Optimizing Computer Science Office Hours Through Technology-Driven Grouping

(Technical Topic)

Efficiency vs. Equity: A Critical Look at Group-Based Office Hours in Computer Science

(STS Topic)

A Thesis Prospectus submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Fall 2024

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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Overall Introduction

Impatience with long wait times and frustration amidst academic crises are common experiences for many students. At the University of Virginia (UVA), one-on-one engagement during office hours is part of the curriculum, intended to offer personalized support and reinforce concepts to foster student success and engagement in the classroom (Carpenter et al., 2021, pp. 550–555). However, for computer science programs, rapid growth in both course offerings and enrollment has led to a surge in office hour traffic. According to the 2023 Taulbee Survey, there was a yearly 17.6% increase in awarded BS degrees and a 9.5% increase in new BS majors nationwide (Computing Research Association, 2023). With demand outpacing capacity, hiring more faculty is not a straightforward solution, as budget constraints and a shortage of qualified teaching assistants (TAs) force schools like UVA to depend on efficient office hour systems to meet students' needs (Seymour & Hunter, 2019, pp. 387–414).

Despite the emphasis of one-on-one engagement, many students find the wait times and unproductivity of office hours discouraging, causing them to avoid office hours entirely. For students who do attend, it often feels more like waiting in line for tech support than a valuable learning resource. Increasingly, students view office hours as a last resort instead of a consistent, supplemental tool (Z. Gao et al., 2022, pp. 300). For underrepresented students who rely on office hours as their primary source of help, having a poorly structured system only puts them at a greater disadvantage (Barker et al., 2014, pp. 1-19).

These issues motivate us to reinvent the office hour system by incorporating two core solutions: grouping and AI. By grouping students with similar questions and integrating an AI chatbot, wait times can be reduced and active, collaborative learning encouraged — key factors in optimizing office hours to better serve a diverse student population. This redesigned office

hour system introduces the question of how does the design and implementation of UVA's technologically enhanced office hour system impact the quality and accessibility of academic support for diverse student populations in computer science? If not carefully analyzed, disadvantaged students will continue to use a lacking tool as their only source of help, widening the achievement gap even more.

Technical Topic

The current office hour system at UVA is straightforward but increasingly overwhelmed. Students arrive at a standard first-in-first-out queue, receive help from a TA or professor, and then provide feedback with a survey afterwards. This traditional setup struggled with accommodating the high demand as students were waiting at least an hour for help in many cases (Smith et al., 2017, pp. 549-554). To meet the growing demand, an enhanced office hour system was designed with features like automated student grouping and a Large Language Model (LLM)-based chatbot for answering common questions.

While these features address the immediate logistical issues, we must acknowledge that the root causes of insufficient faculty hiring and reliance on TAs persist. Factors like budget limitations and a shortage of qualified teaching assistants often prevent institutions like UVA from expanding staff, particularly in resource-intensive STEM fields like computer science (Seymour & Hunter, 2019, pp. 387–414). Since hiring more TAs is not as feasible as it seems, my research focuses on optimizing office hour systems to address these limitations effectively and ensure that students still receive the academic support they need. Central to this new system is an automated smart grouping tool that clusters students with similar questions for collaborative sessions with TAs or professors. Grouping was chosen since research suggests students in groups

were more satisfied, had higher grades on exams and homeworks, and were less likely to use unsanctioned resources (Calver et al., 2022, pp. 829-835). This grouping tool uses a Cosine Similarity algorithm, which measures similarity between texts — in this case, student-submitted questions. The algorithm creates a "hyperspace" of word vectors, and questions with smaller angles between them, indicating shared words, are grouped together. This approach enables TAs to address similar issues collectively, increasing productivity and promoting collaborative learning (Hott et al., 2024, pp. 1684–1685).

The enhanced office hour system improves on prior models by incorporating research in collaborative and automated support. Specifically, focusing on how groups are formed as when structured properly, this collaboration can lead to more positive results for disadvantaged students like peer support, sense of belonging, and improved STEM retention rates (Kohli et al., 2023, pp. 11–17). Comparing various grouping approaches used by other platforms, such as GroupFormation, provided valuable insights to refine techniques. Ultimately, Cosine Similarity was selected over GroupFormation due to its ability to process accurate and efficient student groupings without requiring extensive faculty input (Henry, 2013, pp. 645–650). Another feature is an LLM-based chatbot to provide immediate assistance and reduce queue times for straightforward questions. This AI tool uses uploaded course materials and synchronized Piazza data to answer questions directly or generate an initial response while students wait for a TA, ultimately reducing TA workload and allowing them to focus on guiding group sessions for more efficient and productive office hours.

All of these additional features were added due to the rapid increase in computer science enrollment at UVA. The destabilizing conditions from the old system like long wait times discouraging students from seeking help and overwhelmed TAs unable to provide quality support

resulted in negative feedback from students who felt rushed and underserved. Failing to address these issues have significant costs and consequences for both students and faculty but especially for underrepresented and disadvantaged students whose only resource for external help are office hours. Students who cannot access timely support are at greater risk of falling behind in their coursework, which can impact their grades and reduce engagement with the material (Kinnunen & Simon, 2010). Additionally, having an influx of students waiting in the queue causes office hours to be deemed as unhelpful and time consuming which further deters students from attending even when needed (Guerrero & Rod, 2013, pp. 403–405). There are consequences on the faculty side too with handling large volumes of students at once leading to increased burnout, reduced teaching quality, and high turnover rates for TAs (Smith et al., 2017, pp. 549-554).

By implementing a new technologically advanced office hour system, it aims to answer the question of whether, technically speaking, smart grouping and new technological features like AI can make office hours more efficient, equitable, and accessible. The expected deliverable is a fully integrated grouping and AI office hour system that can handle large volumes, decrease wait times, promote collaborative learning, and provide students with a consistent level of support. Though still in the beginning stages, the system is currently being used by eight UVA computer science courses and could serve as a model to help us understand how innovative technology can improve academic support, reduce faculty burnout, and create a more inclusive learning environment.

STS Topic

Although hiring more TAs could potentially solve the problem of overcrowded office hours, institutions like UVA often face budget and logistical constraints that make hiring more

staff difficult. Studies indicate that institutions struggle to balance enrollment growth with resource expansion, particularly in STEM fields where funding and the availability of qualified teaching assistants are limited (Seymour & Hunter, 2019, pp. 387–414). Instead of focusing solely on increasing staffing, leveraging technological solutions like AI and grouping offers a more scalable approach. However, these innovations also have significant implications for equity and access to academic support, particularly for underrepresented and lower-income students who rely heavily on office hours for help (Y. Gao et al., 2022, pp. 994). I want to focus specifically on computer science programs, where increasing enrollment and resource constraints make office hours a crucial element of academic support (Computing Research Association, 2023). This poses an important research question: How does design and implementation of UVA's technologically enhanced office hour system impact the quality and accessibility of academic support for diverse student populations in computer science?

For many students, office hours are a vital resource, especially for those lacking prior knowledge of the course material or access to private tutors (Barker et al., 2014, pp. 1–19). My research aims to see if technologically enhanced office hours effectively address the needs of diverse student populations or perpetuate educational inequalities. The primary stakeholders for this system are students, TAs, and professors but my research will focus on students from diverse backgrounds, specifically computer science majors. "Diverse backgrounds" refers to underrepresented racial and socioeconomic groups, as well as varying levels of digital literacy and access to academic resources. These stakeholders face unique challenges, including limited familiarity with online tools, which may hinder their ability to access timely academic support (Smith et al., 2017, pp. 549–554). AI and grouping tools aim to address these challenges by clustering students with similar questions, fostering peer learning, and reducing redundancy for

TAs (Calver et al., 2022, pp. 829–835). Without timely support, however, students are at greater risk of academic setbacks, widening the achievement gap and threatening retention in STEM fields like computer science (Seymour & Hunter, 2019, pp. 387–414).

Examining the relationship between technology and society, Melvin Kranzberg's first law dictates that "technology is neither good nor bad; nor is it neutral" (Kranzberg, 1986, pp. 545). Technological design inherently shapes social outcomes, often reinforcing or disrupting existing societal structures. Expanding this truism to the technological determinism framework, it suggests that the design and implementation of technology have far-reaching consequences, often reinforcing or disrupting existing societal structures. This idea emphasizes that design of technology is not merely a technical process but one embedded in and influenced by societal values and power dynamics (Söderberg & Östman, 2020, pp. 433-435). By applying this framework, I can critically evaluate how UVA's enhanced office hour system impacts equity and accessibility for underrepresented computer science students.

If the redesigned office hour system is not carefully implemented, students who depend on it may struggle to access the support they need, worsening their academic challenges (Kinnunen & Simon, 2010). Applying technological determinism to my research involves examining how new features of the system like chatbots and collaborative group sessions are designed and whether they address the needs of marginalized students effectively. "Technological affordances" and "user-centered design" are essential concepts in evaluating how well the system promotes productive academic interactions for all students (Söderberg & Östman, 2020, pp. 445–447). To gather insights, I plan to conduct interviews with a diverse range of students who use office hours and analyze session feedback data since central to this

analysis is understanding whether the system's design integrates inclusive practices based on stakeholder perspectives.

My research aims to show how the new enhanced, technologically-forward office hour system should incorporate sociotechnical approaches with its design. Specifically, how design plays a huge role in educational impact and consequences for underrepresented students in computer science. It must make sure that inclusivity is part of every step to avoid inadvertently hurting disadvantaged students whose only resource outside of class are office hours. Through this research, I hope to help institutions like UVA understand how technology-based office hours can either narrow or worsen educational gaps, offering insights for creating equitable learning environments as demand for academic support continues to grow in computer science.

Overall Conclusion

The redesigned office hour system aims to address critical accessibility issues for underrepresented and lower-income students to ensure retention and academic equality in computer science. Long wait times and rushed sessions from an overcrowded queue leave many students without adequate help, widening education inequalities with a poorly structured system. Hopefully, by creating new features like smart grouping and integrated chatbots, this new system can reduce lines, streamline common questions, and allow TAs to focus on personalized student needs. This solution not only tackles the immediate issues of demand and wait times but also promotes a more inclusive, equitable learning environment where all students can access timely, productive help. From a comprehensive lens, I am working on the larger topic of equitable access in education because I want to find out how intentional design of educational systems can either

bridge or widen achievement gaps, so that I can help other institutions understand how to build support systems that ensure education equity.

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