Enabling Overground Walking During Motion Capture Pulling Force Trial
(Technical Paper)

Constructing Hierarchies: How the Built Environment of a University Contributes to Power Differentials Between Able-Bodied Students and Students with Disabilities
(STS Paper)

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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:

Is disability constant, making an individual is either constantly disabled or not? The idea of continuous disability seems to be the typical definition that "normative" society uses. Yet, there are many who disagree saying that disability is ever changing, dependent on a situation. Rosemarie Garland-Thomson suggests that the idea of disability is time dependent in that "ability and disability are not so much a matter of the capacities and limitations of bodies but more about what we expect from a body at a particular moment and place" (2005). With that in mind, how did the definition of disability become what it is known as today? It is thought that the continuously disabled definition arises from the perception that there is only one model for the human body and everything else is seen as "other." In the same article, it is states that "the concept of 'disabled' does not reflect the situation of the individuals but reflects the approach of public to the subject matter," further highlighting the role of "normative" society in defining the ability of those who do not fit the determined mold (Saltoğlu & Öksüz, 2016). The terms "normative," "normal," and "disability" are all in quotes as they are being used to exemplify further divisions and what has been used in literature.

Several issues could arise through the viewing of an entire group of people as "other." Through the course of the year, two projects will be undertaken that examine potential issues of disregarding those who are deemed "disabled." The first will be a technical project is aimed at creating a bidirectional assistive walking system to further the efforts in designing a motorized walker. The second project will be a Science, Technology, and Society (STS) research paper that examines how historical university campuses integrate equal access into their built environment and how that either contributes to or assists in dismanteling hierarchical power dynamics between "normal" and "disabled" students. Both these projects aim to understand the how

“disability” is defined in relation to the built environment and how divisions based off of that definition can be dismanteled, through technical and social means.

Technical Project Description:

Assistive mobility devices almost always have one similar goal: the attempt to make the world more accessible to those with a mobility issue. The design of these devices will take into consideration different factors based on their pre-determined purpose. In the design of devices that impart pulling forces on their users, such as motorized walkers, the ideal magnitude of the pulling force as a percentage of the user's body weight is an example of one such factor. The typical approach for finding the ideal body weight percentage has been to have a subject walk on a treadmill while wearing a belt that is tugged on by either a motor or a system of pulleys and weights. The subject wears a metabolic cost measuring device that monitors their carbon dioxide output and determines, from that, the amount of exertion their current movement is requiring of them. The treadmill approach has led to consistent results that pin point the ideal percentage of a subject's body weight that should be applied to them as a pulling force during treadmill walking in order to minimize metabolic cost.

However, the percentage of body weight value from the treadmill approach is being used in the development of assistive devices intended for overground (non-treadmill) walking. Overground walking and treadmill walking have been proven to elucidate differences in gait pattern that prevent them from being used interchangeably in biomechanical research (Fellin et al., 2010). Gain entrainment was only seen about 50% of the time in treadmill walking trials in a study by Ochoa et al. compared to over 90% of the time for overground walking. In the same study, it was seen that "convergence to a constant phase relation happened more quickly, taking

an average of 24 and 32 perturbation cycles in OG and TM trials, respectively," OG corresponding to overground trails and TM corresponding to treadmill ones. Gait entrainment refers to the applied torque pulses and the stride period, for there to be gait entrainment, each pulse must occur at the same phase in the gait cycle (Ochoa et al., 2017). There is also the possibility with treadmill testing that noise is introduced into the system via the treadmill belt and motor interacting with force plates (Kram & Powell, 1989). The differences between these two different data collection models are grounds for there to be error in the way that data is applied to assistive mobility devices. Therefore, it is necessary for the development of such devices to find this value for overground walking. The goal of this work is to develop a system to allow for the identification of the ideal percentage of body weight to be used as an assistive pulling force during overground walking.

In regards to the immediate use of the proposed system for assisted overground walking, it will be used in the validation of a model. There are ongoing efforts to develop an assisted motorized walker for children with Cerebral Palsy (CP) through the Motion Analysis and Motor Performance (MAMP) Lab at the University of Virginia. The development of the walker requires a known value for the metabolic cost expended by an individual when "x" amount of their body weight is applied by an assistive pulling force. Through the system for overground walking, the value for metabolic cost and body weight percentage can be found and plugged into a model for how the walker will function. The goal would be for the data collected by using the system to be applied to the model which would then in turn validate the theory behind the motorized walker and whether or not it would actually aid in mobility for children with CP.

STS Topic:

It is impossible to say that every person experiences physical spaces and environments in the same way. Every person will experience a space differently due to a variety of reasons, whether that be physical characteristic or something else, such as a sensory characteristic (Cassi et al., 2021). Yet, most spaces have been built with the idea that there is a "normal" individual that will use the space. Those who have physical characteristics that are different than the "normal" standard are simply seen as "other" when these spaces were designed (Saltoğlu & Öksüz, 2016). The Americans with Disabilities Act (ADA) targeted issues of accessibility through prohibiting public areas from being inaccessible due to physical barriers as was previously typical in older buildings that were built with the "normal" standard in mind (Dunlap, 1997). Even after the passing of the ADA act there is still incredible push back in altering historical spaces to allow for full and equal access due to the idea that the memory of the site will be forever altered (Liebermann, 2019). The push back in altering historic spaces in order to preserve one memory of the space perpetuates the idea that the majority group has a right to use the space more than another and that their view of the history of that site is all that matters. That perspective forces everyone else to adapt, creating a systematic divide between these two groups. This exact sentiment is expressed in the documentary film *Crip Camp: A Disability Revolution* with the statement from one of the campers of "I had to try to adapt. I had to fit into this world that wasn't built for me," expressing the idea of having to adapt to participate in society in any way (Lebrecht & Newnham, 2020). It is clear that when one group is all that is considered in design, a power dynamic is created between who the space is for and everyone else. This power differential leads to the question of how do historical universities incorporate equal access into their physical spaces and is this a sufficient way to dismantle hierarchical differences between "normal" and "disabled" students?

The idea of exclusion and forced adaptation does not exclude the school environment. School could lead to experiencing the power dynamic between those who the space was designed for and the "others" for the first time. Tanya Titchkosky states in her book *The Question of Access: Disability, Space, Meaning,* that "to identify as a disabled student, staff, or faculty member in most universities today is to be confronted with questions of access," whether that question is in regards to physical space or university life, displaying that the idea of the power divide extends further than who can use a space and who cannot (2011, p. 24). In 2020, the University of Virginia (UVA) made changes to create accessible Lawn rooms (*University Makes Two Lawn Rooms ADA-Accessible*, 2020). Prior to this change it would have been impossible for a student with a mobility issue to live in a room due to uneven ground to enter and lack of space to maneuver. Lawn rooms at UVA are seen as a high honor with only about 54 students being chosen to live in them each year, excluding rooms on the Range which are reserved for graduate students(*The Lawn at the University of Virginia*, n.d.). What the University was essentially saying before the modifications were made to the two "accessible" rooms was that students who deviate from the norm in anyway are not worthy of one of this honor. Through not having accessible rooms on the Lawn, UVA participated in creating a power divide between "normal" students and "others."

In order to evaluate how the physical space at historic universities contributes to or works to dismantle the power dynamic between "normal" students and "disabled" students, a science, technology, and society (STS) framework will be applied. The proposed framework that will be used is the political artifacts framework developed by Langdon Winner. The framework of political artifacts suggests that technologies have a hierarchy built into their use and directly contribute what unites and divides people (1980, p. 128). Winner suggests that there are cases,

that the "process of technical development is so thoroughly biased in a particular direction that it regularly produces results counted as wonderful breakthroughs by some social interests and crushing setbacks by others," (1980, p. 125). The suggestion Winner makes here contributes to the basis of what will be researched; that even though there was no intent to create a power dynamic and hierarchical divide between students, the way the physical space was created causes there to be one (Winner, 1980).

There are several critiques to Winner's work and the way he has constructed the framework of political artifacts that will be considered when using it to research the STS topic. There is the opinion that Winner poorly defines "technology" and "politics" that blur their use throughout his writing (1990, p. 47). The varying definitions cause confusion when attempting to examine technology in both macro in micro scales, in which technology is culture in the former and an artifact in the latter (1990, p. 110). Then, depending on the scale, the political nature of technology is determined, giving varying significance to the technology's politics (Donnelly, 1990, p. 111). Winner falls short in this sense causing for there to be binary choices in how technology is evaluated. For the purposes of this project, one scale will be used to view the physical environment as technology, allowing for one way to evaluate the political nature.

Research Question and Methods:

In order to evaluate the research question of how the physical space at historic universities contributes to or works to dismantle the power dynamic between "normal" students and "disabled" students, discourse and documentary research analyses will be used. The University of Virginia will be the focus of the research as it is a historical university and landmark that houses a diverse student population. The keywords that will be used in the search

for documents and media include, but are not limited to, “disability,” “accessibility,”, “ADA,” and “physical barriers.” These words will be used as they are typical descriptors of differences in ability to use a space. When used in conjuncture with the “University of Virginia,” these keywords should aid in the identification of possible examples of how the university implements changes to dismantle any hierarchal power dynamics between student populations. As the research question focuses in on understanding how the built environment impacts access, finding key examples of the existence of these barriers at UVA is key, which is why a discourse and documentary research approach are being taken. Both of these methods allow for the examination of previously documented cases in order to further understanding, which is the basis of the research question.

Conclusion:

The technical project will be to develop a system for bidirectional assisted overground walking to allow for the identification of the ideal percentage of body weight to be used as an assistive pulling force. This project will then be used to further the development of a power walker through previous work done in the MAMP lab at UVA. The STS research project will attempt to understand how historical universities incorporate inclusive access and how that either contributes to or assists in dismantling the hierarchical power dynamic that exists between “normal” and “disabled” students. Both of these projects seek to understand how “disability” is defined, how physical environments create divides between people, specifically students, and how this power division can be dismanteled.

References

Cassi, R., Kajita, M., & Popovic Larsen, O. (2021). User-environment interaction: The usability model for universal design assessment. *Universal Design 2021: From Special to Mainstream Solutions*, 55–70. https://doi.org/10.3233/SHTI210385

Donnelly, R. (1990). *The politics of technology: A critique of the work of Langdon Winner* [Master of Arts (Hons.), University of Wollongong]. https://ro.uow.edu.au/theses/2233/

Dunlap, D. W. (1997, June 1). Architecture in the age of accessibility. *The New York Times*. https://www.nytimes.com/1997/06/01/realestate/architecture-in-the-age-of-accessibility.html

Garland-Thomson, R. (2005). Disability and representation. *PMLA*, *120*(2), 522–527.

Kram, R., & Powell, A. J. (1989). A treadmill-mounted force platform. *Journal of Applied Physiology*, *67*(4), 1692–1698. https://doi.org/10.1152/jappl.1989.67.4.1692

Lebrecht, J., & Newnham, N. (Directors). (2020, March 25). *Crip camp: A disability revolution* [Documentary]. Netflix.

Liebermann, W. K. (2019). Whose heritage?: Architectural preservation and disabled access in boston and san francisco. *Future Anterior: Journal of Historic Preservation, History, Theory, and Criticism*, *16*(1), 35–56.

Ochoa, J., Sternad, D., & Hogan, N. (2017). Treadmill vs. overground walking: Different response to physical interaction. *Journal of Neurophysiology*, *118*(4), 2089–2102. https://doi.org/10.1152/jn.00176.2017

Saltoğlu, S., & Öksüz, A. A. (2016). The concept of "'disability'" in architecture as a power and ideology problem. *ICONARP International Journal of Architecture and Planning*, *4*(1), Article 1. https://doi.org/10.15320/ICONARP.2016120234

The Lawn at the University of Virginia: Charlottesville, Virginia. (n.d.). American Planning Association. Retrieved October 29, 2022, from https://www.planning.org/greatplaces/spaces/2014/thelawn.htm

Titchkosky, T. (2011). Introductions: Access as an act of perception. In *The Question of Access: Disability, Space, Meaning*. University of Toronto Press.

University Makes Two Lawn Rooms ADA-Accessible. (2020, July 27). UVA Today. https://news.virginia.edu/content/university-makes-two-lawn-rooms-ada-accessible

Winner, L. (1980). Do artifacts have politics? *Daedalus*, *109*(1,), 121–136.