Accessible Navigation Mapping:

Supporting People with Mobility Disabilities for Wayfinding

(Technical Paper)

Enhance Inclusion and Accessibility with User-Centered Design Practices

(STS Paper)

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 Systems Engineering

By
Shiyu Liu

May 8, 2024

Technical Team Members:
Iris Chen

Christopher Cook

Manasi Srigiriraju

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.

ADVISORS

Rupa Valdez, Department of Systems Engineering
Tariq Iqbal, Department of Systems Engineering
Richard D. Jacques, Ph.D., Department of Engineering & Society
Bryn E. Seabrook, Department of Engineering and Society

Prospectus

Introduction

In contemporary society, technology has become an integral instrument across various sectors, pivotal in addressing the multifaceted challenges presented by our rapidly progressing world. However, even with noble objectives targeting specific problems, the unintended consequences due to design shortcomings persist. Consider the Notre Dame cathedral fire in Paris, mentioned in Scott Berkun's "*How Design Makes the World."* The fire alarm system that took experts six years to develop failed due to a simple unclear warning message, resulting in the spire's collapse. The tragedy could have been avoided if the designer had put the end user - in this case, an inexperienced security employee - into consideration and adjusted the system according to the actual user demands. As technology advances, more inherited design deficiencies surface. These deficiencies can be broadly ascribed to insufficient inclusivity considerations, a paucity of user-centric design, and occasional deliberate oversights. These consequences could be gravely consequential, especially for individuals with disabilities. As of May 2023, approximately 1 in 4 (27 percent) adults in the United States identify with a form of disability. Of these, 12.1 percent have a severe mobility disability (CDCP, 2023). Narrowing this down to college settings, in the academic year 2015-16, close to 19% of undergraduates acknowledged the presence of a disability (NCES, 2017). These inadvertent challenges possessed to this demographic (among others) could potentially be mitigated by a design process involving the following stages: 1) comprehensive assessment of fundamental user demands, 2) systematic analysis of existing designs and deficiencies, 3) data aggregation and analysis, 4) introduction and prototyping of possible solutions, 5) iterative refining, and 6) final design execution (Phan, 2022).

To avoid potential oversights, a considerate design process is needed when designing user-based technologies. In this regard, the STS and technical segments would each address distinct phases of this process, offering an in-depth application of their respective stages. The STS research dimension will mainly focus on the initial two stages, examining current technological designs with a focus on various platforms, discerning their unintended consequences, and what improvements should be made to avoid such consequences in the future. The technical portion, completed as a capstone team, intends to take the steps further and complete the design process by collecting data from disabled student bodies (potentially extending to associated faculties, too) and devising a more intuitive system to facilitate their movement across the UVA campus.

Technical (Capstone) Project Description

For individuals possessing mobility malfunctions or vision impairments, traveling around UVA Grounds is not always an effortless task, considering a substantial portion of the University is built on hills. The current signages and building indication boards are sporadically placed, causing unnecessary navigation efforts. Furthermore, the physical accessibility features, such as entrance ramps and automatic door openers, are also lacking especially around the older part of the school. Such ambiguity in signage and the absence of essential features can lead to undesirable, occasionally critical, outcomes for those with disabilities. Meanwhile, the navigation system also needs refinement in multiple perspectives. Currently, the University's most comprehensive navigational tool is the GIS map (Fig. 1), functioning primarily as a visitor map website with limited capabilities. The website's user interface is intricate, and its adaptability for mobile devices is also suboptimal.

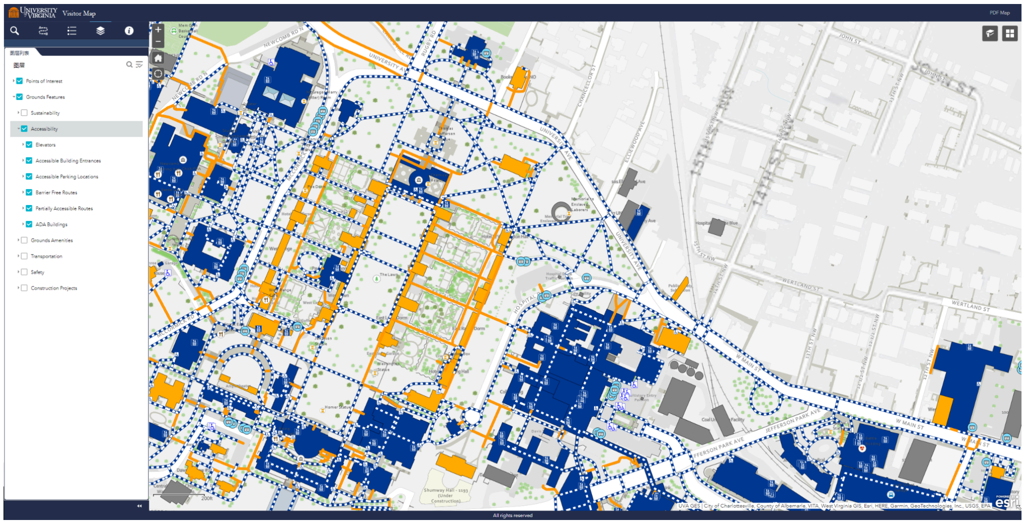

Figure 1. UVA GIS Visitor Map[1]: the UVA current navigation tool designed for visitors.

The initial research underscores different variables affecting accessibility for the disabled demographic, limiting their daily quality of life. These variables include, but are not confined to, floor texture changes, locations of curb cuts, and sidewalk conditions. A sophisticated but well-constructed mapping technology is needed to address this issue.

The main objective of the technical project is to integrate this often-neglected information with frontend technological solutions, thereby facilitating the development of a navigation system that provides comprehensive information about accessibility features and guides people with mobility disabilities along accessible routes. The overall goal of the project is to improve the campus' accessibility and provide wayfinding resources. This objective is achieved through three major phases:

1. Collection of data/information from current students, faculty, and staff with mobility disabilities demanded concerning their navigational needs.
2. Determination and analyzation of existing accessibility features
3. Synthesization of the collected data, recommendations for these features enhancement,

[1] https://atlas.fm.virginia.edu/portal/apps/webappviewer/index.html?id=c54aefa568904e018601a0447eb722bf

and iterative suggestions for the navigation system.

The data acquisition phase would be under the guidance of UVA's Student Disability Access Center (SDAC) by conducting a survey distributed to relevant groups to pinpoint the specific barriers and features that they would like to have information about when navigating through the physical space. Given the sensitivities surrounding interactions with people with disabilities, all engagements would strictly follow the Institutional Review Board (IRB) and Collaborative Institutional Training Initiative (CITI Program) guidelines[2]. All team members are mandated to complete the CITI program courses prior to conducting the research. All data collected will further draw upon previous ground efforts by the UVA Geospatial Engineering Services (GES). Ensuring accessibility inclusion will align with the Americans with Disabilities Act (ADA) accessibility guidelines and be supplemented by additional criteria to guarantee maximum inclusiveness. Analytical outcomes from the information gathered will inform specific recommendations. Working with associated affiliations, additions of physical accessibility implementations will be integrated across locations on campus. Suggestions for the GES will target a more intuitive navigation system, aiming to furnish the disability community with more precise directional instruction and an optimized transit experience.

When designing for individuals with special needs, it is essential to think beyond our understanding and try to be as inclusive as possible. While the ADA standards establish a baseline, designers must remain aware of adjusting to the dynamic requirements and strive to improve the overall user experience.

The project will span two semesters with SYS 4053 and SYS 4054 Capstone project courses. Given time constraints, the project scope has been defined with limitations. The type of disability we are aiming for is specified to be mobility disability. Although our methodology

[2] https://about.citiprogram.org/

holds potential for a broader application, our immediate focus within the project scope is on the mapping process of the Engineering school, since this is where our greatest familiarity lies. The team will work together toward the completion of the project by the end of April 2024. The project is under the direction of Rupa S. Valdez from the Department of Public Health Sciences & Engineering Systems and Environment and Tariq Iqbal from the Department of Systems and Information Engineering.

The process would also involve dynamic collaborations with various departments and organizations within the school to receive stakeholders' feedback and deliver intermediate reports. The process will remain flexible for adjustment along the way. Collaborative entities include UVA's Student Disability Access Center (SDAC), the Geospatial Engineering Services (GES), the Provost Office, Facilities Management, the Global Development Studies division, and the Student Disability Advocacy (SDA) Organization; the latter will focus on disability justice.

STS Project Description

The design landscape has persistently overlooked the importance of comprehensive accessibility and inclusivity. Often, designers, or humans in general, fail to consider situations that do not apply to themselves. Given our escalating dependence on technology, any inadequacy in the design frameworks of digital platforms or daily-used objects can produce profound consequences. Every design oversight would accumulate and place challenges for the user. Beyond mere usability concerns, there is a more profound societal implication. Take wayfinding as an example, it is more than just simply directional adherence and spatial navigation – it is an essential skill that is interconnected with independence, quality of life, mental health, and economic prosperity (Parker et al., 2021). Design insufficiencies could perpetuate stereotypes, reinforce biases, and marginalize minorities, thereby causing emotional distress, reducing productivity, and inducing potential safety risks. Moreover, any efforts to fix a design deficiency can prove costly and sometimes cause irreversible consequences. These aspects underscored the urgent need for a more user-centric and inclusive approach to design. The primary objective of this research is to highlight, analyze, and address the prevailing design inadequacies with emphasis on diverse areas detailed in the subsequent sections.

Understanding human cognition and underlying mental operations is essential before initiating the design process. Such comprehensive insight into human factors provides valuable perspectives in ensuring the deliverable aligns with user expectations, thereby mitigating the possibility of post-launch user rejection. The key consideration for designing is cognitive ergonomics, a discipline that works in harmony with the human mind instead of against it (Bergignat, 2023). This concept involves understanding how the human brain processes information and makes decisions, acknowledging human interactions, innate constraints, and a ed mindset. A practical design approach should be anchored in understanding the human psyche and its interaction with the surrounding environment. By comprehending and integrating these considerations, designers can ensure their delivered products/interfaces are effective without significant shortcomings while resonating with the intended audience.

Critical evaluations of current design practices should be conducted in order to prevent any recurrent mistakes. Examining these practices across various technological platforms aimed to prompt more informed design strategies in the future. The designs should be assessed in multiple dimensions, including usability, accessibility, navigational structure, adaptability, and user satisfaction. Incorporation of user feedback is also essential during this evaluation phase. Acquiring user perspectives and iteratively adjusting designs accordingly can provide real-world implications of design imperfections. Based on the evaluation results, tangible recommendations can be formulated to address these common flaws. This process examines the importance of interactions between designers and users, proposing guidelines to mitigate these inadequacies (most can be easily fixed upon recognition) in the future.

As mentioned previously, the design missteps might have severe impacts on those with disabilities. Therefore, in the context of the technical project, examining designs that target disabled communities and their consequences when deficiencies exist is essential before any improvements can be made. Implementing the same evaluation framework, the focus should encompass the existing wayfinding and navigation aids in comparable settings - such as other academic institutions - to provide concrete recommendations for UVA. Amalgamating insights from the research could serve as a reference not only for UVA but also for other settings looking to enhance inclusivity and accessibility.

Both the designers, developers, as well as stakeholders should have a heightened awareness of the importance of effective design and its direct impact on user satisfaction. Proper design choices and assessment of their social implications should be incorporated within every step of the process. By scrutinizing these areas, the research intends to bridge the gap between design theory and its practical application, ultimately leading to more intuitive and efficient technological platforms for users. The responsibility lies on the designers to ensure equity and inclusivity in the product. This research follows the first two steps of the designing process, focusing on user comprehension and existing design assessment, paving the foundation for the subsequent design and implementation phases.

Research question and methods

The overall thesis focuses on the question of how technology designs can be optimized to ensure maximum diversity, equity, and inclusion, considering its increasing involvement in daily life. The proposed solution is a design methodology emphasizing a user-centered mindset and the efficacy of the result deliverables (Phan, 2022). This process will be separated and, more thoughtfully, carried out by the STS component and the technical component.

Initiating with a thorough exploration of existing literature on technological designs, wayfinding, and mapping technologies, as well as design principles, will provide base grounds for scoping the problem and implementing the plan as proposed.

For the STS segment, it is responsible for the designers to understand the user and identify current design deficiencies. To achieve this, primary data will be collected via instruments such as surveys and usability tests to gather user perspectives and ensure a comprehensive viewpoint. The results would include qualitative and quantitative data, which will then be synthesized to disclose design anomalies. The current design evaluation will be achieved through case studies across diverse technological platforms and daily objects. In order to understand the current stances and pinpoint what gaps need to be addressed, a comparative analysis will be conducted, benchmarking the designs selected in the case study based on the matrices described in the STS section.

Given that the technical segment is executing the implementation phases of the design process, the data accusation would focus on two aspects: user demands and current facilities within the UVA campus. User requisites will be procured through surveys and interviews, targeting a diverse spectrum of users, predominantly within the disability community. These insights will shed light on user experiences, challenges, and potential improvement areas. Since working with a minority community is sensitive, the survey questions and general process should be guided and supervised by advisors and affiliated entities. Information about current physical accessibility features on campus (with a specific focus on the Engineering School) will be collected by the technical project team as a whole. Qualitative data, such as the number of ramps at building entrances, will then be analyzed to assess the current accessibility of UVA Engineering School. The team will also need to define our own threshold of level of accessibility. Merging all the analysis results will empower us to offer thoughtful recommendations to the stakeholders to facilitate the implementation of physical infrastructures and the development of the wayfinding application.

Conclusion

A systemic oversight in ensuring diversity, equity, and inclusivity has left a sizable portion of users - especially those with disabilities - at a disadvantage. The technical component, in collaboration with the end users, seeks to comprehend their needs and strive to cultivate a more accessible community here at UVA, both in terms of physical infrastructures as well as navigational systems. We will ensure that these advancements resonate closely, if not entirely, with user expectations. The STS research, focusing on assessments of diverse technical shortcomings, serves as the bridge to link theoretical concepts to practical applications, making sure that user experience is the top priority in any design process, eliminating the undesired consequences at its root. Furthermore, this synthesis of theoretical understanding and empirical applications will help to achieve the objective of user-centered design. By integrating insights from both components, this project is aiming to elevate the user experience while minimizing any design pitfalls.

References

1. Bergignat, J. (2023, April 17). *Cognitive ergonomics*. Medium. https://bootcamp.uxdesign.cc/cognitive-ergonomics-ab0d7e76c99c#:~:text=Cognitive%20ergonomics%20is%20the%20study,digital%20interfaces%20and%20physical%20products

2. Blythe , M. A., Monk, A. F., & Doughty, K. (2005, December). *Socially dependable design: The challenge of ageing populations for HCI*. IEEE Xplore. https://ieeexplore.ieee.org/Xplore/guesthome.jsp

3. Centers for Disease Control and Prevention. (2023, May 15). *Disability impacts all of us infographic*. Centers for Disease Control and Prevention. https://www.cdc.gov/ncbddd/disabilityandhealth/infographic-disability-impacts-all.html

4. CITI Program. (n.d.). *Research, ethics, and compliance training*. CITI Program. https://about.citiprogram.org/?_ga=2.259419465.2108898213.1698385932-1509116351.1698275800

5. GIS map https://atlas.fm.virginia.edu/portal/apps/webappviewer/index.html?id=c54aefa568904e018601a0447eb722bf
6. Helander, M. (1994). *Handbook of human-computer interaction*. North-Holland.

7. Indeed (Ed.). (2023, July 31). *The 7 steps of the Engineering Design Process | indeed.com*. Indeed Career Guide. https://www.indeed.com/career-advice/career-development/design-process

8. Namer, L., & Smodt-Saenz, A. (n.d.). *When ethical problems arise in Tech, design is an important safeguard*. dscout.com. https://dscout.com/people-nerds/ethical-problems-tech-design

9. NCES, U.S. Department of Education. (n.d.). *The NCES Fast Facts Tool provides quick answers to many education questions (National Center for Education Statistics)*. National Center for Education Statistics (NCES). https://nces.ed.gov/fastfacts/display.asp?id=60

10. Parker, A. T., Swobodzinski, M., Wright, J. D., Hansen, K., Morton, B., & Schaller, E. (2021, September 30). *Wayfinding tools for people with visual impairments in real-world settings: A literature review of recent studies*. Frontiers. https://www.frontiersin.org/articles/10.3389/feduc.2021.723816/full

11. Phan, L. L. (2022, August). *The design process and 5 reasons why it matters*. Zeplin Gazette. https://blog.zeplin.io/the-design-process-and-5-reasons-why-it-matters

12. Pierce , J., Strengers, Y., Sengers, P., & Bodker, S. (2013, September 17). *Introduction to the special issue on practice-oriented approaches to sustainable HCI*. ACM Digital Library. https://dl.acm.org/doi/abs/10.1145/2494260?casa_token=Y-1M9zBUI3QAAAAA%3Ap5eeq6ghNvvLSp0G0LcYAz-EHiLXQpmsohHroQJyYmKPDiRmXKbQIabH2VisfnKF86761emT5SSco6I
13. Ryan, C. (2018, August 8). *Computer and internet use in the United States: 2016*. Census.gov. https://www.census.gov/content/census/en/library/publications/2018/acs/acs-39.html
14. Turner, J. (2023, July 11). *The 8 main ways technology impacts your daily life*. Tech.co. https://tech.co/vpn/main-ways-technology-impacts-daily-life#:~:text=Technology%20has%20had%20a%20huge,explain%20the%20areas%20most%20affected.&text=Technology%20affects%20almost%20every%20aspect,healthcare%2C%20socialization%2C%20and%20productivity

15. Shafiezadeh, E., Mohammadi, M., & Paghaleh, M. J. (2011). Information Technology and its Deficiencies in sharing Organizational Knowledge. *International JJournal of Business and Social Science*, *2*, 192–198.

16. Vogels, E. A., Rainie, L., & Anderson, J. (2020, June 30). *Tech causes more problems than it solves*. Pew Research Center: Internet, Science & Tech. https://www.pewresearch.org/internet/2020/06/30/tech-causes-more-problems-than-it-solves/