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Wilson S. Patton
wsp6502@rit.edu

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Learning to Ride:
Developing an Assistive Device for Two Wheel Bicycling

By

Wilson S. Patton

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Industrial Design

School of Design
College of Imaging Arts and Sciences

Rochester Institute of Technology
Rochester, NY
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Committee Approval:

Alex Lobos  Date
Committee Member, Chair of Graduate Industrial Design Program

Mindy Magyar  Date
Committee Member, Graduate Instructor in Industrial Design Program

Jane Rutt  Date
Committee Member, Occupational Therapist, Registered, Licensed
Abstract

Learning to ride a two wheel bicycle is an unforgettable milestone of childhood development. It highlights a moment where the anxiety of learning a complex physical activity is overcome and replaced with a sense of confidence and empowerment. Cycling also provides a foundation for social participation and connectivity to the surrounding community and environment. However, some children have abilities that make learning how to ride a bicycle a different kind of challenge. This thesis project sets out to bridge the gap between children with upper limb differences and the standard geometries and reach affordances of typical children's two wheel bicycles. A need was identified for a universal bicycle attachment that could be easily adjusted and resized for an individual child, particularly a young girl with ulnar club hand. A solution was pursued that properly locates the control points allowing a child to learn the complex motor skills of cycling while promoting an optimal trunk and head posture. The resulting solution is an integrated kit of components, that is easy to install, intuitive to use, and can be tuned to specific user requirements. It enables and encourages cycling for children with limb differences. Additionally, the project questions the label of "disability" and argues that designing for one individual can result in an inclusive design that changes social perceptions surrounding accessibility.

Keywords: Bicycling, Assistive Technology, Adaptive Cycling, Ulnar Dysplasia, Bike Components
Introduction

Learning how to ride a bicycle is an empowering moment in life. The freedom and excitement unlocked by this combination of human power and mechanical advantage expands the capabilities of the body. Whether relied on for commuting or leisure, cycling has proven physiological and psychological health benefits, allows us to connect with our immediate environment, and provides a foundation for community participation and connectivity. Additionally, the challenges and rewards associated with learning to ride can be an integral part of childhood development.

However, some children are born with or acquire physical and/or cognitive abilities that make learning how to ride a bicycle a different kind of challenge. The standard geometries and typical reach envelope in the cockpit of a child's two wheel bicycle can present an even steeper learning-curve for children with varying degrees of motor control, range of motion, strength, and dexterity. This thesis project develops a solution that enables and encourages children with upper limb differences to learn how to safely and confidently ride a two wheel bicycle.

Ulnar dysplasia, a congenital difference in the development of the forearm, wrist, hand, and fingers, presents an immediate physical challenge to learning how to bicycle. This thesis will target the accessibility and usability challenges children with ulnar dysplasia encounter when learning how to ride a bike. Currently there are relatively few, if any, available assistive devices that solve this particular problem in an approachable, safe, and sustainable manner. Children and caregivers who encounter this challenge are typically advised to use adapted tricycles or seek out ad-hoc, improvised solutions with varying degrees of success. Based on a breadth of research and clinical expertise, this thesis proposes a more robust, sustainable, and effective design solution to help these children learn how to ride a bike. It goes on to develop and test an integrated solution that can be universally attached to any bicycle, can be tuned to a particular child's needs, all while providing the child with a subtle and cool modification for their bicycle.

The resulting design solution challenges the status quo of social constructions and labels of "disability." It argues that designing for a single person engaged in a specific activity can lead to more inclusive, universal, and sustainable design outcomes.
Background Research

Two Wheel Bicycling as a Desired Activity

Physical Benefits

Learning how to ride a two wheel bicycle elevates a child's ability to coordinate motor activities to a new level. Motor control is the ability to regulate or direct the mechanisms essential to movement. It includes how the "central nervous system organizes movement" and involves "the mechanisms, strategies, and development of movement, as well as the causes of motor dysfunction." Children typically develop gross and fine motor skills by exploring their world; they sit, crawl, walk, play, and jump...they feed, dress, bathe, and manipulate small objects with their hands. The practice of these skills and variable positioning helps children learn about their bodies and develop the cognitive and sensory skills that lead to confident and coordinated movement.

When a child is introduced to the particular weight shift and balance required to locate their center of gravity to keep a bike upright and moving forward, the vestibular and proprioceptive systems are immediately challenged to learn a new algorithm for movement. These two systems work together to "monitor the position of joints, the tension in tendons and ligaments, and the state of muscular contraction." The data from these "position sensors" is then relayed to the brain where it is integrated with balance controlled by vestibular system located in the inner ear. This integration "gives us precise information about our position in space and the status of our joints and muscles," which is essential to the maintenance of posture and the coordination of muscular activity. Therefore, it is important to define the points of contact between child and bicycle that are essential to achieving coordinated movement and equilibrium while on a bike.

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2 Jane Case-Smith and Jane Clifford O'Brien, Occupational Therapy for Children and Adolescents, 7th ed. (St. Louis, MO: Elsevier Mosby, 2015), 194.


4 Ibid.
Fig. 1 defines the key physical touchpoints used to ride a bike: the pedals, the saddle, and the handlebars. A neutral and upright posture stemming from contact with the saddle is the essential starting point for successfully riding a two wheel bike. This point of contact provides the spatial coordinates for all integrated movement while on the bike. It requires the child to continue developing the core strength, balance, and muscle memory needed to maintain an upright spinal position, which is crucial for establishing a consistent midline and body organization that contributes to spatial awareness and motor planning. Simultaneously, the child is asked to recruit large muscle groups to pedal against resistance, which helps develop the strength and endurance needed to perform a variety of other activities that rely on similar gross motor skills.

Steering the bicycle and the child's body position both rely on a child's upper extremity coordination and the child's fine motor skills at the contact point with the handlebars. The ability to grasp,

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5 Linda Shriber, interview by author, September 28, 2016.
release, and apply pressure through the wrists, hands, and fingers completes the chain of integrated motor skills and planning needed in the activity. Along with developing fine motor skills, contact at the handlebars continues the development of haptic perception. Haptic perception is how a child uses the active discriminative touch component of somatosensory information to understand an object's properties and characteristics. In fact, haptic perception is "a more direct sense than vision, [it] allows for immediate feedback on the child's use of force, accuracy of movement, and precision of movement." For example, when cycling, haptic perception is used to understand the difference between a soft, textured, rubber handlebar grip and a smooth, hard, aluminum or plastic brake lever. Within the context of cycling, somatosensory information immediately conveys the consequences of applying force to these different surfaces, meaning one does not need to look at the hands and/or cockpit interface to perform a complex controlled fine motor skill (gripping vs. braking) during cycling. Haptic perception guides placement and use force where appropriate in a situation where mistakes can be catastrophic.

As the child successfully combines gross and fine motor planning, the intentional use of force, and a balanced posture, she is able to achieve gyroscopic precession, or more simply, riding a bike. The resulting forward movement produced by balancing and applying downward force to the pedals can have significant cognitive benefits for children; discovering the fluidity and joy of moving through space in this manner can be incredibly calming and freeing. The physical benefits of successfully stacking motor activities in the pursuit of cycling are clear. However, the activity must be considered in an emotional and social context to fully understand the holistic importance of riding a bike to childhood development.

Social and Emotional Considerations

Learning how to ride a two wheel bicycle is incredibly empowering for children. It is one of the most intimidating and complicated physical and cognitive activities to master at a young age. Learning this goal-oriented activity reveals a newfound understanding of the agency and freedom over how and where we move. The self-confidence that results from this new form of intentional movement is a transformative milestone.

The social and emotional context in which a child learns how to ride a bike has significant implications on the learning outcomes and adoption of the activity. Children are "able to achieve motor challenges for which they attribute positive feelings...[conversely] when a child is overly stressed or afraid, the sympathetic system is activated, making it difficult for the child to problem solve or learn a

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6 Case-Smith and O'Brien, 221.

7 Jane Rutt, phone interview by author, September 7, 2016.
new motor skill.⁸ Therefore, a child can be primed for successful participation in a challenging activity if the experience and objects involved are framed in an approachable, familiar, and unintimidating manner.

Cycling provides an opportunity for children to participate socially when learning and upon mastery of the activity. Many children are motivated to learn because their siblings or friends have demonstrated the benefits of this fun form of mobility. This perpetuates a helpful feedback loop, as many children benefit from observing their peers before feeling comfortable and confident enough to approach the activity themselves.⁹ Riding and socializing with others while exploring more distant destinations has profound implications on how a child engages with her community and environment. The ability to move through space in this manner helps establish a personal connection to one's immediate surroundings and grounds them in a community.

There are additional holistic benefits of bicycling over an individual's entire life span and to the communities they are a part of. Learning how to cycle at a young age primes a person for a lifetime of enjoyment, utility, and fitness. Not everyone who learns how to ride a bike becomes a lifelong cycling enthusiast, but those who do account for their motives based on concepts of "autonomy and control, health and fitness, saving money, and fresh air and direct contact with nature."¹⁰ Increasing the number of cycle enthusiasts and cycle commuters can also have environmental effects such as lessening traffic congestion and reducing carbon emissions due to automobile substitution. Additionally, a larger population of enthusiastic cyclists creates demand for cycling facilities such as dedicated bike lanes, paths, and end-of-trip services, which leads to physical and social connectivity between previously isolated neighborhoods and communities.¹¹ In fact, a population that embraces cycling as a primary means of transportation directly impacts urban planning, suburban sprawl, and their approach to residential and employment decisions.

**Bike Fitting Basics**

There are some established fit and modification techniques used to help a child feel comfortable on a bicycle when learning to ride. A properly fitting bike provides the child with the space and comfort

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⁸ Case-Smith and O'Brien, 200.

⁹ Jane Rutt, phone interview by author, November 1, 2016.


which promotes proper body mechanics and is necessary for physical and sensory integration for biking success. The bike should give the child plenty of standover height between the child's groin and the top tube (see fig. 2).

Adjustments to the bike that help foster comfort and balance include: lowering the seatpost so that feet easily reach the ground while seated, adjusting the saddle fore or aft to allow for a slight elbow bend while lightly gripping the handlebars, and removing the pedals to allow the child to coast on the bicycle. Additionally, fig. 3 highlights handlebars with upsweep and backsweep angles that can be swapped or adjusted at the stem in order to achieve slightly different gripping positions and reach affordances for the child in the bicycle cockpit.

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12 Kevin Olson, interview by author, September 14, 2016.
Implementing proper bicycle fitting and adjustment can significantly impact the learning curve for bicycling and is typically performed by a parent, caregiver, friend, bicycle mechanic or salesperson. Setting the child up so that she is in a comfortable and neutral position where she can easily maintain and move her trunk and shoulders in line with her pelvis is critical. Along with properly aligning the spine, this posture supports breathing and stability through the child's center of gravity. It also allows free movement of the head and neck in order to see and plan for obstacles and changes in terrain. With this proper cycling posture established, the child can extend the arm and hand to the handlebar, which serves as the primary touchpoint for control of steering and to support a centered trunk. The bones, muscles, ligaments, and joints involved in this extension can be described in mechanical terms in order to understand the sophisticated physiological motor tasks involved in cycling. "In the body each bone is a lever, each joint is fulcrum, and our muscles apply the forces that produce the movement...the most common levers in the body are third-class levers" where "the applied force lies between the fulcrum and the resistance." These third-class levers are crucial, as they allow for dynamic range of motion where

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13 Rutt, interview, September 7, 2016.

14 Martini and Bartholomew, 129.
speed can also be controlled. For example, the bones (levers) located between the elbow joint (hinging fulcrum) and the hand (resistance) are necessary structures that allow the extension of the hand to a plate of food and flexion back to the mouth. The aggregate mechanics produced by bones, joint motion, ligaments, tendons, and muscles allow for the dynamic articulation of the arm, elbow, wrist, and hand that allow balance, precise control, and absorption of terrain inconsistencies while cycling.

**Cycling Challenges for Users with Limb Differences**

This leads to the conclusion that learning how to ride a typical bicycle in a neutral and balanced position relies on the user having fully developed arms, wrists, and hands. However, not all children fall into this category of physical development. There are numerous causes that inhibit range of motion, physical development, and impair mobility in children. Neurological disorders such as cerebral palsy, traumatic brain injuries, spinal cord injuries, and muscular dystrophy may lead to "muscle weakness or paralysis, sensory deficits, and abnormal muscle tone. These disorders can lead to limitations with joint range of motion, postural control, and mobility." The musculoskeletal system can also be affected by an acquired or congenital amputation, which can impact overall motor development and access to mobility related devices.

Ulnar dysplasia, also known as ulnar club hand, occurs in 1 in 100,000 live births and "refers to a congenital difference in which one of the long bones of the forearm, the ulna, and other soft tissue structures on the ulnar side of the hand develop abnormally." Associated abnormalities may include: absent or disarranged muscles and nerves, missing or deformed fingers and thumb, and a wrist that may deviate toward the little finger causing a bow in the radius bone. Treatment for ulnar dysplasia varies and is determined by a child's pediatrician, taking into account the following: age, overall health, medical history, severity of condition, and tolerance to medications, procedures, or therapies. Treatment options may include surgery, splinting, and therapeutic exercises to increase range of motion. Fig. 4 depicts the immediate challenges typical children's bicycle geometries present to a child with ulnar club hand.

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18 Ibid.
Difficult to read and react to obstacles and terrain

Stress on spine and back

Inconsistent midline affects body organization, balance, and motor planning

Insufficient power to pedals

Figure 4. Challenges faced by child with ulnar club hand learning to ride bicycle. Image by author.

Knowing the benefits of riding a two wheel bicycle and some of the challenges encountered by limb different children, a solution to enable and encourage children with upper limb differences to learn how to safely and confidently ride a two wheel bicycle can be pursued.
Methodology

Models of Occupational Therapy and Assistive Technology

The practice and principles of childhood occupational therapy provide an intrinsic framework for developing mobility goals for children with ulnar dysplasia, particularly those who intend to ride a two wheel bicycle. Occupational therapy (OT) practitioners specialize in identifying discrepancies between a "child's performance and activity demands" and develop interventions to help the child overcome or minimize these discrepancies.19 OTs have a keen understanding of the interrelationship between activities, environments, and people and how these intersections influence social participation and self-esteem. OTs embrace the holistic approach of identifying and leveraging a child's inherent strengths and interests to help the child further engage in physical activities and socialization.

Design review, analysis, and evaluation by trained OTs was critical to developing a set of design directives informed by expert, clinical insight. This resulted in two key aspects of motor control and development being identified to help a child with ulnar dysplasia ride a bike: (1) an intervention that locates a control interface within the child's particular reach and grip envelope and (2) subsequently encourages the child to maintain, strengthen, and realize the benefits of a neutral upright posture.

Interventions that help limb different children successfully engage in a desired activity are typically categorized as Assistive Technology (AT). The US legal definition of AT from the Assistive Technology Act of 1998 is: "Any item, piece of equipment or product system whether acquired commercially off the shelf, modified, or customized that is used to increase, maintain or improve functional capabilities of individuals with disabilities."20 OTs and certified Assistive Technology Professionals (ATPs) work together to help individuals realize their potential in a myriad of daily contexts and environments in the home, at school, at the workplace, and during leisure activities in both self and co-occupational activities. In parallel to the principles of occupational therapy, AT service delivery is guided by a dynamic ecological model that is person-centered and evidence informed, enabling participation in desired activities while service is provided in an ethical and sustainable manner. Accordingly, AT service "comprehensively includes steps to identify technology that is most appropriate for the user" whether cognitive, communication, manipulation, or mobility "[and provides] necessary training and support for initial and ongoing use of the technology, not only for the individual user but for

19 Case-Smith and O'Brien, 1.

20 Cook and Polgar, 2.
the aggregate groups as well.\textsuperscript{21} The Human Activity Assistive Technology model (HAAT) is a holistic framework that considers the human, the activity, and the assistive technology within varying contexts. The HAAT model moves beyond isolating the activity being supported and knowledge of body function, and takes into account a person's experience and motivation with technology, recognizing "that social perceptions, attitudes, institutions, and policies all contribute to the creation of a disability."\textsuperscript{22} Understanding that in certain contexts AT can become a stigma is critical to formulating a successful AT solution for limb different children.

The demand for and development of AT has proceeded lockstep with the principles of universal design: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size / space for approach and use.\textsuperscript{23} In fact, the application of the HAAT model mirrors a robust design process as it calls for product research and development, conducting usability studies, clinical or client assessment, and evaluating the outcome.\textsuperscript{24} One doesn't have to look far to see the mainstream commercial designs that have AT origins such as: touchscreens, voice recognition, automatic doors, and push button toggle switches.

However, AT solutions for limb different children who want to ride a two wheel bike are not readily available. Customized solutions are often implemented and fabricated by an OT, ATP, or amateur maker. Using household and hardware store components, AT solutions can be created quickly and circumvent the inefficiencies baked into health care service delivery. "People who experience disabilities are tired of waiting weeks, months, and years for simple solutions that could be created today in minutes. Do it now! Do it today!"\textsuperscript{25} This sentiment rings true when considering the social and emotional implications of falling behind developmental milestones. Some drawbacks to these ad-hoc AT solutions include: the inability for AT device to grow with the child or be applied to other activities; child, parent, or caregiver may have difficulty maintaining or repairing; materials and subsequent device may compromise the "cool factor" of an activity and foster stigmatization and abandonment of the device.

Therefore, there is an opportunity to design a solution that takes into the account the entirety of the cycling experience and use of AT for a limb different child, see fig. 5. Taking into account the user,

\begin{itemize}
\item \textsuperscript{21}Cook and Polgar, 5.
\item \textsuperscript{22}Ibid, 10.
\item \textsuperscript{23}Ibid, 19.
\item \textsuperscript{24}Ibid, 12.
\item \textsuperscript{25}Therese Willkomm, "Creating Solutions in Minutes: Using Ordinary Items in Extraordinary Ways" (workshop, Closing the Gap conference, Minneapolis, October 7, 2016).
\end{itemize}
the context, and the desired activity, the designer can work toward a holistic solution that balances function, aesthetics, and the context in which the design is being accessed and used.

Design Development and User Testing

I was fortunate to work with a young girl, Emily, with ulnar dysplasia. She is brave, tough, funny, and wants to ride a two wheel bike. Proceeding with invaluable insight from OT professionals and an understanding of AT objectives and service delivery, three design filters were established to help develop a solution for Emily: control, approachability, and safety.
**Control**

The Control filter focuses on the child's ability to mount, balance, steer, and pedal the bicycle. It includes encouraging an upright, heads-up position that allows the child to see, plan for, and adjust to oncoming obstacles and terrain. The child must be able to comfortably move around the bicycle cockpit during operation to keep the bike upright, adjust speed and power, and start and stop. Adjustability of the design is crucial to account for growth and determine the most comfortable and safe position to ride.

I began to establish the "reach envelope" of the user, which is the volume in space where the child can comfortably extend to without compromising balance or posture, see fig. 6. This helped me understand the spatial relationship between user and bicycle and to explore ideas of where the child contacts the bicycle in the most natural way.

Figure 6. Sketch by author developing the user's reach envelope.
I created a range of motion (ROM) coloring book for Emily, her mom, and her occupational therapist, see fig. 7. This provided the data needed to understand Emily's potential for strength and range for control, and also engaged her and her caretakers in the design process, which led to a more familiar and approachable design outcome.

Figure 7. ROM coloring book to determine reach envelope for user. Images by J. Rutt.
I began to experiment with 3D mock-ups at full scale and started to develop a multi-position control interface that is rigid enough in each position to allow the user to grasp, balance, and leverage as she moves her body around the cockpit. I explored points of contact at the hips, sternum, elbow, armpit, and hand / fingers, along with varying attachment points to the bike at the stem, top tube, front fork, and handlebars, see fig. 8.

Figure 8. Sampling of control mock ups and keywords used during initial ideation. Images by author.
Emily and I began to work with prototypes that I attached to her bike. The prototypes were unrefined and flexible, but they allowed us to try different positions and shapes.

Figure 9. Seated and mounting positions. Images by J. Rutt.

The prototype in fig. 9 achieved the goal of encouraging Emily to ride in a more upright, neutral position where she can see what is coming next. It also makes it easier for her to mount the bicycle, locate the pedals, and apply downward force without compromising her contact with and position on the saddle. By altering the shape and line of the prototype, seen in fig. 10, the design became friendlier and offered more gripping positions.
Based on observation and direct feedback from Emily, I began to develop concepts using CAD software that I could translate into 3D printed prototypes to refine the scale, form, and integration of a kit of components she could use on her bike, see figs. 11 and 12.
Figures 11 & 12. CAD rendering with associated 3D printed prototype of two component handlebar extension. Images by author.

The loop handle, or "mitten", provides multiple opportunities for Emily to grasp see fig. 13.
Approachability

The design must encourage and foster confidence in the activity. A familiarity and attractiveness to the senses will make cycling easier to learn, fun, dynamic, and rewarding for the child. Therefore, selection of color, material properties, and integration with standard bicycle forms must be considered so as not to discourage participation in the activity. Moreover, any modification to the bicycle must be considered through how the child perceives herself performing the activity socially, whether with friends, family, or in public.

Fig. 14, shows initial ideation around the concept of incorporating familiar and friendly forms, materials and characters as co-pilots into the design.
Emily displayed some confusion regarding where and how to grip the handlebar extension, see fig. 15. The form and material needed to be tweaked in order to provide a clear, consistent, and friendly experience so that she could focus on the activity of riding rather than the new object on her bike.
In addition to creating the friendly and accessible "mitten" handle, I also began fabricating custom colored and textured silicone grips, see fig. 16. By replacing the stock bicycle grips, I could now control and unify the entire haptic experience, while also allowing Emily to choose how she wanted to personalize her bike and take ownership of the modification.

**Safety**

The design must not cause unacceptable levels of risk during normal cycling activity. It should not increase the footprint of the bike being modified; it should not protrude in a way that could injure or
snag while riding. It should be robust and forgiving, and should allow the child to make mistakes and withstand the normal abuse incurred by similar pieces of recreational equipment. It should be easy to install, adjust, and maintain on any bike by the child herself or an immediate parent or caregiver. It should be easy to transport and store.

Determining a way to create adjustability and secure attachment of the design was a challenge. I experimented with stock hardware, as well as creating my own mechanical joints, see fig. 17.

Test rides revealed that the point where the design attached to the bicycle can result in an over sensitive or twitchy steering input. Therefore building in forgiveness when the child makes an error or encounters bumps, curbs, or quick direction changes, became integral to user safety. Moving the contact point in or out along the handlebars had a dramatic effect on how the bike handled and reacted.
Results and Discussion

While considering and testing solutions to bridge the gap between Emily and her handlebars a few consistent issues pervaded. The first is compatibility. Although there may be some commercial handlebars that provide the reach affordances she requires, these components rely on access to and understanding of a catalogue of innumerable bicycle standards. From bike-to-bike and size-to-size, stems, handlebar clamps, lengths, and shapes change. This means considerable time and resources are spent locating, ordering, and installing components that the child may soon outgrow, or that might be bicycle specific. Another hurdle was a combination of adjustability and integration. For the design to be accepted and used by the child it needs to be versatile enough to function for changing range of motion and ability, while also being cohesive with the shapes and components found on a bicycle.

While working with Emily and her family I experienced what it was like to have a difference that is "adapted for" or that requires "special consideration." Particularly when we visited a bike shop, I began to understand what it must feel like when people point out your difference and then in a well-meaning manner improvise a solution that you feel compelled to graciously accept. I wanted to change this experience from one of an improvised afterthought to one of inclusive design.

Grips are the coolest and simplest way for children to customize their bike. It is an affordable modification that a child or parent can perform in minutes. The selection of grips is very personal; the user can decide between an array of colors, textures, and cushioning. It is a small, but meaningful way to identify your bike and your personality. With this in mind, I pivoted to a dialogue of making this process the same as putting on new grips...colorful, soft, interesting texture, and easy and fun to install. Because handlebar grip diameters are standard, this concept allowed me to circumvent compatibility issues. More importantly, I could implement a custom adjustable handle and create a consistent haptic experience within the cockpit any bicycle.

The end result of the design process and user testing is a grip kit that easily attaches to and extends from the handlebars. The user removes the stock grips from the bicycle and then attaches and adjusts the components of the kit into the desired position. The kit attaches to any bicycle using a standard lock on grip and the handle is adjusted and locked into the elbow adapter using a splined joint that when tightened creates an interference fit. It can be easily stored and transported. See figs. 18 and 19 for component installation and adjustment.
Figure 18. Grip Kit Components and Installation. Photo by E. Torgerson-Lamark

Kit Installation

- A Handle
- B Straight Grip
- C Elbow Adapter
- D 2.5 mm Hex Tool
- E 5 mm Hex Tool

Figure 19. Splined clamp that allows for handle adjustment. Photo by E. Torgerson-Lamark.
Designing for one person doing one activity can lead to inclusive universal design. When designing for one person, the process is imbued with passion and thoughtfulness. This process leads to an outcome that is functionally practical and also unconventional, which will make it desirable due to its ability to do one thing really well for one person. Naturally, the result could be desired by and useful to many others. Making it a practical, elegant, and cool solution.

A simple solution can normalize the accessibility to any activity, for both the user and those already participating in the activity or servicing the activity. This helps chip away at the conflation of a person with their disability, rather they are seen as a person with complex and varied interests contributing to society in all different ways.

Emily's design enables her to express herself and ride a two wheel bike. Moreover, her design accentuates who she is, how it makes her feel, and her emotional connection to the activity. Designing for one person who naturally changes over time has helped to create a kit that is widely applicable to the problem of enabling and encouraging more people to ride a two wheel bicycle.
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