Digital Buddies: Co-designing an accessible lock and locker.

by

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Abstract

In the world today, it remains that some individuals experience challenges with or are not able to use locks available on the market due to barriers related to accessibility. The goal of this study was to understand the characteristics of and design opportunities related to an accessible lock and two research questions were examined: 1) how do people who have insight into the challenges related to using locks respond to using current locks available for schools, home or in day-to-day environments?, and 2) what kinds of new locks could be (re)designed to support broader and more diverse audiences? Four co-designers took part in this study; three adults and one child. The findings from the co-design sessions were grouped into 11 themes and two prototypes (initial designs) were created during the study, including a lock (Thomas) and locker (Tim/Luke). The features of the prototypes were discussed in three sections including: 1) customization, 2) digital buddies, and 3) self-powered technology and trust. Customization was seen as playing five roles including: 1) as a means through which one can make decisions (or choices) about the device and how one interacts with it, 2) as a method of providing multiple points of entry (access) for people of all ages and abilities, 3) as a means of differentiation one individual's locker from another, 4) as a way to specify and personalize security, and 5) as a means to select aesthetic preferences. The concept of digital buddies was discussed with respect to how the "buddy system" (CA) fosters the interdependent connection between individuals and their devices. Lastly, self-powered technology was seen as being a way to promote trust in the individuals who are using the device.

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1) The co-designers who took part in this study including L. Timofte, S. Timofte, J. Rae, and L. Kopansky
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3) The individuals who helped me throughout the course of this project.

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Dedication

For my family, friends and everyone creating more inclusive communities.

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Chapter 1: Introduction

1.1 Research Overview

Currently, some individuals experience challenges with or are not able to use locks available on the market today due to barriers related to accessibility. As Coleman, Lebbon, Clarkson, & Keates note there “is a growing realisation that disability arises not within the individual, due to impaired capability, but is a result of environments, products and services that fail to take into account the needs and capabilities of all potential users” (2003, p.1). The purpose of this study was to understand the characteristics of and design opportunities related to an accessible lock. To explore the project goal, two research questions were examined: 1) how do people who have insight into the challenges related to using locks respond to using current locks available for schools, home or in day-to-day environments? 2) what kinds of new locks could be (re)designed to support broader and more diverse audiences? This study used a mixed methods design where co-design was the main method. Eleven themes were generated based on the results from co-design sessions during this study and two prototypes (initial designs) were created including a lock, Thomas, and a locker, Tim/Luke.

1.2 Document Layout

The study begins with a literature review and environmental scan that discuss assistive device use and design, aesthetics and inclusive design (Chapter 1). The purpose of this chapter is to set the stage by highlighting issues in how assistive devices are designed and by suggesting alternative ways, which were applied in the design of the accessible lock. This includes the use of inclusive design practices such as co-design. Chapter 2 discusses current approaches in design in relation to locks, safety and security products, and assistive devices to provide examples of what is currently available on the market and of design ideas/themes that exist today. Chapter 2 also explores remaining gaps, which is guided by the question -what if there was no longer a distinction between assistive devices and other devices, both in perception and in design? This question and ideas for the future of how assistive devices are conceptualized and designed are discussed in relation to current products on the market. Chapter 3 examines the research goal, questions and design. Chapters 4 and 5 discuss findings from the co-design sessions and justifying design decisions, respectively. Lastly, Chapters 6 and 7 provide input into the contribution to the domain and transferable insights as well as the study limitations, next steps, and unanswered questions.

1.3 Literature Review and Environmental Scan

1.3.1 Assistive Device Use and Design

Assistive devices and independence

" '*Sometimes when [my friends] want to play with others during breaks, they may forget me or feel impatient about having to help me*' " (Huang, Sugden, & Beveridge, 2009, p.102). This quotation is from one of the children who participated in the study conducted by Huang et al., entitled "Children's perceptions of their use of assistive devices in home and school settings" (2009). The study noted that "[i]n such a situation, most children showed a great eagerness to achieve a higher level of independence and to keep up with their peers. This, in turn, facilitated their intrinsic motivation for device use at school" (Huang et al., 2009, p.102). From the research above, we can see that students are driven to use assistive devices to increase independence (Huang et al., 2009, p.102).

What are assistive devices?

Assistive devices are defined in a variety of ways in the literature. Huang et al. present a characteristic example, defining assistive devices as “tools designed to improve the functioning of individuals with disabilities and reduce the effects of environmental barriers” (2009, p.95). This conventional understanding of assistive devices (Huang et al., 2009, p.95) will be questioned and explored in this study. Examples of assistive devices include pencil grips, walkers and power wheelchairs (Huang et al., 2009, p.95).

Assistive devices and difference

Although the study by Huang et al. (2009) notes that students with disabilities are willing to use assistive devices at school (p.102), research by Hemmingsson, Lidström, & Nygård note that “students tried to avoid ATDs [assistive technology devices] that made them feel different or deviant […] If they did so, students might choose to do without an ATD” (2009, p.469). This may also occur with adults. For example, Fraser, Kenyon, Lagacé, Wittich, & Southall, assert that “[t]he unfair attribution of someone with a health condition adopting an ATD being ‘different’ may lead some older adults to refuse ATDs because they represent this ‘difference’ and they do not want to be categorized or marginalized” (2016, p. 1031). Fraser et al. note also that older adults may be hesitant to use ATDs out of concern for being stigmatized (2016, p.1024).

The issue with assistive devices

Studies suggest a key issue with assistive devices: a device can promote independence (Huang et al., 2009, p.102), but if its use results in an individual to "feel different or deviant" (Hemmingsson et al., 2009, p.469) or stigmatized they may be reluctant or refuse to use it (Hemmingsson et al., 2009, p.469; Fraser et al., 2016, p. 1024).

Inclusive design goal

Based on the issue noted above, the goal for inclusive design is to attend to the current perceptions of assistive devices and to rethink the way that assistive devices are designed (Pullin, 2009). This argument is emphasized by Graham Pullin when he speaks about chairs designed for "children with cerebral palsy" (2009, p.75). Pullin notes that "[i]f one of the goals of this furniture is to enable disabled children to attend mainstream schools, then this goal is undermined if the equipment itself stigmatizes the kids among their new peers and prevents social integration" (2009, p. 76). Reflecting on Pullin's conclusions (2009), during the design process in making a conscious effort to consider: 1) the aesthetic or personal preferences of the individual who will be using the device, and 2) the context in which it will be used one is not continuing to perpetuate the stigma surrounding assistive devices, but instead starting to work away at the very foundation upon which the stigma is built.

How are assistive devices designed?

One tendency is to design assistive devices to be invisible as possible, such as with the case of hearing aids (Newell, 2003, p.178). One problem with designing assistive devices in such a way is that it fuels the stigma associated with assistive devices, since by striving to create something invisible, which does not "project an image" (Pullin, 2009, p.15), there is a risk of implying that disability is "something to be ashamed of" (Pullin, 2009, p.15). Instead of thinking about how one might be able to cover up or hide an assistive device, the designer could instead aim to create a device that makes a positive and personal statement (Pullin, 2009, p.38). For example, Mimi Shulman, a designer from Toronto, has created attachments for hearing aids in the form of lightning bolts and bananas in order to bring hearing aids into the realm of "fashionable accessory" (Livingstone, 2009, para. 5), like a pair of eyeglasses (Livingstone, 2009, para. 5).

Who creates assistive devices?

In terms of who designs assistive devices, Pullin suggests that:

> Within design for disability, where teams still tend to come exclusively from clinical and engineering backgrounds, the dominant culture is one of solving problems. A richer balance between problem solving and more playful exploration could open up valuable new directions. (Pullin, 2009, p.xv)

One way to move towards the “playful exploration” (Pullin, 2009, p.xv) that Pullin speaks of, could be by using more inclusive processes including collaboration with individuals of various backgrounds and perspectives, especially “people that can’t use or have difficulty using the current designs” (Treviranus, 2018c, section in italics, para.3).

This collaborative process noted above could shed light onto the following questions:

1) Why does a particular individual use the device?
2) Where does the individual use the device?
3) How does the individual use it and/or how would an individual like to use it?
4) How does the individual feel about the device?
5) What changes might the individual make to the current design or how could it be redesigned entirely?
6) Why does an individual experiences challenges with using the device?
7) Why is an individual not able to use the device and how can it be redesigned?

Financial benefit of re-thinking assistive device design

The non-use of assistive devices

In addition to addressing issues related to stigma, re-thinking the way that assistive devices are designed could also be beneficial from a financial standpoint. A considerable volume of research has discussed the non-use of assistive devices (Arthanat, Douglas Simmons, & Favreau, 2012; Coleman, 2011; Fraser et al., 2016; Gardner, 2016; Johnston & Evans, 2005; Simpson, Horstmann Koester, & LoPresti, 2011; Verza, Lopes Carvalho, Battaglia, & Messmer Uccelli, 2006). The non-use of ATDs means that resources allocated to assistive devices are wasted (Coleman, 2011, p.5; Gardner, 2016, p.2). The percentage of non-use of assistive devices varies among the literature, some of which focus on particular ages and/or types of assistive devices (Gardner, 2016; Johnston & Evans, 2005; Simpson et al., 2011). In a recent article published by Gardner in 2016, she notes that “[i]n some research, abandonment rates of up to 80% have been reported” (2016, p. 1-2). In addition to the reasons related to “feel[ing] different or deviant” (Hemmingsson et al., 2009, p.469) described above, assistive devices are abandoned for a variety of other reasons (see, for example, Verza et al., 2006, p.89).

What promotes assistive device use and what do we need to do?

Interestingly, Gardner notes that “[t]he personalization or customization of mobility devices including the purposeful use of ‘demedicalized’ aids has also emerged as an interesting and previously unconsidered predictor of device acceptance and use” (Gardner, 2016, p.2). If we, as designers and more generally as a society, do not focus on what is perpetuating the non-use of assistive devices and focus on elevating factors that promote their use (see, for example, Gardner, 2016, p.2) then we are risking wasting significant financial resources both today and in the future (McCue, 2017, para.2).

Why do we need to do this?

In an article published in Forbes magazine in 2017, it is noted that “[t]he global elderly and disabled assistive devices market was valued at $14 billion in 2015 and is expected to surpass $26 billion by 2024, according to Coherent Market Insights” (McCue, 2017, para. 2). Furthermore, it is noted that “[w]ith an aging global population and a rise in noncommunicable diseases, more than 2 billion people will need at least 1 assistive product by 2050, with many older people needing 2 or more” (McCue, 2017, para. 5). Given the number (McCue, 2017, para.5) and cost (McCue, 2017, para. 2) projected for assistive devices in the future, more attention needs to be payed towards the relationship between the individual and their device.

1.3.2 Emotion, Aesthetics and Well-being

In this section, the connection between individuals and assistive devices will be discussed. Ideas related to how design can enhance this connection are discussed through the lens of aesthetics.

Emotion and assistive devices

In an article written by De Couvreur, Dejonghe, Detand, & Goossens, the authors note that “[d]espite all efforts and good intentions, the majority of assistive devices are often not a source of happiness” (2013, p.57). To help mitigate this finding a more thorough understanding of the connection between an individual, their device and surrounding environment is needed. This connection is a complex one, as highlighted by Gardner when she notes “that the relationship between people and products is about more than functionality and include emotional attachment to a product, cultural perceptions and stereotyping, and personal preferences and attitudes” (2016, p.5). Given this connection and the findings related to “the purposeful use of ‘demedicalized’ aids” (Gardner, 2016, p.2) noted in the Assistive Device Use and Design section above, one way to elevate the relationship could be by considering the aesthetics preferences of individuals who will be using the device, which will be discussed below.

Aesthetics and assistive devices

Missing and misunderstanding aesthetics

Unfortunately, as Pullin asserts, “[a]esthetic qualities are not usually considered in design for disability, and when they are it is often as an afterthought, a final cosmetic treatment of an already resolved and acceptable design” (2009, p.178). There are two issues in the way that aesthetics are being applied here. First, in relation to what Pullin says about “final cosmetic treatment” (2009, p.178), it is important to note that aesthetics extends beyond appearance and the surface level, and also encompass elements such as “the material science and the excitement one has using the product” (Fain, 2017, p.121). One can understand how these elements are incorporated in aesthetics by looking at beauty for instance, which Don Norman notes “comes from conscious reflection and experience. It is influenced by knowledge, learning, and culture” (2007, p.87). Similarly, Norman discusses how our “[w]ants are determined by culture, by advertising, by the way ones views oneself and one’s self-image” (2007, p.42). Thus, when thinking of aesthetics, one needs to think “below the surface” (Norman, 2007, p. 87) and take these other factors into consideration.

Second, with regards to being applied to “an already resolved and acceptable design” (Pullin, 2009, p.178), Ilse Crawford, a designer from the United Kingdom, speaks of the importance of investigating beauty right from the start (as cited in Wolf Humanities Center University of Pennsylvania, n.d., 10:20-10:35). Elements

such as beauty, care and trust are referred to by Crawford as “unmeasurables” (as cited in Wolf Humanities Center University of Pennsylvania, n.d., 4:29-4:44) as they are things that cannot be counted or quantified (Crawford & Heathcote, 2014, p.61). Crawford notes that **“**[it]’s so important to […] make sure that the unmeasurables get embedded at the beginning because if they’re not there at the beginning, it’s almost impossible to retrofit them” (as cited in Wolf Humanities Center University of Pennsylvania, n.d., 10:20-10:35). In addition to being unmeasurable, beauty does not come in one format, but “has many faces” (Crawford as cited in Owens, & Marding, 2019, para. 6).

How do we incorporate aesthetic preferences into design?

In applying these understandings of beauty to assistive devices, the aim then is to include the individuals who are going to be using the devices throughout the design process so the devices are: 1) informed by elements such as the individual’s self-image and culture (Norman, 2007, p.42 and 87), and 2) is beautiful to them, in whatever way or format that means to them (Crawford as cited in Owens, & Marding, 2019, para. 6; Norman, 2007, p.87). In turn, designing with an individual’s self-image and culture in mind, could reduce the stigma associated with the assistive device.

Aesthetics and other aspects of design

Aesthetics is also an important consideration in relation to how it impacts other components of a design. For instance, as Dieter Rams argues, aesthetics plays a vital role in usefulness through how it impacts our well-being (as cited in Anderson & Mandell, 2017, para.6), which is an important area that is being focused on in the design world today (Crawford as cited in Roma, 2017, 39:30-40:25). As Crawford notes:

> Wellbeing is now a philosophy that's permeating a lot of design. My fundamental hope, really, is that everybody starts to think in terms of putting people first, and that's really something that can be done on an individual basis. I mean, it's a pretty simple mission…and we do it one space at a time. One piece of design at a time. When you prioritize the human needs within a space, design can have a profound impact. (as cited in Roma, 2017, 39:30-40:25)

Pulling together the ideas above, it is in working together with the people who are going to use the device and in understanding their aesthetic preferences and what they find beautiful that the design and purpose of assistive devices can shift from that of primarily function to something that also enhances well-being. This is where inclusive design becomes invaluable.

1.3.3 Inclusive Design

What is Inclusive Design?

This study will apply inclusive design theory to the design of an assistive device that is created for people who have a range of abilities. Inclusive design is defined by the Inclusive Design Research Centre (IDRC) as “design that considers the full range of human diversity with respect to ability, language, culture, gender, age and other forms of human difference” (Inclusive Design Research Centre, n.d., What do we mean by Inclusive Design section, para. 1) and the IDRC further notes that “[o]ptimal inclusive design is best achieved through one-size-fit-one configurations” (IDRC, n.d., The Three Dimensions of Inclusive Design section, para. 2). The idea here is to “create an integrated system that enables one-size-fits-one configurations” (J. Treviranus, personal communication, May 11, 2019). To explore this, one can look to the multivariate scatterplot (Treviranus, personal communication, April 6, 2019), an image of which is included below (community members of the Inclusive Design Research Centre at OCAD University, n.d.c.).

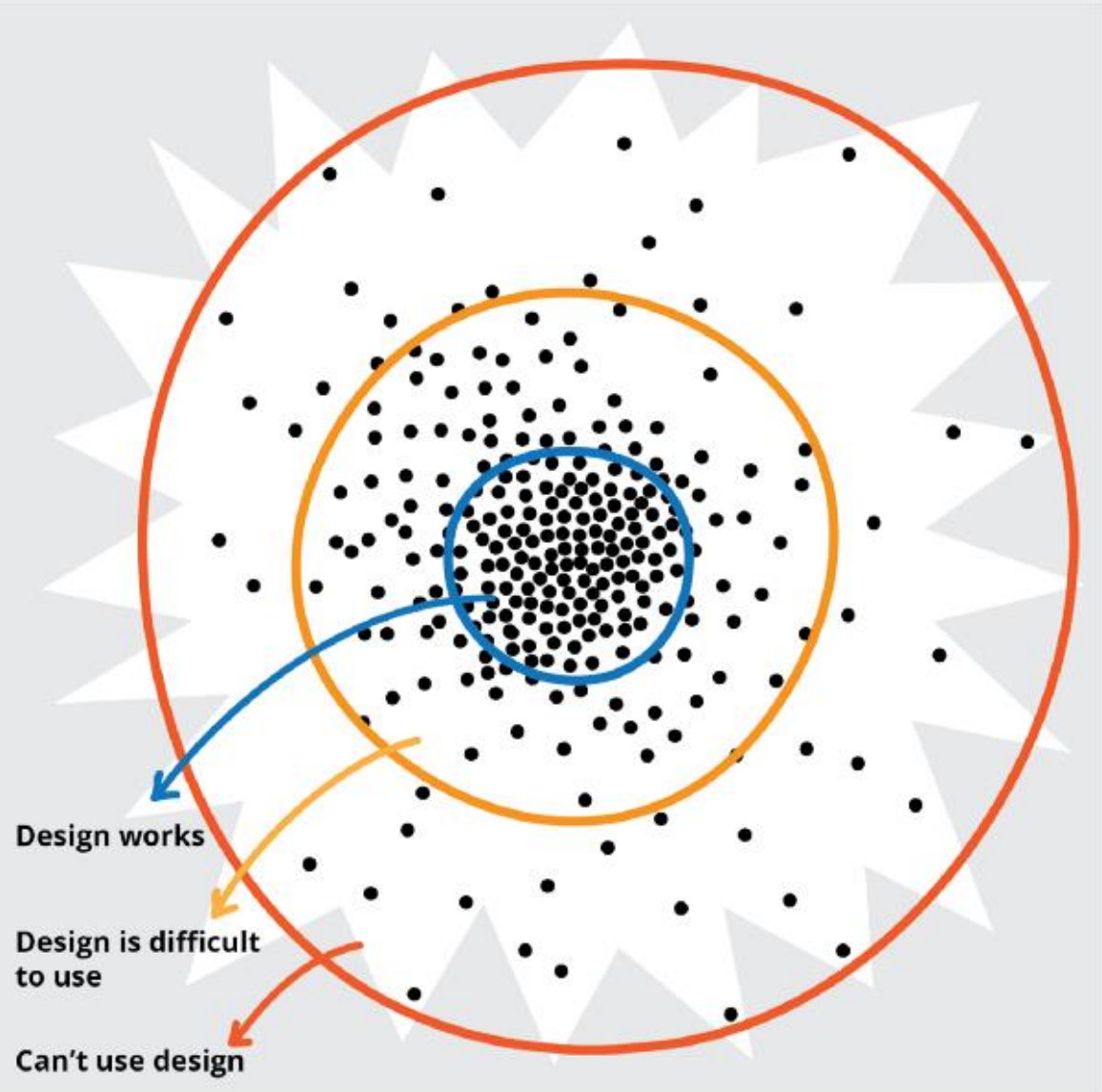

Figure 1. This image is of a multivariate scatterplot, which appears like a starbust (J. Treviranus, personal communication, April 6, 2019). In the starburst, the data points (which are referring to functional requirements) are dense in the centre and located further apart as you go outward from the centre (J. Treviranus, personal communication, April 6, 2019). In the image there are three concentric circles coming out from the centre, whereby going from the first circle (located nearest to the centre of the circle) outwards the circles represent functional requirements for which the "[d]esign works", "[d]esign is difficult to use," and "can't use the design" (community members of the Inclusive Design Research Centre (IDRC) at OCADU University, n.d.c, image), respectively. Image reference: No title, community members of the IDRC, n.d.c., Retrieved from https://guide.inclusivedesign.ca/activities/VirtuousTornado.html. Creative

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The scatterplot depicts data points that are normally distributed, which correspond to functional requirements experienced by “any given population” (J. Treviranus, personal communication, April 6, 2019). The scatterplot resembles a starburst and indicates how data points are more spread out with increased distance from the centre, which signifies that the functional requirements are increasingly dissimilar from one another (J. Treviranus, personal communication, April 6, 2019). As a result, there is a reduced likelihood that you will be able to locate a single unchangeable design that will fit all people who find it difficult to operate the design or cannot use the current iteration of the design (J. Treviranus, personal communication, April 6, 2019). Because of this, there is the need to design a system which is able to be adapted and stretched to produce a one-size-fits-one design all the way out to the edges of the scatterplot (J. Treviranus, personal communication, April 6, 2019). Everyone benefits in the making of such as system, as it has increased adaptability and flexibility (J. Treviranus, personal communication, April 6, 2019). An example of how a design for one could benefit others is that of closed captioning, which was created for individuals who are Deaf or hard-of-hearing, but can also be helpful for people who are watching television in a loud environment such as at an airport or a busy restaurant (Holmes, 2018, p.105). Further examples of how designs created for one person could also be helpful for others (Holmes, 2018) will be revisited

throughout this paper to explore the benefits of using inclusive design in the design of assistive devices.

Inclusive Design Framework

The IDRC and their community have created an inclusive design framework, which includes three dimensions:

> 1.Recognize, respect, and design for human uniqueness and variability. 2. Use inclusive, open & transparent processes, and co-design with people who have a diversity of perspectives, including people that can't use or have difficulty using the current designs. 3. Realize that you are designing in a complex adaptive system. (Treviranus, 2018a, para. 1-6)

With regards to particular roles in inclusive design, "inclusive design intentionally blurs the distinctions between the designer and user, the consumer and producer, the learner and the educator, the expert and non-expert, the service provider, and the client or customer" (Pullin, Treviranus, Patel, & Higginbotham, 2017, p.28-29) and is a collaborative process (Pullin, et al., 2017, p.28-29). The framework of inclusive design will be employed in this study including the use of co-design. As noted in the Inclusive Design Guide:

> The practice of co-design allows users to become active participants in the design process by facilitating their direct input into the creation of solutions that meet their needs, rather than limiting users to the

> role of research subjects or consultants. (community members of the Inclusive Design Research Centre (IDRC), n.d.b., Practice Co-Design section, para. 1)

Please note: participants involved in this study will be referred to as “co-designers.”

Finally, the project team members involved in this study come from a variety of backgrounds including Occupational Therapy, Inclusive Design, Architecture, and Computer Science. Collaboration and inclusive design (including co-design) are the fundamental tenets of this study as the aim is to include as many various perspectives as possible in the design process (Treviranus, 2018a).

Inclusive Design Goal

The goal of this study is to understand the characteristics of and design opportunities related to an accessible lock. The study focused on two research questions:

1) How do people respond to using current locks available for schools, home or in day-to-day environments?
2) What kinds of new locks could be (re)designed to support broader and more diverse audiences?

The research goal and questions will be investigated by co-designing a lock to be used in a school or other environment with individuals who have insight into the

difficulties of operating current locks available on the market. This idea evolved from working with a student with a physical disability who had difficulty operating one of the current school locks on a locker due to the physical demands of the task. I have included a sketch below of a standard lock indicating the various components, which will be useful in the section below.

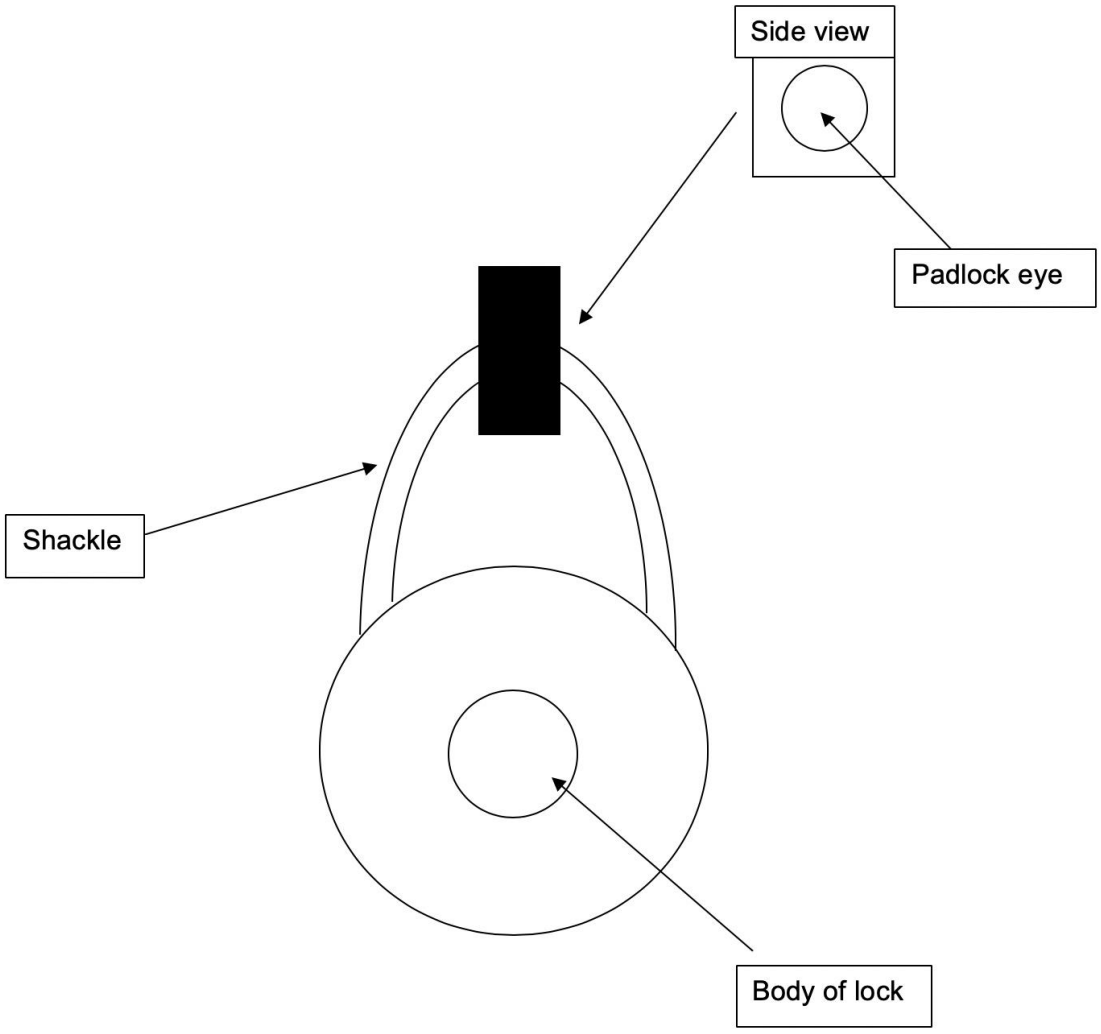

Figure 2. Sketch of Combination Lock. This image is a sketch of a combination lock with some of the components identified (using arrows) including: 1) the body

of the lock (which is in the middle of the image), where the arrow is pointing at the turn dial and 2) the shackle, which is the portion of the lock that threads through the padlock eye of the locker and looks like an upside down “U” (which the arrow is pointing at). The sketch also includes an arrow pointing to the place where the shackle of the lock goes through the padlock eye of the locker (depicted by a dark rectangular box over the middle of the curve of the “U”) and shows the side view of this point where there is a circle depicting the padlock eye (where another arrow is pointing at), which the shackle threads through.

Using task analysis, which is “[b]reaking up an activity into its task sequence” (Creek, & Lawson-Porter, 2010, p.26) to highlight the many parts involved in unlocking/locking a school locker (including the step that involves putting books and/or supplies back and/or taking out new supplies), I found that using a standard lock found on the market today may involve up to nine steps including:

1) Unlocking the lock (e.g. using a combination system or key)
2) Opening the lock by pulling down on the lock
3) Unthreading the shackle of the lock from the padlock eye of the locker
4) Opening the locker
5) Putting books and/ or supplies back and/or taking out new supplies
6) Closing the locker
7) Threading the lock back through the padlock eye
8) Closing the lock
9) Locking the lock (e.g. by moving the dial to change the orientation of the combination system (for security purposes)

In addition to considering how the device is used and operated, it is also important to think of where it will be used so that the final product functions in that

space (Coleman, 2011). Thus, thinking about the school environment and/or other environments where the lock is used are important considerations in the design process.

Chapter 2: Current Approaches and Remaining Gaps

2.1 Current Approaches

In this section, a variety of devices, both assistive and mainstream, will be discussed as a means of representing examples of what is currently available on the market and of design ideas/themes that exist today. Though there is a focus on locks (both used with lockers and other contexts), other devices including safety and security devices and assistive devices that could be insightful for this study are also explored. Where applicable, elements of the devices (e.g. aesthetic considerations and technological components) that could be informative for the design of the lock will be noted. Please note, I will be referencing brand and product names throughout this paper. Brand and product names will include symbols where applicable.

2.1.1 Locks

Standard Locks

Today, there exists a fairly large range of both styles and prices of standard locks that you might find being used by students at school and by individuals in other environments. Examples include a number combination locks including: 1) the Standard (dudley®, n.d.b) or the Claw Mini™ (dudley®, n.d.a) by dudley®, 2) a letter combination lock by Wordlock® (WordLock®, n.d.) as well as locks that are unlocked using a key such as 3) the Solid Brass Padlock by Secure (Secure, n.d.). The design of these locks, including the need to unthread and rethread the shackle of the lock through the padlock eye, can mean that the process of unlocking and locking a lock is physically demanding and could be difficult for individuals with physical disabilities.

More Accessible Locks

T-Series by Digilock®

With regards to locks that address accessibility**,** there is a lock called the T-Series that has been created by Digilock® that is operated by pushing a button, but it requires the lock be installed onto the locker (Digilock®, “Digilock Installation Instructions”, 2016). This would be problematic in terms of allowing the student to use the lock in multiple environments (such as at school or at a gym) as it would have to be installed in each location and some locations would potentially not support installation (e.g. a stand to lock up a bike in the community). Additionally,

in my opinion, the lock has a medical appearance, which could influence an individual's desire to use it. Please note: I am unsure if this product is still available.

Bluetooth Padlock, Tapplock One and Master Lock Bluetooth® Padlock

The Bluetooth Padlock was created by Kirand1 and can be found on Instructables (Kirand1, 2018). Based on my understanding of the Bluetooth Padlock (Kirand1, 2018), although the student would no longer be required to open the lock using a key or combination system, the student would still have to unthread and rethread the shackle of the lock, which could be difficult due to the physical demands of the task. Similarly, this process of unthreading and threading the lock would also be necessary using a lock called Tapplock One created by David Tao and Jayden Li, which can be unlocked either by 1) fingerprint, 2) Bluetooth, or 3) Morse code (McLaughlin, 2018, para.9). Master Lock® has also created a lock called Master Lock Bluetooth® Padlock, which also requires unthreading/threading of the shackle (©Master Lock Company LLC, n.d., Access.Remastered. section, para. 1).

Locks Used in Other Contexts

TSA Travel Lock-Sliding Shackle Type

One lock, which also uses Bluetooth, whose components could help to mitigate some of the challenge noted above with the unthreading/threading of the lock is the TSA Travel Lock-Sliding Shackle Type by eGeeTouch® (eGeeTouch®, n.d.). In this lock, a portion of the shackle slides up and down thus reducing the amount of unthreading/threading required (eGeeTouch®, n.d.). Though it could be beneficial, the individual would still need to slide a portion of shackle up and down as well as unthread/rethread part of the shackle. Thus, the challenges with unthreading/rethreading of the shackle are not eliminated with this lock. It should be noted that I am unsure this lock could be used for purposes beyond that of travel, but it is listed here as it serves as an example of different configurations of locks and of the process unthreading/threading the shackle of the lock through the padlock eye.

Sesame

A home lock has been created by a company called CANDY HOUSE, Inc. © called Sesame, which uses the individual's phone to unlock/lock the deadbolt lock on a door, but this technology does not appear to have been applied to school lockers (CANDY HOUSE, Inc.© 2014-2018, "Detailed Guideline", n.d.). The components of this product and the way it functions could be helpful in

reducing the number of steps required to operate current standard locks as it eliminates the need for the individual to unthread/thread the shackle through the padlock eye.

2.1.2 Safety and Security products

In addition to locks, there have been other products recently released on the market that are also related to safety and security, which provide insight into: 1) current technologies that could be applied to this project, and 2) the trend in design to create devices that prioritize safety and security that are also aesthetically appealing. Examples are discussed below:

Personal Safety: Nimb Ring and Talsam

The Nimb Ring, was created by a company called Nimb (“The 10 Best Ideas”, 2017, Best Security Product: Nimb Ring section, para. 1). As noted in Azure magazine, “this fashion-forward wearable tech conceals a tiny alert trigger on the inside of a chunky bauble. Unlike a phone, the ring is always in hand and a call for help can be sent out silently and secretly” (“The 10 Best Ideas”, 2017, Best Security Product: Nimb Ring, para. 1). Similar to the Nimb Ring, the Talsam by Chipp’d Ltd is a security device that comes in the form of a necklace or bracelet, which “combines a gold- or silver-plated setting with a semi-precious stone, inlaid with six Swarovski crystals” (Donnelly, 2018, para. 4). In terms of options,

individuals can choose between a variety of semi-precious stones as well as the type of setting (Donnelly, 2018, para. 4). The Talsam “also hides a tiny SOS button on the side” (Donnelly, 2018, para.6). Additionally, the device allows for individuals to “receive subtle communiqués with someone special” (Donnelly, 2018, para. 4), which is an interesting feature as it takes the individuals social context into consideration. These two products are good examples of where the design of technology which focuses on personal safety is now (including options to customize and select aesthetic preferences) and could be headed in the future. Customization and its pertinence to this study will be discussed in the Remaining Gaps: The Future of (Assistive) Devices section.

Digital Security: Motiv ring and Titan Security Key

In terms of digital security, the Motiv ring by Motiv, Inc., and the Titan Security Key by Google assist with authentication where passwords are required (e.g. for email) (Schwab, 2018b, para. 2; Wilson, 2018, para. 2). The Motiv Ring, “can fill in 2FA [two-factor authentication] for you, but Motiv aims to one day replace your passwords entirely with just a gesture” (Schwab, 2018b, para. 3). An interesting security feature of the Motiv ring is that it can learn the owners gait pattern as a means of knowing whether it is the owner who has the ring on or not (Schwab, 2018b, para. 6). While including the features noted above, the ring is also marketed as being “stylish” (Motiv Inc., n.d., The Perfect Combination of Form and Function section, para.1).

A similar device to the Motiv ring is The Titan Security Key, which Mark Wilson describes as “[s]imilar to the two-factor authorization that you might with your phone, when you log in to Google services like Gmail you can type your password then plug in the key for the second wave of verification” (Wilson, 2018, para 2.). Furthermore, by purchasing the Google bundle and using the fob that comes with it, you can “unlock your account by pressing a single button” (Wilson, 2018, para 2.).

These two products have been highlighted as their design and features (e.g. being a wearable device (Schwab, 2018b, para. 2), assisting with verification (Schwab, 2018b, para. 2; Wilson, 2018, para 2.), and being “stylish” (Motiv Inc., n.d., The Perfect Combination of Form and Function section, para.1) could help to inform the design of an accessible lock.

2.1.3 Assistive Devices and Aesthetics

Recently, assistive devices designed with a conscious effort to get away from devices that are medical in appearance have been released on the market. Examples are discussed below:

Maptic and Facett

Created by Emilios Farrington-Arnas, Maptic is a device designed for individuals with visual impairments to assist with navigating their surrounding environment (Teo, 2018, Maptic section, para. 1). According to Mark Teo, the device “looks like a fitness tracker” (Teo, 2018, Maptic section, para. 1) as Farrington-Arnas “didn’t want his wearable device to resemble a medical device. Or feel like one, either” (Teo, 2018, Maptic section, para. 1). Similarly, Leah Heiss has designed a hearing aid called Facett, which as Heiss notes “seeks to shift the stigma of hearing loss, to move these devices from disability to desirability” (Heiss as cited in Aouf, 2018, para. 3). This idea is reminiscent of the work by Mimi Shulman described in the Assistive Device Use and Design section (Livingstone, 2009).

Cane and Circleg

Another great example of an assistive device that has been designed with aesthetics in mind is “a purple cane” (Merrick, 2015, para.2) that Liz Jackson speaks so fondly about (Merrick, 2015). At the age of 33, Liz Jackson “was diagnosed with idiopathic neuropathy-nerve damage with no known cause” (Merrick, 2015, para.1) and required the use of a cane (Merrick, 2015, para.1). In addition to the cane, Liz Jackson also had to get glasses to help with migraines and as Amy Merrick notes:

> The cane soon became a source of self-consciousness. ‘My eye glasses would get compliments,’ she told me, ‘but my cane would get a funny tilt of

> the head form people, as if they were thinking, ‘What’s wrong with you?’ ’ For months, she was despondent. One thing that helped her recovery was finding a purple cane, while browsing online, to replace her drab, hospital-issued one. ‘I went from walking hunched down, wanting to hide, to actually being proud of it,’ she said. (Merrick, 2015, para. 2)

Colour customization is also an option with Circleg, a prosthetic limb designed by Fabian Engel and Simon Oschwald (de Klee, 2018, para.2 and para.13).

A couple of questions that arise here are:

1) What if the design of other assistive devices took a cue from devices such as the purple cane Jackson speaks of (Merrick, 2015)?
2) Could they also start to be something that people could be “proud of” (Merrick, 2015, para. 2)?

Guts

In her project, Guts, Teddy Schuyers, designed ostomy bags (Winston, 2018, para.1). Schuyers herself has Crohn’s disease (Winston, 2018, para.2). After her diagnosis, Schuyers interviewed other individuals “who used ostomy bags” (A. Winston, 2018, para.2). As Schuyers notes “‘[t]he aesthetic side of the ostomy bag has stood still for a long time. They have looked the same for years - very clinical, medical and totally not personal’” (as cited in Winston, 2018, para. 6).

Schuyers has designed three types of bags for different contexts; each type has a particular shape and colour (Winston, 2018, para. 8-9).

Marie-T, Prosthetic Covers

Further examples of this concept of considering aesthetics when designing assistive devices include prosthetics such as the Marie-T (Morris, 2018, para.1-2). Marie-T is a prosthetic leg for individuals with amputations to use while doing ballet that was created by Jae-Hyun An (Morris, 2018, para 1-2). An noted that he " 'fell in love with the idea of designing something that could expand the artistic and cultural scene of a community with prosthetic users' "(as cited in Morris, 2018, para. 15). On a similar note, the ©ALLELES Design Studio Ltd. have developed beautiful covers for prosthetic arms and legs (©The ALLELES Design Studio Ltd., n.d.; Treggiden, 2015).

2.2 Remaining Gaps: The Future of (Assistive) Devices

What if there was no longer a distinction between assistive devices and other devices, both in perception and in design? This question and ideas for the future of how assistive devices are conceptualized and designed will be discussed in relation to current products on the market.

2.2.1 (Assistive) Devices

Sara Hendren addresses the irony of the name assistive technology when she notes,

> The first thing is to think about the redundancy of the term ‘assistive technology.’ Every tool you have in your life is offering assistance. ‘Assistive technology’ comes from a field called ‘rehabilitation engineering,’ but, in fact, your knife and fork and your chopsticks and your glasses are assistive technologies, too. (as cited in Collins, 2017, para. 28)

Here we can start to see the blurring of the line between “assistive” and other technology, in that all technology provides assistance in some way (Sara Hendren as cited in Collins, 2017, para.28). The line is also blurred with regards to who uses assistive technology, as historically there have been many inventions that are assistive in nature that were created for an individual or group of people that have benefited several others (Holmes, 2018). This includes email, keyboards, typewriters, OXO Good Grips, FingerWorks (used in touchscreens on iPhones), and the bendy straw (Holmes, 2018, p. 52 & p. 118). And nowadays, it seems as though examples of devices and products that have assistive features incorporated within them are being written about and released regularly. This section will explore a few examples of this concept and highlight how technology designed for a particular person or group could benefit many others.

Magzip

The Magzip is a one-handed zipper designed by Scott Peters, found in some Under Armour®'s jackets (Nguyen, 2013, para 2-3.). Originally designed by Scott Peters with his uncle who has Myotonic Dystrophy ("a condition where the body's muscles slowly deteriorate" (Nyguen, 2013, para. 3)) in mind, the one-handed zipper can also benefit a huge range of people including, for example: other individuals with physical disabilities, people with amputations, people with cognitive difficulties, and people who are in situations where they only have one hand free (e.g. individuals carrying large hockey bags, grocery bags or their child).

Bradley Timepiece

The Bradley Timepiece was created by the brand Eone Timepieces, Inc., which can be read using sight or touch (Eone Timepieces, Inc., n.d.a.). The watch includes a ball bearing that indicates the minutes and another ball bearing to indicate the hour so that the owner can determine the time either by looking at their watch or feeling the position of the ball bearing (Eone Timepieces, Inc., n.d.c., How it Works section, para.1). The company's founder, Hyungsoo Kim, was driven to create a watch for both people with visual impairments and people who are sighted (Eone Timepieces, Inc., n.d.b., Our Story section, para.2). To

develop the Bradley Timepiece, Kim “collaborated with designers and persons with vision impairments (Eone, n.d.b., Our Story section, para.2).

Treo

Treo is the new razor created by Gillette (Schwab, 2018a, para. 2). The razor was designed to “allieviate the challenges of shaving someone else” (Schwab, 2018a, para.2). In terms of how it works, “Treo, […] fuses a razor blade with [a] tube of shaving gel that serves as its handle and gives shavers more control while keeping the mess to a minimum” (Schwab, 2018a, para. 2). In addition to benefitting individuals who shave others (Schwab, 2018a, para.1-2), this product could also be helpful for people who are just learning how to shave, as well as individuals who would prefer the simplicity and efficiency of having the gel connected to the razor itself.

Kitchenware

Designed with people with visual impairments in mind, Aurore Brard, has made bowls, plates, glasses, and a jug that include “strips of colour” (Yalcinkaya, 2018b, para.3) and assist in gauging how much liquid or food to serve (Yalcinkaya, 2018b, para. 1-3). Brard has also designed a knife, spoon and fork that have tactile indicators to help individuals discern which utensil they are (Yalcinkaya, 2018b, para.4). Brard says that she “wanted each functional feature

to become a part of the aesthetics in this tableware set. So that it is really integrated and the collection can appeal to people without vision problems'" (as quoted in Yalcinkaya, 2018b, para. 15). These items could also be useful for other people who could benefit from the visual reminder/cue of how much to put on a plate or how full to fill their glass such as children who are learning to do these tasks independently. As for the cutlery, the tactile components could be useful for people who are reaching for cutlery in the drawer and don't want to have to open the drawer fully as they could glean which utensil it is by touching the handle of the utensil.

Time Timer®

The Time Timer®, is a device which allows an individual to visually track the decrease in the amount of time set, which is "designed to create less stress in the lives of differently-abled people of all ages and abilities, whether at home, school or work" (Time Timer®, n.d. Gift Guide for All-Abilities section, para. 1). The benefits of the Time Timer® has been recognized in mainstream media; it was recently featured in an online article titled "The most important design tool you're not using" on the Fast Company website (Sullivan, 2018).

Shoes by Nike, Inc. and Puma®

Nike, Inc. has recently come out with a pair of shoes called Nike Adapt BB that are without laces and which “tighten at the touch of a button or swipe of a smartphone” (Gibson, 2019, para. 1). As Gibson notes, "[i]n a 2016 interview with Dezeen, he [Tinker Hatfield] said the concept was ‘totally not a gimmick,’ and could help athletes avoid injury and make life easier for people with disabilities” (2019, para. 9-10). The laceless shoe (Gibson, 2019, para. 1) is a great example of how designs created for one person or group can also be beneficial for others. Similar to the shoes noted above, Puma® will also be releasing a pair of shoes in 2020 that “have laces that can be tightened at the swipe of a finger” (Hitti, 2019a, para 1.).

2.2.2 Taking Cues from Mainstream Design

Similar to the style used by Graham Pullin in his book, *Design Meets Disability,* the following sections explore what it could be like if more assistive devices were designed as if they were other products found in the mainstream market and created by other industries such as the technology or fashion industries (2009).

Fashion

While functioning as an earphone, the DP-2 earphones produced by Dotcom Creation are “designed to be worn attached to the ear like hoops earrings” (Han, 2018b, para. 2). The owner simply twists the earphone to put it on (Han, 2018b, para.2). The notion of combining assistive devices and jewelry is not new. Examples of this idea can be found in work discussed previously by Mimi Shulman (Livingstone, 2009) and Leah Heiss (Aouf, 2018). Additionally, there are the HeX earbuds created by Elen Parry, which “could help people who are partially deaf to tune out unwanted background noise, but they also function as regular earphones” (Yalcinkaya, 2018c, para. 1). With regards to style, Parry noted that she “ ‘want[s] to transform hearing aids into a wearable technology product that gives people better hearing, style and confidence - something that anyone might want to wear’” (Parry as cited in Yalcinkaya, 2018c, para. 5).

Here one could ask:

1) What if this idea of combining auditory devices and jewelry or style was used and applied to hearing aids and other assistive devices more often?
2) Could this be one of the ways to stop thinking of assistive devices as “assistive” and simply as “devices”?

Customization

Another trend in devices these days is customization. Here we are shifting away from a one-size-fits-all model found in the examples above to that of the one-size-fits-one, which, as previously noted, is characteristic of inclusive design (IDRC, n.d., The Three Dimensions of Inclusive Design section, para. 2). One example of a product that allows the purchaser to customize the product is luggage created by the company ROAM (Han, 2018a, para.1). Through an online interface, people can choose the “outer shell colors, wheel caps, stitching, zipper and zipper pulls, binding, carry-handle, monogram patch and telescoping handle rods” (Han, 2018a, para. 2). Though you might expect that this customization option would greatly increase the time it takes for individuals to obtain their product, the luggage is produced in three days (business) and then shipped (Han, 2018a, para.2). Another example of customization in the mainstream market is the FES Watch U created by Sony, in which individuals can customize the face and straps of the watch based on an image of their choosing (Han, 2018c, para. 2).

Further examples of customizable products include: 1) customizable earphones, such as those made by brand Ultimate Ears (Gottlieb, 2018, para.3), 2) customizable sweaters by the brand Ministry of Supply, which will be available in 2019 (Schwab, 2018c; para.2), and 3) prefabricated houses that can be customized (McKnight, 2019, para.8). An example of a group that have explored

this concept of customization and assistive devices is Fabian Engel and Simon Oschwald who designed the Circleg, which was discussed in a previous section (de Klee, 2018, para.2).

A few questions to ask here are:

1) What if, like other devices on the market, owners of assistive devices could customize their device more readily?
2) What if they had more say in the colour, components and shape for instance?

Using technology such as 3D printers can result in a product that is not only customizable (Pearce, 2018, What Would Grandma Make? Section, para.2), but also less expensive (Pearce, 2018, para.3). In an article written by Joshua Pearce, a Michigan Technological University professor, he notes that:

> Research I participated in found that using free online designs and a basic 3D printer to make these assistive aids can save arthritis patients more that 94% of the cost of the commercially available products. A typical adaptive aid costs about $25; a 3D printed one costs about a dollar. That generates savings that add up to more than cover the cost of the printer itself. (2018, para. 3).

These findings have implications for the healthcare field, whereby the benefits of using 3D printing (including customization and reduced cost) could mean that

professionals could create and customize assistive devices with their patients for less than what someone would pay for the device commercially (Pearce, 2018, What Would Grandma Make? Section, para.2 and para.3). With customization (Pearce, 2018, What Would Grandma Make? Section, para.2) and reduction in cost (Pearce, 2018, para.3), it could mean that assistive devices are more financially and aesthetically accessible for individuals.

A few interesting questions to ask here are:

1) Would this mean that more people would use assistive devices?
2) Would this in turn, help to reduce stigma? and if so,
3) Could this mean that assistive devices make their way onto the mainstream market and out of a highly segregated industry?

Imagination

There are many examples of imaginative products that are being designed today including: 1) the Aero tyre by Goodyear®, whose design can be utilized for both road driving as well as for flying (Yalcinkaya, 2019, Title section and para. 1), 2) the Firevase by Cheil Worldwide, which is both a vase and a fire extinguisher (Morris, 2019, Title section and para. 5), and 3) the Gomi Speaker, which are wireless speakers made by Gomi, which are made of “non-recyclable flexible plastic waste” (Han, 2019, para. 2). Sadly though, imagination is still lacking in some places (Holmes, 2018, p.130; Sara Hendren as cited in Collins, 2017, para.

12). When discussing the primary narratives about disability in the media, Sara Hendren noted that:

> I'm painting a pretty grim landscape because we suffer from a lack of imagination and dimensionality about people with disabilities, people with atypical bodies and minds, who are disabled by contemporary industrialized life and its landscape. We have a long way to go. (Sara Hendren as cited in Collins, 2017, para. 12).

Kat Holmes notes that habits of exclusion include "[a] limited willingness to imagine how a solution in one context can adapt to provide new kinds of value in a different context" (2018, p. 130). From Holmes (2018) and Hendren (as cited in Collins, 2017) we can understand that more imagination is needed in making a more inclusive world.

With these ideas above in mind, the following questions arise:

1) If devices created to be used in an assistive context were: A) informed and influenced personal preferences and aesthetics, B) customizable, and C) designed with imagination, could this lead to a change in the perceptions associated with difference, whereby it is something that is celebrated as opposed to feared?
2) Could customization and imagination in the design of assistive devices result in the devices being used for purposes beyond what they were originally designed for?

3) Could this also be a way to further reduce the stigma associated with assistive devices?

A somewhat radical example of this can be found in work by designer Keita Augstkalne who has created a device that looks like an intravenous stand (a hospital device) (Yalcinkaya, 2018a, para. 2) that is used “to prevent plants from withering away when left unattended” (Yalcinkaya, 2018a, para.3). This is a playful, imaginative take on a device used previously for medical purposes.

Chapter 3: Inclusive Design Process

3.1 Research Goal/Questions

The goal of this study is: to understand the characteristics of and design opportunities related to an accessible lock. To explore this goal I have created two research questions including:

1) how do people who have insight into the challenges related to using locks respond to using current locks available for schools, home or in day-to-day environments?
2) what kinds of new locks could be (re)designed to support broader and more diverse audiences?

3.2 Research Design

3.2.1 Study design

This study used a mixed methods design where co-design was the main method. A literature search and environmental scan were conducted throughout the course of the study and relevant information was included in the report where applicable. Qualitative data was collected during co-design sessions. There were three types of co-design sessions in this study, including:

1) An interview
2) Prototype (initial design) creation session #1
3) Prototype creation session #2

The sessions will be described below in the Co-Design Sessions section. The qualitative data gathered was coded for themes using thematic coding, which is “the strategy by which data are segmented and categorized for thematic analysis” (Ayres, 2008, p. 868).

3.2.2 Research Ethics Board Application

A Research Ethics Board (REB) application was approved by the Research Ethics Board at the Ontario College of Art and Design University (OCAD University). The REB reference number is 2018-57.

3.2.3 Recruitment of Co-designers

Prior to recruitment, an application was submitted to the Research Ethics Board at the Ontario College of Art and Design University (OCAD University). Once the REB application was approved, recruitment information for the study was posted on websites and social media. Originally, students between the ages of 11-15 years old (male or female) who have a physical disability (such as Cerebral palsy) which impacts their ability to operate a lock/locker independently were

invited to be co-designers in the project. Students' family members and support team members were also invited to take part.

An amendment to the original REB was made and approved in order to expand the original criteria to any individual over the age of 10 who had insight into the difficulty of operating locks that are currently available on the market. Individuals under the age of 17 who took part in this study who were referred to as "minor child co-designers" and those over the age of 17 were considered "adult co-designers."

3.2.4 Co-designers

There were four co-designers who took part in this study, three adults (over the age of 17) and one child (under the age of 17). Due to availability, not all co-designers took part in all the co-design sessions, but each co-designer took part in at least one of the co-design sessions. One of the main requirements of the prototype (initial design) of the lock created in this study was that it was more accessible for individuals.

3.2.5 Co-design sessions

I prioritized the inclusion of as many co-design sessions as possible in this study. Details of the three types of co-design sessions are described in the sections that follow.

The interview

The purpose of the interview was to gain an understanding of the co-designer's experiences with locks and lockers that are currently available on the market and the various environments in which locks/lockers are used. Interviews took place in various formats, including in person, over the phone and in written format (where co-designers provided written answers to the interview questions). Lists of potential interview questions were generated before the interview to serve as a guide for me. Four separate lists were created including one for the minor child co-designer, the parents of the minor child co-designer, the support team member of the minor child co-designer and the adult co-designers. Not all questions on the list were asked. The interviews that were in person and over the phone took approximately one hour per co-designer. I took notes during the interviews that were in person and over the phone. Please note an option outlined in the study was that minor child co-designers could have a parent and/or support team member in the room while they were being interviewed. The

sets of interview questions used in the study and answers can be found in the Findings from the Co-Design Sessions chapter below.

Prototype Generation Sessions

The goal of the prototype generation sessions was to capture the co-designers experience using a lock as well as brainstorm ideas for and begin the creation of the prototype of the lock. After some consideration, it was determined that there would be two prototype generation sessions, which are described in detail below.

Prototype Session 1

The aim of the first prototype generation session was to create a journey map with the co-designer that illustrated their experience using a lock. The purpose of this activity was to understand the components of the individual's journey and to identify areas of difficulty and/or frustration in order to highlight where improvements could be made within the experience. During this session, the co-designer's journey was mapped from the beginning of the experience to the end, details of which will be discussed in the Findings from the Co-Design Sessions chapter. The components of the journey map were chosen based on a journey map example created by Smaply (Smaply, n.d., "The Step by Step Journey Map_a3.pdf") and included:

1) "stages" (the major parts of the journey)

2) “steps” (the parts within the stages)
3) “text box” (which included more details about each particular step)
4) “the emotional journey” (whereby the steps were rated between +2 and -2 based on how the co-designer felt during that step) (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”).

This session took approximately two and a half hours. Please note: only one co-designer was able to attend this session. I brought materials such as markers, pens, sticky notes and poster boards to this session to be used in the creation of the journey map.

Prototype Session 2

The second prototype generation session took place within a week of the first prototyping session and three co-designers attended the session. The aim of the session was to brainstorm ideas regarding locks and lockers and to start building prototype(s) of more accessible lock(s). The first activity of the co-design session included having co-designers brainstorm ideas related to questions about the ‘WHAT, WHY, and WHO’ of lockers, whereby the questions included:

1) WHAT do you keep in your locker
2) WHY do we need lockers and locks
3) WHO do you trust? (what can make a locker more trustworthy and what can be done to increase security?).

The group also discussed future possibilities where locks and lockers are not needed. Once the group had brainstormed a list of answers to these questions, they thought of examples of what more accessible locks could be like and then the co-designers started to build out prototypes of what a more accessible lock may look like. I brought materials such as paper, pens, markers, pipe cleaners, play dough, googly eyes, scissors, puff balls and sticky notes to the session to be used to build the prototypes. The session ran for just over two hours.

Chapter 4: Findings from the Co-Design Sessions

In this chapter, the findings from the co-design sessions will be highlighted, whereby results and themes from the sessions will be noted and the prototypes generated in this study will be presented. The findings will be presented in relation to each co-designer specifically, except for the second prototype generation session as multiple co-designers were present. While the findings will be presented in this section, they will be discussed in the next chapter titled: Justifying Design Decisions and Verifying Design Decisions.

4.1 My assumptions and expectations

Prior to describing the results from the co-design sessions, I will discuss my assumptions (in numbered format) and expectations (in lettered format) leading to the co-design sessions and the way in which these directed the questions during the interviews and the format of the prototype generation sessions.

4.1.1 Assumptions One and Two

The two primary assumptions that I had were that:

1) the forms of current locks make it difficult for individuals with physical disabilities to use them
2) aesthetics or the appearance of assistive devices could play a role in whether an individual would use it or not.

Therefore, some of the interview questions were geared towards learning more about these assumptions. Based on the questions posed, I expected that:

A) the co-designers would speak about: how the current design of locks made it difficult for them to operate them (including the requirement of having to unthread and rethread the shackle from the padlock eye), what they did and did not like about locks, and their previous experiences with lockers (potentially including lockers that worked well/ didn't work well). I also expected that they would want to change the way locks and/or lockers are currently designed to make one that would work better for them.
B) the co-designers would also discuss how aesthetics influenced their choice in the design of the lock, the use of assistive devices, and more generally, the purchase of products based on the questions asked.

4.1.2 Assumption Three

I also had assumptions about how:

3) the medical appearance of assistive devices would negatively impact their use.

This assumption prompted a question during the interview that asked about the impact of aesthetics on the use/non-use of assistive devices as well as a question that inquired about the co-designer's thoughts or experiences relating to the medicalization of assistive devices.

4.1.3 Assumption Four and Five

My other two assumptions were that:

4) the social environment, especially with respect to the minor child co-designer, would impact their experience with or use of assistive devices and that it would influence their design decisions when it came to the lock (e.g. to use something that peers would want to use).
5) The notion of security could be a theme for this study.

For this reason, I included questions regarding whether the co-designer's friends use their lockers in the list of the minor child co-designer interview questions and about security.

4.2 Findings from Co-Design Sessions

4.2.1 Interview Questions

The interview questions for both adult and minor child co-designers can be found in the tables below. The purpose of including the questions here (as opposed to in the Inclusive Design Process section or Appendix) is so that the reader can read through the questions directly prior to seeing the answers. Please note: the main questions are in bold with follow-up/ additional questions found below in regular font. Sentences in italics were meant as cues for me as the interviewer. The answers are in the section that follows the interview questions.

Interview Questions (Adult Co-designers)

*Please note: This is a list of potential questions to be asked. Not all questions have to be asked nor do they have to be asked in the order shown below.

Table 1. Interview Questions (Adult Co-Designers)

Question Number:	Question:
1	**Can you tell me about the lock that you use right now or locks that you have used in the past?** • What does/did it look like? • How does/did it work? • What is/was it made of?
2	**What do you think about the lock (do you like/ dislike it/feel neutral about it)?** • If like: what do you like about it?, Do you like what it looks like? If yes, why? • If dislike: what would you change about it (e.g. how it looks, works)?
3	**Is it easy or difficult to use the lock?** • If easy: what makes it easy? • If is difficult: what makes it difficult to use?, what would make it easier for you to use?

Question Number:	Question:
4	**If you could change your lock what would you do?**
5	**If you could change your experience with the lock what would you do?**
6	**What would a lock designed for you look like?** • How would it work?
7	**What has your experience been with lockers?** • Have there been lockers that work well/ don't work well
8	**Are there things you do/use instead of using a locker?** • What do you do/use instead?
9	**Are there things you have done in the past to help with using the locker?**
10	**Has your experience with the lock and/or locker (or current locker set-up) meant that you have had to change what you bring with you?**
11	**Are there other things (apart from using a locker) that you have used a lock for? If so, what?**
12	**Is there an alternate way to keep your belongings secure?**
13	**Is there a place where you store your belongings other than in a locker (e.g. when you are at the gym?)** • If so, where?
14	**If you could change your locker experience what would you do?**
15	**What about if you could invent a new locker what would you do?** • What would a locker designed for you look like?
16	**(If applicable), how might aesthetics influence your design decisions when creating the lock?**
17	**More broadly, do aesthetics influence your decision when you are deciding what products to purchase?** • If so, can you tell me about how they do? • Can you give me an example of a product you have recently purchased and how aesthetics influenced this choice? • What about with regards to assistive devices? Are aesthetics an important consideration for you?
18	**In your experience, what is the impact (if any) of aesthetics on the use/non-use assistive devices?** • What are your experiences/thoughts with respect to the medicalization of assistive devices (with respect to how some assistive devices are medical in appearance)?

Interview Questions (Student)

*Please note: This is a list of potential questions to be asked. Not all questions have to be asked nor do they have to be asked in the order shown below. During the interview the student researcher may draw out on a piece of paper a typical day for the student based on information provided by the student.

Table 2: Interview Questions (Student)

Question Number:	Question:
1	**What are some of your favourite activities to do at school?** • Why do you like these activities?
2	**Are there other activities that you enjoy doing?** • If so, what are they?
3	**Are there any activities that you find difficult to do at school?** • If so, what makes them difficult?
4	**What is it like getting from class to class and around the school?** • Are there areas that are easier to navigate? o If so, what areas are they and why are they easy/easier to navigate? • Are there areas that are difficult to navigate? o If so, what areas are they and why are they more difficult to navigate?
5	**What was your favourite day ever at school?** • **Why was it your favourite?** • **What made it so (*insert word that student has used to describe it e.g. fun, awesome*)?** • **What kinds of activities did you do that day?**
6	**What are some of your favourite things to do during recess?** • Are there things that you find difficult to do at recess?
7	**What are some of your favourite things to do during lunch?** • Are there things that you find difficult to do during lunch? *If the student has not mentioned their locker (see question 8):*
8	**What do you do when you first arrive at school?**

Question Number:	Question:

	• *If the student has not mentioned their locker:*
	  ○ Does your school have lockers?
	  ○ If yes:
	  ▪ Do you use your locker at school
	  ▪ How many times would you say you use your locker in a day?
	  ▪ What do you use your locker for?
	  ▪ If not:
	  • Are there things you do/use instead of using a locker (e.g. have textbooks needed left in respective classes)?
	  ○ If no (to school having lockers):
	  ▪ What do you use instead?
	  ▪ Is there an alternate way to keep your belongings secure?
	  ▪ Is there a place where they can store your belongings?
	  • If so, where is it? How does it operate?

9	**Do you like using your locker at school?**
	• If so:
	  ○ Why?
	• If not:
	  ○ Why not?
	• *AND/OR (refer to question 10)*

10	**Do you find it easy or difficult to use your locker at school?**
	• If it is easy:
	  ○ What makes it easy for you?
	• If it is difficult:
	  ○ What makes it difficult to use?
	• Are there things you have done in the past to help with using the locker?

11	**If you could change your locker experience what would you do?**
12	**What about if you could invent a new locker what would you do?** • What would the best locker for you look like?
13	**Do your friends use their lockers?** • If yes: ○ Does it seem that they use their lockers at lot?

Question Number:	Question:
	• If not: ○ Why?
14	**Can you tell me about the lock that you use at school right now?** • What does it look like? • How does it work? • What is it made of?

15	**What do you think about the lock-do you like or dislike it (or feel neutral about it)?**
	• If like:
	  ○ What do you like about it?
	  ○ Do you like what it looks like?
	  ▪ If yes:
	  • Why do you like what it looks like?
	• If dislike:
	  ○ What would you change about it (e.g. how it looks, works)?

16	**Is it easy or difficult to use the lock?**
	• If easy:
	  ○ What makes it easy?
	• If is difficult:
	  ○ What makes it difficult to use?
	  ○ What would make it easier for you to use?

17	**If you could change your lock what would you do?**
18	**If you could change your experience with the lock what would you do?**
19	**If you could make the best lock for you what would it look like?** • How would it work?
20	**Has your experience with the locker and/or lock at school (*or current locker set-up at school*) meant that you have had to change what you bring to school? (e.g. different clothing that will fit in the locker or a larger backpack to carry items)?**

21	**Are there other places where you lock up your belongings?**
	• If yes:
	  ○ Where?
	  ○ How do you lock them up there?

4.2.2 Results from the Co-Design Sessions

The narratives below include numerous quotes from the co-designers which is intentional, so that, as much as possible, their answers are described in their words not mine. The quotes are from the notes that I took during the interview. In addition to quotes, I have also paraphrased what co-designers said in the narratives below. The results are presented by co-designer (apart from the prototype session #2 as it was a group session). I have grouped answers together based on content.

Co-Designer A (CA)

CA is an adult who uses a power wheelchair. CA took part in the interview and both prototype sessions, results of which can be found below.

Interview Answers

A) Past and Current Experiences with Locks/Lockers

According to CA, they have used locks in the past including a “combination lock”, which was made of “steel” and “gray” in colour. When asked about what they thought of the combination lock (do you like/dislike it/feel neutral about it) they reported: “I liked it. I felt I fit in to everybody else. We had to do the same thing” and in terms of dislike they responded: “forgetting numbers” and “when you didn’t directly land on the #’s. You had to start again”. Currently, CA uses a Master

Lock® for their storage locker, which is “quite cumbersome: locker opens out, difficult to get it in, go around and finally push it up” (CA). CA mentioned that it is “difficult to unthread and thread” the lock through the padlock eye, whereby it is “awkward to lift lock out of where it is hitched onto”. The lock is fairly large (“about the size of half a hand” (CA)). According to CA, the Master Lock® has a piece of rubber which is attached to the lock that covers the place where the key is inserted and this rubber piece needs to be moved out of the way before the key can be inserted into the lock (“MasterLock®: rubber part you have to take off everytime on the bottom part” (CA)). When asked if their experience with the lock and/or locker has meant that they have to change what they bring with them, CA noted that they “have to take less.”

CA noted that they also use a “key to unlock” their mail box, which they find is “easy to use: easier, smaller, lighter.” When asked about what other things they use a lock for, CA noted “opening iPhone,” which requires a “passcode” as well as to lock the front door to their condominium whereby there is a key which is a “black square” where in “the middle of it is a small white button and you press it, it automatically unlocks door” and then “the door automatically swings open”. After some time, the door then “swings shut & automatically locks” (CA). The door “can open [from] about 5 feet away” and there is “still an option for a key” (CA).

In terms of how they would change their experience with locks, CA noted “time it takes to undo the lock” and “reducing time,” (e.g. with “the combination lock”) which takes “ridiculously long (e.g. if you forget)”.

B) Strategies with locks/lockers

In terms of strategies that CA has used/uses to help with using locks and lockers, they noted “writing the combination down,” (for combination locks) “have someone help me, helping with unthreading/threading”, which is the “buddy system” (CA). Also, CA made a comment (that was sarcastic) that another strategy is to “take something to keep calm” as it causes “undue stress” and “a lot of stress”. Based on their experience with the lock/locker, it has meant that CA has to “take less” (CA) when they are using the current locker set-up.

C) Ideas for a new lock and locker

When asked what they would do if they could change their lock, CA noted “why couldn’t it be like a dome like structure that would be easily identify as palm print.” According to CA, the dome would be medium in size (similar to the “size of an orange or golf ball”) and could be used in similar situations as the Master Lock® ie. for the storage “locker in their condominium”. With regards to the steps needed to operate this new lock, CA noted: 1) the individual would “come up to the dome” (on the lock), 2) their “hand goes over it”, 3) “it reads their palm print”, 4) “unclicks the lock”, 5) “automatically opens the door.” During the following co-

design session, CA noted that an alternate way of operating the lock would be to hold the side of a closed fist onto the lock to be read instead of the palm for “one day when you can’t uncurl your fingers so using the side of your hand to read”. This would be in times when it was difficult for the individual to open their hand. In terms of what the lock would look like, CA mentioned that it would be “neon purple (‘futuristic’)”.

When asked about what they would do if they could invent a new locker, CA said that they wanted the “locker to be like Star Trek™ lockers” where “door could automatically go up” and it would be “based on voice.” Another example given by CA is if you were “sitting down at a desk” and “ask computer for something it comes out of wall.”

D) Aesthetics

When asked about an example of a recent purchase and how aesthetics influenced their choice, CA provided an example of two items of clothing and mentioned they “wanted the lavender one” and that “the other one was pearl looking” and “had texture as well (lace).” CA noted that in terms the relationship between aesthetics and use of assistive devices that “all of it would be” and noted that “the chair I use now is midnight purple.”

Prototype Generation Session #1

As noted in the Inclusive Design Process section, a journey map template was used as a reference during the first prototype generation session (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”). Components including “stages”, “steps”, “text box”, and “emotional journey” (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”) were discussed in the journey map. For the “emotional journey” (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”), CA chose a number between -2 and +2 to describe that particular step, where -2 was “this sucks” and +2 was “awesome” (CA) (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”). In addition to the number, CA also provided a few words about what that number meant at that step (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”). The journey map was used to illustrate the co-designer’s experience of using a lock from beginning to end (Smaply, n.d., “The Step by Step Journey Map_a3.pdf”). The information in the journey map will be detailed in the section that follows.

The Journey Map:

The title of the journey map was identified to be “Using the Master Lock® at the storage locker” (CA). I took notes of what CA was saying. Thus, the information presented in the tables below is notes of CA’s words. After completing the journey map, the journey map consisted of seven stages and 17 steps. For each step there is also a text box with more information about each step (if applicable)

as well as an emotional journey number and words (which appear in quotation marks) to describe the emotion at that particular step. The results from the journey map are depicted in the figure and tables below. Please note: the same information is included in both the figure and table, but the information is presented differently. In the figure (which is an image), the information is presented horizontally, whereas it is presented vertically in the second table.

Title of Map: Using the Master Lock® at the storage locker

Stage	Stage A: Plans for when I go to locker				Stage B: Meeting up with buddy		Stage C: Proceeding to 1st locked door		Stage D: Getting to locker			Stage E: Manipulating Master [word removed] Lock®		Stage F: Closing caged gate and manipulating lock	Stage G: Getting out of 1st door, turning off light		
Steps	Step 1: Having someone be able to assist with the lock.	Step 2: A good stretch of your hands and fingers to be able to turn the key.	Step 3: Planning what I need out of the locker in advance, also things to take from apartment to locker.	Step 4: Make sure that you would have the key. Find the key for the Master Lock®.	Step 5: Buddy comes to assist.	Step 6: Go up to the locker.	Step 7: Go through first door to get to storage locker.	Step 8: Check if there is anyone else in the room.	Step 9: *&^%# [word removed] and complain how awkward it is. With buddy there things would be more cohesive.	Step 10: Go on down to the locker.	Step 11: Deciding who will do what (1 person manages lock and key and opens the locker, other person opens the cage door).	Step 12: 1 person operates the lock, the other opens door (cage door).	Step 13: In the locker. Finding what we need and potentially putting something away or asking someone to do it for me.	Step 14: Close the locker. 1 person makes sure that things are placed accordingly (within the locker), the other one cheers them on (direction), 1 person holding cage door and the other assisting with the lock.	Step 15: Go through first door to get out. Door is resistant, have to hold it open otherwise it will close. Easier if someone there "buddy system."	Step 16: Go back down to unit. Includes going in the elevator and holding the door open.	Step 17: Get onto floor (note: number removed for confidentiality purposes), drive to unit and open door.
Text Box	• Arranging someone who is able to be there on the date at a certain time. • Usually something done by phone. • Or arrange with roommate. • Probably takes about 15 minutes - 30 minutes to arrange. • They arrive to go to locker (note: this is said again in a later stage).	• Range of motion for fingers and hands and rolling wrists. • Usually about 5 minutes.	• Having item(s) in your mind/ jotting them down either on paper or digital • Having items accessible.	• Looking down at collection of handy dandy keys (on wheelchair). Note: Master Lock® keys always on collection of keys.	• Usually people don't have a problem. • Sometimes I have to bargain with nieces and nephews.	• Pressing key to open apartment door. • Letting buddy go first • I can follow • Automatic lock of apartment door • Go to elevator • Press button for elevator to go up.	• Few feet from elevator to first door • Unlock door with key • Open door (opens out) either me or the buddy. • If light isn't on, turn it on.	• Light is indicator • note: cage like door that I have to open (which opens out). If there is someone else who is beyond my locker they will not be able to get out. (note: additional information removed for confidentiality purposes).	no additional information for this step.	• Drive down to the locker. (note: additional information removed for confidentiality purposes).	• Conversation between two of us	• Pass key to buddy for Master Lock®. • Rubber piece comes off (but stays on lock) • Key goes in • Twist to unlock • Unthread lock (lock can stay hanging). • Cage door opens (1 person opens usually person in wheelchair (me)) • Stay behind cage door. • Other person goes into locker.	• May have a few notes to indicate where things go or which item box comes.	• Reverse of opening locker. • Rethreading lock. • Click it in. • Take key out. • Put rubber piece back.	• Someone is holding door open. • Person in wheelchair shuts light off and drives out of the first door. • Door automatically shuts • Does not need to be locked. • Elevator to apartment floor (note: this step is said again in the next step).	• Button for elevator • Holding the door or vice versa • Getting on elevator • Floor … (note: number removed for confidentiality purposes) • Go down … floor (note: number removed for confidentiality purposes) and get off	• Open door with automatic door opener. • No one needs to hold it open unless someone is holding something (as it opens/closes quickly).
***Emotional Journey Number and Words**	+2 "wohoo"	0 "getting ready," "warming up"	-1 "bummer," "so-so," "it's work"	0 "got it"	+2 "yay"	+1 "here we go" (note: sentence meant in a good way).	-1 "frustrating"	0 "no big deal"	-1 "frustrating that I can't do this on my own"	0 "getting ready to roll up my sleeves"	+1 "negotiating"	0 "this should be easier," "why can't this be easier"	+1 "now we are getting it"	+2 "mission accomplished"	+1 "wondering how it could be easier," "how can this be easier?"	+1 "almost there"	+2 "we did it!"

Figure 3. Journey Map titled “Using the Master Lock® at the storage locker” (CA). The information presented in this image is found in Table 3 below. Template reference: “The Step by Step Journey Map_a3.pdf”, Smaply, n.d., Retrived from https://www.smaply.com

For the table below (Table 3), the first column of the table indicates the stages, which are identified using letters e.g. A, B, C and so on and the second column indicates the steps relevant to that stage including their respective text box (TB) and emotional journey number (EJN) and a few words related to that number, if applicable.

Table 3. Journey Map: Titled “Using the Master Lock® at the storage locker” (CA)

Stage	Steps, Text Boxes, EJNs and Words for each stage

Stage A: Plans for when I go to locker	Steps:
	1) Having someone be able to assist with the lock.
	• Text Box:
	  ○ Arranging someone who is able to be there on the date at a certain time.
	  ○ Usually something done by phone.
	  ○ Or arrange with roommate.
	  ○ Probably takes about 15 minutes - 30 minutes to arrange.
	  ○ They arrive to go to locker (note: this is said again in a later stage).
	• EJN, words: +2, “wohoo”
	
	2) A good stretch of your hands and fingers to be able to turn the key.
	• Text Box:
	  ○ Range of motion for fingers and hands and rolling wrists.
	  ○ Usually about 5 minutes.
	• EJN, words: 0, “getting ready,” “warming up”

Stage	Steps, Text Boxes, EJNs and Words for each stage

	3) Planning what I need out of the locker in advance, also things to take from apartment to locker.
	• Text Box:
	  ○ Having item(s) in your mind/ jotting them down either on paper or digital
	  ○ Having items accessible.
	• EJN, words: -1, “bummer,” “so-so,” “it’s work”
	
	4) Make sure that you would have the key. Find the key for the Master Lock®.
	• Text Box:
	  ○ Looking down at collection of handy dandy keys (on wheelchair). Note: Master Lock® keys always on collection of keys.
	• EJN, words: 0, “got it”

Stage B: Meeting up with buddy	Steps:
	5) Buddy comes to assist.
	• Text Box:
	  ○ Usually people don’t have a problem.
	  ○ Sometimes I have to bargain with nieces and nephews.
	• EJN, words: +2, “yay”
	
	6) Go up to the locker.
	• Text Box:
	  ○ Pressing key to open apartment door.
	  ○ Letting buddy go first
	  ○ I can follow
	  ○ Automatic lock of apartment door
	  ○ Go to elevator
	  ○ Press button for elevator to go up.
	• EJN, words: +1, “here we go” (note: sentence meant in a good way).

Stage C: Proceeding to 1st locked door	Steps:
	7) Go through first door to get to storage locker.
	• Text Box:
	  ○ Few feet from elevator to first door
	  ○ Unlock door with key
	  ○ Open door (opens out) either me or the buddy.
	  ○ If light isn’t on, turn it on.
	• EJN, words: -1, “frustrating”

Stage	Steps, Text Boxes, EJNs and Words for each stage

	8) Check if there is anyone else in the room.
	• Text Box:
	  ○ Light is indicator
	  ○ note: cage like door that I have to open (which opens out). If there is someone else who is beyond my locker they will not be able to get out. (note: additional information removed for confidentiality purposes).
	• EJN, words: 0, “no big deal”

Stage D: Getting to locker … (please note CA said number of the locker here which has been removed for confidentiality purposes)	Steps:
	9) *&^%# [word removed] and complain how awkward it is. With buddy there things would be more cohesive.
	• Text Box:
	  ○ no additional information for this step.
	• EJN, words: -1, ‘frustrating that I can’t do this on my own”
	
	10) Go on down to the locker.
	• Text Box:
	  ○ Drive down to the locker. (note: additional information removed for confidentiality purposes).
	• EJN, words: 0, “getting ready to roll up my sleeves”
	
	11) Deciding who will do what (1 person manages lock and key and opens the locker, other person opens the cage door).
	• Text Box:
	  ○ Conversation between two of us
	• EJN, words: +1, “negotiating”

Stage E: Manipulating Master [word removed] lock	Steps:
	12) 1 person operates the lock, the other opens door (cage door).
	• Text Box:
	  ○ Pass key to buddy for Master Lock®.
	  ○ Rubber piece comes off (but stays on lock)
	  ○ Key goes in
	  ○ Twist to unlock
	  ○ Unthread lock (lock can stay hanging).
	  ○ Cage door opens (1 person opens usually person in wheelchair (me))
	  ○ Stay behind cage door.
	  ○ Other person goes into locker.

Stage	Steps, Text Boxes, EJNs and Words for each stage
	• EJN, words: 0, “this should be easier,” “why can’t this be easier” 13) In the locker. Finding what we need and potentially putting something away or asking someone to do it for me. • Text Box: ○ May have a few notes to indicate where things go or which item box comes. • EJN, words: +1, “now we are getting it”

Stage F: Closing caged gate and manipulating lock	Steps:
	14) Close the locker. 1 person makes sure that things are placed accordingly (within the locker), the other one cheers them on (direction), 1 person holding cage door and the other assisting with the lock.
	• Text Box:
	  ○ Reverse of opening locker.
	  ○ Rethreading lock.
	  ○ Click it in.
	  ○ Take key out.
	  ○ Put rubber piece back.
	• EJN, words: +2, “mission accomplished”

Stage G: Getting out of 1st door, turning off light	Steps:
	15) Go through first door to get out. Door is resistant, have to hold it open otherwise it will close. Easier if someone there “buddy system.”
	• Text Box:
	  ○ Someone is holding door open.
	  ○ Person in wheelchair shuts light off and drives out of the first door.
	  ○ Door automatically shuts
	  ○ Does not need to be locked.
	  ○ Elevator to apartment floor (note: this step is said again in the next step).
	• EJN, words: +1, “wondering how it could be easier,” “how can this be easier?”
	
	16) Go back down to unit. Includes going in the elevator and holding the door open.
	• Text Box:
	  ○ Button for elevator
	  ○ Holding the door or vice versa
	  ○ Getting on elevator

Stage	Steps, Text Boxes, EJNs and Words for each stage
	○ Floor … (note: number removed for confidentiality purposes) ○ Go down … floor (note: number removed for confidentiality purposes) and get off • EJN, words: +1, “almost there” 17) Get onto floor (note: number removed for confidentiality purposes), drive to unit and open door. • Text Box: ○ Open door with automatic door opener. ○ No one needs to hold it open unless someone is holding something (as it opens/closes quickly). • EJN, words: +2, “we did it!”

Template reference: “The Step by Step Journey Map_a3.pdf”, Smaply, n.d., Retrived from https://www.smaply.com

Co-Designer B (CB)

CB is an adult who is totally blind. CB took part in the interview, answers of which are below.

Interview Answers

A) Past and Current Experiences with Locks/Lockers

In the past, CB has used a padlock that was “made of metal,” where you put the “key in the bottom” and “twist to unlock” (CB). Nowadays, CB identified three places where they use locks including 1) at the “front door of their condo”, which uses a “fob,” where they “wave fob at door”, 2) “personal door", which is unlocked/locked using a “key” and 3) a “mail slot”, which also uses a “key”. When asked about what they thought about the locks (in this case plural as they

identified multiple), CB noted “they all work, fairly easily” and that the “padlock depends on size, weight.” CB also mentioned that a “combination lock doesn’t work for [a] blind person.”

With regards to other things that they had used a lock for, CB said they had used a “lock on a suitcase. Little padlocks [that] open with a key.” When asked about alternate ways to keep your belongings secure, CB noted “hiding them. Hiding something that is of value” and “security deposit.”

In terms of things that CB has done in the past to help with using a locker, they noted that the “issue is finding the locker. My mail slots, mine is on the bottom row. I [? count] along the doors.” Furthermore, CB said that it is “easier when your’[s] is at the end/near the end it’s easy. In the middle of the row that’s more difficult” and that “tactile markers are always helpful”. With regards to tactile markers, CB mentioned that “it’s possible/ it’[s an] easy adaptation” and that “you could put a little dot”.

B) Changing lock (1) lock itself and 2) their experience with locks)

1) In terms of what they would change about the lock, CB said “don’t think so” and that “they all work.” CB also said that with regards to “size/weight” that they “can be heavier/bigger than they need to be,” but that “for someone with dexterity issues not sure if [it] needs to be bigger/smaller.”

2) In terms of what they would do to change their experience with the lock if they could, CB mentioned “probably nothing. I’ve been able to use locks that I’ve had. My suspicion is that padlocks, there are probably a finite number of keys that open them. I don’t imagine that each one has a unique key. The issue is security. That’s the whole point of why you have a lock. I guess I’ve watched too many courtroom/detective shows. Picking locks. Professional thefts have relatively easy time picking locks.”

C) New ideas for locks

When asked about what a lock designed for them would look like, CB noted that they were “happy with the ones I’ve had.” CB said that “in terms of [the] future [there are] two possibilities: A) Airports: facial recognition. I doubt this could apply to locks. I don’t think this would work: the size of [a] face is bigger than a lock, B) fingerprints: we’re told that fingerprints are unique. Use thumb against lock. Unlocks without a key. For person with dexterity problems, they could touch it and unlock it. The issue of course is security.”

D) Changing their locker experience

When asked about what they would do if they could change their locker experience, CB noted “I am not sure I have problems with existing ones” and “putty/tape anything that will show yours as being different from anyone else’s.

Shows that your locker is the one you are looking for. Has to stay. Some people use elastic bands on the outside of the door handle. Anything to differentiate it from another. Has to do with finding your [word missing], not getting into them. I can use regular locks, not combination locks."

E) Aesthetics

With regards to (if applicable) how aesthetics would influence their design decisions when creating a lock, CB noted "I don't care about aesthetics. More interested in size, not appearance. Easy and cheap." Furthermore, when asked about how aesthetics influence their decision when choosing a product to buy, CB said "not visually," that "they can but sometimes they might" and that they were "more interested in functionality and cost than aesthetics." When I asked when aesthetics do matter, CB mentioned "colour might matter if I was trying to match something." With respect to their experience of the impact of aesthetics on use/non-use of assistive devices, CB said "looks like versus works. Those are apples and oranges. Not much connection. Something that is pleasing to the eye might be something that someone chooses. Not on high list of priorities. In the case of a lock, aside [from] colour, not sure how aesthetics come in. I suppose shape might be useful. I would put that in functionality. I suppose it could be in either one. Distinctive, funny shape would be useful. Would be easier to find. Aesthetics = what it looks like, functionality = does it work. If I am buying something for aesthetic purposes, that wouldn't be a lock. Shape: would help with

identifying, that is a functional things. Different size/unique shape; different size might make it easier for someone with limited strength, needs to be strong enough to be secure." When I asked CB what aesthetics is to them, they noted "[with locks] needs to be made of a material that is strong enough. Material and size are important. Whatever material is made of it needs to be strong enough to be secure."

F) New ideas for combination locks

When I inquired about how combination locks could be changed so that it is easier for them to use, CB said "things that could be considered in my mind could reduce usefulness (e.g. dots to indicate numbers -that's inviting someone to break into lock). Might be some kind of tone. That's giving it away. Maybe you design a lock with some sort of computer chip in it. When you put your fob or some kind of device and hold it against dial and when you get to yours it would emit some kind of noise. I wouldn't want to use [it] because if [the] computer chip malfunction[ed] then you are up *&^% [word removed] creek."

G) Trial and error

CB further noted that with regards to locks, "most of these other things, if you have a lock, you are going to access [it] on a regular [basis] you get used to where it is (e.g. where to put key in), size. Trying keys by trial and error (e.g. try one and if it doesn't work then try another. Some people have multiple keys."

Co-Designer C (CC)

CC is a child, who took part in the interview and prototype generation session #2, results of which can be found below.

Interview Answers

As was noted to me, CC is a child who is homeschooled, but in terms of lockers they have current experience using them in environments such as private storage spaces and public areas including the gym and swimming pool at Community Centres for example. CC has also used lockers in the past at public school.

A) Likes and dislikes about their locker at school

With respect to if they like (in this case liked) using their locker at school and if so, what they liked, CC noted “[a]fter all, yes it is better using locker than the backpack because you have more room, but I wish the locker was wider. It brings more advantage in storing stuff. I do like using the lock because it is an interesting object to use, you can play with it and you make a pattern in your mind and if you keep doing it, you will never forget it.” In terms of why they didn’t like using their locker, CC said “[n]ot big enough. Material door a bit flimsy.”

B) What makes it easy and difficult to use the locker at school

In terms of what makes it easy for CC to use their locker at school they said “[t]hough the locker it is better storage for stuff than backpack, the space inside is

not enough. Using the locker is easy for me because I can remember the combination and I didn't have problems at school with it." In contrast, CC noted that, with regards to what made the locker difficult to use, "[t]he only problem I see is that when you are done using it you might forget to lock the locker. Then you will get problems when you get back to school." CC has used "some partitioning helpers (shelves, racks)" (CC) in the past to help with using the locker.

C) Whether or not friends use lockers at school

With respect to whether their friends used their lockers and if so, if they used them a lot, CC shared "[y]es, for storage."

D) How they would change locker experience and new ideas for lockers

With respect to what CC would do if they could change their locker experience, they noted that "I would have made lockers larger." CC said that, with regards to what they would do if they could invent a new locker and what the best locker for them would look like, "[o]ne with mini cooler for drinks in hot summer, a charger for digital devices and remote lock."

Co-Designer D (CD)

CD is an adult who has a power wheelchair. CD took part in the interview and prototype generation session #2, the findings from which are below.

Interview Answers

A) Past and Current Experiences with Locks and Lockers

In terms of locks that they are either currently using or have used in the past, CD said that “I do not use currently any lock due to physical confinement. However, my experience with locks and lockers in the past has been frustrating.” CD further noted with regards to what it does/did look like that “a) locks: are nice and intriguing objects, I have tried different things over time, physical individual/ built in units key or number combination based; electronic/RFID [radio-frequency identification] b) lockers: vertical box for larger objects, safety box.” With regards to how the lockers/lock does/did work, CD described that “a) lockers: inaccessible for user wheelchair bound and limited hand mobility (narrow spaces, major gap between wheelchair footplate and locker approaching tangent, better when approaching from the side, too low or too high reaching range, some free to compartment with the participation of the user” and with regards to locks “sometimes heavy, problematic if located out of the user hand range, difficult to handle key/padlock/knob, difficult to set up combination or experiencing opening error, power down creating usability errors with electronic/RFID.” The [student researcher thinks this is in relation to the lock] were is/was made of “usually metal, electronic components in other cases.”

In terms of what CD liked and disliked about the lock, they noted the follow in terms of what they liked “a) key lock: portability for non-built in unit, useful to have

level handle with built in unit b) combination lock: portability for non built in unit, keyless and better with knob and c) electronic/RFID: remote access." With regards to what they did not like, they said "a) key lock: problematic if located out of the user hand range (low hand mobility), difficult to handle key/padlock and door knob b) combination lock: problematic if located out of the user hand range (low hand mobility), difficult to handle key/padlock difficult to set up combination or experiencing opening error c) electronic/RFID: problematic if located out of the user hand range (low hand mobility), power down creating usability errors with electronic/RFID." With regards to whether or not the locks were easy or difficult to use, CD referred back to the previous responses and noted that "to me like=easy, dislike=difficult."

Examples of other things that CD uses a lock for (apart from a locker) include a "safety box at bank," (CD) which they noted was "even a bigger hassle." CD shared that alternate ways to keep their things secure include "safety room, security guards" and that places to store their belongings (other than in a locker) include "chairs, tables, wheelchair/power."

In terms of their experience with lockers, CD noted "frustrating most of the interactions" and that with regards to if there have been lockers that work well or don't work well, "I haven't seen an accessible lock to me as it is currently designed." With respect to things that they do/use instead of using a locker, CD

shared that “avoidance is the inevitable option; appealing human support was the other” as well as “backpacks, appealing human support.” Based on their experience with the lock and/or locker, CD has had to change what they bring with them, whereby they bring “less belongings.”

B) How they would change their lock

With respect to how if they could change their lock what they would do, CD noted that “first, I would rethink the locker system; the lock itself works in a context. As space the current lockers might be found completely inaccessible to Pwds [people with disabilities] with sever mobility issues (e.g. quadriplegic). As well a lock, anything that mediates remote interactions would help.” CD mentioned that the way in which they would change their experience with the lock if they could would be “assigning a locker room based on remote interactions” and that a lock designed for them would be “one remote based, assisted by automatic door opener.”

C) How they would change their experience with lockers

With respect to how they would change their experience with lockers, CD mentioned referring to the other responses and that “[a] radical option is to have no need of it.” CD said that if they could invent a new locker they would do “something that can be used by the power of mind, so then back to remote solutions.”

D) Aesthetics

With regards to aesthetics and how they might influence their design decisions when they were creating the lock, CD noted that “in this matter, aesthetic is aspect the last to consider by me.” When asked about if more broadly, if aesthetics influence their decision when they are deciding what products to buy, they noted, “in general I acknowledge this factor but it’s not my favourite” and when asked if so, about how they (aesthetics) do influence, CD mentioned that “a pleasant appearance is always tempting but I always conjoint functionality, quality and price before making purchases. ‘Beautiful’ is not always the best as ‘ugly’ is not necessary a bad choice. De gustibus non est disputandum [“ ‘[i]n matters of taste, there can be no disputes’ ” (Wikipedia, 2018, para. 1)].” When asked for an example of a product that they have recently purchased and how aesthetics influenced their choice, CD said “Apple [Inc.] products. Not recently have bought one but a good example of how beauty, function and quality can work together. Not the price though.” In terms of if in relation to assistive devices if aesthetics are an important consideration for them, CD mentioned that “it depends. European devices tend to be more beautiful & functional than their counterpart in North America on this area. I have a Swedish power chair.”

With regards to the impact (if any) of aesthetics on the use/non-use of assistive devices, CD noted that “I think this is an influential factor in this industry where quite often quality is not at the level of the aesthetic. When they go both that’s

fine but that is rare in my experiences." Lastly, in terms of their experiences or thoughts with respect to the medicalization of assistive devices (in how some assistive devices are medical in appearance), CD shared that "[t]his may go quite subjectively since it is rooted in how medicalization is deployed and even perceived b[y] subjects from all sides. Most likely, nobody likes hospitals and anything related. People would go always with things familiar to their home experience. Pwds quite often cannot choose due to the current options available on the market. However customization is a key factor. Things cannot be improved in this industry without involving the customers in the design processes."

Prototype Generation Session 2

Three co-designers were present during the second prototype generation session including CA, CC, and CD. As noted in the Inclusive Design Process section, the aim of the second prototype generation session was to: 1) brainstorm ideas about locks and lockers and, 2) to begin creating prototype(s) of lock(s) that are more accessible. The information presented below is notes of CA, CC, and CD words as well as quotes and paraphrased information from co-designers CC and CD noted in post session correspondence. The results from two parts of the session are described below:

Part 1

The session began with the "WHAT, WHY, and WHO" activity, where co-designers were asked to brainstorm ideas about:

1) WHAT do you keep in your locker
2) WHY do we need lockers and locks
3) WHO do you trust? (A) what can make a locker more trustworthy, and B) what can be done to increase security?).

The results from this activity can be found below in Table 4. In addition, ideas for 1) future possibilities where lockers and locks are not needed, and 2) future systems were generated and the results are found in Table 5.

Table 4. Results from the WHAT, WHY, and WHO activity

Question:	Ideas:
WHAT do you keep in your locker?	• Books • Clothes • Jackets • Cell phones • Tablets and devices • Secrets
WHY do we need lockers and locks?	• Privacy. Keep things hidden from others • To store • Too much to carry. We carry with us too much stuff • Keep it safe: from theft or borrowing, from fires or other threats. • Don't see necessity
WHO do you trust? (including A) what makes a locker more trustworthy, and B) what can be done to increase security)?	A) What can make a locker more trustworthy? • Eyes make it more trustworthy→witness→ less likely to steal B) What can be done to increase security? • Marking robber with dye • Other deterrents • Disguise value

Table 5. Ideas for future possibilities where lockers and locks are not needed and for future systems.

Category of ideas	Ideas
Future possibilities where lockers and locks are not needed:	• Bring less stuff • Carry things in backpack • Put things in secret spot in a room • Biometric entry • Have virtual necessities called up when we need them. • Invisible wall.
Ideas for future systems:	• Use system similar to automatic door (a limitation is that it only works if there is power). • Have somebody at school to assist • Buddy system • Robotic lock: has robotic arm, lock that attaches to locker that can be triggered by voice. • Electronic lock, remote control (power?)

Part 2

The second portion of the session consisted of creating prototypes of more accessible locks. Two prototypes were created (a robotic lock called Thomas and a robotic locker called Tim/Luke) and are discussed in point form below based on discussion during the co-design session.

Prototype 1: Thomas (Robotic lock with arms)

The design of Thomas was led by CC with input from others. Below is a photograph of the Thomas prototype with its various components identified.

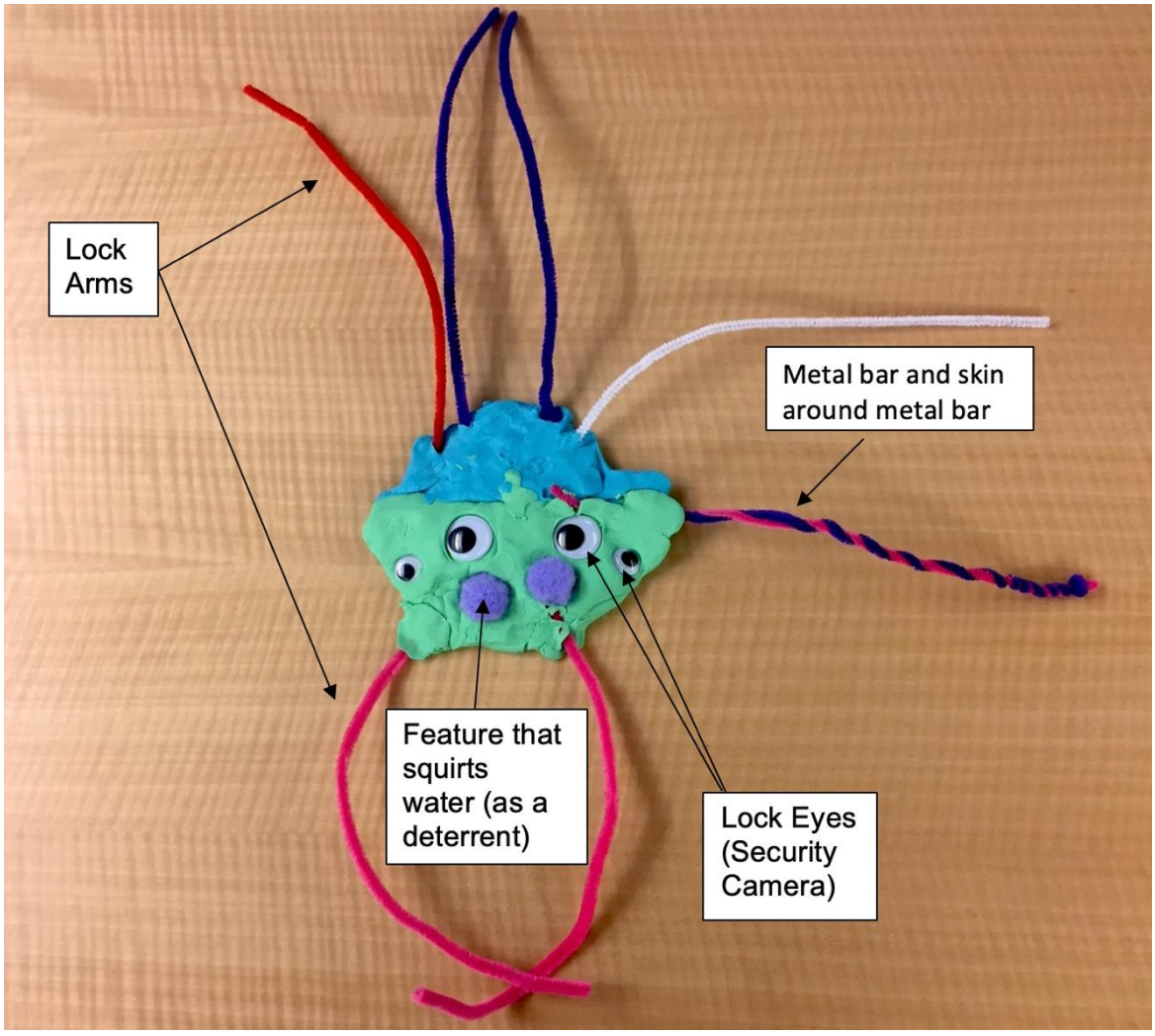

Figure 4. Photograph of the Thomas prototype. This image is of a photograph of the Thomas prototype with some of the components identified. The body of the prototype is roughly circular and is made of plasticine, the top of which is blue plasticine and the bottom is green plasticine. There are arrows pointing to: two of the total four googly eyes located on the body of the prototype (the googly eyes represent the lock eyes that are security cameras), one of the total two puff balls on the body of the prototype (the puff balls represent the features that squirts water if someone is trying to break in), two of the total six pipe cleaners coming off of the top and bottom of the body of the prototype (which symbolize the lock arms), and two pipe cleaners that are twisted together and are coming off the right side of the body of the prototype, which represent the metal bar (dead bolt) and the skin (extra strengthening layer) around the metal bar. The prototype was created by one of the co-designers. The information about the prototype noted above was notes from co-designers words during the session as well as quotes

and paraphrased information from co-designers CC and CD noted in post session correspondence.

Characteristics of Thomas including features, how to install Thomas, how to initiate an interaction with Thomas and how Thomas functions are described in the Table 6. below.

Table 6. Characteristics of Thomas

Characteristics of Thomas	Ideas
Features:	• Robotic arm, robot has bionic arms. Arms are only for the lock • Lock is movable as a spider. Detachable if needed. • Prototype includes two pipe cleaners, whereby 1 signifies metal bar, and the other is the skin around metal bar. The metal barrier cannot move (it remains in its position through the padlock eye on the locker). The metal bar is the element (dead bolt) of the lock working as in a door locker that moves in/out locking the door of the locker through a padlock eye/strike plate. The skin is an extra metal layer for enforcing durability of the main one. • Is friendly. And protective/security oriented. • Could acknowledge you - one possible feature is that it could say hi. • This (the Thomas prototype) could also be applied to fridge, closet and first aid in addition to lockers.
How to install Thomas:	• Add name to Thomas • Thomas makes picture of you so it always recognizes you • Say something to it so it can recognize your voice. • Thomas is installed on locker. Lock could be moved (itself or by someone) onto different lockers.
How to initiate an interaction with Thomas:	• Thomas waits for you to tell him something to do e.g. command.
How Thomas functions:	• Has a security camera on it. Looks at person to verify (Thomas' eyes are represented by googly eyes).

Characteristics of Thomas	Ideas
	• Has password, person has to say password. Could also use finger print. • Squirts cold water/boiling hot water (in all directions) to act as a deterrent. Would squirt only if person tries to break in. • Arms fold/unfold from the lock. • You ask for what you want and arm goes into locker and brings it out. • Could also take something from you. • Different levels of security (e.g. something that is really precious versus somewhat precious). Individual tells robot what is most precious. • When you change grades you take robot arm, someone would have to help you move it. Lock itself can do this since it can move through its arms. • It moves with you to your next locker. Buddy system.

Prototype 2: Tim/Luke (Robot Locker)

The design of Tim/Luke was led by CD with input from others. Below is a photograph of a sketch of the Tim/Luke prototype by CD with its various components identified.

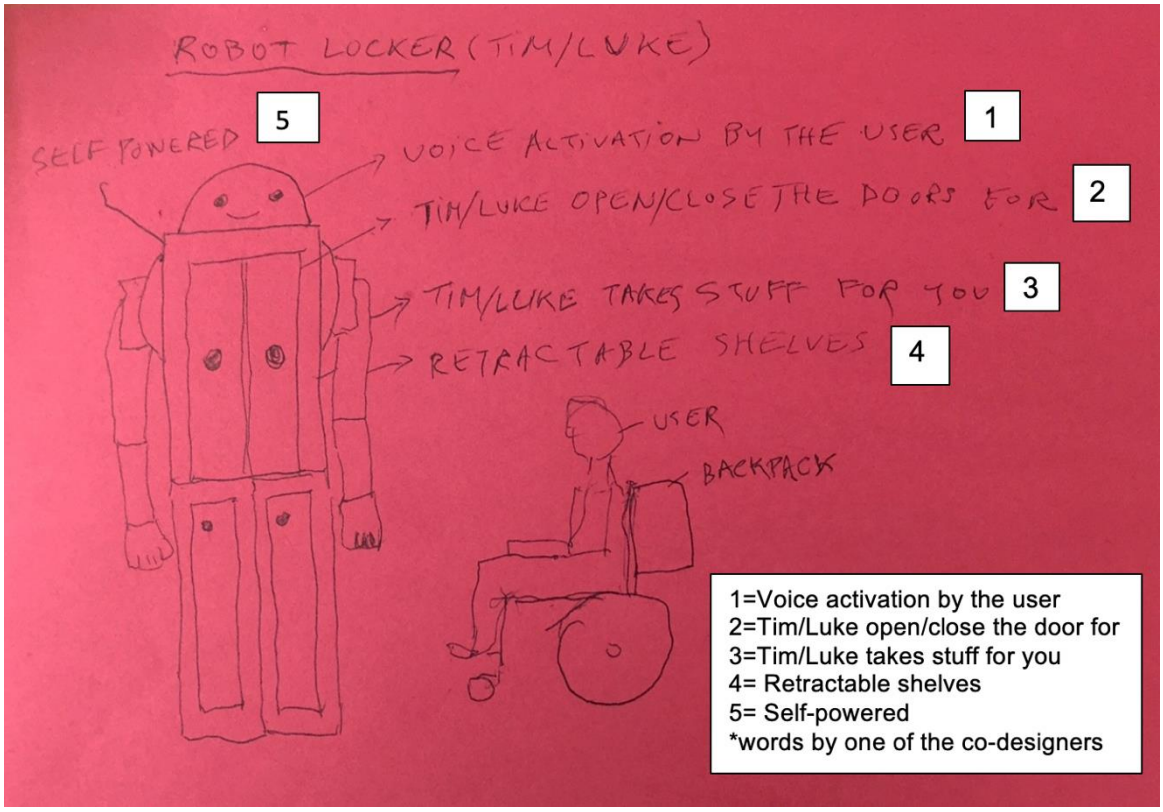

Figure 5. Sketch of the Tim/Luke prototype. This image is of a photograph of the sketch of the Tim/Luke prototype with some of its features identified. Also in the sketch is the “user” who is drawn beside it in a wheelchair with a “backpack” on the back of the wheelchair. The prototype is a robot with a head, body, two arms (including hands) and two legs. The features identified include: 1) “voice activation by the user”, which is connected with an arrow to the head of the prototype, 2) “Tim/Luke open/close door for”, which is connected to the door located on the body of the prototype, 3) “Tim/Luke takes stuff for you”, which is connected to the arm of the prototype, 4) “retractable shelves”, which is connected to the body of the prototype, and 5) “self powered”, which is also connected to the body of the prototype. Additionally, there is a line that points to

the “user” and their “backpack”. The drawing and words on the sketch, which this is an image of was created by one of the co-designers.

Characteristics of Tim/Luke including features, how Tim/Luke functions and options/customizations for Tim/Luke are described in the Table 7 below:

Table 7. Characteristics of Tim/Luke

Characteristics of Tim/Luke:	Ideas
Features:	• Robot Locker. Please note: in terms of automatic features it could be: 1) robot or 2) could be typical locker with automatic features. Could function like classical interaction between an individual and their locker. • Could interact friendly. • Features of robot with arms (see “Thomas” prototype above). Thomas is a lock with arms, Tim/Luke is a locker/robot with arms. • There is a component located on top so that it can recognize you. • Person can set up means of interaction. Remote (voice activation, facial recognition) or tactile. • Communicates with you somehow. • Self-powered (in case power goes off). Batteries examples could be: Tesla, Inc., rechargeable, charge itself because it has arms. • Has retractable shelves. Shelves could come out at different elevations. Legs could be shelves. E.g. Top half: doors opened, shelves can come out. • Extreme- could walk with you. Your locker buddy. • If there were many of them it could be like line up of locker robots.
How Tim/Luke functions:	• As noted previously person chooses how they would like to interact with it. Remote (voice activation, facial recognition) or tactile. • Arms work in some way as manner described by Thomas (see “Thomas” prototype above).

Characteristics of Tim/Luke:	Ideas
	• Tim/Luke opens and closes the doors of the locker for you. • Tim/Luke takes stuff for you. • Could put things in backpack or over lap.
Options/customizations for Tim/Luke:	• Can choose shape of Tim/Luke (cylinder, box, classical locker, robot). Choosing the best shape possible based on the person's condition. • Change how you interact with it (tactile, remote interaction). • You can set up and customize a voice that comes out of it (e.g. male/female voice, mothers/fathers/familiars/favorites voice). • Could change colour of it. Up to user to choose colour and aesthetic features. Colour can be changed just by saying it. Voice commanding. • Could adjust it based on height. Change height of it. • You can make it look more like a robot. • Could be a female robot, child robot. • Change what's inside e.g. cooler to keep drinks cold. • Could be (wireless) connected to security system (e.g. within vicinity, police) or it is security itself. • Could be so strong that it is unbreakable (e.g. fire). • If it's the end of the world, it could defend (e.g. building collapses it could still remain).

4.3 Themes from the co-design sessions

A total of 11 themes were drawn from the results of the co-design sessions including:

1) Challenges with current lock design

2) Challenges with using lockers
3) Aesthetics and choice
4) Identification of locks and lockers
5) Security
6) Emotional context of current locks and lockers
7) Tactile authentication
8) Affordances of technology
9) Limits of digital technology
10) A new take on the buddy system
11) Customization, choice and inclusive design.

Each of the themes will be discussed in the next section and will include notes identifying information that correlated to my prior assumptions and expectations (which were noted previously at the beginning of Chapter 4), but also to new and unexpected information. Additionally, information related to the research questions will be presented within the themes where applicable.

The information below includes quotes and paraphrased information from co-designers from the co-design sessions. Please note: the information from Prototype Generation Session #2 includes: 1) notes of CA, CC, and CD words and 2) quotes and paraphrased information from co-designers CC and CD noted in post session correspondence. The themes will be described in this section and

discussed in detail in the Justifying Design Decisions and Verifying Design Decisions section.

4.3.1 Challenges with Current Lock Design

As was expected, co-designers did voice difficulties with using locks that are currently available on the market, but details and insights into these challenges were new. Co-designers mentioned for instance, that:

- it is “awkward to lift lock out of where it is hitched onto” (CA)
- “Master Lock®: rubber part you have to take off every time on the bottom part” (CA)
- “I do not use currently any lock due to physical confinement” (CD)
- “a) key lock: problematic if located out of the user hand range (low hand mobility), difficult to handle key/padlock and door knob, b) combination lock: problematic if located out of the user hand range (low hand mobility), difficult to handle key/padlock difficult to set up combination or experiencing opening error c) electronic/RFIC: problematic if located out of the user hand range (low hand mobility), power down creating usability errors with electronic/RFID” (CD)
- “I haven’t seen an accessible lock to me as it is currently designed” (CD)

Also, during the journey map, CA noted a part of the experience involved “a good stretch of your hands and fingers to be able to turn the key.”

In addition to the physical barriers to accessing a lock, dislikes related to locks were also noted such as “forgetting numbers” (CA), “when you didn’t directly land on the numbers. You had to start again” (CA). Furthermore, CA noted what they would do if they could change their experience with the lock would be “time it takes to undo the lock” (CA), as well as a co-designer noted that they were not able to use a particular type of lock due to an barrier to accessibility, whereby they said a “combination lock doesn’t work for blind person” (CB).

4.3.2 Challenges with Using Lockers

Though there were questions regarding challenges related to lockers in the interview, I was interested to learn more about other challenges with lockers as they are currently designed, beyond the difficulties with the padlock eye. For example, CD mentioned, with regards to how lockers work, “a) lockers: inaccessible for user wheelchair bound and limited hand mobility (narrow spaces, major gap between wheelchair footplate and locker approaching tangent, better when approaching from side, too low or too high reaching range […])” Furthermore, when asked what they would do if they could change their lock, CD noted “first, I would rethink the locker system; the lock itself works in a context. As space the current lockers might be found completely inaccessible to Pwds with severe mobility issues (e.g quadriplegic).” As result, when asked what they do or use instead of using a locker, CD said “avoidance is the inevitable option;

appealing human support was the other" and "backpacks." When asked if their experience with the lock and/or locker has meant that they have to change what they bring with them, both CA and CD noted fewer belongings, whereby they noted "have to take less" (CA) and "less belongings," (CD) respectively. When asked why they didn't like using their locker at school in the past, CC said "[n]ot big enough. Material door a bit flimsy." With regards to the locker, CC also noted that they "wish the locker was wider" and that "though the locker it is better storage for stuff than backpack, the space inside is not enough." In relation to what makes the locker difficult to use, CC noted "[t]he only problem I see is that when you are done using it you might forget to lock the locker. Then you will get problems when you get back to school."

Please note: that while the two themes above address challenges with locks and lockers, CB provided a different perspective with regards to locks and lockers whereby they noted the following: 1) when asked about what they thought about the lock, they noted "[t]hey all work, fairly easily," 2) when asked about what a lock designed for them would look like, they said that they were "[h]appy with the ones I've had" and, 3) when asked what they would do if they could change their locker experience, they noted "I am not sure I have problems with existing ones."

4.3.3 Aesthetics and Choice

As noted previously, it was unclear whether or not aesthetics would impact the co-designers choice with regards to: 1) the design decisions for the lock, 2) the use or non-use of assistive devices, and 3) products more generally, but thought that it could potentially be a factor that influenced their choice. Details as to how aesthetics would impact the three areas noted above were unknown to me. Thus, new and unexpected information about aesthetics, choice, quality and function was presented by the co-designers.

Aesthetics and the Lock

When asked about how aesthetics might influence their design decisions when creating the lock co-designers noted the following:

- CB said “I don’t care about aesthetics,” that they were “more interested in size, not appearance” and “easy and cheap.” CB also said “[i]n the case of the lock, aside [from] colour, not sure how aesthetics come in,” and that “I suppose shape might be useful,” which they then said “I would put that in functionality. I suppose it could be either one.” CB later noted “if I am buying something for aesthetic purposes, that wouldn’t be a lock.”
- CD said “in this matter, aesthetic is aspect is the last to consider by me.”

Relationship Between Aesthetics and Use

When asked, about the relationship between aesthetic and use, CA noted “all of it would be” and that “the chair I use now is midnight purple.” When asked about in their experience what the impact (if any) of aesthetics on the use/non-use of assistive devices, co-designers mentioned the following:

- CD noted that, “I think this is an influential factor in this industry where quite often quality is not at the level of the aesthetic. When they go both that’s fine but that is rare in my experiences.”
- CB said that “looks like versus works. Those are apples and oranges. Not much connection,” “something that is pleasing to the eye might be something that someone chooses,” and “not on high list of priorities.” CB further noted that “aesthetics= what it looks like, functionality= does it work.”

Aesthetics and Assistive Devices

When asked about whether aesthetics were an important consideration for them with regards to assist devices, CD said that “it depends. European devices tend to be more beautiful & functional that their counterpart in North America on this area. I have a Swedish power chair.”

Medicalization of Assistive Devices

With regards to the medicalization of assistive devices (which is speaking to how some assistive devices are medial in appearance), CD said “[t]his may go quite subjectively since it is rooted in how medicalization is deployed and even perceived buy subjects from all sides. Most likely, nobody likes hospitals and anything related. People would go always go with things familiar to their home experience. Pwds quite often cannot choose due to the current options available on the market. However, customization is a key factor. Things cannot be improved in this industry without involving the customers in the design process.”

Aesthetics and Products

Lastly, with regards to if aesthetics influence their decision when they are deciding what products to purchase, CB said “not visually,” “they can but sometimes they might,” and that they were “more interested in functionality and cost than aesthetics.” For this question, CD noted “in general I acknowledge this factor but it’s not my favorite.” In terms of when aesthetics do matter (in relation to products), CB noted “colour might matter if I was trying to match something.” With respect to if aesthetics influence their decision when deciding what products to buy how they do, CD said “a pleasant appearance is always tempting but I always conjoint functionality, quality and price before making purchases. ‘Beautiful’ is not always the best as ‘ugly’ is not necessary a bad choice. De

gustibus non est disputandum [“ ‘[i]n matters of taste, there can be no disputes’ ”(Wikipedia, 2018, para. 1)]” When asked about how aesthetics impacted their choice with regards to a recent product they purchased, co-designers noted the following:

- CA provided an example of two items of clothing and mentioned they chose the “lavender” and “pearl looking” ones and the one that was “pearl looking” “had texture as well (lace).”
- CD’s response for this question was “Apple [Inc.] products. Not recently have bought one but a good example of how beauty, function and quality can work together. Not the price though.”

4.3.4 Identification of Locks and Lockers

From a social perspective, it was stipulated that individuals may want to create a lock that resembled ones that others would use. The study revealed important information regarding how it would be helpful to design a lock and lockers that could be differentiated from others for identification purposes. For instance, CB elaborated on the idea of shape and locks (noted in the aesthetics section above) and said “distinctive, funny shape would be useful. Would be easier to find” and that “shape: would help with identifying, that is a functional things.” When CB was asked about things they did in the past to help with using a locker, they noted “[i]ssue is finding the locker” and they mentioned in relation to “tactile markers”

that “it’s possible/it easy adaptation,” “you could put a little dot” and that it is “easier when your’[s] is at the end/near the end its easy. In the middle row that’s more difficult” and lastly that, “tactile markers are always helpful.” Additionally, when asked about if they could change their locker experience what would they do, CB noted that “putty/tape anything will show yours as being different from anyone elses,” “shows that your locker is the one you are looking for,” that it “has to stay,” and that in relation to strategies that “some people use elastic bands on the outside of the door handle. Anything to differentiate it from another.”

4.3.5 Security

One of the assumptions that I had was that the notion of security could be a theme for this study and a question about alternative ways to keep one’s belongings secure was asked during the interview. Though I had this assumption, new information about security was presented during the co-design sessions. For instance, when asked about if they could change their experience with locks what they would do, CB noted “[p]robably nothing. I’ve been able to use the locks that I’ve had. My suspicion is that padlocks, there are probably a finite number of keys that open them. I don’t imagine that each one has a unique key. The issue is security. That’s the whole point of why you have a lock. I guess I’ve watched too many courtroom/detective shows. Picking locks. Professional thieves have relatively easy time picking locks.” Security was also noted during the “WHAT,

WHY, AND WHO” activity in the second prototype generation session as a reason why we use lockers, whereby “[k]eep it safe: from theft or borrowing, from fires or other threats” was mentioned. During the interview when asked about aesthetics, CB noted with regards to the lock that “[w]hatever material is made of it needs to be strong enough to be secure.” CB then noted when asked about how a combination lock could be changed so that it is easier for them to use it, “things that could be considered my mind could reduce usefulness (e.g. dots to indicate numbers-that’s inviting someone to break into lock)” and another idea “might be some kind of tone. That’s giving it away.” Lastly, with regards to the interview question about if there was an alternate way to keep your belongings secure, CB noted, “[h]iding them. Hiding something that is of value. Security deposit” and CD said “safety room, security guards.”

The concept of security is also relevant to the prototypes that were generated during the second prototype generation session as Thomas “[h]as a security camera on it,” “[l]ooks at person to verify (googly eyes)” and “different levels of security (e.g. something that is really precious versus somewhat precious” whereby you “tell robot what is most precious” and Tim/Luke “could be (wireless) connected to security system (e.g within vicinity, police) or it is security itself”, “could be so strong that it is unbreakable (e.g. fire),” and “if it’s the end of the world, it could defend (e.g. building collapses it could still remain)”.

4.3.6 Emotional Context of Current Locks and Lockers

Though it was expected that co-designers would refer to: 1) challenges and what they liked or didn't like related to locks, 2) what worked well/didn't work well with lockers, and 3) their emotion during particular steps during their experience using a lock and locker (in the case of the journey map), the content of their responses were new to the researcher. For example, though sarcastic, CA noted, when asked about things that they had done in the past to help with using a locker, "take something to keep calm". CA also noted that it "causes a lot of stress". In a response to an interview question, CD mentioned "[h]owever, my experience with locks and lockers in the past has been frustrating." In addition, CA used phrases and words such as "frustrating that I can't do this on my own," "bummer," "this should be easier," "why can't this be easier", and "frustrating" when describing their emotional journey during various steps of their experience of "Using the Master Lock® at the storage locker".

In contrast, co-designers also shed light on the positive aspects of current locks and/or lockers. For instance, CA, when asked about what they liked about what they liked about the lock (in this case it was a combination lock used in the past), said "I liked it. I felt I fit in to everybody else. We had to do the same thing." CD said that "locks: are nice and intriguing objects" and that with respect to what they

liked about locks “a) key lock: portability for non-built in unit, useful to have level handle with built in unit b) combination lock: portability for non built in unit, keyless and better with knob c) electronic/RFID: remote access.” CC noted that “I do like using the lock because it is an interesting object to use, you can play with it and you make a pattern in your mind and if you keep doing it, you will never forget it.” When asked if they liked using their locker at school, CC mentioned that “[a]fter all, yes it is better than using the locker than the backpack because you have more room […] [i]t brings more advantage than in storing stuff.” Furthermore, when asked about what makes it easy to use the locker, CC said that “[u]sing the locker is easy for me because I can remember the combination and I didn’t have problems at school with it.”

4.3.7 Tactile Authentication

Tactile authentication, which in this case means being able to unlock the lock using touch, is something that is currently being used in locks (please refer to the Locks paragraph in the Current Approaches and Remaining Gaps section) and was mentioned during the co-design sessions. For instance, when asked what a lock designed for them would look like, CB noted firstly “[h]appy with the ones I’ve had” and then “[i]n terms of future two possibilities: A) airports: facial recognition. I doubt this could apply to locks. I don’t think this would work: the size of [a] face is bigger than a lock. B) fingerprints: we’re told that fingerprints are unique. Use

thumb again lock. Unlocks without key. For person with dexterity problems, they could touch it and unlock it. The issue of course is security."

Similarly, when asked about if they could change their lock what would they do, CA noted "[w]hy couldn't it be like a dome like structure that would easily identify as palm print" and when asked about steps to use such a device, CA noted a couple of the steps would be "hand goes over it" and "it reads palm print." Tactile authentication is also a possible component of both prototypes Thomas and Tim/Luke that were created in the second prototype generation session as during the discussion for Thomas it was noted that "could also use finger print" and for "Tim/Luke:" "[p]erson can set up means of interaction. Remote (voice activation, facial recognition) or tactile" was noted.

A detail that was very unexpected was that of designing the tactile authentication to be able to read different portions of an individual's hand (CA). This idea was noted by CA when they proposed "using the side of your hand to read" on days when "you can't uncurl your fingers" as an alternate way to provide authentication apart from the palm print.

4.3.8 Affordances of Technology

As noted in the Tactile Authentication section above, it was known that digital technology has been incorporated into locks (e.g. through touch), but new

information, that was unexpected to me, pertaining to other ways technology could be applied to locks and lockers was presented in the co-design sessions.

Voice Recognition

One example is that of voice recognition, which was noted by CA who, when asked what they would do if they could invent a new locker during their interview, noted for “locker to be like Star Trek™ lockers: A: door could automatically go up. Based on voice” and another example was “if you were to ask for something e.g. sitting down at desk-ask computer for something, it comes out of wall.” This idea of voice recognition came up again during the second prototype generation session when the group was discussing ideas for future systems and mentioned “[r]obotic lock: has robotic arm, lock that attaches to locker that can be triggered by voice.” The idea of having “virtual necessities called up when we need them” was also mentioned when during the discussion about future possibilities where lockers and locks are not needed.

Technology and the Prototypes

Technology, including voice activation, was a large component of both the prototypes that were generated during the co-design session. For instance, technological components in the Thomas prototype includes: “a security camera on it”, voice recognition (“has password, person has to say password,” “[s]ay

something to you so it can recognize your voice"), "robot has bionic arms," is "lock is movable as a spider," and "squirts cold water/boiling hot water (in all directions) to act as a deterrent. Similarly, the Tim/Luke includes: "person can set up means of interaction. Remote (voice activation, facial recognition) or tactile," "takes stuff for you," "could put things in backpack or over lap," is "self powered (in case power goes off)," and as an "extreme" idea, "could walk with you. Your locker buddy."

Enabling "Remote Interactions" (CD)

Ideas around enabling "remote interactions" (CD) were also noted during the co-design sessions. For instance, when asked about they would do if they could change their lock and what a lock designed for them would look like, CD noted "as well a lock, anything that mediates remote interactions would help" and "one remote based, assisted by automatic door opener," respectively. Additionally, when asked if they could invent a new locker what they would do, CD said "something that can be used by the power of mind, so then back to remote solutions."

Digital technology and co-designers current locks

Digital technology was also mentioned by co-designers when they spoke of locks that they currently use. For instance, when asked if there were other things that

they have used a lock for (apart from lockers), CA noted “opening iPhone, passcode” as well as the system for their front door. CB noted that for the “front door of condo” that they use a “fob,” whereby they “wave fob at door.” In terms of locks that they have used in the past, CD said that “I have tried different things over time” and included “electronic/RFID” as one of the examples.

4.3.9 Limits of Digital Technology

Though technology as a large component of the conversations during the co-design sessions, a couple remarks from the sessions alluded to the limits of digital technology, which were new to me. One was from CB when asked about how they might create a more accessible combination lock they said “maybe you design a lock with some sort of computer chip in it, when you put your fob or some kind of device and hold it against the dial and when you get to yours it would emit some kind of noise. I wouldn’t want to use because if the computer chip malfunction then you are up $#%& [word removed] creek.” When talking about what they disliked about locks, CD noted a dislike related to electronic/RFID locks was “power down creating usability errors.” The issue of powering technology was mitigated in the case of Tim/Luke when it was noted that Tim/Luke was "self powered (in case power goes off).”

4.3.10 A New Take on the Buddy System

The notion of the “buddy system” (CA) was very new and unexpected. The concept of the “buddy system” (CA) was brought up by CA during the interview and prototype session #1, whereby they noted that they use the “buddy system” (CA) during their experience of “Using the Master Lock® at the storage locker.” In the “buddy system” (CA) someone assists them during this journey (CA). Additionally, the notion of the “buddy system” (CA) came up when discussing ideas for future systems.

The idea of a “buddy” (CA) appears to also be incorporated within the prototypes that were generated, whereby it was noted that Thomas “is friendly” and “Tim/Luke” “could interact friendly.” Though not related to a person, these features noted above are a new take on the “buddy system” (CA), whereby instead of it being a person who is assisting with the lock/locker it is a robot. Additionally, it was noted that Thomas “could acknowledge you- one possible features that it could say hi” and “moves with you to your next locker. Buddy system.” An “extreme” idea for Tim/Luke was that it “could walk with you. Your locker buddy.” Another option for the Tim/Luke prototype is that “you can set up and customize a voice that comes out of it (e.g. male/female voice, mothers/fathers/familiars/favorites voice).”

Furthermore, with regards to assistance, with Thomas “you ask for what you want and arm goes into locker and brings it out” and it “could also take something from you.” With regards to Tim/Luke, it “takes stuff for you” and “could put things in backpack or over lap.” These features are relevant to what CD said when they noted that “first, I would rethink the locker system; the lock itself works in a context. As space the current lockers might be found completely inaccessible to Pwds with severe mobility issues (e.g quadriplegic)” in response to what they would do if they could change their lock. These “buddy” (CA) features could potentially enable someone who could not access their lock/locker previously as their device provides assistance with doing so. In this way, the lock/locker system is being rethought with a new form of interaction between the person and their device.

4.3.11 Customization, Choice and Inclusive design

As noted previously in the Aesthetics and Choice theme, when addressing the question regarding the medicalization of assistive devices, which is speaking to how some assistive devices are medial in appearance, CD brought up three important observations, amongst others, including: 1) choice: “Pwds quite often cannot choose due to the current options available on the market”, 2) customization: “customization is a key factor”, and 3) inclusive design: “[t]hings cannot be improved in this industry without involving the customers in the design process” (CD). The notion of customization and choice were integrated within the

Tim/Luke prototype where individuals would have the choice to select elements such as: “shape of Tim/Luke (cylinder, box, classical locker, robot). Choosing the best shape possible based on the person’s condition,” “change height of it,” “you can set up and customize a voice that comes out of it,” “change how you interact with it (tactile, remote interaction),” “could change colour of it,” “change what’s inside e.g. cooler to keep drinks cold.”

Chapter 5: Justifying Design Decisions

In this chapter, the components and characteristics of the proposed designs are discussed in relation to the themes identified from the co-design sessions as well as current literature. Discussion related to the research questions (1. how do people respond to using current locks available for schools, home or in day-to-day environments?, and 2. what kinds of new locks could be (re)designed to support broader and more diverse audiences?) will be presented throughout this section where applicable.

The information below includes quotes and paraphrased information from co-designers from the co-design sessions. Please note: the information from Prototype Generation Session #2 includes: 1) notes of CA, CC, and CD words and 2) quotes and paraphrased information from co-designers CC and CD noted in post session correspondence.

5.1 Characteristics of Prototypes

(Thomas and Tim/Luke)

5.1.1 Customizable Features

The prototypes, Thomas and Tim/Luke, generated in the co-design session include components that can be customized by the individuals who are going to be using them, examples of which are noted at the end of the previous chapter. These customizations could serve many different functions, as outlined below:

A) Customization: as a means through which one can make decisions (or choices) about the device and how one interacts with it.

Customization=Choice

The features of the Tim/Luke prototype enable an individual to choose: 1) how, 2) who, and 3) what they are interacting with. First, with regards to how they are interacting with the device, with the Tim/Luke prototype, the "person can set up means of interaction," where options include "[r]emote (voice activation, facial recognition) or tactile." Second, the customizable features of "you can set up and customize the voice that comes out of it (e.g. male/female voice, mothers/fathers/familiars/favorites voice)" mean that individuals can select who they are interacting with. Third, customizations such as "shape", "colour" and

“height” also mean that individuals can decide what device they are interacting with.

By incorporating customization options (and in doing so, including avenues for choice), it could be that the mismatch or the gap between what the product offers (in this case the lock/locker) and the individual’s preferences and/or needs are reduced, which promotes inclusion and could have implications on the well-being of individuals (Holmes, 2018). This is relevant to results from the study as, for instance, co-designers in this study spoke of their “frustrating” (CD), “stressful” (CA) experiences with locks/lockers in the past.

Choice=Independence

The notion that customizations provide an avenue for individuals to make choices related to their product connects to independence. It is important here to highlight which definition of independence is being referred to. As Reindal notes,

> Professionals tend to define independence in terms of self-care activities. So, independence is measured against skills in relation to performance of these activities. Disabled people however, define independence as an ability to be in control of and make decisions about one’s life. (1999, p. 353)

A similar definition of independence was noted by Patricia Rock (1988, p.27). In terms of the relevance of Reindal’s (1999) understanding of independence to this study, one can note that customizations enable choice, which could positively

impact one's feeling of independence in relation to their life. The concept of choice in relation to assistive devices and current design practices will be discussed in the following section.

Choice and Inclusive Design

Choice is lacking in the realm of assistive devices, a point which was emphasized by CD when they noted that with regards to the medicalization of assistive devices, that "Pwds quite often cannot choose due to the current options available on the market". CD then noted that "[h]owever customization is a key factor," which is applicable to this study as customizations were included in the designs. CD also stated that "[t]hings cannot be improved in this industry without involving the customers in the design processes," which is particularly relevant to conversations about current design practices. Individuals such as Jutta Treviranus, Kat Holmes, Emily Ladau and Toby Olson have written about concepts including the problematic nature of disability simulations and the limitations of personas, which are used in design (Holmes, 2018, Ladau, 2017; Olson, 2014; Treviranus, 2018c, Impossible Understanding section, para. 1). Treviranus asserts that:

> [N]o amount of background research and statistics; no persona (however well researched, fulsome, evocative, and motivating); and, no empathy exercises or disability simulations; can ever teach you enough about the

> very personal and unique requirements and characteristics these individuals bring. (Treviranus, 2018c, Impossible Understanding section, para. 1)

This is why the second dimension of the inclusive design is paramount, which underlines the importance of working with (co-designing) individuals with many different points of view, including “people that can’t use or have difficulty using the current designs” (Treviranus, 2018c, section in italics, para.3). The idea is that you are designing “*with* rather than *for*” (Pullin et al., 2017, p.27) the people who are going to be using the device, product or service that you are creating. Furthermore, it is not just about including individuals who are going to be using the device at the end of the design process, but throughout the entire process, and as co-designers instead of participants (Treviranus, 2018c, Authentic Expertise section, para.1). Sadly, inclusive design isn’t always practiced this way, as Liz Jackson notes, when she speaks of her experiences of inclusive design, which include being left out of the discussion and not being acknowledged for her part when she does finally given the opportunity to share (as cited in Creative Mornings HQ, 2018,16:33-16:43). As noted above, it is about the entire process, not just a stage (Treviranus, 2018c, Authentic Expertise section, para.1). Furthermore, using inclusive design practices has implications for choice as a system informed by various perspectives is “dynamic”, can “notice promising opportunities,” and has “far more choices” (Treviranus, 2018a, Perfection and Change section, para 1-2).

The Financial Benefits of Inclusive Design

Additionally, employing inclusive design techniques from the beginning is also beneficial from a financial perspective as it could mean that the need to retrofit the product or system to make it more inclusive is avoided (Holmes, 2009, p.126-127; Treviranus, 2019, What are we missing? Section, para.5). One can see the financial incentive to design with inclusion in mind when one considers websites for example, which if inaccessible, require “huge resource investments to fix” (Holmes, 2018, p.126-127). Similarly, lawsuits, which can also be costly, could be avoided if companies applied more inclusive practices in the development of their products or systems (Holmes, 2018, p. 127).

B) Customization: as a method of providing multiple points of entry (access) for people of all ages and abilities.

Customization = Diverse Access Options

The interaction customizations for Tim/Luke including “remote (voice activation, facial recognition) or tactile”) and options with Thomas to use tactile authentication or voice recognition mean that individuals have various options in terms of points of entry or access to the device. In designing the prototypes this way, it could mean that more individuals are able to use them and that barriers to accessing current locks and lockers could be mitigated. For instance, the options

with Thomas to use voice recognition or tactile authentication could be beneficial for individuals who have difficulty using or cannot use current locks due to the physical demands or requirements (such as sight) of the task. This is relevant to the interviews from this study as examples of challenges related to current locks were noted by co-designers, as described above in the Challenges with Current Lock Design theme. But by being able to unlock/lock the lock using voice activation or tactile authentication and either “voice activation”, “facial recognition” or “tactile” authentication for the locker, the steps of having to insert the key to unlock or input the combination into the lock are eliminated from the process, thereby potentially providing entries to access that weren’t there before.

Customization = Increasing Access

In addition to the authentication system, Tim/Luke also has customizable features that related to shape, where the “shape” could be a "cylinder, box, classical locker, robot,” and there would be the possibility of “choosing the best shape possible based on the person’s condition,” and the ability to “change the height of it” mean that an individual who potentially didn’t have access to lockers before are now able to access and use them. For instance, CD noted that “a) lockers: inaccessible for user wheelchair bound and limited hand mobility (narrow spaces, major gap between wheelchair footplate and locker approaching tangent, better when approaching from side, too low or too high reaching range[…])” and being

able to customize the shape and/or height of the locker could help to mitigate some of these challenges.

Flexible Systems

More importantly, the proposed systems (prototypes) could be flexible even within the proposed options. As identified by CA during a co-design session, one design consideration would be to create a tactile authentication system that is able to read different portions of an individual's hand such as reading the side of an individual's hand instead of the palm, such as for "when you can't uncurl your fingers." In this way, individuals have options related to what components they are interacting with and how they are interacting with them. The notion of providing multiple and different points of entry or interaction is an important one for inclusive design especially given the affordances of our ever-increasing digital world (Treviranus, 2018a, para.1). As Treviranus notes, in "a digital system we can present a different door configuration to each person, even if they are entering as a group, and going to the same destination. […] the door can morph and adapt to needs of each visitor" (Treviranus, 2018a, The Qualities of the Digital and the Networked section, para.1). With features such as tactile authentication that is able to read different areas of the hand (e.g. palm or side of the hand (CA)), there are options for individuals to customize their own particular door or entry into the device based on what works best for them at the time

(Treviranus, 2018a, The Qualities of the Digital and the Networked section, para.1).

Benefits of Flexible Systems

There are benefits to designing a system that supports human complexity and diversity, both from an individual (Treviranus, 2018a, Responsible Designers section, para. 1) and social perspective (Treviranus, 2018b, para. 5). From the perspective of the individual, as Treviranus notes, “[a]verage is an artificial construct. There is not even an average us, we each vary from context to context, from goal to goal” (2018a, Responsible Designers section, para. 1). When we design a system that is flexible and has many doors, we are also creating a design that can meet us where we are at in that given moment instead of us facing a mismatch (Treviranus, 2018a, The Qualities of the Digital and the Networked section, para.1). For instance, by designing a tactile authentication system that can read the side of the hand as well as the palm, one is able to use the design even on days when they are having difficulty opening their hand (CA).

From a social perspective, providing options and acknowledging diversity in designs goes beyond the individual and impacts the larger system (Treviranus, 2018b, para. 5). For instance, the option of using the side of the hand for authentication (CA) could also be beneficial for individuals who, for instance, are carrying books or valuables in their hands and cannot in that moment put their

palm on the device to unlock it. Additionally, the options to use facial recognition and voice activation provide avenues for individuals to access the locker without touch, which could be useful for individuals with physical disabilities, but could also be helpful for individuals with visual impairments and parents carrying children for example.

C) Customization: as a means of differentiating one individual's lock/locker from another.

Customization= Helpful in Identifying What is Yours

Customizable features for Tim/Luke such as "shape", "colour" and "height" could mean that individuals could more easily identify which locker is theirs. For example, being able to customize shape and height could be helpful for people with visual impairments as these features could serve as indicators that differentiate their locker from others. These features are relevant to the point that CB made, when asked about what they have done in the past to help with using a locker, which was that "[i]ssue is finding the locker" and noted that with regards to locks a "distinctive, funny shape would be useful. Would be easier to find." Additionally, these features could also be beneficial for individuals who are navigating busy environments such as schools or gyms as they could aid in the individual identifying and locating their locker more quickly and easily. The notion addressed by CB above about being able to create a device that has a

“distinctive” (CB) element is relevant to a story regarding the personalization of walker frames in Britain, whereby in this case, it is the appearance that is distinctive (Gardner, 2018, “Pimp My Zimmer”!? section, para. 1). As mentioned in the BBC News video, in personalizing their walker frames, residents with dementia in an Essex care home were able to identify which frame was theirs (Tanya Strange as cited in BBC News, 2017, 1:12-1:26). It was reported that “falls reduced by 60%” (Tanya Strange as cited in BBC News, 2017, 1:26-1:28). Lastly, in addition to using shape and height to identify an individual’s locker, it could also be that future iterations of the prototypes include a feature within the voice activation that allows an individual to talk to their locker from a distance to locate it.

Tactile Markers

During the interview, CB also provided examples of ways tactile markers are: 1) used in other contexts beyond the lock/locker (“some people use elastic bands on the outside of the door handle”) and 2) could be used in relation to the locker (“putty/tape that will show yours as being different from anyone else’s”) to help in identifying what is yours. In her cutlery designs, designer Aurora Brard (mentioned previously in the Remaining Gaps: The Future of (Assistive) Devices section) has used tactile markers as a means of helping individuals to differentiate the knife, spoon and fork (Yalcinkaya, 2018b, para.4). Future

iterations of the prototypes, Thomas and Tim/Luke, could include options for tactile markers.

D) Customization: as a way to specify and personalize security (note: need to clarify if features are customizations or prototype features).

Customization= Means to Personalize Security

Both Thomas and Tim/Luke include elements related to security that can be customized by the individual who is using the lock/locker. In the case of Tim/Luke, customizations include that it “could be (wireless) connected to security system (e.g within vicinity, police) or it is security itself,” “could be so strong that it is unbreakable (e.g. fire).” These particular options are particularly relevant to one of the discussions that took place during the co-design session related to why we use lockers, where it was noted that one of the reasons we use lockers is to “[k]eep it safe: from theft or borrowing, from fires or other threats”. In addition, they are also relevant to points CB made in the interview regarding security, which were noted in the Security theme above. The customizations identified above for Tim/Luke as well as the ability to customize the way one interacts with Tim/Luke enable the individual who is using the locker to customize how the security system itself is set up, both in relation to the materials that are

used to create the locker and the technological components, but also how it operates within a larger system or context (e.g. linked to the police, changes in the environment such as a fire).

For Thomas, it has “different levels of security (e.g. something that is really precious versus somewhat precious)” and the individual “tell[s] robot what is most precious.” These customizations allow the individual to select which items receive the highest level of protection versus the least (e.g. a granola bar receives a low level of protection versus an iPhone which would receive more). The selection process is vested within the individual and is thus, is personalized to them.

Changing How We Unlock a Lock

What is also interesting to note is that with the various forms of authentication that can be integrated within the prototypes the whole notion of unlocking changes. With standard locks, individuals unlock them by physically moving parts of the lock (e.g. putting the key inside the lock and twisting to unlock or moving the combination dial to unlock), but now we are unlocking the lock by simply being present (e.g. facial recognition, voice activation) or by one touch (e.g. tactile authentication). Additionally, the concept of personalization also changes when it comes to locks/lockers as before, one could maybe choose or personalize the combination for the lock, but now it is our person, our very body

(e.g. face, voice, and hand), that is initiating the process of the lock or locker being unlocked.

The idea of using features of the person's body to unlock a lock is not new, as noted in the introduction section, where examples of locks that use touch include the Bluetooth Padlock (Kirand1, 2018) and Tapplock One by David Tao and Jayden Li (McLaughlin, 2018). Furthermore, with respect to future options in terms of products and authentication systems more generally, the company Motiv, Inc. (which discussed earlier in the Current Approaches and Remaining Gaps section), "has revealed its smart ring will soon use its wearer's unique heartbeat to verify their identity and make payments" (Aouf, 2019, para. 1). Though these options provide new avenues for access and authentication, it should be noted that with incorporating the person's body in the unlocking of devices (such as the lock/locker proposed in this study) there need to be appropriate measures put in place to ensure that the individuals identity and personal information are not at the risk of being stolen and used by others.

E) Customization: as a means to select aesthetic preferences

Aesthetics=Subjective

As noted in the results section, the opinion regarding aesthetics varied amongst co-designers. This reflects the subjectivity of aesthetics and how it means different things to different people. The level of importance also varies from person to person as well as how aesthetics is defined. CD summarizes these thoughts when they said “ ‘Beautiful’ is not always the best as ‘ugly’ is not necessary a bad choice. De gustibus non est disputandum [“ ‘[i]n matters of taste, there can be no disputes’ ”(Wikipedia, 2018, para. 1)]”. The purpose of this section is not to find a single definition of aesthetics nor to determine whether it matters or not, but to open up the dialogue about aesthetics especially in relation to other features of products and in the design of assistive devices.

Customization= Avenue for Aesthetic Preferences

For Tim/Luke, one customization is that it is "up to user to choose colour and aesthetic features” and the “colour can be changed just by saying it,” which could be one way for an individual to select their aesthetic preference for the device. Based on the responses from co-designers, further conversations regarding what aesthetics means to individuals could be beneficial in the future so that future iterations of the designs incorporate these perspectives. An interesting concept

that emerged from discussions regarding aesthetics includes categorizing characteristics of products, which will be discussed in the following section.

Categorizing characteristics of products

The notion addressed above, where CB talks about how shape could be placed in either the category of aesthetics or functionality is an interesting one and will be explored further. It highlights the difficulty in creating distinct categories for characteristics of products, which, in turn, brings the conversation back to Dieter Rams and his ideas regarding aesthetics (Anderson & Mandell, 2017). As Rams notes,

> In my 10 principles of good design, I have written that the aesthetic quality of a product is an integral aspect of its usefulness, for the appliances that we use daily have an impact on our personal environment and influence our sense of well-being. (as cited in Anderson & Mandell, 2017, para. 6)

Here Rams helps to draw connections between aesthetics, usefulness and well-being and in doing so, shows how they are not separate entities (as cited in Anderson & Mandell, 2017, para. 6). In a similar vein, Pullin notes in his book that, "[t]he interviewer asked [Charles Eames] whether design implies 'the idea of products that are necessarily useful,' rather than 'solely for pleasure'. Eames's reply challenged this distinction: 'Who would say that pleasure is not useful?' " (Pullin, 2009, p.305). In this statement, Eames is communicating how pleasure

and usefulness are not mutually exclusive concepts, but are linked (Pullin, 2009, p.305).

Based on the words and ideas of Rams and Eames above the following questions emerge:

1) What if a broader view of aesthetics, one which embraced and acknowledged the connection between beauty, usefulness, and well-being, was taken with respect to the design of assistive devices?
2) Could this broader understanding of aesthetics and its relationship to other areas mean that one area (such as quality or beauty) was not being sacrificed at the expense of another (such as functionality), but instead be seen as elements that are elevated when thought of together?
3) Furthermore, could this mean that individuals do not have to weight some qualities of a product against others when making a choice, a concept which was illustrated by CD when they said “a pleasant appearance is always tempting but I always conjoint functionality, quality and price before making purchases” ?
4) Lastly, could it be through aesthetics- in seeing the importance of aesthetics and its connection with other qualities of a product, that designers take the time to reach out to the individuals who are going to be using the devices and include them in the design process so that the

components and/or customization options of the devices better reflect those individuals' preferences?

This last question is relevant to what CD said with regards to the medicalization of assistive devices including concepts such as choice, customization and inclusive design (CD).

5.1.2 Digital Buddies

"Buddy System" (CA)

As CA introduced in their co-design session, they use a "buddy system" (CA) when it comes to utilizing their "Master Lock® at the storage locker". This "buddy system" (CA) involves having someone else present to help with the steps involved in the process. The notion of a "buddy" (CA) appears to also be integrated within components and features of the Thomas and Tim/Luke prototypes. For instance, the prototypes involve elements of friendliness. Further examples include that: 1) Thomas "could say hi" and "moves with you to your next locker," and 2) for Tim/Luke, the individual is able to select the voice, whereby it could be "mothers/fathers/familiars/favorites voice," and an "extreme" idea for Tim/Luke was that it "could walk with you. Your locker buddy."

In addition to having features of friendliness and personal connection (e.g. "mother/fathers voice"), both prototypes can also provide physical assistance with

the activity as they have arms. Arms are important features of the prototypes because they can help to mitigate challenges related to lockers such as those identified by CD as both prototypes can give objects to the individual from the locker as well as take objects from the individual. In their ability to provide both emotional support (through friendliness) and physical support, the prototypes can be seen as “digital buddies” for the individuals who are interacting with them. The notion of a “buddy” (CA) will be discussed further in relation to three concepts including: A) interdependence, B) identity and, C) anthropomorphism.

A) Interdependence

The notion of a buddy is relevant to an idea that Kat Holmes discusses in her book *Mismatch*, whereby she draws attention to how our lives include many instances when we are dependent on other things, such as technology (2018, p.58-59). We are also dependent on other people. For individuals with disabilities, these relationships, whether it be with other individuals or technology, play a very important role (Holmes, 2018, p. 58-59). Interdependence and the various ways that systems are connected are what inclusive designers focus on as it is in doing so that we “shift toward inclusion” (Holmes, 2018, p. 61).

Sara Hendren also discusses the importance of acknowledging and designing for interdependence when it comes to technology when she notes that “[t]he enduring human always needs assistance. The goal is not, in other words,

elimination of assistance or elimination of exchanges with one to another. The goal is thriving communities over the whole life cycle" (Sara Hendren as cited in Collins, 2017, para. 51). The idea being here that we are not looking to create a world where we no longer rely on others or things, but that we are enabling positive connections between people as well as with their surrounding environment (Sara Hendren as cited in Collins, 2017, para. 51). The "buddy system" (CA) features of the Thomas and Tim/Luke prototype (such as friendliness, customizing voice and assisting with putting objects into/out of the locker) can be seen as acknowledging this interdependent relationship between the individual and their lock/locker.

B) Identity

The concept of interdependence and recognizing the important link between individuals and their technological devices is also discussed by Treviranus when she notes that, with respect to people who use "computer based AAC [alternative and/or augmentative communication] systems" (Treviranus, 1994, Introduction section, para.2) that the device is something that they are rely upon and "it becomes a part of their identity" (Treviranus, 1994, Introduction section, para.2) and "[a]s result it plays a much more intimate and personal role in the user's life than the average computer" (Treviranus, 1994, Introduction section, para.2), which is why including features of the buddy system (such as friendliness) are important to the lock and locker prototype designs.

The connection between identity and devices is an important one to note and to take into consideration when designing as amongst other reasons, assistive device abandonment " 'relates to people's perception of themselves as disabled, and to broader issues of identity'"(Clare Hocking as cited in Pullin, 2009, p.125-126). Based on the complex relationship between device use and identity, both in how devices are integrated within identity (Treviranus, 1994) and how identity impacts use (Clare Hocking as cited in Pullin, 2009) noted above, more attention needs to be payed to this area. As Pullin so poignantly states, "[a]s with any other design, the acceptability of design for disability depends not just on its functionality and usability but also on how using it makes an individual feel" (Pullin, 2009, p. 153). In the design process, there needs to be more time taken to understand an individual's emotional context in relation to devices, which is yet another reason why designing "*with* rather than *for*" (Pullin et al., 2017, p.27) is vital.

C) Anthropomorphism

Anthropomorphism is "the attribution of human motivations, beliefs, and feelings to animals and inanimate objects" (Norman, 2007, p. 136). Norman notes that individuals are more likely to anthropomorphize with the "more behavior something exhibits" (Norman, 2007, p.136). Thus, incorporating friendliness as a feature of the device could: 1) lead to increased anthropomorphism of the device by the individual, which in turn could 2) create a connection that is more similar to

that of a person to person connection than other devices which do not incorporate these features (Norman, 2007, p. 136). Further research could explore how this form of connection impacts an individual's well-being. Additionally, an interesting observation is that human names were chosen for both prototypes (Thomas and Tim/Luke), which could be a great topic to discuss in future design sessions.

5.1.3 Self-Powered Technology and Trust

One of the features of the Tim/Luke prototype is that it is "self-powered (in case power goes off)." This feature could be beneficial in mitigating the difficulty noted by CD, who mentioned, when asked about what they disliked about lock in the interview questions, that one of their dislikes with regards to the "electronic/RFID" was "power down creating usability errors with electronic/RFID."

The self-powered feature of Tim/Luke can be a feature that helps to promote trust in the device by the individual who is using the device as they know that it is self-powered and will not "power down," (CD) which could be seen as a "technical error" (Treviranus, 1994, Prerequisities to Skill acquisition section, para.8). In an article titled "Mastering Alternative Computer Access: The Role of Understanding, Trust, and Automaticity," Treviranus notes that, with regards to "alternative access systems" (Treviranus, 1994, Prerequisites to Skill Acquisition section,

para. 1), “[a]nother prerequisite to a skilled tool use is trust of the tool or system” (Treviranus, 1994, Prerequisites to Skill Acquisition section, para.7). Treviranus further notes that “[a] trustworthy device is both dependable and predictable. It is consistent in its performance. It lives up to its expectations. Technical breakdown, or technical errors are not conducive to trust, or new learning” (Treviranus, 1994, Prerequisites to Skill Acquisition section, para.8). Sadly, Arthanat, Douglas Simmons, & Favreau (2012) note “frequent breakdown of technology” (p. 311) as one being of the problems with assistive technology (Arthanat et al., 2012, p.311), which needs to be addressed as it has implications for the use of devices. Tool abandonment is noted by Treviranus as a possible consequence “if trust is broken” (1994, Prerequisites to Skill Acquisition section, para. 8 and para.9). Similar findings were found by Gardner who notes that “[a] mobility device that is poorly designed for example, can elicit feelings of frustration and inadequacy among users that could translate into reduced self-efficacy and device abandonment” (2016, p.5). Thus, more attention needs to be paid towards the quality and components of an assistive device, both from an emotional and financial perspective (in the case where devices are abandoned) (Gardner, 2016, p.5).

Chapter 6: Contribution to Domain and Transferable Insights

6.1 Contribution to domain

6.1.1 About the Study

In her most recent novel, Virginia Eubanks notes that “[a]nother way to understand inclusion is by thinking of it as the ability to thrive *as your whole self* in community” (2018, p.195). “*As your whole self*” (Eubanks, 2018, p.195) implies that no part of you is excluded- that there exists no mismatch between you and the environment which surrounds you. With inclusion in mind, this study explored how inclusive design practices could assist in answering two questions: 1) how do people who have insight into the challenges related to using locks respond to using current locks available for schools, home or in day-to-day environments? and 2) what kinds of new locks could be (re)designed to support broader and more diverse audiences?

6.1.2 Findings from Study

With respect to the contributions to the domain, the findings from the co-design sessions, which included answers to the research questions were grouped into 11 themes including:

1) Challenges with current lock design
2) Challenges with using lockers
3) Aesthetics and choice
4) Identification of locks and lockers
5) Security
6) Emotional context of current locks and lockers
7) Tactile authentication
8) Affordances of technology
9) Limits of digital technology
10) A new take on the buddy system
11) Customization, choice and inclusive design.

Two prototypes were created during the study, named Thomas and Tim/Luke, respectively. The features of the prototypes were discussed in three sections including: 1) customization, 2) digital buddies, and 3) self-powered technology and trust, which were explored in relation to research questions and findings from the study as well as relevant literature and current designs on the market. Firstly, the purpose of customization was explored, whereby it was identified as playing five roles including:

1) As a means through which one can make decisions (or choices) about the device and how one interacts with it.
2) As a method of providing multiple points of entry (access) for people of all ages and abilities.
3) As a means of differentiation one individuals locker from another.
4) As a way to specify and personalize security.
5) As a means to select aesthetic preferences.

Secondly, the concept of your robot buddy (including prototype features such as friendliness) was discussed with respect to how the “buddy system” (CA) acknowledges and fosters the interdependent relationship between individuals and their devices and connections were drawn between the robot buddy, identity and use of assistive devices. And thirdly, the feature of using self-powered technology was seen as being a way to promote trust in the individuals who are using the device.

6.1.3 Applicability

Though the prototypes, Thomas and Tim/Luke are only initial designs and contain a variety of features and numerous technological components, the designs are not outside of what is currently possible. For instance, Fedex® has created an autonomous robot called SameDay Bot, which will be tested in the summer whose purpose is to deliver purchases to customers (Hitti, 2019b, para.13). The robot includes features such as wheels (for movement), cameras (to navigate the

environment around it), a vestibule (to carry deliveries), and a screen (for communication) (Hitti, 2019b). Furthermore, TouchID (tactile authentication technology) and Facial ID are found in select Apple, Inc. products (Apple, Inc., 2019a; Apple Inc., 2019b.). In terms of voice recognition technology, VoiceOver is also an option with Apple, Inc. products (Apple Inc., n.d.). Lastly, robots with arm-like structures are already in existence with examples including robots created at ETH Zurich University (Block, 2018) as well as those by the Jason Bruges Studio (Morby, 2017) and Ory Laboratory Ltd. (Locker, 2018).

6.2. Transferable Insights

With regards to transferable insights, which in this case would be helpful hints for people who are going down this path or are interested in this area, there are a few things that I would note:

1) The term inclusive design is used in various ways. It is helpful to describe what definition and/or conceptual understanding of “inclusive design” you are using and how you are going to apply it from the beginning, for both yourself and audience, as this is the foundation for your work.
2) Inclusive design and the process of co-design and how it is applied varies from project to project. As such, it is helpful to provide more details about these areas so that individuals who have not heard about them before can learn about them and/or gain an understanding of the context in which

they were used. With regards to inclusive design and co-design, I found that articles and work by Jutta Treviranus were helpful for me as well as the Inclusive Design Guide. Additionally, the book *Mismatch* by Kat Holmes (2018) was useful with respect to inclusive design. Please see References section for information about work by Jutta Treviranus, Kat Holmes as well as the Inclusive Design Guide (see references for community members of the IDRC at OCAD University).

3) Terminology matters. If you are applying co-design in your project, the people you are working with are “co-designers” not “participants” and should be addressed as such throughout your work.

Chapter 7: Limitations, Next Steps, Unanswered Questions

7.1 Limitations and next steps

7.1.1 Limitations

I would like to note that with inclusive design, the intent is that designs go through many iterations over time so that “you will be stretching the design to encompass more and more needs” (community members of the IDRC, n.d.c., Iterating on the Design-The Virtuous Tornado section, para.2). This process is referred to as the “Virtuous Tornado” (community members of the IDRC, n.d.c. Title of Page). Instead of a final unchangeable product (community members of the IDRC, n.d.c., Iterating on the Design-The Virtuous Tornado section, para. 1), the idea is to have a design that is flexible and can morph for each individual (Treviranus, 2018a, The Qualities of the Digital and the Networked section, para.1). Thus, limitations regarding the development of the final prototypes (the fidelity) and number of co-design sessions will not be discussed as limitations as the theory is that the design is constantly a work in progress and could benefit from future iterations and redesigns (community members of the IDRC, n.d.c., Iterating on the Design-The Virtuous Tornado section, para.2). This is also congruous with qualitative research where the aim is to create a theory, which is something that

is constantly evolving (Hoepfl, 1997, p.56). With that said, next steps for the prototypes generated in this study will be discussed in the next steps section.

Additionally, inclusive design focuses on the individual and creating designs that work for them (IDRC, n.d., The Three Dimensions of Inclusive Design section, para. 2). As such, the small number of co-designers in this study is not seen as a limitation, but instead as an asset and positive example of inclusive design practices (Treviranus, 2018a, Human Uniqueness section, para.1) and consistent with qualitative research (where no particular number of co-designers is required) (Hoepfl, 1997, p.50).

7.1.2 Next Steps

In terms of next steps, it would be beneficial at this point to continue developing the prototypes generated (both the sketch of Tim/Luke and the plasticine prototype of Thomas) so that co-designers have something tangible to be building off during the future co-design sessions. The prototypes could only benefit from more co-design sessions and having more co-designers stretch their designs (community members of the IDRC, n.d.c., Iterating on the Design-The Virtuous Tornado section, para.2). Continuing to discuss the prototypes in an open discussion format (such as the WHAT, WHY, and WHO activity used in co-design session) could be beneficial as a way to keep the design of the prototypes moving to “encompass more possibility” (community members of the IDRC,

n.d.c., Iterating on the Design-The Virtuous Tornado section, para.1) versus towards a “single design solution” (community members of the IDRC, n.d.c., Iterating on the Design-The Virtuous Tornado section, para.1).

Another future step would be to collate the findings from this study to create additional facets for the “Inclusive Design Mapping Tool” (community members of the IDRC, n.d.a, Figure 1. Description section). The “Inclusive Design Mapping Tool” (community members of the IDRC, n.d.a, Figure 1. Description section) is a tool used to illustrate the discrepancy “between needs and requirements” (community members of the IDRC, n.d.a, Inclusive Design Mapping section, para.3). The idea would be to create new facets that build on the current facets in order to explore elements such as customization, digital buddies and power source.

7.2 Unanswered Questions

It should be noted that I have posed questions to the reader throughout this paper and these questions are meant to encourage discussion and to question the situation or system as it currently stands (e.g. with regards to the design of assistive devices). In addition to these questions is a list below of other questions that remain unanswered that could benefit from further attention and exploration:

- What is the impact of using co-design in the design of an accessible lock?

- More broadly, what is the effect of using co-design in the design of assistive devices and devices more generally?
- Is there a link between using co-design and the use of (as opposed to abandonment of) assistive devices? How could this be better understood?
- Is there a link between using co-design and reducing stigma or stereotypes related to disability? How could this relationship be better understood?
- How does the social environment influence the design of the accessible lock and assistive devices more generally?
- How can aesthetics (a highly subjective and complex concept) be discussed in the context of the design of products (including an accessible lock, assistive devices and products more broadly)?

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