The development of a powered posterior walker for children with cerebral palsy

(Technical Paper)

The inclusion of disabled people in design

(STS Research 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 Biomedical Engineering

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Fall, 2021

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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

Cerebral palsy (CP) is the general term for a group of disorders that affect posture, muscle tone, and movement. CP presents as a mixture of several symptoms: involuntary movements, floppiness or spasticity of the limbs and trunk, exaggerated reflexes, unusual posture, and/or unsteady walking (*Cerebral Palsy - Symptoms and Causes - Mayo Clinic*, n.d.). To assist with the last two symptoms, people with CP often use a walker or wheelchair. For those who can stand and attempt to walk, they often use a walker rather than a wheelchair in order to strengthen their muscles and improve their posture. Anterior walkers follow behind the user and provide support and stability. However, normal anterior walkers add extra weight that the user must pull behind them as they walk. This poses an extra challenge for children with CP who already have muscle weakness. The life expectancy of children with CP depends on the number of disabilities that child has (Haak et al., 2009). However, life expectancy can be optimized by improving mobility and independence (*Life Expectancy*, n.d.).

The purpose of my technical project is to develop a working prototype of a powered posterior walker into a commercialization ready product. This prototype uses an algorithm in conjunction with motion sensing cameras, to drive the walker forward according to the user's body positioning and gait. While the prototype is functional, it is not market ready. There are improvements to be made to the aesthetics of the walker, and the development of a unique posterior walker to be manufactured specifically for the intelligent powered walker. As of right now, the prototype is a commercially available walker that has been modified through the addition of attachments. By developing a unique walker that can be used as a base for the attachments, it makes the design independent from existing products, freeing it from potential issues due to other walkers going out of production. Overall, the walker will help improve the quality of life for people with CP and other disabilities, by increasing the user's independence and mobility.

This project as well as my STS research project both relate to accessibility and inclusion for disabled people. As medicine progresses, disabled people are living longer and more normal lives. As such, they are more present in the daily and normal life of non-disabled people. My thesis will explore the effectiveness of design teams that do not include disabled people whose sole purpose is to design devices for the disabled . While designers can brainstorm and foresee some difficulties with a particular disability, they haven't actually experienced the disability and are therefore designing from a disadvantage. I will explore if it is possible for the non-disabled to make effective technology for the disabled, and different ways designers have attempted to bridge the knowledge gap. I will also explore if current technology is accessible and meets diverse needs. This investigation is not limited solely to technologies aimed at CP, but at any and all technologies designed to improve mobility of individuals with disabilities.

Technical Topic

My technical project is to develop a working prototype of a powered posterior walker into a commercialization ready device. My team consists of one other biomedical engineering undergraduate student, as well as two advisors from Barron Associates Inc., who developed the original prototype. The project consists of three parts: developing a full CAD assembly of the walker, pursuing FDA clearance, and increasing public awareness of the project.

For part one, we plan to use existing CAD files and SolidWorks to develop a full CAD assembly of the walker, while simultaneously making improvements to the design and creating an original walker to be manufactured for the sole purpose of being used as the base for the powered walker. Similar to how cars are offered in models, and then upgrade packages to the base model, the end goal of the part is to have a completely independent commercializable product for Barron Associates to license to a partner. Currently, the prototype consists of a widely available posterior walker with additions added on. A motion sensing camera is mounted to the back of the walker, offset by some functional distance such that the camera will focus properly. A motor is attached to each rear wheel, encased in a plain black box, which is then wired to an onboard Windows machine (also encased in a plain box) that applies the algorithm to the camera footage and outputs power to the wheels. Also on board is a lithium battery that powers the entire setup. For the purposes of this project, we will treat the Windows machine as a black box. We will focus on improving the housing of the black box and motors as well as the mounting for the camera(s). The final product will be functional, but also aesthetically pleasing and user friendly.

For part two, we will be pursuing appropriate Food and Drug Administration (FDA) clearance for the walker. This will include research into prior art, which will inform which clearance pathway through the FDA that is appropriate for the walker. We suspect that this device will fall into one of two categories. It will either qualify for a 510k Premarket Notification, or it will require a Premarket Approval. This will also determine classification of the walker under FDA guidelines. From there, we will prepare and file the appropriate application. Part two leads into part three as FDA clearance is a requirement for any medical device to proceed to market.

For part three, we will increase public awareness of the device to elicit commercialization partners. This will involve conducting technical demonstrations of the walker in various settings as well as reaching out to current and prospective medical device sales companies or sales people to find a partner to take the device to market. One of the partners will most likely be a manufacturing partner who will manufacture the device for distribution. This ties back to part one and the complete CAD model and assembly. In order for part one to complete part three the CAD model must allow for manufacturing tolerances. We will not be applying for a patent as the design is obvious and is mostly additions to a well known solution. However, the design is unique as there are no known equivalents to this design.

As a member of this team, I will be responsible for equal work with my partner on all parts. We plan to spend the majority of our time working on parts one and two before proceeding to part three. Thus far, we have CAD sketches of some of the parts added to the walker. We hope to complete the assembly and model by the end of December.

STS Topic

Medical devices are constantly evolving. As time goes on and medicine improves, new challenges arise, especially for those with disabilities. The way disabilities are treated medically have changed over the years, allowing disabled people to lead more normal and independent lives. I will trace connections of relations between disabled people and the technologies they use. I will identify all of the actors, their connections, and the flow of power. I will also answer the question: "Can able-bodied people make good technology for disabled people that is functional, accessible, and meets diverse needs?"

The most important actor here is the disabled person who is the user of the technology. The way disabled people, especially those who rely on technology for mobility, self identify and view their own disabilities is very important to this investigation. Some disabled people that use transmobility technologies — that is technologies that allow the ability to move between various modes of mobility — refer to themselves as *cripborgs*. The way cripborgs select and utilize technology depends on their disability and their lifestyle. These technologies can also influence the way they see themselves and the way others perceive them (Nelson et al., 2019). The emphasis is placed on transmobility and how no one solution will fit all needs, or even all of the needs of a single person with disabilities.

In Hamraie et al.'s *Crip Technoscience Manifesto*, the authors describe disabled people as "experts and designers of everyday life." However, they disagree with the ideal of productivity and independence as requirements for existence. This highlights the difference between the non-disabled and disabled point of view. Non-disabled people and designers most likely see technology as a necessary and sole pathway for disabled people to become valuable members of society (i.e. those who work and contribute to the economy), whether they realize it or not. Here, the authors argue for four distinct political commitments for crip technoscience — "practices of critique, alteration, and reinvention of our material-discursive world" — that do away with the current imperative and paradigm of most disability centered technology to cure, fix or eliminate disability all together. The major argument here is that crip people are not inherently broken, they do not need to be fixed. What they require is access, justice, and transformation of societal disability relations (Hamraie & Fritsch, 2019).

Another important aspect of the network is societal perception of disabled people. As a society, we most often think of the disabled as those with fancy and shiny prosthetics, those in wheelchairs, or those who have mental and intellectual disabilities. However, this is nowhere near an inclusive list of all disabilities or even the visible ones. We often forget about non-visible disabilities, or disabilities that we do not perceive as disabilities such as a reliance on tank oxygen or dialysis. As such, we often leave those invisible disabilities out of our discussions on disability and we leave them out of campaigns for disability awareness. Jillian Wiese analyzes and comments on these topics and many more in her *Common Cyborg* ("Common Cyborg," 2018). Here she analyzes the perception of the disabled by the non-disabled, engineers, and authors. She directly mentions and analyzes the *Cyborg Manifesto* by Donna Haraway and then completely rejects it. This highlights the large disparity between the perception of the disabled by the non-disabled and the perception the disabled have of themselves. Wiese also talks about the great love engineers have of the disabled as the disabled allow engineers to manipulate the human performance. This leads directly into my research topic.

By utilizing these texts and others found in my research I will be able to trace relationships between disabled people, the technology they use, and the people who design those technologies. These relationships will illuminate the concerns and possible potholes involved in the development of technologies for disabled people.

Next Steps

In the coming weeks, I will continue to look for actors and power relations surrounding disability technology as it is today, societal perceptions of disability, and how they compare to the four ideals set out in the *Crip Technoscience Manifesto*. I will also use the *Cyborg Manifesto* in my research paper, though I have not read it yet. In terms of my technical project, I will soon begin work on developing the full CAD assembly and iterate through some possible designs to improve the aesthetics of the walker and its attachments.

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