear guide rails. The beads will be 3D printed and will have pockets for the magnets as shown in Figure 1. The beads will be the only part of the clock visible to add to the mysterious aspect of the clock. An opaque sheet of acrylic will separate the beads from the mechanisms that move them.

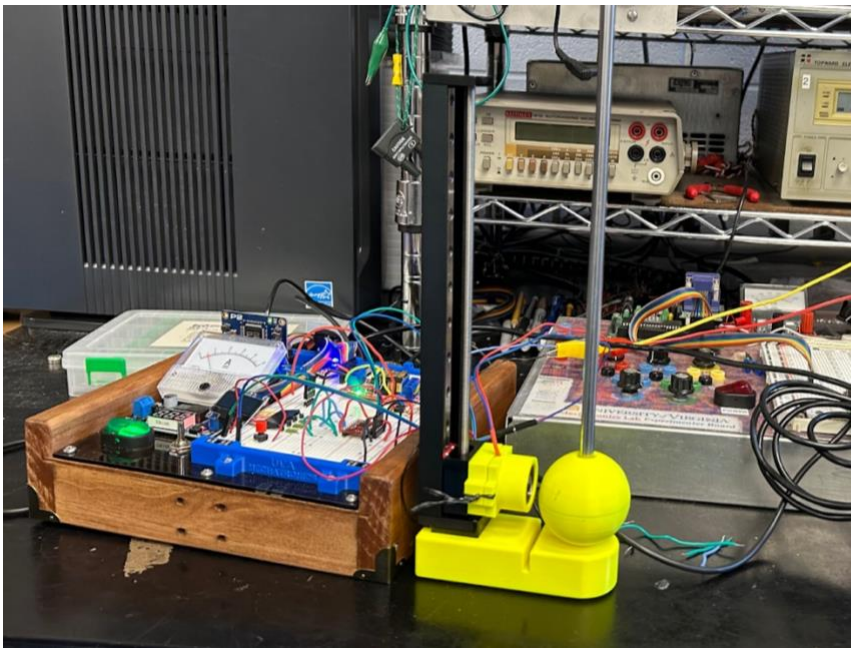

Figure 2: Prototype one of the "Abaclock" featuring one column, bead, and electromagnet (Bauer, 2022)

For each column of beads, a stepper motor and lead screw system will move a linear actuator up and down. The actuator will engage and retract a permanent neodymium magnet that will use its magnetic field to interact with magnets in the beads. The magnetic force combined with the force of friction will allow the lead screw system to move the beads while being hidden behind the acrylic sheet. A prototype of a single column mechanism can be found in Figure 2.

The abacus clock will be designed, tested, and built during the 2022 fall semester under the guidance of Gavin Garner, a professor of mechanical and aerospace engineering in the Department of Mechanical and Aerospace Engineering at the University of Virginia. The design process used to complete the project will consist of the following steps: (1) define the problem, (2) identify constraints, (3) generate designs, (4) test prototypes, and (5) build and validate final design. The team members included in this project are Jack Thomson, Timothy Peoples, Mrinaal Lorengo and Mollie Bauer. Each team member is a fourth-year student studying mechanical engineering at the University of Virginia School of Engineering and Applied Science. The final goal of this project is to have a clock display in a prominent location on grounds in order to demonstrate the practical skills of undergraduate engineers. This project will be fully documented in a final technical report.

STS Topic

Defining technology is no easy feat, and throughout the class's study of STS, it became apparent how transient the meaning of the word is. In Nye's *Technology Matters: Questions to Live With*, the author vehemently combats the idea that technology is synonymous with the cell phones and televisions we subconsciously associate the word with today and instead poses an argument that frames technology in more of an abstract manner, comparing it to language or art. A major theme that runs throughout the text is that no tool or piece of technology can be fully understood when standing on its own, it must be seen in the context in which it was created. The social constructs against women are important factors to be considered when analyzing certain technologies in the past few decades.

Machine learning is a defining technology of the internet age and can be attributed to anything from the rise of social media, chat boxes on websites, and autonomous vehicles.

Machine Learning is used to create Artificial intelligence (AI) which teaches computer models to make human-like, intelligent decisions. It is a way to give computers the ability to learn without explicitly being programmed (Brown, 2021). What these programs are given to learn from is data generated by and collected from humans that holds all the biases we do (Rankin et al., 2020).

Amazon infamously enacted a biased AI recruiting tool that filtered out women's resumes more often than men. The computer models were trained to vet applicants by observing patterns in resumes submitted to the company over a 10-year period. Due to historical gender inequalities in the tech industry, the AI taught itself male candidates were preferable for Amazon's engineering roles (Dastin, 2018). Furthermore, Facebook was alleged to profile users using algorithms within their platform. This data was used to present biased job openings to users and women tended to get advertisements for more inexperienced and unskilled job openings. This instance is one of many times the tech giant has come under fire for discriminatory ad targeting and is only a reflection of gender bias in our society (Kerpen, 2021). The large-scale collection and analysis of internet data on Amazon and Facebook is one way these stereotypes can be perpetuated. Security issues, privacy risks, and unintended discrimination all come with Big Data analytics due to the sheer amount of precise data collected (Joshi, 2008).

The STS theory of the social construction of technology (SCOT) will be used to analyze these technologies and their perpetuation of discriminatory societal patterns. SCOT was originally presented by Pinch and Bijker and argues that human action shapes technology and that said technology cannot be understood without the appropriate societal context. Klein and Kleinman are two important critics of this original theory. A very common criticism of SCOT that will be explored in the paper is that it examines the social groups that contribute to the

creation of new technology, not necessarily ones that are left out of the design process (Klein et al., 2002). The idea that historically marginalized groups are still affected by these engineering choices even if SCOT does not account for them will be discussed in the STS paper as well.

Research into data privacy and biased AI algorithms is very important due to the enormous implications it has on everyone in this new technological era. These technological innovations have caused a revolution, but consequently have also required engineers to ask more questions about the ethical implications of autonomous machining (Carneiro et al.). Engineering decisions can have devastating, if not deadly, effects on those not directly represented or thought of during the design process (Niethammer, 2020). Men's greater historical contributions and continuing dominance in the industry pose an impossibly high barrier for women seeking equality. But, given a concerted effort to rectify biases within people's minds and technologies, the new opportunities presented to women will be vital to future innovations (Devillard et al., 2018).

The STS paper will explore the following research question: In what ways has the emergence of Big Data and Machine Learning technologies caused marginalization against women in the STEM community? Being as data privacy is a high profile, highly complex issue and one with no clear correct answer, wicked problem framing will be a method used to analyze the foundational issues of the technologies being discussed. Furthermore, case studies will be an important method during analysis. They will be used track patterns in use cases of Machine Learning as well as show the inter-actor relationships between different social groups and their technologies. This research question addresses only a small portion of a huge puzzle as to how to reduce biased technologies while maintaining privacy. Wicked problem framing and case

study analysis will help narrow the scope to analyze the niche concerns of women in STEM being affected by these new technologies.

Conclusion

The final deliverable of the technical capstone project will be a large-scale clock in the form of an abacus with the goal of putting it up for permanent display in the UVA community. This will further our skills as mechanical engineers as well as help us become more thoughtful leaders. The deliverable for the STS report will be an analysis on the effect Big Data and Machine Learning practices are having on women in STEM. The discussion will include methods of analysis such as wicked problem framing and case studies and try to help the reader understand the implications of biased technologies. These projects, although different, serve to amplify women's voices in engineering, and lead to more thoughtful conversations of this topic in the Charlottesville community and beyond.

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