BEYOND ACCESS:

TECHNOLOGY, BLINDNESS, & SELF-DETERMINATION

by Belinda Rudinger

A dissertation submitted in partial fulfillment

of the requirements for the degree of

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Abstract

This mixed-methods study sought to examine the user experience of technology related to self-determination from the perspective of persons who are blind. Connections between assistive technology and Deci and Ryan's (2017) Self-Determination Theory (SDT) were explored through the three basic needs of autonomy, competence, and relatedness. The study was designed within the frameworks of post-phenomenology and positive technology, with clients from Computers for the Blind, a non-profit organization that offered computers with screen reading and screen magnification software. The TENS-Interface, a recent SDT-based instrument (Peters, Calvo, & Ryan, 2018), was administered, followed by qualitative interviews and observations called *Technology Biographies* (Blythe, Monk, & Park 2002). Findings showed evidence of some correlations and qualitative corroborations related to the user experience of technology related to self-determination. Recommendations are offered for further research and improvement in practices for serving individuals who are blind.

Dedication

This dissertation is dedicated to the city of Stevens Point, for welcoming me home.

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"We stand in the midst of a transition where we cannot remain standing…we have changed, as a house that a guest has entered changes…the future enters us in this way in order to be transformed in us, long before it happens."

~Rainer Maria Rilke, *Letters to a Young Poet*

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Chapter 1. Introduction

Self-determination can be seen as an individual's ability to find and follow their own north star. This experience may differ by individual, but the search is universal. Technology is one area that can affect the way humans experience this journey. It could serve as a flashlight to illuminate the pathway, or a compass to guide their steps toward their true north. Technology means different things to different people. On the way toward a north star, technology could serve as a distraction, a valued part of the experience, or even a symbol of where they are along the way.

Technology has become a central part of the way people live their lives. It shapes the ways people experience the world, as well as how they act within the world. Different persons have different relationships to technology. These relationships depend upon individual preferences, habits and attributes. To some, technology is a necessary nuisance, while to others it represents much more than a means to an end. In this modern world, it has become a pathway to experience and action.

Technology has considerable impact upon individuals who are blind. According to the social model of disability, the purpose of assistive technology (AT) is to bridge any gap between what a person with a disability wants to do and any environmental barriers in a given setting (Hersh & Johnson, 2008). Assistive technology is a priority in the field of education and rehabilitation for individuals with blindness or low vision (VI) because it "equalizes the ability to access, store, and retrieve information between sighted people and those with visual impairments" (Sapp & Hatlen, 2010, p. 341). Its use is necessary for reading, writing, and math, and its complex learning curve requires additional time and instruction. Furthermore, technology "ensure(s) blind and visually impaired individuals are seamlessly integrated within their home, school, and work communities" (Siu & Presley, 2020, p. 9).

Self-determination, defined as "… a person's right to decide freely and without undue influence how he or she wishes to live his or her life," is a complementary priority in the field of education for individuals who are blind or have low vision (Sapp & Hatlen, 2010, p. 341). Although educators recognize the importance of self-determination and assistive technology for these individuals, only they themselves can author their own narratives. As children who are blind grow into adults, technology may mediate access to the books they want to read, the careers to which they aspire, their hobbies and pastimes, and sometimes even their relationships. Technology is ever-present in how they define and then pursue how they wish to live their own lives.

Individuals who are blind have relied upon technology to provide access to the written word long before the rapid shift to ubiquitous computing and technology use in recent decades. This use of technology was a necessity rather than a choice or preference. Mechanical braillewriters opened the door to writing, while books embossed in Braille allowed entry to the world of literature. The original 1980s-era personal computers had textual (i.e., word based) user interfaces and were operated entirely by keyboard commands, which made them easily adaptable for blind users. Before long, graphical user interfaces (i.e., picture based) using a mouse instead of keyboard commands were introduced and became the new standard. As computers became more visual, they grew easier to use for sighted people, but more difficult for persons who were blind. As technology continues to evolve, it closes some doors while opening others.

Kapperman and Kelly (2018) wrote, “obtaining access to the printed word is one of the most challenging aspects of education for a student who is blind…not all printed information that he or she needs to read may be easily acquired. (p. 390). Echoing this salient point, Carey (2007) explained,

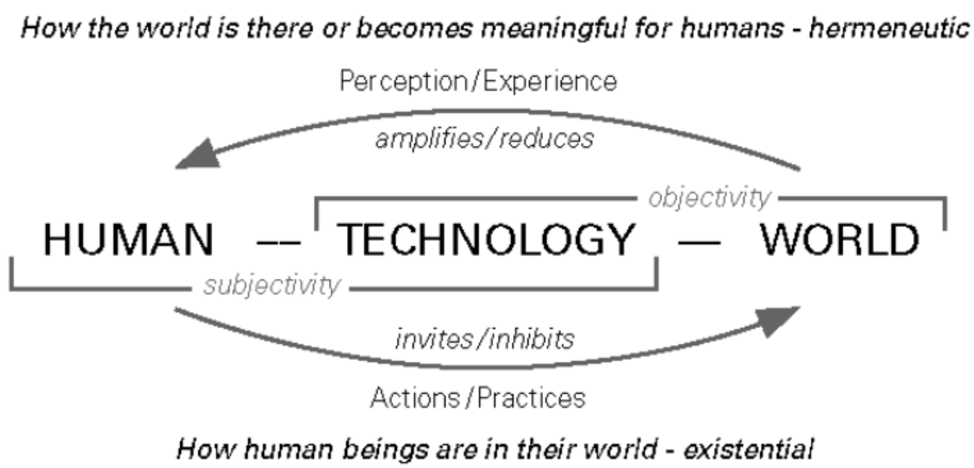
> Imagine you went into a bookshop with 4% of its shelves filled with books; those books were at least two years old and consisted almost entirely of light fiction, textbooks and an idiosyncratic miscellany. How would you feel? How, do you think, would this affect your life as a human being, as a citizen, as a person intent on rewarding work and stimulating leisure? *(*p. 770)

Hingson (2011) added, “I will know that I am truly integrated into society… when I can go to meetings or conventions where all the materials given to sighted people are automatically available to me in Braille or another accessible form.” (Ch. 13, Para. 15). Even in 2020, there is still a long way to go toward ensuring accessibility to print and other media for these individuals.

For persons who are blind, technology mediates both access to the written word as well as all written exchanges between blind and sighted persons. Both access and exchange are necessary for their self-determination. However, because sighted and blind persons experience information access and exchange differently, it can be difficult for designers, educators, co-workers, friends, and family to *see* the whole story even with best intentions.

One way to study the complexity of non-visual information access and experience is through the field of post-phenomenology. This emergent area of study considers “ … the ways technology affects, shapes, and transforms humans, their experiences, and relationship with the world" (Hauser, 2018 p. 21). Technology can be observed to invite or inhibit a human to act in particular ways within the world, and simultaneously, through technology the world is amplifying or reducing the subjective experiences of the human engaged in being-in-the-world. The dynamic balance of technological mediation between humans and the world they inhabit is shown in Figure 1.

Figure 1. Technological Mediation



Note: from Hauser (2018, p. 8); used with permission.

An examination of the user experiences of persons who are blind, framed within this human-technology-world relation, has the potential to offer an expanded understanding of these dynamics. Underestimating the degree to which technology opens and closes doors can lead to both unintentional exclusion and obfuscation of the full story through a reductionist approach. Salient symptoms of the problem often command the most attention, yet they may not tell the whole story. Such symptoms include the high cost of technology, its complexity, the increased popularization of unintentional exclusion via text embedded within pictures, steep learning curves for technology faced by individual students as children or adults, as well as similarly daunting learning curves for teachers who must understand enough to instruct students in its use.

Technological innovation has also led to a convergence of proprietary assistive technology designed specifically for persons with disabilities, such as a braillewriter and mainstream technology built with universal design principles that allow for use, such as an iPhone with its built-in screen reader that is not designed specifically for blind individuals, but affords their use. As Siu (2015) stated, “Given the rise in use of digital instructional materials and media in the modern classroom, students now more than ever need technology skills for independent and timely access to information” (p. 30). These materials are not always designed with accessibility in mind, and at times technology closes as many doors as it opens.

Learning more about the interplay between technological artifacts and their users may offer additional insight and implications for design and instruction. As Csikszentmihalyi (1981) wrote,

> Objects affect what a person can do, either by expanding or restricting the scope of that person’s actions and thoughts. And because what a person does is largely what he or she is, objects have a determining effect on the development of the self, which is why understanding the type of relationship that exists between people and things is so crucial (Chapter 2, Section 9, para.3).

Much of the research done in the field of assistive technology for persons who are blind has focused on a practitioner point of view (such as teachers’ perceived readiness and competence to teach assistive technology to students who are blind) rather than the user perspective (Kapperman & Kelly, 2018; Zhou et al., 2012). An illustrative example comes from an article in which two statistics professors who are blind share their guidance regarding the technology that blind university students need to be successful in a statistics course. This publication was written as a rebuttal to a previous paper on the same subject written by authors with vision. Godfrey and Loots (2015) stated that the authors of the original paper could not have given the “whole story,” as follows:

> We think there are real differences between the important issues for blind students and what their sighted teachers think are the crucial issues for teaching blind students. In many respects, the classroom is an environment where perhaps those irritating aspects of living in a visual world will be intensified. Blind students are likely to know more about the worries sighted teachers have than do sighted teachers about the needs of blind students. As a consequence, we feel that sighted teachers need to find out what the issues are for the students, which means thinking about the learning side of the teacher-student relationship beyond those initial impressions which are primarily sighted-teacher-centric (pp. 3-4).

This example is illustrative of the dichotomy between an individual user’s actual needs and preferences compared to the well-intentioned effort and assistance on the part of teachers, AT specialists, colleagues, family members, or friends.

Former president and CEO of the American Foundation for the Blind (AFB) Carl Augusto (2008), who is both a service provider and blind, himself, contrasted the top five concerns of service providers and of individuals who are blind. He stated,

> According to my…point of view, the major issues facing the field of visual impairment and blindness, as viewed by service providers and by blind people, do not intersect. The implications of this are profound. Should you as a service provider care? Absolutely! What can you do?...Ask consumers on a regular basis what their concerns are, share yours with them, and determine ways in which you can work together on issues. Prioritize together, strategize together, but most important, mobilize your collective resources toward achieving objectives (p. 456).

Augusto listed critical issues facing service providers in the field of vision education and rehabilitation as follows:

- Personnel shortage;
- Demographics;
- Limited funding;
- Measurement of outcomes; and
- Preservation of specialized organizations (p. 453-455).

Augusto's list of critical issues for clients included the following:

- Safe and easy travel;
- Access to information and the environment;
- Access to assistive technology;
- Employment; and
- Social reactions to blindness (p. 455-457)

Although critical issues on both lists are important, they are a reminder that issues for individuals who are blind are part of the whole story.

In the field of human-computer interaction (HCI), user experience (UX) considered the interplay between users, systems and contexts and offers a potential "holistic approach to understanding the human–computer relationship and its underlying experience." (Lallemand et al., 2015, p. 36). UX publications are written primarily from the perspective of design rather than education, but they provide multiple detailed examples of how technology mediates access and exchange of information from the perspective of blind persons. Such glimpses into the world of user experience reveal how meaning can change from user to user, individual to individual. Each person has different experiences and relations with technology, based not only on context and situation, but also on individuals' desires to live their own lives, as Sapp and Hatlen (2010) defined self-determination (p. 341.)

A deeper interdisciplinary look into the concept of self-determination reveals a strong history of research within the field of psychology spearheaded by Deci and Ryan (2017), and replicated in multiple studies (Peters, Calvo, & Ryan 2018). Their Self-Determination Theory (SDT) posits three basic psychological needs that must be fulfilled to attain self-determination, as follows:

- *Competence* (i.e., feeling able and effective);
- *Autonomy* (i.e., feeling agency, acting in accordance with one's goals and values); and
- *Relatedness* (i.e., feeling connected to others, a sense of belonging) (p. 2).

Sapp & Hatlen's definition of self-determination aligns with Deci & Ryan's category of autonomy and its focus on agency. Through the needs of competence and relatedness, SDT offers a way to expand educators' understanding of self-determination, which, in turn, has implications for how students are guided through the complexities of technology use.

Purpose of the Study

The purpose of this study was an examination of ways in which blind users perceive technology as a mediating influence within the contexts of their lives to meet their needs for competence, autonomy, and relatedness on the path toward self-determination, as defined by Deci & Ryan's (2017) self-determination theory (SDT) By accepting Godfrey & Loots' challenge to find out what the issues are for persons who are blind, this study can contribute to the existing knowledge base by examining the complexity of this problem space through the interdisciplinary lenses of education (a.k.a. accessing to learn and learning to access) human-computer interactions (a.k.a. user experience), and psychology (a.k.a. self-determination theory). This expanded, multidisciplinary understanding may illuminate implications for the education of students who are blind, as well as areas for future research. This study sought to expand current understanding by both examining user experience within a framing of the human-technology-world relation offered by post-phenomenology, and by examining users' perceptions of self-determination within a positive technology framework.

Glossary

- Positive Technology: "… an emergent field within human-computer interaction that seeks to understand how interactive technologies can be used in evidence-based well-being interventions." (Riva, Chirico, Serino, & Gaggioli, 2018, p. 1)
- Post-Phenomenology: "A holistic perspective on the matters concerning the field of HCI [human-computer interaction] that can be complementary to previous

ways of understanding. Post-phenomenology opens up a view of the human that in one way decenters the human and puts technology and the mediating effect of technology at the center. In this, the human, still a central concern, is understood as technologically mediated" (Hauser, 2018 p. iv).

- Screen Readers: "… convert digital text into synthesized speech. They empower users to hear content and navigate with the keyboard. The technology helps people who are blind or who have low vision to use information technology with the same level of independence and privacy as anyone else" (WebAim, 2017).
- Technological Mediation: "Technologies co-shape the human world and thus also human relations with technology itself. Human beings are not sovereign with respect to technology, but are, rather, inextricably interwoven with it" and that mediation is the force that "shapes the mutual relation in which both subject and object are concretely constituted. The mediating capacity of artifacts is no essential property of things themselves, but emerges from the interplay of things and their context" (Hauser et al., 2018, p. 2).

Theoretical Frameworks

Post-Phenomenology

Post-phenomenology examines the ways that technological artifacts affect human experience and action in the world. Fallman (2011) asserted,

> As computing and digital technologies started to become ubiquitous in our daily lives during the end of the 1990s, the boundaries between public and private, as well as work and leisure, started to blur. Technology changed from being a tool for work to something through which the world could be experienced (p. 3)

Though post-phenomenology has been applied primarily by those interested in the philosophy of technology or involved in designing new technological products for use, it holds promise for expanding analysis of technological mediation of the written word to allow for access and exchange by blind persons. A post-phenomenological theoretical framework allows both sides of the human-technology-world equation to be examined, which potentially offers fuller understanding of the whole story.

Positive Technology

A combination of both user experience and the self-determined pursuit of one's own life is reflected in an emergent field called *Positive Technology*. As described by Gaggioli, Riva, Peters, & Calvo (2017), this field can be defined as "the scientific and applied approach to the use of technology for improving the quality of our personal experience…personal experience is the dependent variable that may be manipulated through the technology (2017, p. 488). In describing the positive technology approach, Triberti et al. (2016) stated:

> The interaction with a technology can be really satisfying if no need to initiate a problem-solving process arises. In these cases, the user is able to fluently act with no need to consciously think about how to achieve his/her own single-interaction goals, the actions on the interface following one another in the context of a profound involvement within the task. *(p*. 250).

A key in many technology-human relations for blind users is their situatedness within a context where many websites, documents, software programs, and applications exhibit misfires of access and usability while interacting with the screen reading software necessary for use of a computer. These technological breakdowns stymie moments of fluid engagement for individuals who rely on screen readers to mediate use of a computer to access print and exchange information.

Positive technology's focus on well-being from a human perspective may not seem aligned to post-phenomenology, with its emphasis on the role technology plays in enacting change upon the human world. However, these two ideas can be seen as the two sides, or dimensions, of human-technology-world relations. According to Fallman (2011), "Technologies transform experience, however, subtly, and that is one root of their non-neutrality" (p. 49). Positive technology and post-phenomenology each provide theoretical frameworks for this examination of how technology mediates the experience of persons who are blind, as well as how this mediation can invite or inhibit self-determination.

Significance of the Study

In 2015, the United Nations created the 2030 Agenda for Sustainable Development, with a series of 17 Sustainable Development Goals (SDGs) and corresponding targets (UN General Assembly, 2015). Barriers between print and the visually impaired individuals fall within two of the United Nations' 17 Sustainable Development Goals (SDGs): #4 Quality Education and #10 Reduced Inequalities according to the Sustainable Development Knowledge Platform. Specifically, Target 4.6 of SDG#4 states that all youths will achieve literacy and numeracy. Students who are unable to read print are at a disadvantage in receiving quality education; they require significant adaptations and instruction to learn at a level commensurate with their peers.

Access to print can be affected by a widespread lack of training and information for those responsible for producing braille or facilitating access to auditory material.

Training students to access their own materials requires instruction in the use of complex devices, and research shows that teachers of the visually impaired feel themselves at a disadvantage with their level of preparation and training in this area (Kapperman & Kelly, 2018; Zhou et al., 2012). These issues are infused with additional concerns related to the digital divide, infrastructure, and economic disparity (Gulati 2008) The digital divide refers to the ways in which reduced access and opportunity limits users' ability to access and produce digital content, which puts individuals farther behind with respect to opportunities both in the workplace and socially (Selwyn, 2004). The concept of the digital divide reflects the degree to which technology and self-determination are related.

Technology now affords blind persons opportunities to access source material directly and immediately on a daily basis rather than waiting for another human to mediate print. Experts have identified skills related to assistive technology that blind students and young adults need to be capable of performing (Kapperman & Kelly, 2018), but not necessarily the best workflow from the non-visual perspective. Attending school, participating socially in their communities, and becoming gainfully employed are all affected by these human-technology-world relations.

Positionality

The field of educational sustainability is a potential bridge between the philosophical and pragmatic theories across various perspectives. Phenomenologically, technology can be seen as belonging within a consideration of educational sustainability because of its ability to engender well-being, connection, and empowerment.

Technology is non-neutral; as humans act with and through technology, the non-human technological artifacts influence human experience as well.

In considering the role of technology within sustainability, Orr (1992) posed the following three questions: “What kind of technology, at what scale, and for what purposes?” (p. 39). Complexity theorist Arthur (2009) wrote,

> If we examine the stories we tell ourselves, we see the question is not whether we should possess technology or not. It is whether we should accept technology as faceless and will-deadening versus possess technology as organic and life-enhancing. In the movie Star Wars, the malign aspect of technology is the Death Star. It is an object huge and disconnected from humanness that reduces its clients to clones — recognizably human, but all identically in thrall to the machine, all drained of color and drained of will. If you look at the heroes, they have technology as well. But their technology is different. It is not hidden and dehumanizing; their starships are rickety and organic and have to be kicked to get running. This is crucial. Their technology is human. It is an extension of their nature, fallible, human, individual, and therefore beneficent. They have not traded their humanness for technology, nor surrendered their will to technology…Technology is part of the deeper order of things. But our unconscious makes a distinction between technology as enslaving our nature versus technology as extending our nature. This is the correct distinction. We should not accept technology that deadens us; nor should we always equate what is possible with what is desirable. We are human beings and we need more than economic comfort. We need challenge, we need meaning, we need

> purpose, we need alignment with nature. Where technology separates us from these it brings a type of death. But where it enhances these, it affirms life. It affirms our humanness." (2009, Chapter 11, Section 5, para.10).

Humankind's relationship with technology is complex, and the answers to Orr's questions of type, scale, and purpose often vary according to the individual. As an assistive technology specialist for individuals with blindness or low vision, I value the ways technology can promote well-being, empowerment and connection. My answer to what kind of technology, at what scale, for what purpose is access technology, at an individual scale, for the purpose of self-determination through autonomy, competence, and relatedness. When technology serves to connect us with deeper meaning and purpose, it does indeed extend our humanity.

Summary

The role of technology within the field of educational sustainability can be grounded within the theoretical frameworks of positive technology and post-phenomenology. Conducting this study to examine the influence of technology on fulfillment of the basic needs of competence, autonomy, and relatedness may offer a richer understanding of the issues from the perspective of blind persons themselves. Combining insights from different disciplines such as education, human-computer interactions, and psychology allows for a broader conceptualization of these issues, with potential implications for practice and future research.

Chapter 2. Literature Review

The following review of literature examines the changing landscape of the experience of technology for people who are blind, and how technological artifacts influence self-determination through user experience. The purpose of assistive technology is mediating the gap between what a person who is blind wants to do and any barriers in a given context. As such, technology may invite or inhibit these individuals' experiences of the basic needs of competence, autonomy, and relatedness.

In this study, literature was reviewed and synthesized, with the intention of better understanding the problem space of vision, technology, and self-determination. This literature review informs the research methods, and it illuminates ideas and phenomena that may be relevant in the analysis and implications.

Three multi-disciplinary perspectives were examined:

- VI education & rehabilitation: access to learning vs. learning to access;
- Human-computer information systems: user experience; and
- Psychology: Self-Determination Theory.

VI Education & Rehabilitation: Access to Learning vs. Learning to Access

Both the United States and the United Kingdom have a curriculum for the education and rehabilitation of persons with blindness or low vision. In the US, this curriculum is called the expanded-core curriculum. Both curricula are means to independence as adults, and extend beyond academic subjects that all students are intended to master. McLinden, Douglas, Cobb, Hewett, & Ravenscroft (2016) undertook a comprehensive analysis of the concept of access to information for students with vision loss. In the first approach, *Access to Learning,* a specialist teacher provides the student with the information itself in an alternate mode (braille, tactile graphics, auditory input, etc.) to allow the student to learn various school subjects/curricula (McClinden et al., 2016). In the second approach, *Learning to Access,* students learn to use technology to access information independently, without human-mediated assistance. The balance of these two dimensions of access may ebb and flow throughout the students' experience in public education. Younger students have a greater need for provision of materials to access curriculum, whereas older students have more responsibility for independently accessing their own materials. At the same time, it can be very difficult for vision professionals to prioritize the long-term benefits provided by teaching *learning to access* when the day to day needs of providing access to learning are vast, immediate, and compelling (McClinden et al., 2016).

Siu & Emerson (2017) reinforced the importance of both access to learning and learning to access by re-imagining the role of the teacher of students with blindness or low vision as an accessibility facilitator. In making this case, the authors refer to the:

> effect of ubiquitous computing on daily living and learning experiences, the increased prevalence of multimedia in the classroom and community, advancements in delivery options for accessible educational materials…and the need for more transdisciplinary collaborations, including partnerships in the design, technology, engineering, and architecture fields (p. 593).

This increase in presence of technology across all educational domains underscores the importance of facilitating access.

Tools for access

Individuals who are blind rely on assistive technology to gain access to the written word. According to Sapp and Hatlen (2010), “Assistive technology refers to the mainly electronic tools that are designed to provide access to text and other learning materials and opportunities, and the support needed to learn to use the tools. Technology equalizes abilities to access, store, and retrieve information” (p. 341). Screen reading software allows individuals who are blind to use computers by reading aloud the text on the screen, including menus, dialog boxes, location of focus and cursor, as well as information contained within files or websites. To add tactile feedback to the auditory experience afforded by a screen reader, individuals can pair a refreshable braille display (RBD) with a device running a screen reader. According to an international screen-reader-user survey of blind persons (N = 1,358) 33.3% (n = 453) of respondents reported use of braille output with their screen reader (WebAim, 2017).

Kapperman & Kelly (2018) compiled a list of essential technological tools and skills needed by blind high school students to master assistive technology, as follows:

- Amazon products and services (e.g., Alexa, Echo, and Tap);
- Apps (i.e., accessible apps for portable devices);
- Beacons;
- Braille reading (reading braille tactually at a minimum of 30 words per minute);
- Braille notetakers connected to a computer and monitor;
- Braille notetakers connected to a tablet and smart phone;
- Cloud-based storage;
- Configuration of technology;

- Dictionary and encyclopedia content available from online search engines and built into programs;
- Downloading and storing of eBooks (no format specified);
- Downloading and storing of eBooks in multiple formats (e.g., audio, brf, DAISY, and EPUB);
- Legally downloading and storing music;
- Email programs (skill with multiple programs is necessary);
- Exploration of emergent technology (e.g., 3D printing and haptic technologies);
- Gestures for accessing Apple/iOS devices;
- Global Positioning System (GPS) and wayfinding accessible applications/devices;
- Google-based products (e.g., Google Chrome, Chromebooks, Drive, and Home);
- Internet browsers and search engines (skill with multiple programs is essential);
- Keyboarding (touch typing a minimum of 50 words per minute);
- Keystroke commands for both desktop and laptop computers (p. 386-387).

D'Andrea (2012) examined how blind users aged 16 to 22 years used a combination of embossed braille and assistive technology in their schoolwork. Students preferred use of technology/auditory access over braille because of its speed and the advantage of searching and indexing functions within bodies of text. They preferred to write electronically using word processing software on computers or electronic braille input with a refreshable braille display (D'Andrea, 2012). College students, as compared to high school students, reported very little access to embossed braille, but had strong preferences for using it specifically for foreign languages, science, and math. Some students indicated that they had actually deferred enrollment in such courses until they could find out how to get access to the books in braille. D'Andrea (2012) said, "when students described how they 'read,' they might be referring to reading braille on paper, on a refreshable display, or using speech to access text on a computer or other device such as an audio book reader...the lines have blurred between the concepts of 'reading' and 'access,' and between 'book' and 'information'." (p. 595). These examples illustrate both users' preferences and realities related to multiple modes of non-visual access to print.

Context of access

The social model of disability, with its focus on removing barriers and discrimination, frames disability as a series of diminished opportunities to take part in the normal life of a typical community in a manner similar to others, based on barriers that can be physical, environmental, or social (Hersh & Johnson 2008). Relationships within a context affect use of technology; friends, family, instructors, and co-workers are all forms of support for technology use (Cook & Polgar, 2015). The purpose of assistive technology is to bridge the gap between what a person with a disability wants to do and is able to do in a given context or situation (Hersh & Johnson, 2008).

As it happens, what a person with a visual disability wants to do in a given context or situation is often mediated not only by technology or complexity, but by social constructs and a desire to fit in among a sight-centric world. Shinohara & Wobbrock (2011) interviewed 16 adults with blindness or low vision regarding their technological devices. Participants most valued having access to the information and services that everyone else had, and the majority preferred mainstream technology to proprietary technology created specifically for persons with disabilities. For example, one interviewee shared, “You know, if someone’s using an iPhone, and I’m using an iPhone, that’s normal, right? It’s the same thing... like universal design, you build the accessibility directly into the products, then you’re not using some clunky, blindness specific product” (Shinohara & Wobbrock, 2011).

Another participant shared:

> … it’s just neat that I can do things… that other people can do. Like, I can have books to read that I want to read… when I first got my scanner I was really excited about it because then I could … buy books that weren‘t available, and I could read those books,…I would say your technology is your lifeline…it opens up worlds of opportunity. *(p*. 708)

Affordances & Constraints

Changes in technology have changed print itself, and thus the way it is experienced and accessed by braille users. The first screen readers did not have to contend with the myriad of formats of information available from websites and other current educational applications. Educational programs and instructional technology as a field continue to propagate and spread, but many are still not designed with accessibility in mind, which renders them useless even with the appropriate equipment, such as a screen reader and refreshable braille display. For example, when screen shots are taken of text (rather than using copy and paste functions), the resulting files are actually pictures. Even if these pictures look like they contain words, such as a famous quote shared on social media, they are unreadable by assistive software. This difference is subtle and may be undetectable to a visual user. Although such exclusion is largely unintended, it is prevalent. This example illustrates a new barrier created by technology. As Carey (2007) wrote,

> While everybody will have access to much more content in the digital age than at any previous time in history, the gap between VIPs [visually impaired persons] and their peers will inexorably widen even in terms of access to text. An increasingly multimedia society with the focus on the visual, however, will further widen the gap…Image-only content will have an incalculably high exclusion potential." *(p*. 782)

Whitney and Kolar (2019) confirmed these predictions when they found that 48% of Facebook posts included text embedded within images. These technological changes affect the effectiveness with which braille readers can use technology to access information. The field of Human-Computer Interaction (HCI), specifically the branch of user experience (UX) research, offers multiple examples from the perspective of the blind user related to accessing information through technological means. There is a wide variance of ways that any given individual chooses and uses technology. Users employ not only their non-visual needs, but also personal preferences when determining what devices are right for them within given contexts.

Human-Computer Information Systems & User Experience

Research in the area of human-computer interaction (HCI) and user experience (UX) highlights the fact that access to information may be the initial threshold, but is not enough to ensure usability, and usability is not enough to ensure equivalence. As technology evolves, the landscape of access to the written word continues to change for persons who are blind. There are more opportunities than before, with more direct options without human-mediated interaction; however, these new affordances are entangled with new constraints.

Shinohara and Tenenberg (2009) carried out a single-case study with a braille user in her own home in to examine the intersection of technology use and personal contexts. The authors learned that “technologies invisibly embed taken-for-granted assumptions concerning trade-offs in functionality, usability, and situated meaning; developing an understanding of these trade-offs for particular people and populations can improve technology access for increasing numbers of people” (p. 66). The examples from their case study illustrated the way that variables such as meaning and usability affect both users’ choices and habits related to assistive technology devices.

In describing Sara’s use of the screen reader JAWS with her computer, Shinohara and Tenenberg (2009) noted that one of the most frequent problems encountered in screen reader use is maintaining orientation and employing navigation strategies. “If Sara moves to another task or accidentally hits the wrong hot key, she might find herself in an unfamiliar virtual setting that requires her to suspend the current task, reorient herself, then resume where she left off” (p. 63). The authors offered a transcription of the screen reader’s responses and Sara’s speaking her thoughts aloud. This passage illustrates the issues of usability that potentially arise even in a situation with a user who has received both training and access to an expensive, commercial, and robust screen reader:

> Sara: I’m going to go back into the links list [JAWS speaks through the links in order: “communication, assignments, rules, contacts...”] no, silly, I wanted to go to discussion board. [tries a few more links, and the computer says them out

> loud] okay, it's not in the right place where I thought it was. Let me try that again, I'm sorry. [starts through the links list again] Okay, discussion board, I'm tabbing through this time and not going through the links [the computer talks] I'm on there, c'mon go back to the discussion board [silence, then the computer speaks] come on... Go to the discussion board. Now. [the computer speaks again] okay, let's try this again. I'm going to right-click it. I press the right mouse button, which is this one... Okay, press Enter and see if I go anywhere. Why is it misbehaving? Okay, now it's taking me back to the home page. So let's try this again. Okay, I'm going back into the links list. Pressing Enter. Come on... [quiet for some time; the computer appears to be opening the link and suddenly speaks again] Oh, here we go. [the links list appears on the screen] Okay, now let's go to the discussion board. 'D' for discussion board. [the computer goes through the details for the page, a heading, the number of links, and more] p. 64).

The authors stated that these usability difficulties affect not only efficient functioning, but also issues of socially situated meaning. (Shinohara & Tenenberg, 2009, p. 64). Accessibility opens the door to usability, which in turn affects meaning and potential self-determination.

In describing her problem-solving techniques (a.k.a. "work-arounds"), the authors observed that "Sara's actions and associations with objects and tasks were guided by both the usability of the object and the meaning she accorded to the task. A stronger personal preference or significant item or task often motivated her to overcome physical obstacles at almost any cost." (*p*. 63) On the other hand, problems with only non-preferred potential solution, such as asking for help from a sighted friend, led her to avoid certain tasks entirely (Shinohara & Tenenberg, 2009). This avoidance of certain tasks because of the need to ask for sighted assistance also speaks to her desire to relate on an autonomous level with friends and peers.

In examining more than just her use of technology and workarounds, Shinohara and Tenenberg considered the way Sara felt about her experiences and what she wanted from her relations with technology. Beyond access and usability, they also considered “aesthetics, affect, meaning, historical associations of use in context” (p. 59). The authors asserted that “these technologies hold meaning that affects the ways individuals understand themselves in relation to the communities to which they belong” (Shinohara & Tenenberg, 2009, p. 59). Individuals use technology in diverse ways to make meaning.

This meaning-making is illustrated by the ways in which Sara used technology in an effort to meet her need for relatedness, an important component of self-determination. Throughout the case study, there were examples of Sara’s interest in relating to others, from the postcards she placed on her wall to spark conversation with sighted visitors, and her longing for a braille labeler that combined braille with print, so that she could label compilation CDs she made for her sighted friends. Sara was aware that she lived in a sight-centric world, and sought out opportunities to exchange meaningful, yet independent, interactions.

Godfrey and Loots (2015) noted that technology from prior decades “did not facilitate much independent access to information,” leaving users “completely reliant on humans for reading all printed material” (p. 7). The authors also stated categorically that “access to information is crucial for the blind person’s success in education and future employment," highlighting the importance of access for their own self-determination (2015, p. 4). Though universities should be expected to provide materials in accessible formats to blind students, students should then also be expected to render work in a format readable by their professors or classmates, without human mediation (Godfrey & Loots, 2015). Technology now opens the door to this independent access with the right equipment and proper training.

Adding to their suggestion of leaving behind human-mediated translation of content, Godfrey and Loots also noted that with respect to graphs, the author of content should be the person to provide a description, rather than a braille transcriber who may not be an expert in that content area: "Behind every graph that has been created lies an intention to pass information, not usually data; it is this intention that should be communicated in the description." (2015, p. 10) From their perspective, with the new affordances allowed by technology, it is imperative that students in higher education and individuals in the workplace prepare their own documents without the mediation of another human.

Another suggestion from user-experience research involves changing text into different forms, such as visual, oral/auditory, and tactile. When content is transposed into different sensory modalities, an equivalent experience cannot necessarily be assumed. According to Cook & Polgar (2015),

> Information from each sense is organized differently. Visual information is organized spatially, which means that items are related by space in reference to one another: up, down, left, right. Auditory information is organized sequentially and temporally; the primary relationship is that of time. Tactile information is

> actually organized both spatially and temporally. It can function as a bridge, enhancing the transposition from visual to auditory by providing the spatial sense that is otherwise missing (Cook & Polgar, 2015, p. 316-318).

For these reasons, providing access by only transposing visual to auditory is not equivalent. Auditory information, compared to visual or tactile, is “fleeting, sequential, and a function of time” (Giraud, Therouanne, & Steiner, 2018, p. 24). Buzzi, Buzzi, Leporini, & Mori (2012) described another difference in the various modalities of text. The visual channel can absorb new information faster than the auditory channel, but the auditory channel can absorb new information faster than the tactile channel. In contrast, the tactile sensory channel is ideal for repeated information (Buzzi et al., 2012). Buzzi et al. (2012) also noted that a user can be easily distracted while listening to auditory information. In addition, memorization while listening can be very difficult. The authors concurred that “it is necessary to explore multiple routes to equivalent experience.” (Buzzi et al., 2012, p. 126). To further cement how visual information expressed in an auditory manner is not an equivalent means of access, Giraud et al. (2018) explained,

> When access to information is restrained to give a textual equivalence of visual information of web pages, all visual information is then linearly transposed into auditory information. However, the auditory modality does not have the same properties as the visual modality...auditory perception does not allow an equivalent transposition. Even if the visual information is orally transposed, there is an impoverishment of information because the auditory modality is fleeting, sequential, and a function of time. … Sight allows a user to quickly filter out

> redundant or unnecessary information, whereas a non-visual user has no equivalent of a ‘simple glance’ used as a filter (p. 24).

These differences between the sensory channels must be considered in on a task by task basis, within context. It cannot be assumed that content transposed for delivery from one channel to another represents an equivalent way of receiving and processing the content.

Through UX and HCI research, accessibility is revealed as only “a prerequisite for users to reach online application content, while usability offers simple, efficient and satisfying navigation and interaction” (Buzzi et al., 2010, p. 92). In other words, “normative accessibility could lead to a misleading evaluation of a website as accessible or not…providing access to content is not enough.” (Giraud et al., 2018, p 25). In one study, web-browser-search suggestions and hints that required a screen reader user to navigate away from a search box were ignored by blind users (Sahib et al., 2012). These same suggestions were used by those with sight, because their workflow was not interrupted. In addition, spelling suggestions given were not utilized by screen reader users because they were on different heading levels. (Sahib et al., 2012). As stated by Shinohara & Tenenberg (2009),

> Simply replacing one interaction mode, such as the display of text on a screen with a functionally equivalent mode, as in speaking the text aloud, is not necessarily equivalent from the point of view of user experience. This is because functional equivalence might not account for the meaning of the mode of interaction for particular users in specific contexts. (p. 66)

Increased cognitive effort is another theme that emerged from the UX research. The use of screen readers imposes specific constraints upon users. An example of these constraints includes the transposition of visual content to auditory content (Buzzi et al., 2012). Another example is the “serialization” of content; screen readers read aloud textual information in a particular order, while visual users can choose to read text in whatever order they prefer. (Buzzi et al., 2012). Blind users have no overall perception of the entire interface of content, and that places a greater cognitive load upon users. These users must keep up with information as it is read aloud, in an order that often mixes content and structure (Buzzi et al., 2010 & 2012). At times, screen reader software even reads items in the wrong order, such as reading table headings by rows instead of columns. (Buzzi et al., 2010, p. 93). Unlike visual users, screen reader users must remember (or use a keyboard command to ascertain) the location of their cursors’ foci and whether or not they are in navigation mode or editing mode. Users may also not always know where they are within the context of a document or a webpage. Screen reader users have choices between moving their cursor serially between objects using arrow keys or the tab key or using first-letter navigation commands to move their cursor instantly to a desired location. As one user stated in Giraud et al.’s study (2018),

> When I use CTRL + F it is like you want to get the salt from the table and somebody takes your hand and gets the salt, then you would not know what else is on the table and what is around it, etc., if the black pepper is next to it and you need that, you wouldn’t know. You have to ask that person to take your hand again. It is exactly what is happening here *(*p. 31).

This quote demonstrates the loss of context and location that is traded off in the use of a quick, efficient navigational command. Visual users do not face these same constraints in usability.

Another usability issue that arises for screen reader users is the frequent repetition of irrelevant information. A desire to skip past repeated auditory information can lead users to disregard screen reader announcements and explore webpages via the tab key or arrow keys (Buzzi et al., 2010). Websites with frames and tables often do not clearly distinguish connections between pages or sections. This means that users have to figure out those connections for themselves while navigating auditorily through the series. Craven and Brophy (2003) found that consequent cognitive load can lead to a longer information-seeking process for screen reader users (p. 115-117). This longer process may lead to frustration and subsequent task abandonment. Sahib et al. (2012) found that screen reader users also use high cognitive effort to ignore repeated or irrelevant information like banners. At the same time, they are also busy constructing their own mental models of websites by connecting sections of web pages to facilitate overall understanding (p. 380). Craven and Brophy found that this consideration of cognitive effort bears a significant cost for these users. Screen reader users who were given information-seeking tasks took sixteen keystrokes for every six taken by visual users completing the identical tasks. (p. 116). These details demonstrate the complexity of using assistive software and devices to access text. Access is not always enough to ensure usability, which is not always enough to ensure equivalence.

HCI research on user experience recognizes that the context of a given task can affect the degree of persistence exhibited by users. Some contexts invite individuals to withstand difficulty or disruption, rather than abandoning certain tasks or use of particular devices. Wendt (2015) stated that usability is not only function-based, but involves both meaning and adequate investment to withstand disruptions. He argued that task abandonment or device abandonment caused by usability issues can be mitigated when a high level of meaning is attributed to the task at hand. According to Wendt (2015),

> Post-phenomenology highlights the role of technological objects as the source of insight about the world and our relationship to it, along with how embodiment can explain our involvement with tasks, goals, and other people ... our goal as designers, then, is to understand how users interpret their own involvement with the world as a meaningful activity. We are interested in what actions users take and how those actions result in meaning formation (p. 10).

These studies illustrate the complexity inherent in use of different sensory modalities of non-visual access to print. User experience involves not only access through technology, but usability, equivalence, cognitive load, and the relative meaning ascribed to a given task or outcome.

A study by Mitchell et al. (2015) included a description of several sensory ethnography methods that extended the technology biography method, such as a technology tour with a video and re-enactment of common routines involving technology (Mitchell et al., 2015). The authors used these methods to “see through the messiness and ongoingness of the reality of everyday life as it is actually lived” (Mitchell et al., 2015, p. 5). They noted that the purpose of ethnography within the human-computer interaction field has primarily been focused on understanding user experience for purposes of design implications. They asserted that “the true value of ethnography is how it works at an analytical level to reveal novel ways of seeing…by studying in detail specific intersections and interrelations, we can gain a more detailed understanding of their meanings and complexities” (Mitchell et al., 2015, p. 6). One of the authors, Pink (2015), introduced the term sensory ethnography and pioneered new ways of thinking about using sensory ethnography research methods.

Sensory ethnography originated in the human-computer interaction field, but has been extended to education of individuals with disabilities in a few instances in the literature. Morris (2017) examined sensory ethnography and blindness or low vision and the need for understanding the intersection between sensory schemas and the requirement of given educational tasks. Alper (2018) discussed the need for “inclusive” sensory ethnography that includes neurodivergent individuals with sensory differences such as autism. Alper reported utilizing multiple activities such as interviewing parents with and without their children, visiting homes and observing an activity involving technology or media that is enjoyed by a child and another family member (p. 3566). This combination of methods allows for overlapping layers of information to reveal themselves. These methods provide potential ways of capturing more of the whole story from the perspective of individuals who are blind.

Self-Determination Theory

As access to learning is balanced with learning to access, individuals who are blind take on greater roles in their own learning and personal agency. Self-determination theory (SDT) is a model of motivation originally proposed by Deci & Ryan (2017) that considers three basic human needs, as follows: autonomy, competence, and relatedness (Peters, Calvo, & Ryan, 2018). According to the authors, “Research in a variety of countries, including some cultures with collectivist, traditional values and others with individualist, equalitarian values, have confirmed that satisfaction of the needs for competence, autonomy, and relatedness do indeed predict psychological well-being in all cultures” (p. 182). According to Guay et al. (2008), “The conceptual lenses of SDT have guided more than 200 empirical studies. Most have emphasized contextual and personal considerations that facilitate optimal learning, engagement and well-being” (p. 233). This history of research offers guidance in the understanding of how the basic needs are related to the pursuit of self-determination in the lives of individuals.

Self-determination & vision

Sapp and Hatlen (2010) asserted that the development of self-determination skills requires that people who are blind or have low vision learn about available choices, have the skills to avail themselves of these particular choices, and receive opportunities to make their own choices whenever possible. Agran, Hong, & Blankenship (2007) added that to the greatest extent possible, persons with disabilities should be active participants in decisions that can affect their learning and independence. The authors noted that self-determination is one of the most important instructional areas, particularly because of its role in promoting independence.

Only a few studies in the vision field have referenced SDT. Jessup, Bundy, Hancock, & Broom (2018) compared themes they found in qualitative interviews to the basic needs of autonomy, competence, and relatedness. Using video excerpts, Haakma, Jannsen, and Minnaert (2017) found that need-supportive instructional practices fostered student engagement. These studies marked a beginning of tapping the potential of the use of SDT with individuals who have blindness or low vision. They also illuminated the need for observational research techniques in SDT, such as technology biographies and sensory ethnography techniques (e.g., video) to complement self-report based research.

Hewett, Douglas, McLinden, and Keil (2018) studied personal agency from the perspective of university students with low vision or blindness. Successful transition to higher education for VI individuals has been linked to self-determination and assistive technology (Hewett et al., 2018, p. 14). The authors illustrated ways that students in higher education negotiated options for access with professors.

In one example, student collaborated with her math professor to circumvent inaccessible software while still attaining competency required to demonstrate learning the content (p. 8). In another example, a student received access to the professor's electronic slides via screen reading software. However, it was unclear when he was advancing to the next slide during his presentation in class (p. 8). By introducing herself to the professor and setting up a meeting, they agreed on some verbal clues that he could use when advancing slides: "He's actually altered the way that he sort of goes through things in his lectures to make it easier for me...he's kind of come up with a way of making me aware of when he changes slides, without making it aware to everyone else." (p. 8). This example shows how working with her professor allowed this student to better access the materials and their meaning.

Unfortunately, even when students initially advocate for what they need, they may not initially be understood. One unsuccessful example included an online learning management system in which teacher feedback was uploaded in PDF format; the student shared that her screen reader was unable to read aloud the text because of the format, which meant she could not independently access the information. (Hewett et al., 2018) Despite taking action, the situation was still unresolved; the student shared as follows:

> I asked them to email me my exam results, because they get posted up [in PDF] which I can't access with a screen reader very easily. So, I asked them to email it to me, obviously asked for it in Word, and they sent it to me the other day in picture PDF – again! (p. 11).

This example illustrates the disconnections that can still occur even when persons who are blind advocate for what they need.

In a review of literature on self-determination for persons with blindness or low vision, Cmar & Markoski (2019) found 11 articles over a 13-year period. Their literature review builds on a prior review of self-determination interventions for people with blindness or low vision and developmental disabilities by Lewis, Savaiano, Blankenship, & Greeley-Bennett (2014). The authors reviewed various operationalized definitions and theories, such as Deci & Ryan's SDT, Wehmeyer's functional theory of self-determination that emphasizes volition and choice-making, and Mithaug's self-determined learning theory that emphasizes interventions for opportunity and capacity (Cmar & Markoski 2019). In the 11 articles reviewed, topics ranged from opportunities to participate in decision making, correlations between employment and self-determination, a specific curriculum for self-determination, student choice regarding visual accommodations, goal-setting, and self-perceptions of athletic competence and social acceptance (the closest example to Deci & Ryan's SDT). The implications included recommendations that educational professionals and family members emphasize opportunities for choice-making, goal-setting, self-awareness, and risk-taking. These recommendations reflect SDT's basic need of autonomy, but do not consider the basic needs for competence or relatedness (Cmar & Markowski, 2019). None of the articles reviewed mentioned the relationship between technology and self-determination for persons with blindness or low vision.

SDT & assistive technology.

Individual use of assistive technology is related not only to functionality, but to meaning. The meaning ascribed to a task or activity by a particular individual has implications for how technology may invite or inhibit use. Cook & Polgar (2015), stated that, "the human-centered aspect of meaning is the self-determined perspective of an activity. The sense of competence or accomplishment and the perceived challenge of an activity similarly contribute to personal meaning." (p. 49) The authors cautioned against making assumptions regarding what meaning a given activity may hold for a specific person without that person's input. They also noted that the higher the choice and control (i.e., autonomy) in a given situation, the greater the satisfaction that may be achieved by that person. Similarly, greater skill and competence may also affect the meaning of a given activity for a person. The authors also noted the effect of social connections and relatedness to the possible meaning of an activity (Cook & Polgar, 2015, p. 49)

SDT's basic needs for autonomy, competence, and relatedness have been widely applied. According to Peters, Calvo, and Ryan (2018), these basic needs "are a sort of minimum common denominator, which come with the widest research evidence available to explain causal relationships between independent variables and dependent variables" (p. 2). Referencing four decades of empirical data, the authors asserted that the three basic needs of autonomy, competence, and relatedness comprise "the most predictive and reliable mediators of motivation, engagement and wellbeing." (Peters, Calvo, & Ryan, 2018, p. 3) The authors also detailed how technology can support competence, autonomy, and relatedness. Regarding competence, the authors refer to challenge, feedback, and opportunities to learn and the degree to which technology affords these options. The authors stated that "technologies can facilitate greater autonomy within daily life by removing obstacles or augmenting capabilities, allowing people to pursue self-determined goals more fluently" (Peters, Calvo, & Ryan, 2018 p. 5). Beyond daily behaviors, the authors asserted that "some technologies such as educational tools, might help users develop a greater sense of autonomy in their lives generally and to more effectively realize their personally held values." (Peters, Calvo, & Ryan, 2018, p. 5). In reference to relatedness, the authors cautioned that not all opportunities for social interaction afforded by technology actually lead to the feeling of connection and sense of belonging that SDT indicates. The authors noted the importance of assessment to determine whether technology is contributing toward or detracting from a sense of relatedness.

Peters, Calvo, & Ryan (2018) created a new model, called *Motivation, Engagement, and Thriving in User Experience (*METUX*),* to examine ways in which the three needs of competence, autonomy, and relatedness mediate technological experiences from the UX perspective (p. 6-8). The phases of adoption, interface, task, behavior, life, and society are included in this model. The METUX model offers a new lens for examining the effects of technology upon users.

Competence, autonomy, & relatedness.

While the Shinohara & Tenenberg's case study (2009) did not specifically examine self-determination, several examples illustrate the basic needs in Sara's experience of technology. Competence was demonstrated in the efficient routines that allowed Sara to experience meaning and enjoyment, whereas inefficient routines caused frustration, wasted time, and avoidance. (Shinohara & Tenenberg, 2009, p. 64). Autonomy was evident in Sara's interest in accomplishing tasks without relying on help from others, her appreciation of any device that gave her freedom and flexibility, and her tenacity and problem-solving. Regarding relatedness, Sara was very aware of living in a world with sight and strove consistently to blend into that world. (Shinohara & Tenenberg 2009, p. 64)

Additional studies have highlighted ways that technology can improve relatedness for blind persons. Smedema and McKenzie (2010) found that "participating in online chat/instant messaging was positively associated with psychological well-being" for persons with blindness or low vision (p. 323).In addition, they found that "participants' overall sense of well-being was found to be marginally significantly correlated to total hours of Internet use per week" (Smedema and McKenzie, 2010, p. 323). Pfeiffer and Pinquart (2013) discovered that adolescents who were blind used their computers for communication in particular. In addition, a romantic relationship was a significant correlate of computer use in adolescents who were blind. Finally, the association between computer use and social relations was stronger in adolescents who are blind than in sighted peers. “[Blind] adolescents used computers more regularly for communication than adolescents with low vision which indicates that the internet helps with compensating for problems with building and maintaining social contact" (p. 104). Della Líbera & Jurberg (2017) noted that despite issues with accessibility, blind persons enjoyed the use of social media to stay connected with friends and family members (pp. 250-251). The findings from these studies indicate evidence that technology has the potential to support the basic need of relatedness.

As individuals use technology to strive toward self-determination, the user perspective must not be forgotten. This perspective is frequently situated within the social context of a sight-centric world. As Shinohara and Wobbrock (2011) wrote,

> We found that people with disabilities balance complex relationships with their environment and with others while using their assistive technologies. When using their devices, participants negotiated feeling self-conscious with the desire to be independent and the need to be productive (p. 707).

There may be times when the basic need of competency contradicts the basic need for relatedness. Autonomy is also occasionally in contradiction with relatedness. As Shinohara and Wobbrock (2011) explained,

> Participants negotiated when they asked for help, especially if they had an assistive device at hand. P4 was careful when asking for help so as not to burden friends or family, and also because she did not want them to think less of her. Here, P4 associates asking for help with her own abilities, and consequently, how she wants others to identify her. She is concerned with what is portrayed about her if she asks for help too much: *I don’t want people to – just view me as*

a disabled person. I want them to view me as Karen, so, it's like when I ask them questions, it's like, okay, I'm this disabled person asking questions. It's not Karen asking questions. And it's just sort of like – sometimes if I ask questions a lot, then it's like my – it's like I'm losing my… personality." (p. 710)

As Shinohara & Tenenberg (2009) wrote, "meaning can be as important as usability in the design of technology…elements of meaning, such as socialization, efficiency, flexibility, and control strongly influence the use of digital artifacts by blind users…an individual's internal values and desires affect their technology preferences." (p. 58). This interplay between the basic needs and variables such as access, usability, equivalence, and meaning creates the context of the user experience.

Summary

This chapter shows that the fields of education and rehabilitation have established the importance of both self-determination and assistive technology for blind individuals. Non-visual access to print is mediated through complex assistive technology. Studies of human-computer interaction illustrate users' experiences of access and how these experiences vary according to person, device, and preference. Studies related to self-determination theory (SDT) and its basic needs of autonomy, competence, and relatedness offer a broad level of research to be drawn upon to inform research and practice in the field of VI education and rehabilitation. However, no studies to date have examined the influence of assistive technology on fulfillment of autonomy, competence, and relatedness for individuals who are blind. In addition, observational and ethnographic methods are needed within SDT research to complement self-report measures.

Chapter 3. Methods

The purpose of this mixed-methods study was to examine ways in which blind users perceive technology as a mediating influence within the contexts of their lives to meet their needs for competence, autonomy, and relatedness on the path toward self-determination, as defined by Deci & Ryan's (2017) self-determination theory (SDT). Participants were clients of Computers for the Blind, a non-profit organization that provides refurbished computers with accessibility software to individuals who are blind to support independence, employment, and access to information. A convenience sample of 99 individuals who received refurbished computers with accessibility software from Computers for the Blind completed the TENS-Interface questionnaire developed by Peters, Calvo, Ryan (2018), with additional survey items covering demographics, use, and training. A self-selected sample of four individuals was then interviewed for the qualitative phase of the study using the technology biography method by Blythe, Monk, & Park (2002).

This study addressed the following three research questions:

1) How do technological artifacts influence blind adults' self-perceived competence?
2) How do technological artifacts influence blind users' self-perceived relatedness?
3) How do technological artifacts influence blind users' self-perceived relatedness?

It tested the following five hypotheses:

- H1: Participants who report prior knowledge of computer use and accessibility software have higher competence subscale scores (RQ1)
- H2: Participants who report that they both read braille and use a refreshable braille display (RBD) with the computer have higher competence subscale scores (RQ1)
- H3: Participants with higher competence subscale scores have higher autonomy subscale scores (RQ1 & RQ2)
- H4: Participants who report advanced screen-reader proficiency have higher autonomy subscale scores. (RQ2)
- H5: Participants who report accessing video calling applications, email, online chat, instant messaging, social media, or forums on a daily basis have higher relatedness subscale scores (RQ3).

Design

This study used explanatory sequential mixed-methods to collect and analyze quantifiable and qualifiable data. As Conway and Elphinstone (2017) stated, "While self-determination theory can provide us with an empirical measurement of the extent to which something satisfies the needs for autonomy, competence, or relatedness, phenomenology can elucidate *how* this occurred" *(p*. 59). In the first phase, a questionnaire with additional survey items was administered, followed by a second phase in which qualitative interviews were conducted with a self-selected sub-sample of volunteer respondents.

Instruments

The survey instrument in this study was entitled the *Technology Experience of Needs Satisfaction*, or TENS-Interface (Appendix A). An invitation to complete the survey was sent to all current and former clients who received refurbished computers with accessibility software from Computers for the Blind. 99 individuals completed the survey in its entirety. This fifteen-item questionnaire had been field tested by its authors with 400 individuals (Peters, Calvo, & Ryan 2018).

A self-selected sub-sample (n = 4) participated in follow up face-to-face questioning of their individual past, present, and future relations with technology, using Blythe et al.'s (2002) technology biography method (Appendix B). Participants were asked to give technology tours of specific devices in their homes or offices, such as a desktop tours of their computers (Table 1).

Table 1. Technology Biography

Element	Area of Interest
Present: Technology tour, last time questions	Pattern, routine, disruption
Past: Personal history	Nostalgia, loss, celebration
Future	Hope, fear, problems addressed

This method was used in Shinohara & Tenenberg's case study of Sara (2009).
It has also been used in several different studies, including examinations of older adults' first experiences with new technology (Burrows et al., 2016), user interaction within families with interactive television (Park, 2014), and an examination of sensory ethnographic human-computer interaction research methodology in the home (Mitchell et al., 2015). Mitchell et al. referenced the ways technology biographies can elicit different information than direct interview questions:

> To explore the interrelations between people and their environments in more detail... we invited them to guide us through their home and tell us what they do, on an everyday basis” (2015, p. 7)

Procedures

In the initial quantitative phase of the study, Computers for the Blind clients aged 18 and up who were listed in the company’s customer database were emailed with a cover letter (Appendix A) and a link to a Qualtrics XM survey containing the TENS-Interface questionnaire (Peters, Calvo, & Ryan, 2018) and additional items (Appendix B). The final item on the survey provided an opportunity to indicate whether participants were willing to take part in follow-up interviews.

In the qualitative phase of the study, a self-selected sample of individuals who indicated willingness to participate in follow-up interviews was reviewed. The Computers for the Blind operations manager was consulted regarding the phone number, address, and email address for the list of potential participants. Contact was initiated by phone and email, and appointments for in-person interviews were made. Each participant in the qualitative phase of the study was interviewed once, for approximately one hour, using the technology biography method (Appendix B).

Data Collection

The operations manager at Computers for the Blind emailed a cover letter (Appendix A) and link to the Qualtrics survey (Appendix B) to former clients. The survey was open for 10 days, and clients received both a reminder email and a date indicating when the survey would close.

One hundred and five respondents completed the survey. This number was a potential limitation in this study. Individuals who had incomplete responses to the 15 items for the TENS-Interface or were missing responses to items Q8 (Braille), Q9 (Prior Use), or Q10 (Screen Reader Proficiency) were removed, leaving a sample of 99. Quantitative data were analyzed by first computing Cronbach's *alpha* values for the subscales, then descriptive statistics, then Pearson's *r* correlations.

The survey from the quantitative portion of the study included a question asking whether participants were willing to participate in a follow-up interview. Semi-structured interviews using Blythe et al.'s (2002) technology biography method (Appendix B) took place in person and included an observation of participants' technology uses while thinking-aloud and verbalizing thoughts. Interviews were audio-recorded and transcribed, and notes were recorded on the observation protocol (Appendix B). Data was coded for themes using according to an a priori codebook created with predetermined themes of competence, autonomy, relatedness, and technological mediation (Appendix C). Some themes were added to the codebook as they emerged.

Data Analyses

Quantitative.

The scoring information for the TENS-Interface (Technology Enabled Need Satisfaction-Interface) is based on previous questionnaires in the SDT literature that have been tested extensively. It is most closely related to the BPNSS (Basic Psychological Needs Satisfaction Scale) and the PENS (Player Experience of Need Satisfaction), whose directions recommend scoring by averaging the responses to items in each section to provide subscales. Negatively worded items were reverse scored.

The authors of the TENS-Interface questionnaire assessed internal consistency using a pilot study of 400 participants, where individuals rated four different technologies: Facebook, Google Docs, a music streaming application, and a fitness band (Peters, Calvo, & Ryan, 2018).

Data for this study were analyzed in the following tests:

- Cronbach's *alpha* measures of subscales' internal reliability;
- Measures of central tendency among responses to each subscale (i.e., competence, autonomy, & relatedness);
- Pearson's *r*-value correlations to identify relationships among variables; and
- Post-hoc power analysis to determine whether sample size (n = 99) was adequate for analysis

Qualitative

Because explanatory sequential mixed methods were used in this study, quantitative results from the TENS-Interface questionnaire and additional survey items were analyzed along with results from the semi-structured interviews. Interviews were audio-recorded, transcribed, and coded for themes. The preliminary codebook (Appendix C) reflects SDT's three basic needs of competence, autonomy, and relatedness, as well as technological mediation and blank codes for potential emergent themes.

Combined Data Analysis

In mixed-methods research, both quantitative and qualitative methods are applied to uncover a fuller picture of an area of study. According to Creswell and Creswell (2018), after results from the quantitative and qualitative phases are reported, "this design then employs a third form of interpretation: how the qualitative findings help to explain the quantitative results." (p. 223). The authors cautioned against merging the two databases of results or performing a direct comparison of the overall results. Instead, the results should be connected, or tied together in a manner that allows the qualitative results to give deeper shading and texture to the quantitative results.

Validity

Peters, Calvo, & Ryan (2018) reported initial pilot validation studies of the TENS-Interface with 400 participants rating four different technologies. They found Cronbach's *alpha* values in the satisfactory range (n.p.). According to George and Mallery (2003), a Cronbach's *alpha* value of above .9 is excellent, above .8 is good, above .7 is acceptable (pp. 84-87). Emerson (2019) noted that an "acceptably high value" is .7 or .8 or above (p. 327). Consistently high Cronbach's *alpha* values on survey items indicated that individuals with blindness or low vision responded similarly to individuals without vision loss in the pilot study. These results supported the use of this instrument with these individuals (Emerson, 2019, p. 327). Internal reliability of items on each subscale of the TENS-Interface indicated that this tool was acceptable for use with blind individuals. Cronbach's *alpha* values for both the competence and relatedness subscales were good, approaching excellent, and values for the autonomy subscales were acceptable, approaching good. (Table 2).

Table 2. Internal Reliability Scores

Subscale	Cronbach's α in pilot study *(n = 400)*	Cronbach's α in this study (*n* = *99*)
Competence	0.79	0.86
Autonomy	0.67	0.77
Relatedness	0.75	0.88

Ethics and Trustworthiness

A statement of consent was included as the first item on the survey. Exposure to the Computers for the Blind database of clients was limited to individuals who self-selected for the qualitative phase of the study. As interview appointments were made, individuals were asked if they preferred an electronic or braille copy of the interview consent form; consent forms were read aloud at the beginning of the interviews, and forms included a tactile sticker indicating the location where they were asked to sign (Appendix A).

This study was approved by the Institutional Review Board at the University of Wisconsin-Stevens Point; David Jeppson, executive director for Computers for the Blind approved this study; and a cover letter disclosed the purpose of the study was included via email with the link to the survey (Appendix A).

Controls for Bias

Asking direct questions during interviews could encourage interviewees to report what they believe the interviewer wants to hear. Using Blythe et al.'s (2002) technology biography method of interviewing and observation provided an opportunity to initiate and curate a conversation in which themes were encouraged to emerge naturally. As interview participants were prompted to discuss past, present and future thoughts on technology they shared information regarding the themes of interest without feeling the need to reflect in a particular manner. Furthermore, providing the interviewees with opportunities to demonstrate use of technology while thinking aloud also allowed for the opportunity for themes to emerge without direct questioning.

Delimitations

One potential limitation was that the TENS-Interface was a new instrument. Furthermore, it was not specifically tested with visually impaired and blind individuals who face obstacles to access through technology. For this reason, results could have been skewed.

A complicated issue was whether to pre-determine codes (i.e., a priori coding) or to allow themes to emerge. In the design of this study, a priori coding was chosen because of the intent to examine specific uses and perceptions of technology (i.e., self-determination and mediation). For this reason, a blank code (i.e., 5) was included to capture any themes that emerged consistently across interview sessions. Using pre-determined codes may have focused on some themes to the exclusion of others.

Another potential limitation to the study was its small sample size, which might have reduced the power of the analysis. A post hoc power analysis was calculated using G*Power (3.1.95) statistical software to determine the achieved power. When the four parameters were set to reflect the sample size for the study ($n = 99$), an *alpha* of .05, and medium effect size (Cohen's $d = 0.3$), the results indicated adequate power (0.86) for the analysis of bivariate correlations.

Summary

The purpose of this study was an examination of ways that blind users perceive technology as a mediating influence within the contexts of their lives to meet their needs for competence, autonomy, and relatedness on the path toward self-determination. A mixed-methods study utilizing both quantitative and qualitative analysis was used to attain both breadth and depth. Interdisciplinary methods were used to analyze the complexity of this particular problem space.

Chapter 4. Results

This mixed-methods study examined the relationship between technology and self-determination for individuals who are blind. Quantitative data were collected with the Technological Experience of Need Satisfaction (TENS)-Interface instrument, which examines user experience (UX) as related to the three basic psychological needs of Self-Determination Theory (SDT) as defined by Peters, Calvo, & Ryan (2018):

- Competence: feeling able or effective
- Autonomy: feeling agency; actions are in line with one's values or goals
- Relatedness: feeling connection and a sense of belonging (p. 2).

Qualitative data were collected using the technology biography method of interviews and observations (Blythe et al., 2002).

Three research questions for this study were as follows:

- RQ1: How do technological artifacts influence blind adults' competence?
- RQ2: How do technological artifacts influence blind adults' autonomy?
- RQ3: How do technological artifacts influence blind adults' relatedness?

The following hypotheses for the quantitative phase of the study were proposed:

- H1: Participants who report prior knowledge of computer use and accessibility software have higher competence subscale scores.
- H2: Participants who report that they both read braille and use a refreshable braille display (RBD) with the computer have higher competence subscale scores.
- H3: Participants with high competence subscale scores have higher autonomy subscale scores.

- H4: Participants who report advanced screen-reader proficiency have higher autonomy subscale scores.
- H5: Participants who report accessing video calling applications, email, online chat, instant messaging, social media, or forums on a daily basis have higher relatedness subscale scores.

In the quantitative phase of this study, clients who received computers with accessibility software from the organization Computers for the Blind were asked to complete an online survey of approximately 30 items. An additional 15 items on demographics and use patterns were included with the TENS-Interface to develop a fuller picture of the connections between the basic needs and the variables of prior experience, screen-reader proficiency, and braille use, among others.

The qualitative phase of the study involved three steps. First, individuals who took the survey had the opportunity to indicate interest in participating in a follow-up interview. Then, those who self-selected into the interview pool were considered and potential participants were contacted. Finally, four individual semi-structured interviews were conducted. The interviews used guided questions and observations with the Technology biography method (Blythe et al., 2002). Participants were prompted to consider their experiences with technology in the past and present, in tandem with their hopes for the future. Rather than being interviewed over the phone or video conference, these interviews were conducted in person, either in the subjects' homes or workplaces.

The observation component was particularly important because the survey was already dependent on self-reporting from individuals. Observing participants in their own homes or workplaces allowed for other devices to be noted and discussed, as well as observing the various sensory modalities employed in use of devices. It also offered a way of discussing technology throughout the lifetime and for maintaining a natural flow of conversation. This mix of observation and discussion offered the opportunity for a different experience than a linear series of items (e.g., a survey administered orally over the phone). During a survey, the participants may be more inclined to report what they think the researcher or interviewer hopes to hear. In contrast, the conversational flow and the home or workplace setting can elicit more authentic responses. As Mitchell et al. stated, this method can be used to “provide new ways of imaging the relationship between people and technology” (2014, p. 4).

Quantitative Results

Half of the respondents reported being over age 60, 21% reported being ages 50 to 60, and 14% reported being between ages 40 to 50. Over half of participants reported being legally blind, and 27% identified themselves as having no usable vision. Slightly more than half reported female gender than male. Auditory strategies were the most frequently reported sensory channel (52%), and only 7% reported using tactile strategies (Table 3).

Table 3. Demographics

Gender	Level of Vision	Age Range	
Male (44.4%)	Low Vision (13.1%)	18-25	3%
Female (56.6%)	Legally Blind (59.6%)	25-30	4%
	CF/HM/LP/NLP (27.3%)	30-40	7%
		40-50	14%
		50-60	21%
		60+	51%

Notes: CF (counts fingers), HM (hand movement), LP (light perception), NLP (no light perception): these categories indicate nearly no intact usable vision.

Legally blind refers to an acuity worse than 20/200 with best correction, but also to a field restriction of 20 degrees or less in the best eye

Respondents reported highest scores on the *Autonomy* subscale and lowest on relatedness subscale scores. The mean of scores across all three subscales was 4.0. Variance was lowest on scores on the autonomy subscale. (Table 4).

Table 4. Measures of Central Tendency

Subscale	Min	Max	*M*	*Mdn*	Mode	*sd*
Competence	1.00	5.00	3.87	4.20	5.00	1.12
Autonomy	1.20	5.00	4.23	4.60	5.00	0.84
Relatedness	1.00	5.00	3.56	3.80	5.00	1.15

Research Question 1 asked how technology influences competence for blind individuals. Weak positive correlations were found between competence items and screen-reader proficiency, daily email use, daily forum use. (Table 5).

Table 5. Competence Subscale Correlations

Variable	r	p
Autonomy subscale	.69	.00
Relatedness subscale	.50	.00
Screen reader proficiency	.33	.00
Daily email	.29	.04
Daily forums	.20	.05

Research Question 2 considered the impact of technology on *Autonomy* needs for blind individuals. Scores on the autonomy subscale were positively correlated with prior experience, daily email, and using the computer to shop online and access the internet (Table 6).

Table 6. Autonomy Subscale Correlations

Variable	r	p
Competence subscale	.69	.00
Relatedness subscale	.55	.00
Prior experience	.22	.03
Use computer to shop online	.28	.01
Use computer to access internet	.28	.01
Traded tips with fellow users	.21	.04

Research Question 3 asked how relatedness was affected by technology. Weak positive correlations to the relatedness subscale means included daily email, daily social media, and daily YouTube, trading tips with fellow users, and being coached on technology by a friend. (Table 7).

Table 7. Relatedness Subscale Correlations

Variable	*r*	*p*
Competence subscale	.50	.00
Autonomy subscale	.55	.00
Daily email	.38	.00
Daily social media	.36	.00
Daily YouTube	.22	.03
Traded tips with fellow users	.24	.01
A friend coached me	.21	.04

The research questions included sub-items regarding the impact of prior experience with computers with accessibility software, the effect of screen-reader proficiency, and the impact of refreshable braille display use. Prior experience was weakly and positively correlated to using a computer to access the internet (*r* =.21, *p* = .04), using a computer for recreation *(r =.27, p =.01*), and using a computer to stay in touch with friends and family *(r =.20, p =.04*). Screen-reader proficiency was weakly and positively correlated with competence scores (*r* = .33, *p* =.01). Refreshable braille display (RBD) use was positively correlated with participating in summer or short-term training programs *(r=.24, p =.02*), trading tips with fellow users *(r =.24, p =.02*), being coached by a friend *(r =.35, p =.01*), and using a computer for recreation *(r =.25, p =.02*).

H1 hypothesized that participants who reported prior experience of computer use and accessibility software will have higher competence subscale scores. No bivariate correlation was found. However, competence scores and screen-reader proficiency were weakly and positively correlated (*r =.33, p =.00)*, and prior experience was positively correlated to autonomy (*r* =.69, *p* =.03).

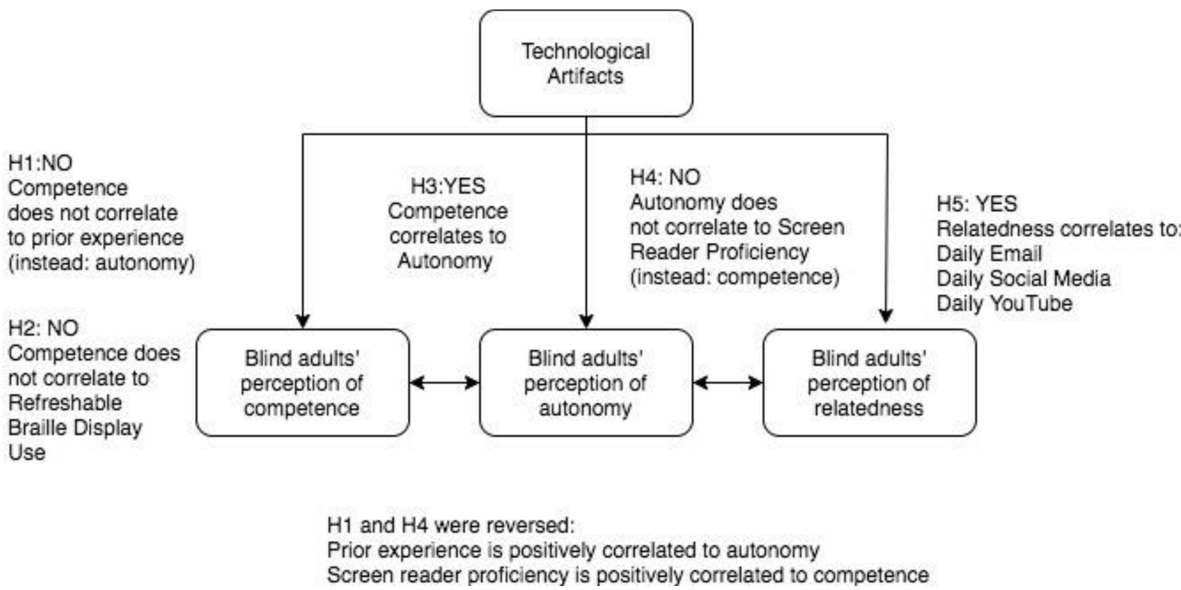
H2 hypothesized that participants who reported that they both read braille and used refreshable-braille displays (RBD) with their computers will have higher competence subscale scores. Only 10 of the 99 respondents reported use of a refreshable braille display, and no bivariate correlation was found.

H3 predicted a positive correlation between competence and autonomy subscale scores, which was upheld (*r* =.69, *p* =.00).

H4 hypothesized a correlation between screen-reader proficiency and the variable of autonomy; no correlation was found between screen-reader proficiency and autonomy subscale scores. At the same time, a positive correlation (*r* =.33, *p* =.00) was found between screen-reader proficiency and competence. Competence and autonomy scores were positively correlated (*r* =.69, *p* =.00).

H5 hypothesized that participants who reported accessing video calling applications, email, online chat, instant messaging, social media, or forums on a daily basis will have higher relatedness subscale scores. The data showed weak positive correlations with daily email (*r* =.38, *p* =.00), daily social media (*r* =.36, *p* =.00) , and daily YouTube access (*r* =.22, *p* =.03). Figure 2 shows some of these relationships.

Figure 2. Hypotheses



Qualitative Results

Seven participants self-selected into consideration for the qualitative phase by indicating interest in participating in interviews. Of these seven, one had health problems that interfered with scheduling, one failed to respond to scheduling attempts via email and phone contact, and one indicated that he did not use his computer at all because of a lack of training. The four remaining individuals were interviewed in person, using Blythe et al.'s (2002) technology biography method of interview and observation

(Appendix B). Interviews were recorded using Sound Studio software on a computer and uploaded to Rev.com for professional transcription. All participants' names have been replaced with pseudonyms. Responses were analyzed by one researcher according to the codebook (Appendix C), and interrater reliability was established at 81% by having a second researcher use the codebook to code one out of the four interviews.

Participants were evenly split between gender and each represented a different age group. Three participants identified as legally blind, while one had no light perception. Because the qualitative phase followed the quantitative phase, the TENS-Interface subscale scores were available for each participant (Tables 8 & 9).

Table 8. Qualitative Interview Demographics

Name	Age	Vision	Employment:
Abraham	30s	No light perception	Self-employed, university student
Jolene	50s	Legally blind	At an office
Gary	60s	Legally blind	Retired
Maria	70s	Legally blind	Retired

Technology Biographies

Jolene

Jolene lost her vision as a complication of a stroke. She is legally blind with some residual vision in one eye with a very narrow field, which means that anything magnified takes up a lot of space within that field. Magnification of print is not a solution, and she needs auditory or tactile options to access print. She is in her 50s, and she is employed full time. She identifies as an auditory learner, does not use braille, and is an intermediate screen reader user. She uses her laptop from Computers for the Blind in the workplace.

Table 9. Jolene's Technology Biography

Element	Area of Interest
Present: Technology Tour	Pattern, routine, disruption: Computer with JAWS & MAGic, standing desk, large monitor, handheld magnifier, iPhone (Seeing AI, Color Reader, OrCam OCR headset, movie audio description, white cane
Past: Personal History	Nostalgia, loss, celebration: Field trip to Texas Instruments in 5th grade, art teacher, first iPad (early adopter), curated online university and museum collaboration of local artists' work
Future: Guided Speculation, wishes	Hope, fear, problems addressed: Better OCR on columns, charts, training for Pearl Camera to increase work productivity

Competence and autonomy were Jolene's highest subscale scores on the TENS-Interface (4.8) and her technology biography reflected strengths in tasks, problem-solving, flexibility, and independence. Her subscale score for relatedness was 4.0, and her frequencies according to the codebook were highest on the category of other blind individuals.

Although Jolene still used a combination of visual and auditory strategies while using technology, she consistently demonstrated a preference for accessing print through auditory means, such as the wearable OrCam OCR camera. Regarding her use of a screen reader to access email and other options on her computer, she said, "I'm just thrilled that [JAWS] will actually read what I need it to." This preference extends from work to recreation, such as her enjoyment of going to movie theatres and using the headphones with auditory description. "I know some [blind] people that don't go to the movies because they don't get anything out of it." Jolene had shared with other blind individuals that each movie theatre has the audio description headphones and described how it helped at least one individual was enjoying the cinema again, *"*now that he knows what's actually happening up on the movie screen.*"* She shared how she enjoyed that the audio descriptions sometimes included information that visual users didn't have access to, such as specific character names before they were referenced in the film.

Gary

Gary has age-related macular degeneration. He's a retired male in his 60s who is legally blind, identifies as a visual learner, doesn't use braille, and is a beginning screen reader user.

Table 10. Gary's Technology Biography

Element	Area of Interest
Present: Technology Tour	Pattern, routine, disruption: First PC ever (from family at age 65), uses it for education, email, Google Drive, online webinars and vision groups, online research, news, and online shopping; flip-phone with disruptive notifications; printer/scanner
Past: Personal History	Nostalgia, loss, celebration: Apple II computer in 1984, working in technical support for Mac & Windows, took Mac courses at community college, got blue iMac in 1988
Future: Guided Speculation, wishes	Hope, fear, problems addressed: Driverless cars, electric cars, anything helpful for friends with vision loss

Gary's competence subscale score on the TENS-Interface was 4.6. During his technology biography, he demonstrated and discussed a large variety of tasks performed using his computer. Other areas of high frequency according to the codebook were Control and Other Blind Individuals. He expressed satisfaction regarding the ways in which his computer allowed him to access resources and connect with other individuals, such as his average daily inbox of 350 emails. The highest frequency of his responses in the autonomy section of the codebook was control, and this desire for control was evident in his deliberate non-use of Amazon in lieu of other online ordering sites to have exact items delivered, such as specialty coffee from his out of state hometown. He also expressed autonomy and control in his desire to use his devices as he preferred. He spoke about how his National Library Service reading device had buttons he didn’t use or need, as well as a timer function he found unnecessary: “Well, it’s got a timer on it. It will turn itself off. Why do I want that? I turn it off when I want to turn it off, I don’t need the thing to turn off for itself.”

Regarding his use of his computer, Gary stated that he took a keyboarding class in college. “It’s the only course I ever took in junior college that helped me…typing, I took that. That’s good for life.” He also expressed a desire for simplification rather than too much magnification or auditory access: “I don’t do the audio things on the computer either. Text to speech and all that. I don’t use all that…my vision’s good enough that I don’t need that.” He stated that he belongs to a dozen different vision organization email mailing lists. “I set the world record about a month ago. I got 400. I think 410 in one day. If it says, ‘sign up for email,’ I sign up for it. Send it to me! I don’t care what it is, just send it to me.”

When demonstrating his computer use, he explained, “Well, first when I turn it on, I get rid of all this notification stuff, because I don’t need it. I like to check the news and my emails. I check the news, and whatever I've got up here [points cursor to Bookmarks list], the papers and the TV stations, check the news from them. Over here, I've got all of the vision organizations."

Although he exhibited a strong enthusiasm for information and education, he mentioned slight frustration with people in the vision groups who were not interested in learning more because of their age. "You can tell them whatever's going on the latest. I usually catch up on whatever the latest thing is. They come up with this thing like, 'well I'll never see that happen.' I said, 'Well, are you planning on being alive five minutes from now? That's how fast it's changing.'"

Maria

Maria is a legally blind woman in her 70s who identifies as a visual learner, does not use a screen reader, and uses magnification software. Her decreased vision is due to age-related issues.

Table 11. Maria's Technology Biography

Element	Area of Interest
Present: Technology Tour	Pattern, routine, disruption: Desktop computer with MAGic screen magnification software, pays rent online, writes letters in word processor, keeps up with medications with word processor, deletes emails to save space on screen, ads a constant distraction from visual space, Ruby handheld magnifier from her son, Mouse Magnifier, CCTV-TV combination for reading bills, writing checks, basic phone for calls (no text), no social media or email on phone (too much reading), NLS talking book player
Past: Personal History	Nostalgia, loss, celebration:

	Kelly Air Force Base government job as operator in the computer room, bought son a computer from Radio Shack for medical school, wishes her mother with the same visual condition had all the options she does
Future: Guided Speculation, wishes	Hope, fear, problems addressed: Settings to remove ads while browsing the internet to keep more visual space open, wishes for a training company who could come to the house to help with software issues and provide training

Maria’s comments during her technology biography echoed her scores on the TENS-Interface. Her competence score was low compared to her other sub-scores (2 out of 5 composite). She frequently referred to a need for training, as well as an awareness that she should be able to do something more efficiently. While demonstrating tasks using her computer, she shared, “Believe me, I know there are quick ways to do this, but I don’t know the quick way, so I just do it my way.” She gave an example of how it took her two hours to order three items on Amazon.com, pointing out that someone else could have probably accomplished this task in 10 minutes. During the interview, she asked for advice regarding how to remove advertisements as well as asking for help to identify certain items on her desktop screen. At the same time, she exhibited strengths in problem solving. Training in the area of auditory access to a computer could potentially decrease the amount of problem solving necessary and increase her satisfaction with tasks that involve reading. Her autonomy subscale score on the tens-interface was considerably higher than her scores for competence or relatedness.

Although her relatedness score on the TENS-Interface was only a 3.6 out of 5, family was her high score. She spoke often about how much her son had helped her find different options (e.g., Ruby handheld magnifier, Mouse Magnifier, computer) and how frequently they email one another. She also spoke about her mother's vision loss, how she learned about National Library Service auditory books from her, and how she wished her mother could have had some of the advances her son had found for her when she was alive.

Maria's behavior was inhibited by any technology that involved visual reading; though she used magnification software and devices to do accomplish necessary tasks (e.g., paying rent online using her computer and magnification software, reading insurance papers using her Mouse Magnifier), she preferred auditory experiences. In her own words: "I don't use chat rooms, not Facebook, none of that stuff because it would just be more reading…I don't have text, and I don't want text because I'd have to have my magnifier with me. It's not worth it."

Though Maria identifies as a visual learner and has a variety of tools to access print visually, during her interview she expressed greater satisfaction with auditory experiences, such as talking on the phone instead of texting, using her National Library Service audiobook reader, and the microphone option on her phone.

Maria's consistent interest in relatedness was stymied by the necessity of reading when using visually-mediated methods (e.g., Facebook, texting, etc.). If Maria had training in auditory methods of accessing print, such as screen readers or devices with optical character recognition (OCR), she might enjoy staying in touch with family through these other methods. In short, based on her survey responses and technology biography, she may have been using the wrong reading media (i.e., large print) as compared to auditory print possibilities.

Abraham

Abraham is a man in his 30s with retinal detachments related to diabetes. He has no vision whatsoever (i.e., no light perception), he identifies as a tactual learner and was exposed to braille during a training program as an adult, but he does not use it. He is an intermediate screen reader user and a self-employed university student who is in an honor society and holds leadership roles in several organizations.

Table 12. Abraham's Technology Biography

Element	Area of Interest
Present: Technology Tour	Pattern, routine, disruption: Laptop with JAWS screen reader, Blackboard LMS, NFB website, Olympus recording device with simple options, battery life, and 72 hours recording space; human mediation such as readers, notetakers, wife or parent assistance; online coursework saves time but less effective for some subjects, requests all assignments as Word documents
Past: Personal History	Nostalgia, loss, celebration: Grew up using the internet for recreation (downloading music) not productivity, not dependent on it like today's generation, used Blackberry for work prior to losing vision, received first computer 5 years ago at a rehabilitation training center as a young adult after losing vision
Future: Guided Speculation, wishes	Hope, fear, problems addressed: Wants technology to slow down, more privacy, less data tracking or facial recognition, wants

	technology to advance in ways that benefit people, not corporations

Abraham has had extensive training after his vision loss, and while this included the opportunity to learn braille as a potential learning modality, he stated that he didn't pick it up easily and prefers auditory means of print access.

Describing his use of technology, Abraham noted, "I was never the technical person. But now I'm the most technical person in the family." Demonstrating the confidence that presented at a high frequency according to the codebook, he stated: "Everybody starts with what they know, and I can get things done real quick. I know once I get on it, once I learn it, I'll be good to go. No problem."

Abraham's autonomy subscale score on the TENS-Interface was 4.4, and his interview included a high frequency of comments coded in this category. While speaking, several examples illustrated his Autonomy and the way he understood his own learning styles and what strategies worked best for him. For example, while he has access to National Library Service and Bookshare electronic books, his preference for studying is to purchase the necessary books in print and have a family member or hired reader read to him in person or on recording. He said, "I know I learn better with somebody actually there talking to me. And because a computer is different from somebody talking, so that's what I do—I buy the book."

Abraham's autonomy is also evident in the way he coordinates assistance from family members, teachers, readers and notetakers: "So, I listen to the lecture, I have my recorder going. I let my note-taker take notes—whatever she feels is important. And the teacher will ask if there's anything else I missed, anything else I need. Pretty much got it. If there is, I'll go back to my notes, and if I can't find it on the recording or the note-taker didn't take it, I'll shoot her an email and request or call the office and leave her a message."

Abraham's autonomy is further illustrated by his preference for simplicity and lack of overreliance or dependence upon technology. "I know there are specific [digital media players] assigned for the blind, but I've never seen those. I use one that I found that has the least amount of buttons. It's very easy, you just record, stop, play. Very simple, very basic. Not too complicated so anybody can use it."

Themes

Competence

Of responses on the TENS-Interface, mean score of responses on the competence subscale was 3.87 out of 5.00. Hypothesis 1 proposed a positive correlation between responses on the competence subscale and prior experience with computer use. No correlation was found between those two variables. However, screen-reader proficiency was positively correlated to the competence subscale.

Hypothesis 2 proposed a positive correlation between the competence subscale score and participating braille readers who used a braille display to mediate access of their computer from Computers for the Blind. A correlation was not found between the competence subscale and refreshable braille display use.

In qualitative data, competence was expressed in different ways by individual interviewees. Jolene ascribed great importance to competence in her work life, and valued technology that could contribute to this end (i.e., her new Pearl camera with OCR functionality). Gary demonstrated competence across a range of tasks as he used technology for purposes of continuing education. Maria rated herself low on her competence subscale score, yet she displayed an awareness of problem-solving techniques and work-arounds. Abraham exhibited both problem solving and confidence related to his competence.

Table 13. Competence Tasks & Artifacts

Artifact	Task	Evidence
Computer	Daily Forums	Weak positive correlation (r =.20, p =.05)
Computer	Paying rent	Technology biography
Computer	Accessing school work	Technology biography
NLS Player	Listening to audiobooks	Technology biography
Mouse Magnifier	Reading bills	Technology biography

Autonomy

Of responses on the TENS-Interface, the mean response on the *Autonomy* subscale was 4.23 out of 5.00. Hypothesis 3 proposed a positive correlation between autonomy and competence, which was supported in this analysis. Hypothesis 4 proposed a correlation between autonomy and screen-reader proficiency, which was not demonstrated to be true; however prior experience with computers with accessibility software was positively correlated to the autonomy subscale.

Autonomy was displayed to varying degrees by the interview participants. Gary and Abraham both had specific ideas and strategies for what worked best for their individual workflows. Maria and Jolene each stated that they knew there might be better ways to do something, but that they chose the ways that worked the best for them, based on current levels of training.

Table 14. Autonomy Tasks & Artifacts

Artifact	Task	s
Computer	Internet use	Weak positive correlation (r = .28, p =.01) & Technology biography
Computer	Shopping online	Weak positive correlation, (r =.28, p =.01) & Technology biography
Computer	Using JAWS + Word for class notes	Technology biography
Olympus audio recorder	Record class discussion	Technology biography
OrCam wearable OCR device	Identify items while grocery shopping	Technology biography

Relatedness

According to the statistical analysis of the TENS-Interface, the mean subscale of relatedness was 3.56 out of 5.00. Hypothesis 5 proposed that participants who report accessing digital communication tools (i.e., video calling applications, email, online chat, instant messaging, social media, or forums) on a daily basis will have higher relatedness subscale scores. This hypothesis was supported by the data for daily email, daily social media, and daily YouTube access.

Each of the interview participants mentioned how their technology devices had involved interactions with others. Gary mentioned a nephew helping set up his printer, while Maria shared how much her son helped her with visual technologies and assistance. Abraham received support and assistance from not only his wife, but also his parents who live nearby. Jolene referenced support from co-workers, and Abraham also discussed receiving assistance from his university’s disability accommodations office regarding notetaking, recording books, and accessing materials.

Three of the four technology biographies heavily referenced technology related interactions with other blind individuals. Gary wore a Hadley School for the Blind hat and t-shirt during his interview. He spoke at length of other individuals in the online blindness/visually impaired community, as well as more specific macular degeneration groups. He sought out authors, webinars, online chats and trainings, and other groups and connections related to his visual diagnosis. Jolene worked at an organization that provides support for other individuals with blindness or low vision. She described recommending technology such as the movie theatre audio descriptions by headphones, as well as learning about new options from other users, such as the Pearl Camera for OCR. Abraham referenced how he stays in touch with four of the people he went through rehabilitation training with after losing his vision, as well as maintaining board membership in his local chapter of the National Federation for the Blind.

Table 15. Relatedness Tasks & Artifacts

Artifact	Task	Evidence
Computer/Tablet/Smartphone	Send & receive email	Weak positive correlation (r=.38, p =.00) & Technology biography
Computer/Tablet/Smartphone	Check social media	Weak positive correlation (r =.36, p =.00)
Computer/ Tablet/Smartphone	Watching YouTube	Weak positive correlation (r = .22, p =.03)
Computer/ Tablet/Smartphone	Traded tips with users	Weak positive correlation (r = .25, p =.01)
Computer/ Tablet/Smartphone	Coached on technology by a friend	Weak positive correlation (r = .21, p =.04) & Technology biography
iPhone+What's App	Stay in touch with NFB chapter members	Technology biography

Artifact	Task	Evidence
Computer	Blindness specific video chats/webinars	Technology biography

Technological Mediation

Technological mediation refers to a post-phenomenological concept that describes the ways that technological devices or artifacts influence the experience and actions of an individual. According to Verbeek (2016), “Post-phenomenological studies…do not approach technologies as merely functional and instrumental objects, but as mediators of human experiences and practices.” (p. 190). The topic of technological mediation is particularly relevant to blind individuals, because they must rely on either human mediation or technological mediation to access print.

For Maria, actions such as texting or using social media were inhibited by her phone’s small print size. However, her computer’s large screen monitor invited her to send and receive email. Her MouseMagnifier invited the action of reading mail and bills. Devices with auditory access consistently invited action, such as making calls with her phone or listening to audio books on her National Library Service device.

Jolene’s example of going to the movie theatre and using the auditory descriptions provided by the headphones illustrates how a technological artifact can both amplify an experience and invite an action. As Shinohara and Wobbrock (2011) noted in their study, “Participants valued technology enabling equal access because it allowed them to do things *just like everyone else*… participants recognized that no assistive technology would fully replace sight, hearing, or any kind of functioning.

Rather, they most valued having access to the information and services everyone else had." (p. 708).

Perhaps the best example of inviting action can be seen in Abraham's description of his experience of deciding to purchase an iPhone. Despite its expense, the device won him over because of how easily he could use it. Rather than signing up for training, Abraham was able to use this technological artifact immediately.

These examples illustrate the utility of the post-phenomenological concept of technical mediation as an analytical tool. Considering how technological artifacts affect the experience and actions of individuals through this lens could offer potential implications for research and practice.

Training

This study was conducted with a cautious respect of the complexity of the lived experience of an individual with a disability. For example, several themes were predicted to be relevant, while also leaving open the discovery of unforeseen themes. Such a theme, Training, was in fact discovered.

Computers for the Blind is clear and upfront about the fact that they aren't able to provide training along with the computers they provide, and interviewees understood that they needed to find help elsewhere. According to Cook & Polgar (2015),

> The definition of assistive technology includes two categories. Devices, software, and applications are considered hard technologies. Soft technologies include training opportunities or references used to assist a user in operating hard technologies. Soft technologies can be provided in a number of forms such as

> (1) directly through people (e.g., professional providers, family, informal care providers);
>
> (2) written manuals, tip sheets, and other documents; or
>
> (3) electronic (e.g., built-in help screens, online help, websites).
>
> By labeling these aspects as another technology, they become more tangible. Without these aspects of technology, the full potential benefit of the use of hard technology is limited. (p. 29.)

One potential interview subject from the survey literally never used his computer because he had no training. Training was one of Maria's wishes for the future from her technology biography, as follows:

> To me, it would be wonderful if there could be a software company like Computers for the Blind for the hardware part … it would be nice to know a reputable company that you could call to come to the house….I need someone to sit down with me. I'll pay them to sit down [and help with things] just like getting rid of that ad. Show me how to do that. I want to uninstall McAfee…I don't want these ads. But I don't know how to get rid of them.

Abraham referenced the power of his training experiences at an in-depth vision rehabilitation program, as well as how he and other National Federation for the Blind (NFB) chapter members share training with one another during meetings. Recent topics include smart home technology, such as Alexa and Google Home: "[At NFB chapter meetings], we offer a quick 30-minute technology class of what's the difference, what can we get, and what's cheaper, what's better. And then for those who want their own training, we will go out there."

Abraham also mentioned the importance of ongoing training as technology changes. He described how much more comfortable he is using Windows 7 with JAWS, and how he has made plans to attend training for Windows 10: “I’m using Windows 7 right now, but planning to get training for Windows 10…although it’s supposed to be similar, it’s not. I got a laptop, I had it for a little bit, checking it out basically to notice how different it was. And I’m like, I need training. I knew right away.”

Jolene mentioned training frequently during her interview. “I use the mouse and a keypad. I use whatever works. I guess it’s because I haven’t gone through any formal training, I use a little bit of both. Sometimes I use the arrows, sometimes I use the mouse.” At the time of her technology biography, she had a new optical-character recognition (OCR) device called Pearl camera. Though this device was in her possession, she had not yet experimented with using it to scan and read documents. She was waiting on an upcoming training session to learn how to use it.

Because of his background as an early adopter of technology and technical support employment, Gary exhibited the ability to self-teach himself through online resources and correspondence courses. However, he gave an example of how he received a free white cane from one organization, but donated it to someone else, because he couldn’t teach himself how to use a cane on his own.

A combination of autonomy, competence, and relatedness were illustrated in Abraham’s recount of his initial experience with an iPhone:

> So then I started losing my vision, and it’s like ‘Ok how am I going to make a phone call?’ I didn’t know anything about VoiceOver or anything. My [rehab] counselor was like, ‘There are smartphones available. Go check them out. Then

> you'll be able to do everything.' So, I went and looked at the Android phones, the iPhones, everything, but the iPhone is so expensive…but so easy to use, easy. The first five minutes I was at the store, they're like, 'Here it is, I turned VoiceOver on. Here you go, sir. Give it a test drive.' Five minutes. I'll take it. It was so easy. I go, what do I normally do to make calls. Ok, yeah, we'll try and make the call, yeah. So, I went to the phone, dialed a number, no problem. Called my wife, called my mom. It works. Coming back, easy to answer, easy everything. So, I said, okay, well it's expensive, but I know it's going to work out.

Table 16 illustrates the four participants' TENS-Interface scores compared to the themes and sub-themes reflected during their technological biographies.

Table 16. Qualitative Summary with TENS-Interface Scores

Theme	Jolene	Gary	Maria	Abraham
C	4.8; Tasks	4.6; Tasks	2.0; Problem- solving	4.0; Confidence
A	4.8; Independence	3.8; Control	4.8; Control	4.4; Flexibility
R	4; OBI	3.8 OBI	3.6; Family	5; Family, OBI
TM	Amplify	Invite	Inhibit	Invite
TR	Screen reader	Specific to VI	Remove ads & programs	Screen reader

Legend: C = Competence; A = Autonomy R = Relatedness; TM = Technological Mediation; TR = Training; OBI = Other Blind Individuals

Summary

Using an interdisciplinary combination of quantitative and qualitative methods to probe three a priori themes of competence, autonomy, relatedness allowed for a broader examination of research questions and hypotheses in this study. In quantitative results, Hypotheses 3 and 5 were supported by the data, and Hypothesis 2 was not supported. Hypotheses 1 and 4 predicted positive correlations between the basic needs and the variables of prior experience and screen-reader proficiency. Prior experience was positively correlated to autonomy scores but not competence scores, as predicted. Screen-reader proficiency was positively correlated to competence scores but not autonomy scores, as predicted.

The qualitative phase of the study expanded the exploration of competence, autonomy, and relatedness, in addition to examining the role of technological mediation. The emergent theme of training was also explored. Two out of four participants who had rated themselves high on the TENS-Interface for competence had high frequencies on the sub-theme of tasks. Regarding autonomy, two out of four participants had high frequencies on the sub-theme of control, but this similarity was not reflected in their TENS-Interface scores. Other blind individuals were the highest frequency for sub-themes of relatedness for three of four participants, while family was the second highest. Abraham had a perfect score on the TENS-Relatedness, and had equally high frequencies for *both* family and other blind individuals. All four of the participants had high frequencies for training.

Using a combination of quantitative and qualitative methods allowed for a more thorough examination of user perceptions of how technological artifacts influence fulfillment of three basic needs based on Self-Determination Theory (SDT)

Chapter 5. Conclusions & Recommendations

This study was novel in its interdisciplinary approach to examining a complex convergence of humanist and post-humanist perspectives in unpacking relationships between individuals who are blind and technologies that they use. However, beyond philosophical musings, this study also situated itself within a sincerely pragmatic desire to improve the research, recommendations, training, and provision of technology within the fields of education and rehabilitation for individuals who are blind.

Technology mediates an individual's experience of the world. As technology has become more ubiquitous, individuals with and without disabilities have experienced a shift in how they experience technology and integrate it into their lives. Those without disabilities may make choices about the use of technology based upon preference, experience, and interest. The diversity of variables involved in decision making often includes enjoyment, cost, peer influence, identity, meaning, and values. At times, people may choose technology that reflects their sense of identity, both real and aspirational.

Conway and Elphinstone (2017) stated that the three basic needs of competence, autonomy, and relatedness are “inherently intertwined with individual differences and contextual factors...whether I encounter a glass cup as decoration, tool, weapon, or power-up depends upon a plethora of contextual variables impacting the meaning of the object, my identity, emotional state, and so on.” (p. 57, p. 60). An awareness of what technology means to different individuals and how it fits into their goals, dreams, and aspirations for life and identity is key to examining the ways in which technology mediates action and experience in the world. Pairing a post-phenomenological approach (which is post-humanistic in nature) with the humanist positive-psychological approach of self-determination theory allowed for integration of both objective and subjective perspectives that place blind individuals at the center of their own stories. Within a recommended array of possibilities, only users can truly determine what a given technological artifact means in their own lives. Sometimes the most efficient choice may not align with a user's preference or experience; the truth of which devices work best for a given individual lies somewhere in between the subjective and the objective. This interdisciplinary approach honors the inherent complexity within the ways that blind individuals negotiate meaning-making and identity in their lives.

Key Findings

Technology

Mean scores on the TENS-Interface showed that technology positively affected participants' autonomy scores to the highest degree (M = 4.23), followed by mean scores for competence (M = 3.87) and relatedness (M = 3.56). Competence subscale scores were positively correlated to screen-reader proficiency and daily use of email and forums. relatedness subscale scores had positive correlations with daily email, daily social media, being coached on technology by a friend, and trading tips with fellow users. These results suggest that certain aspects of artifacts and usage patterns may have impacts worth investigating further. For example, if trading tips improves relatedness, it would be valuable to identify variables that catalyze this behavior.

Individual tools, such as screen-reader software and refreshable braille displays, provide nonvisual access to print for individuals who are blind. Quantitative analyses found that screen-reader proficiency was positively correlated to the competence subscale, while qualitative data highlighted the importance of training in the attainment of assistive technology skills. Although the hypothesized positive correlation between refreshable braille display use and the competence subscale was not supported in this study, positive correlations were found to formal training, informal coaching and trading tips with other users, and use of a computer for recreation.

The technology biographies provided illustrations and texture regarding the influence of technology on autonomy, competence, and relatedness. Technological artifacts positively impacted individuals' basic needs when easy to use and aligned to individual preferences. Technological artifacts inhibited users' experience of the basic needs when they were too complicated, unappealing to individual preference, or when there was a lack of training on how to use accessibility features. Technology use is personal, may be highly subjective, and different for each individual.

Vision Loss & Age

According to the Cornell University Disability Statistics website (Erickson, Lee, & von Schrader, 2017), in the year 2017 in the United States a visual disability was reported by an estimated 2% of non-institutionalized males or females aged 18 to 64 of all racial identities and ethnicities, with all education levels. In the same data set, visual disabilities were reported by an estimated 6% of among ages 65 or older.

Girdler, Packer, & Boldy (2008) conducted a focus group with 22 older adults (ages 65-93) with age related vision loss to explore the issues from their perspective. In the first theme that emerged, the impact of age related vision loss were listed as discontinuity in occupations, loss of roles, and threat to independence (Girdler at al. 2008.) The authors described how the participants "saw their life stories in two distinct periods: before and after vision loss” (p. 112). The second theme involved variables that helped the participants adapt. Adaptations included cognitive strategies, occupational variables (e.g., new meaningful ways to spend time), adaptive strategies, social supports, and assistive and adaptive devices (Girdler et al., 2008). Learning about their visual conditions, filling their time with meaningful pursuits, and spending time with others with vision loss were all important steps. Regarding assistive devices and technology, the authors stated that, “Assistive devices were important because they supported participants’ independence. Use was often described as symbolic of a deeper psychological acceptance of their vision loss” (Girdler et al., 2008, p. 117).

Although a focus on older blind adults was not intentional in this study, a majority (72%) of participants as well as three of the four (75%) qualitative interview subjects were over the age of 50. Their age-related vision loss could impact all three of the basic needs, in different ways than may be experienced by individuals with congenital or early onset vision loss. Blind individuals may feel a loss of autonomy as their ability to control their environment diminishes and they lose the ability to drive. Their sense of competence may suffer as they struggle to complete tasks they were formerly easily able to do and are faced with daunting learning curves for accessibility software and devices. Their experience of relatedness can be affected by diminished opportunities to socialize because of transportation, in addition to visual difficulty in accessing common modes of communication such as texting, email, or social media. Although accounting for onset of vision loss was beyond the scope of this study, information gleaned from it offers some insights into the intersection of age, technology, and basic needs.

Quantitative analyses showed a negative correlation between age and the competence subscale (r=-.24, *p* =.02). No relationships between age and autonomy or relatedness were supported by the data. A positive correlation between age and one particular question of the competence subscale was also demonstrated: “I found the interface and controls confusing on my computer from Computers for the Blind” (r=.22, *p* =.03). A negative relationship between age and “I use my computer for socializing” was also demonstrated (*r* =.20, *p* =.05).

Because a positive relationship was demonstrated between competence and screen-reader proficiency, diminished competence in older participants may indicate a difference in screen-reader proficiency, as well. According to the 8th consecutive WebAim screen reader survey (WebAim 2019), a majority of respondents (62%) rated their skills as advanced, a minority rated themselves as beginners (5%), while 40% rated their skills as intermediate. In comparison, the majority of respondents indicated intermediate proficiency; fewer respondents indicated advanced or beginner proficiency. This difference may be due to age; the WebAim survey had a greater spread of younger participants compared to this study (Table 17).

Table 17. Screen Reader Comparisons

	WebAim Survey (*n* =1,213)	This Study (*n* = 99)
Beginner Proficiency	5%	19%
Intermediate Proficiency	32%	40%
Advanced Proficiency	62%	24%
Ages 18 to 40	46%	14%
Ages 41 to 60	30%	35%
Ages over 60	15%	51%

Data from the qualitative phase of the study offered additional insight regarding the intersection of age and vision loss from the three participants over age 50. Their technology biographies illustrated past events related to technology use while their vision was intact, and future wishes for technology that would help adapt for their vision loss. For example, Maria originally had a government job on an air force base as a computer operator, and she remembered buying her son a computer to use in medical school. She was highly aware of how long formerly easy tasks took since losing vision and asserted that there were better ways to do things technologically—she just didn't know them. Her hopes for the future included software to screen out unnecessary elements and a training company specific to accessibility software. Gary also shared many examples of past technology use, such as being an early adopter of several Macintosh products and working in technical support. For the future, he was interested in driverless cars and "anything that could help his friends with worse visual impairments." Jolene recalled a field trip to Texas Instruments as a little girl, getting the first iPad, and creating an online series of educational modules showcasing local artists when she worked as an art teacher. Her hopes for the future included pragmatic improvements to optical character recognition software.

Age and vision loss are an additional set of considerations that add to the complexity of the lived experiences of blind individuals. As technology use becomes a necessity rather than a preference during such a period of difficult transition and loss, its impact upon the basic needs of autonomy, competence, and relatedness may be profound. Technology has the power to generate new ways of acting and connecting, but can also provide barriers to the individuals who need it most.

Discussion

Interdisciplinary methods and frameworks provide valuable ways to uncover the complex stories of persons who are blind. Self-determination comprises more than just autonomy; it includes the basic needs of competence and relatedness according to self-determination theory. Recognizing the significance of competence and relatedness offers practitioners and researchers alike the opportunity to better serve students and clients. A user-centered approach is integral to understanding non-visual access to print. Screen-reader proficiency is crucial to competence and research is needed to identify evidence based practices and a greater prioritization of training in screen-reader skills. Further research examining connections between technology, self-determination, and braille holds promise for uncovering more of the whole story.

UX Meets SDT: Use of the TENS-Interface

The TENS-Interface is the latest installment in a 40-year history of questionnaires developed, used, and replicated based upon Deci & Ryan’s Self-Determination Theory (SDT). It combines the fields of psychology and human-computer interaction by using both SDT and user experience (UX). Using SDT-developed instruments in research is another way for the field of VI education/rehabilitation to learn more about fostering these needs in students and clients. Cronbach’s *alpha* values scores indicated good internal reliability, which supports the use of the TENS-Interface with a population of individuals who are blind.

Use of Technology Biography method

The technology biography method from the field of human-computer interactions was chosen as a way to have a guided conversation about technology that included observations. Interviewing individuals in their homes or workplaces in person allowed for direct observation of not only their actions, but other technological artifacts that participants may not have mentioned in a conversation via telephone or webcam. In addition, observation allowed for the clarification of misunderstood questions. Discussing past and present experiences with technologies also allowed for reflection upon not only change in technology in society, but also change in their own lives and levels of vision. Often an item or artifact in the home or workplace became a topic of conversation, such as a battery-operated flyswatter device or an eye anatomy chart. Situating the interviews and observations in the home or workplace allowed for a deeper, richer exploration of technology from the perspective of the individual. These elements showed that technology biographies, and other observational context-based methods (e.g., sensory ethnography) are valuable methodologies for research with individuals with blindness or low vision

Screen-Reader Proficiency & Competence

The importance of screen-reader proficiency for individuals who are blind cannot be overstated. In this study, screen-reader proficiency was positively correlated to the competence subscale of the TENS-Interface. These results indicate that screen-reader proficiency is not only important to access for the purpose of individual performance in school or work, but also self-determination. As McCarthy, Pal, & Cutrell (2013) noted, “Without access to screen readers, independent access to computing and office applications, web use, and even communications can be severely limited, and these are consequently critical to the workplace and social environment of people with vision impairments” (p. 222). This point was illustrated poignantly in Shinohara & Wobbrock’s

(2011) qualitative study that described a young adult whose screen-reader proficiency afforded him a job offer:

> In the individual interview, they asked me one question, ‘How you gonna do the paperwork and stuff we have?‘ I say, ‘I got a Dell laptop that has screen reading software and if you can send it to me I can do it.‘ The head of human resources says, ‘Well, you got the job, congratulations.‘ I say, ‘What about the rest of the interview?‘ He says, ‘You don‘t need it. You impressed us at the group interview, so we only had one question for you“ (p. 711.)

In this study, interview participants consistently highlighted the importance of training related to their screen reader skills. For example, Abraham was confident in his technology skills, but he sought out training to transition from using Windows 7 to Windows 10 with a screen reader.

Refreshable Braille Displays (RBDs)

In addition to screen reading software, braille represents another non-visual means of accessing print for individuals who are blind. In this study, the hypothesized relationship between braille and the competence subscale was not supported. The sample size may have been too small to demonstrate an effect. Of the 99 survey respondents, 37 reported reading braille; only 10 responded that they also used a refreshable braille display (RBD). Repeating the study with a larger sample of braille readers who use refreshable braille displays might allow for a positive correlation between RBD use and competence to be revealed. In addition, the majority of the participants in this study were older individuals who are less likely to have received braille instruction or have access to refreshable braille displays. Repeating the study with a sample of younger individuals (i.e., high school, university, young adult) might be more likely to determine a correlation between braille display use and competence. Finally, Likert-type items on the TENS-Interface can be used with different types of technology. A sample item from the competence subscale is: “I feel very capable and effective at using the technology.” (Appendix A) In this study, the stem used in place of “the technology” was “your computer from Computers for the Blind.” Administering the TENS-Interface to a larger, younger sample of refreshable braille display users with the stem “your refreshable braille display” might be more likely to produce data showing more positive correlations among competence and RBD use.

Analysis of descriptive statistics from this study showed additional information regarding refreshable braille display use. Use of an RBD was correlated positively with receiving formal training in public school in grades K through12, participating in extra-curricular or summer training programs, referencing online handouts, being coached by a friend, and trading tips with fellow users. Interestingly, there was also a positive correlation between RBD use and use of a computer for recreation. These additional findings hint that there is more to the story regarding refreshable braille display use.

Implications

Beyond autonomy

The higher mean scores of the autonomy subscale and the positive correlation between prior technology experience and the autonomy subscale suggest that technology had the greatest positive impact on autonomy for the sample in this study. This parallels the VI education-rehabilitation field’s definition of self-determination as “a person’s right to decide freely and without undue influence how he or she wishes to live his or her life" (Sapp & Hatlen, 2010, p. 341). This definition of self-determination matches the SDT definition of autonomy as feeling agency or a sense that one's actions are aligned with values and goals. However, SDT includes not only autonomy, but also the basic needs of competence and relatedness.

Interdisciplinary approaches for uncovering complex stories

Combining different methods and frameworks from diverse disciplines can allow for a richness and complexity of information that is necessary when trying to understand more about individual experience. Technological mediation as a concept was not developed to examine use of assistive technology, yet it provides a compelling narrative for understanding diverse experiences to various devices from different individuals. It also provides a language to use in thinking through observations and self-reports. Adopting the psychology field's definition of self-determination, which includes competence and relatedness, offers the potential to guide additional research and intervention strategies for the field of education and rehabilitation for those with blindness or low vision.

Technological artifacts exist in different relation with different individuals based upon the intersection of preferences, meaning, and functionality. For example, in Shinohara and Tenenberg's case study (2009), Sara would abandon a task before resorting to asking for help from a sighted friend or family member, whereas in this study, Abraham was perfectly comfortable reaching out for such assistance. Observing, asking, and learning to understand these complex relationships between individuals and technology has implications for selection, instruction, and use of these artifacts.

Training for screen-reader proficiency → competence

For blind individuals, screen readers provide non-visual access to text allowing for the use of computers, tablets, and smartphones. Their importance cannot be overstated. As Lazar (2019) noted,

> Given that the Braille literacy rate is very low for blind students, approximately 10-percent, screen readers are the primary assistive technology for blind students. Furthermore, they are used on a daily basis, not only for standard coursework, but also for using email, web-surfing, e-commerce, and most other interactions with PCs, smartphones, and tablet computers. Screen readers, therefore, are the most familiar assistive technology for blind users, utilized on a daily basis for information access (p. 194).

At the same time, screen reader use is a complex task that is not learned overnight. it can be hard for sighted teachers to teach complex workflows that they themselves do not use, have not been taught, and may find counter-intuitive.

Screen reader vendors have developed training guides for sale, as well as users, but there is no research based curriculum or set of strategies. Little research on designing and implementing instruction exists, and there are no established evidence-based practices to guide the field. The field of human-computer interaction provides multiple studies regarding the user experience that would provide an excellent starting point (Buzzi et al., 2012; Craven & Brophy 2004; Lazar et al., 2007; Sahib,Tombros, & Stockman 2012). Although these studies originate from a design perspective, they could potentially be adapted and extended toward the design of instruction. Intentional research into effective instructional practices for screen reader use is clearly warranted and has impactful potential.

Refreshable braille displays: There's more to the story

Several HCI studies that examined the user experience of individuals using screen readers do mention refreshable braille displays, but dismissed their use as prohibitively expensive (Buzzi, et al., 2012; Lazar et al., 2007; McCarthy, Pal, & Cutrell 2013; Lazar 2019; Sahib et al., 2012). However, several studies in VI education-rehabilitation literature describe refreshable braille display use by elementary and high school age students in public-school settings (Bickford & Falco. 2012; Kamei-Hannan, & Lawson 2012; Kapperman, Kelly, & Koster 2018; Kelly & Kapperman, 2018). As Martiniello, Wittich, and Jarry (2018) noted, "In contrast to students with visual impairments, the variability of braille instructional services and equipment available for adult and senior clients is more restricted and dependent on geographic location and funding models" (p. 196). Between the recency of refreshable braille displays on the market, the disparities between what is available in different funding sectors for children and adults, and the low percentage of braille readers overall, assembling a full picture of the influence of refreshable braille displays upon autonomy, competence, and relatedness proves complex. Further research is needed to explore potential links between this technology and self-determination.

Recommendations

Drawing upon interdisciplinary perspectives in the design, execution, and discussion of this study allowed for more avenues for understanding a complicated topic. The relationships between individuals and technologies are layered and complex.

Nevertheless, educators, researchers, and developers can better understand these relationships by applying multiple perspectives with humility and with a resilient commitment to support individuals on their journeys. Individuals who are blind deserve user-centric, timely tools, training, and support, which involves a detailed awareness of the differentiated nuances between visual and non-visual access to print. Ultimately, to continue examining the whole story, three broad steps are recommended by this study:

1. Expand the educational and rehabilitative approach to self-determination for individuals who are blind beyond autonomy to include competence and relatedness.
2. Extend exploration of interdisciplinary research methods and theories for the blind individuals such as self-determination theory, technology biographies, sensory ethnography, post-phenomenology, and positive technology.
3. Embrace user-centered approaches for research and practice in the areas of screen reader use and refreshable braille display use

Specifically, these broad recommendations can be broken down into specific action steps according to research and practice.

Researchers should investigate effective training and instructional methods for teaching non-visual access to print, whether through screen reader software, tactual means such as braille, or multi-modal combinations of access. Regarding screen reader access, there is a need for further research to identify evidence-based practices and interventions for efficient and targeted instruction. Several studies in the field of human-computer interaction can illustrate avenues for exploration. Buzzi et al. (2010) and Harshman et al. (2013) both offered examples of depicting diagrams, use transcripts, and schematics in a way that can help sighted researchers and practitioners understand the differences inherent in transposing visual content to print. Studies have drawn comparisons between control groups of visual and non-visual access (e.g., Craven and Brophy 2003, Sahib et al., 2012), while others highlight common frustrations experienced by screen reader users (Lazar, 2007). Researchers could use ethnographic methods such as video and screen recordings to develop case studies of the workflows of power users of screen reader software, potentially offering common attributes and practices of efficient access. Common, but different, screen reader software packages could be compared and contrasted, such as Job Access With Speech (JAWS), Non-Visual Desktop Access (NVDA), and VoiceOver. Focus groups of highly proficient users of each screen reader option could also be employed to further sketch out the details of proficient user experience to aid in developing best practices. Single subject research designs could be employed to demonstrate differences between potential instructional interventions and their effectiveness.

In addition to researching non-visual access through screen reader software to improve individual self-determination via competence, there is a need for research to further examine the influence of refreshable braille displays on autonomy, competence, & relatedness. The current study was limited by the age and size of the participants using refreshable braille displays. Now that it has been validated for use with a visually impaired sample, the TENS-Interface questionnaire could be used with both a larger and younger sample of braille display users. In this case, the items could use the phrase “your refreshable braille display” instead of “your computer from Computers for the Blind” as this study used. Additional items related to use with additional devices (e.g., computers, tablets, smartphone, or stand-alone note-taking capabilities) could clarify the impact of these devices on individuals' user experiences.

Researchers should investigate best practices in the interplay of multi-modal access in the completion of tasks. Combinations of screen-magnification software with screen reader software, or screen reader software with tactile options such as refreshable braille displays or touchscreen access offer individualized options for users that can ease transitions between methods of access while also reinforcing new learning and practice. Furthermore, research using menu-driven assistive technology software for older users who prefer a streamlined and simplified interface should be considered.

Finally, researchers should expand upon the current work done in the use of virtual communities of practice (CoPs) to strengthen and build relationships and technological repertoires for teachers of students with visual impairments (Siu & Presley, 2020). CoPs could serve to connect users of similar devices and software with one another, impacting members' feelings of competence and relatedness.

Ideally, these research recommendations would impact practice through the provision of increased understanding of complex workflows that may be counter-intuitive to visual users of technology. Practitioners can follow the three broad recommendations by taking several actions. Prioritizing training in screen reader skills would allow for an impact on self-determination via competence, as well as improved autonomy by offering additional experience with technology. Competence is an experiential phenomenon that is integrated within autonomy for individuals. Practitioners can further support competence through using multi-modal combinations of access, such as audio supported reading (ASR). Combining different access options allows for both exploration and reinforcement of skills and information. Finally, practitioners should support students' needs for relatedness during assistive technology instruction for individuals who are blind by through teaching skills involving email, social media, and connections to other blind individuals for trading tips and coaching. This could also take the form of a community of practice.

As practitioners are responsible for meeting students' instructional needs in the areas of the expanded core curriculum, leveraging technology in support of self-determination through the basic needs of competence, autonomy, and relatedness offers them a way to streamline the provision of services.

Summary

This study sought to expand current understanding by both examining user experience within a framing of the human-technology-world relation offered by post-phenomenology, and by exploring users' perceptions of self-determination within a positive technology framework. It examined how technology-mediated access and exchange of print affected blind individuals' self-determination from their own perspectives. Although there is still much to uncover regarding the whole story, this study illuminated avenues for further research and consideration. As a professional working in the fields of education and assistive technology for visually impaired individuals, my hope for my students is that our work together offers them a few more tools to use along the way of their personal journeys in life. Their stories are their own to write.

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Appendix A: Invitation, Consents, & Approval

Quantitative Phase Survey Cover Letter

Dear Participant,

I invite you to participate in a research study entitled "Beyond Access: Technology & Self-Determination for the Blind." I am currently enrolled in the doctoral program in Educational Sustainability at the University of Wisconsin-Stevens Point and am in the process of writing my doctoral dissertation. The purpose of the research is to determine how technology supports individuals in the areas of competence, autonomy, and relatedness, which are components of Self-Determination Theory. The questionnaire at the link below has been designed to collect information on how assistive technology (such as a computer with accessibility software from Computers for the Blind) can support individuals' self-determination.

Your participation in this research project is completely voluntary. You may decline altogether, or leave blank any questions you don't wish to answer. There are no known risks to participation beyond those encountered in everyday life. Your responses will remain anonymous and confidential; data will be compiled into groups and any individual quotes will be assigned a pseudonym. Data from this research will be kept under lock and key.

If you agree to participate in this project, please answer the questions on the questionnaire at the link below as best you can. It should take approximately 15 minutes to complete.

If you have any questions about this project, feel free to contact Belinda Rudinger, 940-595-0193, belinda.rudinger@uwsp.edu. Information on the rights of human subjects in research is available through UWSP's Institutional Review Board at 2100 Main Street Stevens Point, WI 54481; website: https://www.uwsp.edu/acadaff/orsp/Pages/What-is-IRB.aspx *(Anna Haines, IRB Chair, 715-346-2386, ahaines@uwsp.edu)*

Thank you for your assistance in this important endeavor.

Sincerely yours,

Belinda Rudinger,

University of Wisconsin-Stevens Point

Qualitative Phase Consent Letter

**Participants will receive either an electronic or brailled copy of this form. The letter will be read aloud in its entirety at the beginning of the interview session, and there will be a tactile marker indicating the location for a signature.*

Dear Participant,

I invite you to participate in a research study entitled "Beyond Access: Technology, Blindness, & Self-Determination." I am currently enrolled in the doctoral program in Educational Sustainability at the University of Wisconsin-Stevens Point and am in the process of writing my doctoral dissertation. The purpose of the research is to determine how technology supports individuals in the areas of competence, autonomy, and relatedness, which are components of self- determination theory. The questionnaire at the link below has been designed to collect information on how assistive technology (such as a computer with accessibility software from Computers for the Blind) supports individuals' self-determination.

Your participation in this research project is completely voluntary. There are no known risks to participation beyond those encountered in everyday life. Your responses will remain anonymous and confidential; any individual quotes will be assigned a pseudonym, and data from this research will be kept under lock and key.

If you consent to participate in this project, please sign at the tactile marker below:

** ____

If you have any questions about this project, feel free to contact Belinda Rudinger, 940-595-0193, belinda.rudinger@uwsp.edu. Information on the rights of human subjects in research is available through UWSP's Institutional Review Board at 2100 Main Street Stevens Point, WI 54481; website: https://www.uwsp.edu/acadaff/orsp/Pages/What-is-IRB.aspx *(Anna Haines, IRB Chair, 715-346-2386, ahaines@uwsp.edu)*

Thank you for your assistance in this important endeavor.

Sincerely yours,

Belinda Rudinger,

University of Wisconsin-Stevens Point

COMPUTERS FOR THE BLIND

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RICHARDSON, TEXAS 75081

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INFO@COMPUTERSFORTHEBLIND.NET

WWW.COMPUTERSFORTHEBLIND.NET

2/19/2019

Dear Ms. Rudinger,

Thank you for your interest in doing some research for Computers for the Blind. As I understand it, you will be submitting your proposed research project to your advisors for approval. I am in full support of this.

I believe you said that you will be developing a questionnaire to send out via email and that you would also be doing follow up interviews with some of the respondents that express willingness to do so.

I understand that the research is geared at helping us better understand how receiving computers from our organization has helped them or has not helped them and perhaps give us some quantitative data that we can use to improve our program. If this is the case, we are willing to be provide you with the names, email addresses, and phone numbers of our consumers, so long as you follow the policies and ethical practices of your institute and profession in dealing with confidentiality, etc.

I look forward to seeing the questions that you have developed and in providing you the information you require for the successful completion of our project.

Sincerely,

David L. Jeppson

David Jeppson

Executive Director

Computers for the Blind

214-293-8819

4/30/19

Principal Investigator: Kym Buchanan
Protocol Number: 2019-19-04-15
Protocol Title: Beyond Access: Technology, Blindness & Self-Determination
Protocol Approval Date: 4/15/19
Protocol Expiration Date: 4/14/20
Review Category: Full Board Review
UWSP FWA: 00017591

Dear Dr. Buchanan:

The above-referenced human-subjects research project has been approved by the University of Wisconsin-Stevens Point Institutional Review Board (IRB) Committee. This approval is limited to the activities described in the approved protocol, and extends to the performance of these activities at each applicable sited identified in the application for IRB review. In accordance with this approval, the specific conditions for the conduct of this research are listed below, and informed consent from subjects must be obtained as indicated. Additional conditions for the general conduct of human-subjects research may be detailed below.

Additional Conditions:

All individuals engaged in human-subjects research are responsible for compliance with all applicable UWSP Research Policies. The Principal Investigator is responsible for assuring all protocol personnel review and adhere to applicable policies for the conduct of human-subjects research.

The IRB maintains an official protocol file for each study to meet the University's regulatory obligations for record keeping. Principal Investigators are responsible for maintaining all records related to the protocol, and are required to share with the IRB. The IRB is not responsible for maintaining study documents for researchers.

Your project approval expiration date is listed above. As a courtesy, approximately 30 and 60 days prior to the expiration of this approval, IRB Administration will notify you via e-mail reminding you to apply for continuing review. It is your responsibility to apply for continuing review and receive continuing approval for the duration of the study. Lapses in approval should be avoided to protect the safety and welfare of enrolled subjects. When you plan to close your study, submit a Protocol Closure Form to irbchair@uwsp.edu.

No changes are to be made to the approved protocol or study documents (i.e., consent forms, surveys, etc.…) without prior review and approval of the IRB. To modify an existing protocol, complete the Protocol Modification Form and submit to irbchair@uwsp.edu.

If there are any injuries, problems, or complaints from participants, you must notify the IRB at irbchair@uwsp.edu within 24 hours.

If you have any questions, please contact me. Good luck with your project.

Sincerely,

Anna Haines

Anna Haines, Ph.D.
IRB Chair ahaines@uwsp.edu 715-346-2368

Appendix B: Instrument & Protocol

Technology-based Experience of Need Satisfaction – Interface questionnaire

Administration Guidelines:

• Respondents typically rate their level of agreement to each item using a five-point Likert-type scale (1= *Do Not Agree*, 5 = *Strongly Agree*);

• All items are weighted equally in scoring;

• Items are randomized in their order when presented to participants;

• Reverse-scored items are indicated by "(-)";

• Questions are framed by the following stem:

"Reflect on your experience using the technology and rate your agreement with the following statements:" in which "the technology" can be replaced by a more specific name (e.g. "the app" or "Fitness Pal") OR a specific interface component being assessed (e.g. "the community forum", "the video conferencing tool") throughout the questionnaire.

Competence

1. I feel very capable and effective at using the technology.
2. I feel confident in my ability to use the technology.
3. Learning how to use the technology was difficult. (-)
4. I found the interface and controls confusing. (-)
5. It wasn't easy to use this technology. (-)

Autonomy

6. The technology provides me with useful options and choices
7. I can get the technology to do the things I want it to.
8. I feel pressured by the technology. (-)
9. The technology feels intrusive (-)
10. The technology feels controlling. (-)

Relatedness

11. The technology helps me to form or sustain relationships that are fulfilling.

12. The technology helps me to feel part of a larger community.

13. The technology makes me feel connected to other people.

14. I don’t feel close to other users of the technology. (-)

15. The technology doesn’t support meaningful connections to others. (-)

1. Dear Participant,

I invite you to participate in a research study entitled “Beyond Access: Technology, Blindness, & Self-Determination.” I am currently enrolled in the doctoral program in Educational Sustainability at the University of Wisconsin-Stevens Point and am in the process of writing my doctoral dissertation. The purpose of the research is to determine how technology supports individuals in the areas of competence, autonomy, and relatedness, which are components of self- determination theory. This survey has been designed to collect information on how assistive technology (such as a computer with accessibility software from Computers for the Blind) can support individuals’ self-determination. Your participation in this research project is completely voluntary. You may decline altogether, or leave blank any questions you don’t wish to answer. There are no known risks to participation beyond those encountered in everyday life. Your responses will remain anonymous and confidential; data will be compiled into groups and any individual quotes will be assigned a pseudonym. Data from this research will be kept under lock and key. Please indicate your consent by selecting the appropriate option below:

Yes, I consent to participate in this study.

No, I do not consent to participate in this study.

2. What is your age?

- 18-25
- 25-30
- 30-40
- 40-50
- 50-60
- 60+

3. What is your gender? ______________

4. Select all of the following statements that apply to you:

- I live alone
- I live with children
- I live with parents/guardians, siblings, or other family
- I live with my significant other
- I live with a friend
- I am in a long-distance/online relationship

5. Select all of the following statements that apply to you:

- I work/volunteer from home
- I work/volunteer outside the home
- I attend university or college classes in person
- I attend university or college classes online

6. What category best describes your level of vision with best correction?

Low Vision (20/70-20/199)

Legally Blind (20/200 or worse)

Counts Fingers, Hand Motion, Light Perception, or No Light Perception

7. How do you typically access electronic information?

I use visual strategies

I use tactile strategies

I use auditory strategies

8. Which of the following describes your braille use:

I do not use braille

I read braille and I use a refreshable braille display with my computer

I read braille, but I do not use a refreshable braille display with my computer

9. Before receiving this computer from Computers for the Blind, did you have prior experience with computer use and accessibility software?

YES, a lot of experience

YES, some experience

NO, no experience

10. How would you rate your screen-reader proficiency?

I do not use a screen reader

Beginner (“I’m still new to using a screen reader”)

Intermediate (“I’m not a beginner, but I still have a lot to learn”)

Advanced (“I got this”)

[TENS-Interface questions: Q11-Q25]

26. What resources have helped you with your current level of technical proficiency? (Choose all that apply)

I received formal training before graduating high school

I received formal training after graduating high school

I participated in extracurricular or summer experiences (e.g., camps)

A friend coached me

A family member coached me

A significant other coached me

I traded tips with fellow users of devices or software

I used online resources (e.g., forums)

I used technical support (e.g., manuals, phone call, store employee)

I used online handouts

I enjoy messing around until I figure it out

27. Which of the following options do you use on your computer on a daily basis?

Email

Online chat/Instant Messaging

Social media (Facebook, Twitter, Instagram, etc.)

Forums (Reddit, etc.)

YouTube

Video calling applications (Skype, Google Hangouts, Zoom)

28. Consider a typical day. How often do you use your computer for work, education, or personal use?

28a Work

Rarely or Never

Less than 1 hour/day

Between 1-5 hours/day

More than 5 hours/day

28b Education

Rarely or Never

Less than 1 hour/day

Between 1-5 hours/day

More than 5 hours/day

28c Personal use

Rarely or Never

Less than 1 hour/day

Between 1-5 hours/day

More than 5 hours/day

29. Which devices do you use in addition to your computer (select all that apply):

Smartphone

Tablet

Refreshable braille display

Braille notetaking device

Other: ___________________

30. Select all of the following statements that apply to you:

I access the internet with my computer

I shop online with my computer

I pay bills online with my computer

I write résumés with my computer

I apply for jobs with my computer

I use my computer at work

I use my computer for self-employment

I use my computer to communicate with friends and family

I use my computer for recreation (e.g., games, entertainment, etc.)

I use my computer for socializing (e.g., Facebook, other social media)

31a. Which of the following issues have you experienced with your computer (select all that apply):

Hardware problems: ___________________

Software problems: ___________________

Usability problems with specific applications or programs: _________________

Accessibility problems with specific websites: __________________

Other: ____________________________

31b. How would you rate your level of satisfaction with the computer you received from Computers for the Blind on a scale from 1 to 5, with 1 as the lowest rating and 5 as the highest rating?

31c. If you live in the state of Texas, and are willing to participate in a follow up interview, please type in your first name and last initial here: __________________________

Qualitative Interview & Observation Protocol

Scripted Introduction

Good morning/afternoon/evening. Thank you so much for taking the time to meet, and for offering me the opportunity to interview you. You might remember from the survey that my research involves technology and self-determination. This is an exploratory study, which means that there are no “right or wrong” answers. I’m just interested in gaining a glimpse of what technology means to you and how you use it. Before we begin, I’ll share a little with you about what technology means to me. My mother was a computer programmer, and my twin brother (who has Asperger Syndrome), always loved technology. Compared to them, I was the non-techie of the family, but I saw first-hand what a difference it made to my brother and how it opened up his world. As an adult, I have worked as a special education teacher with students who have autism, dyslexia, multiple disabilities, or visual impairments. My career later evolved into consulting with teachers and parents about assistive technology specific to visual impairment. Personally and professionally, I have noticed how we all bring different attitudes, experiences, and preferences to our use of technology. To me, technology will always mean love, family, and connection; today, I’d like to find out a little more about what it might mean to *you.*

Present

How do you use your computer, personally and professionally?

Would you show me a few examples and talk me through your process?

Personal Use

Professional Use

Tasks Demonstrated

Think Aloud Comments

Past

When did you get your first computer?

How did you learn to use it?

How have things changed from your first computer to your current computer?

First Computer;

Learning;

Changes.

Future

What technological advances interest you?

What do you wish you could do with a computer in the future?

Advances:

Wishes:

Appendix C. Codebook

Codes	Sub-Codes			
Competence: 1	Effective task execution: 1	Feeling confident: 2	Problem-solving: 3	Variety of tasks: 4
Autonomy: 2	Flexibility: 1	Control: 2	Independence: 3	Goals/Values: 4
Relatedness: 3	Friends: 1	Family: 2	Connection: 3	Other blind individuals: 4
Technological mediation	Amplify: 1	Reduce: 2	Invite: 3	Inhibit: 4
Emergent Themes	:1	:2	:3	:4

Definitions

Competence: user feels able and effective

Effective task execution: completing a task without problems or interruptions

Feeling confident: expressing self-confidence in ability to complete tasks

Problem-solving: user employs workarounds to fix a problem or finds another way to complete task

Variety of tasks: user can competently execute at least 3 different tasks

Autonomy: user feels agency, acting in accordance with one's goals and values

Flexibility: user has more than one option in a given situation

Control: user can direct actions and make choices

Independence: user can take action without depending on others for help

Goals/Values: user identifies values or goals and technology aids in pursuit

Relatedness: user feels connected to others, has a sense of belonging

Friends: user mentions friends in relation to technology use.

Family: user mentions family in relation to technology use

Connection: user mentions feeling connected or a sense of belonging to a community

Other blind individuals: user mentions relating to other people who or blind or have low vision

Technological Mediation

Amplify: user mentions an increase in perception/experience related to technology

Reduce: user mentions a decrease in perception/experience related to technology

Invite: user refers to an action afforded by technology

Inhibit: user refers to an action inhibited by technology