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PRESENTS:

IMPROVING MOBILE APPLICATIONS FOR LIMITED MOBILITY ACCESS AND NAVIGATION IN THE U.S.

Design-Thinking Methods and Solutions to the Problem

RADFORD UNIVERSITY
DEPARTMENT OF DESIGN

AUTHOR NOTES

A final research project submitted to the faculty of Radford University in partial fulfillment of the requirements for the degree of Master of Fine Arts in the Department of Design.

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TITLE PAGE

IMPROVING MOBILE APPLICATIONS FOR LIMITED MOBILITY ACCESS AND NAVIGATION IN THE U.S.

By

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A thesis submitted to the faculty of Radford University
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ABSTRACT

According to the World Health Organization, over a billion people, about 15% of the world's population, have some form of disability. People who have limited mobility, and are often classified as disabled, are unfortunately still faced with a number of physical barriers that prevent them from using public spaces. The purpose of this study was to understand the experiences that the limited mobility disabled community face while navigating both rural and metropolitan areas when using assistive mobile applications and to provide suggestions to improve these existing applications. Design-thinking methods were used to help implement the research process including: system usability scale (online questionnaire), walk-a-mile, video journaling, and think-aloud testing. Assistive navigation apps yielded truly important understandings about user experiences, as the study clearly showed. It was found, through a System Usability Scale (SUS) survey of 51 participants, that while apps such as Google Maps enjoyed common use, subtle accessibility challenges were often unaddressed. Inaccurate GPS positioning, an important lack of real-time updates, along with severely limited usability in rural areas, were among the commonly encountered problems. Participants drew attention to a need for importantly greater accuracy, more user-driven content, along with larger coverage of smaller towns as well as rural areas, in spite of mostly favorable ease-of-use, and integration ratings. Poor infrastructure in rural areas, along

with the lack of real-time feedback mechanisms in mobile apps, were discovered during the Walk-a-Mile video immersion as additional barriers. App limitations became strikingly more apparent due to severely difficult weather conditions, uneven terrains, along with temporary barriers such as pandemic-related restrictions. Adaptive design, dynamic updates, and improved reporting systems are absolutely critical, as reflections clearly showed, for supporting the diverse needs of mobility. Improved app functionality urgently needs development to help users with disabilities gain more independence as well as accessibility.

Kallie J. Nielsen, M.F.A
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Acknowledgement Page

To all the people out there told that they were too disabled, weak, or not qualified enough to accomplish a task, I dedicate my final research project to you.

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INTRODUCTION

In 2022, there were 331,940,000 people in the United States (U.S.) and of these people, 46,227,000 were disabled (Houtenville & Boege, 2024, p. 9). In other words, people with disabilities comprised 13.9% of the U.S. population (Houtenville & Boege, 2024, p. 9) (see Figure 1). Alison Kafer once said,

Table 1. Number and Percentage with Disabilities

Year	Total Population Estimate (#)	Pop. w/Disabilities Estimate (#)	Percent with Disabilities	
			Estimate (%)	St. Error (%)
2008	302,819,000	38,560,000	12.7‡	0.03
2009	305,701,000	38,583,000	12.6†‡	0.02
2010	308,291,000	38,463,000	12.5†‡	0.02
2011	310,572,000	39,383,000	12.7†‡	0.02
2012	312,873,000	39,710,000	12.7‡	0.02
2013	315,143,000	41,242,000	13.1†‡	0.03
2014	317,861,000	41,827,000	13.2†‡	0.03
2015	320,399,000	42,050,000	13.1†‡	0.02
2016	322,110,000	42,940,000	13.3†‡	0.02
2017	324,689,000	42,776,000	13.2†‡	0.02
2018	326,155,000	42,630,000	13.1†‡	0.02
2019	327,011,000	43,227,000	13.2†‡	0.03
2020	328,242,000	44,061,000	13.4×	0.01
2021	330,562,000	44,482,000	13.5‡	0.02
2022	331,940,000	46,227,000	13.9†	0.03

Source: Authors' estimates from using the 2008-2022 ACSs for civilian respondents of all ages.
×No tests conducted with 2020 data.
†Significantly different from the previous year at the 95 percent confidence level and a one-tailed test.
‡Significantly different from 2022 at the 95 percent confidence and a one-tailed test.

Figure 1 *- Annual Report on People with Disabilities in America (data taken from Houtenville & Boege, 2024, p. 9)*

> "The value of a future that includes disabled people goes unrecognized, while the value of a disability-free future is seen as self-evident, often because the political nature of disability namely its position as a category to be contested and debated goes unacknowledged" as cited in Hamraie (2017, p. 25).

For centuries we have tried to cure disabilities and have shamed people for having them. But the world needs to recognize that the future will always hold some form of disability (Hamraie, 2017, pp. 259-260). That is why we need design for a better future (Hamraie, 2017, p. 234).

While advances in technology have occurred that celebrate disability (e.g., fashionable glasses, elevators, etc.), access to roads, sidewalks, transportation, and old buildings remain dated (American Society of Landscape Architects (ASLA), n.d.). By law, the Americans with Disabilities Act (ADA) says that businesses – such as public accommodation, public transportation, employment, state, and local government services – are required to accommodate the disabled (What is the Americans with

Disabilities Act? n.d., para. 1). Yet, even with the development and establishment of the Americans with Disabilities Act (ADA), there is still a lack of innovation in navigation for the disabled limited mobility users when traveling throughout the U.S (Arroyo, 2018, para. 3-5; U.S. Department of Transportation, n.d.). It is of grave inconvenience for someone with a disability to try to travel to a new location or visit a nearby city that they are unfamiliar of. Often there is no pre-warning to an individual who is disabled of the un-accommodation for their disability (Park & Chowdhury, 2018, p. 361). This wicked problem could be solved through the use of big data collection and crowdsourced information input through an online application or assistive technological devices to help with the navigation of the disabled individual.

This idea and concept that the public needs to spend less time speculating on how and why architects and designers have arrived at the standards that are in place, and put more time and focus into changing the world around us is the focus. If we as designers spent more time focusing on the person for whom we are designing for and less about trying to meet the needs of the masses, we could, in turn, learn to discover a better design overall (Guffey, 2018, p. 132).

The advent of the smart phone has allowed those with disabilities to access a host of navigation apps advertised to provide accessible routes and spaces. While this invention is paramount, how well these apps perform for those who have limited mobility is not extensively known. To illustrate, Apostolidou and Fokaides (2023) found 25 apps focused on enabling accessibility for those who are disabled in buildings; yet, testing these apps was not conducted. Further, examining navigation outside of buildings was not considered in these investigations.

During this process, the student researcher hoped to further the educational knowledge of the lack of current disability access in the United States among current technologies, and how design-thinking solutions using

crowdsourced big data application techniques and combining software could improve the navigational abilities of the limited mobility disabled community.

DEFINITION OF TERMS

Access

A means of approaching a direction or place. The right or opportunity to use or benefit from something (Guffey, 2018).

Accommodation

An adjustment or modification of the environment or situation; Often done to help remove barriers in the workplace, a persons' environment, or uncomfortable situation. This adjustment is to help individuals find a more reasonable and comfortable modification that would be deemed unfit to what would be normally acceptable (Guffey, 2018).

Affinity Clustering

Human centered design-thinking research understanding method used as a graphic technique for sorting items according to similarity (Luma Institute, 2012).

Americans with Disabilities Act (ADA)

The ADA is a United States piece of legislation signed into law on July 26, 1990, that prohibits discrimination and guarantees that people with disabilities have the same opportunities as everyone else. These include employment, to purchase goods and services, participation in state and local programs and services (Hamraie, 2017).

Assistive Mobile Applications

Programs that improve the accessibility of a device or technology for individuals with limited mobility access or disability (Australian Human Rights Commission, 2018, p. 41).

Assistive Technologies

Assistive, adaptive, and rehabilitative devices (Pullin, 2009); technology that is specifically designed to support a person with a disability to perform a task (Australian Human Rights Commission, 2018, p. 41).

Barrier

Factors in a person's environment that, through their absence or presence, limit functioning and create disability (Guffey, 2018).

Big Data Application

The large volume of data – both structured and unstructured – collected through mobile or computer application that inundates a business, person, or group on a day-to-day basis. This data can be analyzed for insights which lead to better strategic designs and technological developments (Jeble et al., 2018).

Crowdsourced Data Collection

Data collected through a means of large crowds voluntarily inputted via means of mobile or computer applications. This data is collected and could help to improve the overall wellbeing of the general public and the data collected is done through the means, awareness, and understanding of the public through big data approval (Kraemer et al., 2017).

Design Thinking

An interdisciplinary methodology to advance empathy-based solutions to seemingly unsolvable or complex problems. Design thinking involves a series of steps to actively look at the problems through evaluative research, understanding the problem through a system of problem framing, and finally by making concept ideation through design rational while working toward innovative solutions.

Disability

An evolving concept that results from the interaction between persons with impairments an attitudinal and environmental barrier that hinders their full and effective participation in society on an equal basis with others (United Nations, 2006).

Empathy

The art of stepping imaginatively into the shoes of another person, understanding their feelings and perspectives, and using that understanding to guide your actions (Krznaric, 2014).

Fly-on-the-Wall Observation

Human centered, design-thinking, research looking method used as an approach to conducing field research in an unobtrusive manner. This method allows the researcher to immerse themselves in the environment unnoticed to the observer in order to gather more research information (Luma Institute, 2012).

International Symbol of Accessibility (ISA)

A symbol developed to internationally represent the disabled community. This symbol is used to designate the disabled as well as disabled accessible devices, paths, restrooms, parking, and designated locations (Guffey, 2018).

Likert Scale Survey

Is a rating scale, often found on survey forms, that measures how people feel about something. It includes a series of questions that you ask people to answer and ideally 5-7 balanced responses people can choose from (Luma Institute, 2012).

Limited Mobility

Limited mobility refers to disabled individuals who have limited range of movement for their lower extremities and require the use of assistive devices such as wheelchairs, scooters, canes, or walkers either part-time or full-time. Limited Mobility is also known as a mobility impairment that can cause a restricted range of motions due to a number of factors such as disease, an accident, congenital disorder, and may also be the result from neuro-muscular and orthopedic impairments (Disabled World, 2019).

Misfit

A term used to define a person who does not fit the normal physical or mental status perceived by the public. This can be used to describe both the disabled and non-disabled in certain situations (Guffey, 2018).

Navigation

The process or activity of accurately ascertaining one's location and actively planning a trip or destination without any errors or re-routing along the path (Oxford English Dictionary, 2018.)

Video Journaling

Video journaling is defined as a reflective practice that allows individuals to document their thoughts, experiences, and emotions through video recordings. It facilitates deeper metacognition by combining verbal reflection and development (Schalow, 2015).

Person with Disabilities

Those who have long-term physical, mental, intellectual, or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others (United Nations, 2016). Some organizations like the American Psychological Association prefer person-first language where the person is put before the disability such as a person with a disability. Other organizations such as the National Federation of the Blind use identity-first language such as disabled person (Jajou, 2024). Both forms of language are used in this research project.

Public Transportation

Buses, trains, subways, planes, and other forms of transportation that charge set fares, run on fixed routes, and are made available to the public (English Oxford Dictionary, 2018).

Rural Area

In the United States, settlements with 2,500 inhabitants or less are defined as rural. Rural areas, often called “the country”, have low population density and large amounts of undeveloped land. Rural areas are the opposite of urban areas (Dunn, 1993).

System Usability Scale (SUS)

A short survey for quantifying feedback from subjective assessments of usability (often used is the SUS Likert Scale Survey) (Luma Institute, 2012). For this final project research, an online questionnaire was used that was developed by the student researcher. Online questionnaire and system usability scale are used interchangeably in this paper.

Think-Aloud Testing

A testing format where people narrate their experience while performing a given task (Luma Institute, 2012).

Urban Area

The urban area is the region surrounding a city. Settlements with 2,500 inhabitants or more are defined as urban. "Urban area" can refer to towns, cities, and suburbs. Many urban areas are called metropolitan areas, or "greater," as in Greater New York or Greater London (Dunn, 1993).

Walk a Mile

A way of building empathy for people through firsthand experience research (Luma Institute, 2012).

LITERATURE REVIEW

THE CURRENT PROBLEM

It is true that now, more than any generation before, we have more access to information and navigation via the internet (Jiang, 2018, para. 1-4). Unfortunately, most of the U.S. is not as adequately equipped with the proper information to help a disabled person navigate a city by themselves (Institute for Transportation and Development Policy, 2022; Rosenbloom, 2007, p. 519). An excellent example of this is New York City, which unfortunately had much of its iconic infrastructure built before anyone could consider the needs of the disabled (Arroyo, 2018, para. 4). Even though some builders follow the rules and guidelines set by the ADA, there are still instances where building owners or managers – who believe the ADA only applies to new construction or alterations – believe that their building does not need to be made accessible (Guffey, 2018, pp. 156-157; Riley, 2016, para. 1).

Often disabled individuals cannot access certain roads, transportation, or buildings because they have not been properly retrofitted with correct ramps or technology to allow entry. To illustrate, automatic wheelchairs will not fit inside older style buildings or museums (see Figure 2) even though these establishments claim they have made the limited necessary alterations to the property. This problem may cause the disabled individual to turn around and go home, which can put a damper on both the intended business, tourism, and the spirits of the disabled

Figure 2 *- Disabled individual dealing with environmental barriers in public.*

individual (Cavinato & Cuckovich, 1992, p. 46). The same can be said for navigating the busy streets of an unfamiliar city. The disabled population often wants or needs to know where the ramps, curb dips, street crossings, construction, benches, clean water fountains, and accessible bathrooms are located (Cavinato & Cuckovich, 1992, p. 51; Inclusive City Maker, n.d.; TechBullion, n.d.). However, there is limited literature concerning this journey which investigates the different barriers for which a person might experience or perceive (Park & Chowdhury, 2018, p. 362).

PERCEPTIONS OF CURRENT SITUATIONS

Guaranteeing accessibility is an area where more progress still needs to be made. Laws have been adopted, strategic documents formulated, and international conventions ratified, but the level of practical application has remained low (Kerbler, 2012, p. 238). Due to a growing awareness of these issues, there has been a noticeable increase in the number of researchers and other experts engaged in this field (p. 236).

According to a review done by June Park and Subeh Chowdhur for the *Journal of Transport and Health*, it is evident that people with physical impairments face many barriers when traveling independently by public transport (2018, p. 363).

CURRENT EFFECTS OF THE SITUATIONS ON THE DISABLED

Missed Opportunities

There are opportunities that disabled individuals often have to give up or turn down because of the physical or mental obstacles for which they are not able to overcome (Lindsay et al., 2024). For example, Dayniah Manderson – a 38-year-old veteran public school educator and single mother (see Figure 3 on next page) – was discriminated upon and disqualified for a position because of her disability even though she was the most qualified candidate. Manderson is quoted in a USA Today article saying, "It is disheartening to see how the future is totally at the mercy of individuals who might have their own mistaken assumptions about people with disabilities" (Manderson, 2018, para. 15). Manderson also said despite her professional qualifications, there have been some programs she is unable to take full advantage of because of lack of disability access. Issues such as front door and bathroom access are still a problem today. Unfortunately, she is not the only person to experience this type of discrimination and lack of appropriate accommodation (Pappas, 2020, p 38).

HISTORY THAT HAS PAVED THE WAY FOR THE FUTURE

Establishment of the ADA

In the 1990s with the establishment of the Americans with Disabilities Act (ADA), many disgruntled cities, government officials, builders, and architects resisted or refused to comply with the newly established rules that the ADA and disabled civil right activists fought for (Hamraie, 2017, pp. 1-3). The massive retrofitting and alterations that often historical buildings undergo proved to be an uphill battle for the next couple of decades. It was also a time when architects and designers felt limited due to the additional rules and guidelines to follow. Instead of embracing this change, often they resisted and

went against the rules (p. 199). Disability law scholars and policymakers have documented the ADA's failures to improve access to employment, transportation, and public spaces, attributing these limitations to the law's limited provisions and inability to address structural, systemic, and attitudinal discriminations that disabled people face (p. 3).

International Symbol of Accessibility

Figure 3 *- Rehabilitation International's new wheelchair symbol as the new symbol of access (Guffey E, Designing Disability, 2018, p. 135)*

The development of the International Symbol of Access actually predates the ADA and much of the design credit goes to Susanne Koefoed (Guffey, 2018, p. 122) (see Figure 4). Although her original design did not include the round dot, which represents the head of the figure – which would later turn the chair into a figure – she did come up with the overall basics of the original design (p. 122). Her design was presented alongside others and was chosen during the 1969 Dublin conference hosted by the International Commission for Technical Aids (ICTA), an authorized committee within the Rehabilitation International (RI) (pp. 122-123). However, the ICTA committee expressed their concerns about her design being too abstract (p. 123). The committee chair, Karl Montan, suggested that a head be added to the symbol, which transformed the shape into a figure (p. 131). The armrest becomes the arm, the footrest becomes the foot, and the backrest becomes

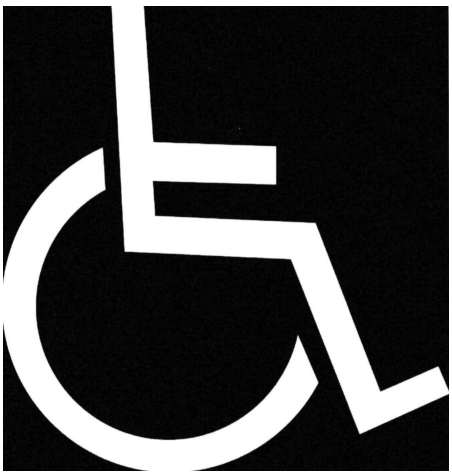


Figure 4 *- Access Symbol created by Susanne Koefoed 1968 (Gffey, E. Designing Disability, 2018, p. 122)*

the back of the figure. Even though the simplistic line of the form was still modern, they humanized the figure and together the two created what is recognized today as the International Symbol of Access (ISA) (see Figure 3 on previous page). This symbol was widely marketed and distributed among hospitals, organizations, and countries to be established as the ISA (Guffey, 2018, p. 135).

Curb Cuts

Passage of the ADA and design of the ISA are holistic U.S. guidelines that entailed a number of grass root initiatives such as curb cuts. Alterations to something that seems so mundane such as a declined curb was something that had to be fought for. Disabled civil right activists fought for accessibility during the 1970s (Hamraie, 2017, p. 98). Such a colorful picture is painted about this time in Sonny Kleinfield's book "The Hidden Minority: American's Handicapped" about the so-called "crip mecca" that was Berkeley University (Kleinfield, 1979, pp. 67-78) (see Figure 5). Originally it seemed like such an ordeal to create a curb incline, by having to break up the concrete and fix the road. The initial curb cut of the late 1960s at Berkley was just the beginning of the struggle between the public and the government push (Hamraie, 2017, p. 98). The first curb cut was not placed on the corner like they are today, but instead, placed up the street where traffic was not so busy. Patrick Connally – a well-known artist and activist within the disability's rights community - who was present on campus at Berkeley at the time and a friend of Ed Robert and others during Berkeley's Independent Living movement, said they put the first

Figure 5 *- The First Curb Cuts by Patrick William Connally, The Berkeley Revolution Archive*

curb cut up the street from the corner but at a location that was less visible to motorist and much more dangerous. But at the time it sure beat rolling halfway around the block in search of a driveway (Connally, 1990, para. 2). Even though funding was allocated, the installation of ramps and cuts on pre-existing curbs were slow. Members from the Center for Independent Living (CIL) used asphalt to pave some of their own curbs as they waited for the city to complete the job (Hamraie, 2017, p. 95). Another grass-root approach that was often taken by disabled students was the addition of custom-built ramps over stairs so that students could access their classrooms (Guffey, 2018, p. 54).

The Internet and the Smartphone had a Baby called Apps

After the establishment of the ADA in the '90s, the U.S. along with the rest of the world began the booming movement known today as the technological era. With this boom in technology and the creation of new assistive devices, the internet and telephone would help to pave the way for future innovation in assistive mobile technology.

The internet was invented through the work of dozens of pioneering scientists, programmers, and engineers who each developed new features and technologies that eventually merged into what we know today as the "information superhighway" (Andrew, 2013, para. 1). The Web as the public would come to recognize it took its online form and debuted when computer scientist Tim Berners-Lee invented the World Wide Web in 1990 (para. 3). Often confused with the internet itself, the web is just the most common means of accessing data online in the form of websites and hyperlinks (para. 1).

Not long after that came the first smartphone. People did not start using the term smartphone until around 1995, but the first smartphone was called the Simon Personal Communicator and it was created by IBM in 1992 (see Figure 6) (Tweedie, 2015, para. 1-2). It was the first combination of a cellphone and Personal Digital Assistant (PDA) (para. 3). This phone did not quite have the capabilities of what we classify as a smartphone today, but it paved the way for innovation. It even had its own built-in applications including calendar, world clock, note pad, calculator, and more.

Figure 6 *- Simon Personal Communicator, the first PDA phone created by IBM in 1992. (seen on the left) and the first-generation iPhone created by Apple in 2007 (seen on the right)*

Mobile applications boomed in 2007 when Apple created the first iPhone (Jones, 2014, para. 7) (see Figure 7). Now the world was able to take their internet, calls, emails, and maps on the go (para. 1-4). It was with this final combination that smart technology was in effect and the technological age was booming with excitement. Ever since the development of the iPhone and applications, designers have been running wild with application development for just about

Figure 7 *- The first iPhone featuring their advertising catchphrase for the phone's release "There's an App for That"*

anything and everything you could imagine.

CURRENT CHANGES IN EFFECT

The United Nations Conventions on the Rights of Persons with Disabilities 2006

Although the ADA was a breakthrough for the United States, the United Nations and Europe progressed much better in the accommodation for the disabled individual. The United Nations Conventions on the Rights of Persons with Disabilities trails decades of labor by the United Nations to modify attitudes and approaches to persons with disabilities (United Nations CRPD, 2006, para. 1). The Convention on the Rights of Persons with Disabilities and its Optional Protocol was adopted on December 13, 2006, at the United Nations Headquarters in New York and was open for signatures on March 30, 2007 (para. 1). This convention is the first comprehensive human rights treaty of the 21st century (para. 1). With the support of 82 signatures of the convention, 44 signatures to the optional protocol, and one ratification, the Convention entered into force on May 3, 2008 (para. 1). This convention was about rectifying the previous rules that were established about accommodating a person with a disability, which stated that countries should initiate measures to remove barriers to participation in the physical environment (Kerbler, 2012, p. 237). The new set of established rules would make it so that all people around the world with and without disabilities are treated equally (United Nations Children's Fund, 2008, p. 7) (see Figure 8). All types of disability would be recognized, not just physical

Figure 8 *- Disability is diverse flag representing everyone*

limitations but also sensory, auditory, and visual accommodations as well (Kerbler, 2012, p. 251; United Nations CRPD, n.d.). This can also include access to information such as websites as well (Kerbler, 2012, p. 244).

In 2008 – after the UN convention went into effect – the U.S. Americans with Disabilities Act Amendments Act (ADAAA) was signed into law and became effective on January 1, 2009. This act included the changes in the definition of disability as well as applied the changes of the ADAAA to the previous ADA. This included enforcing private businesses to accommodate people with disabilities as well as requiring public accommodations to remove barriers from existing buildings (ADA National Network, n.d.).

Removing Barriers at Conferences for Disabled Scholars

The act of removing barriers for individuals with disabilities has been the focus of the past two decades in the U.S. with the establishment and updated ADAAA. However, as often when it comes to temporary events – such as concerts, conventions, and conferences – making accommodations and modifications for the disabled individual comes as a last idea or resort (Whaley et al., 2024). In the past few years, there has been some improvement in removing barriers to participation for disabled scholars at conferences (Perry, 2015, para. 7) (Figure 9). Often barriers to participation for disabled scholars within the realms of a conference are likely not even visible to conference organizers (Daniel, 2023, p. 15; Perry, 2005, para. 1 and 3). The core problem is that conferences involve a set of activities that most

Figure 9 *- Wheelchair user at conference*

academics take for granted and feel are mandatory to the enterprise. Going from place to place, and often having to learn how to navigate and move quickly from location to location, is an instance where it would be difficult for someone with a vision impairment, mobility issue, or other disability to navigate (Perry, 2015, para. 4). Every one of the average activities at conferences – often listening to lectures, social networking, navigating for food, hotel, bathrooms, etc.– is a potential barrier and accessibility challenge (2015, para. 4).

Two of the suggestions that David Perry makes in his article, "Removing the Barriers to Participation for Disabled Scholars" are to make accessibility a known priority of the conference as well as to listen when disabled people tell you what they need (Perry, 2015, para. 19). It can honestly be that simple. When you show that you are willing to put forth the effort to make the change and recognize that people are going to need accommodations, often that is all that it takes to make it work.

Assistive Technologies

The invention of the internet, mobile applications, and motorized scooters are a few examples of how certain assistive technologies have helped create more independence for those who are disabled individuals with limited mobility. For example, people used to solely require others to push their wheelchair – or have some assistance with certain tasks – can now have mobility freedom with the motorized wheelchairs and scooters (Thoreau, 2015, pp. 269-275) (see Figure 10). In association with this independence, a great deal of disabled individuals use public transportation or a means of self-transportation

Figure 10 *- Disabled individual using a motorized wheelchair*

to get to their destinations (Thoreau, 2015, pp. 269-275). With this being said, the individual often has to do extensive research before venturing somewhere new to know if they will be accommodated for their disability or mobility impairment along the way and at their location. Often some individuals expect that with such rules in place – as with the establishment of the ADA – that businesses, transportation, and streets will be required to create accessible access. Unfortunately, that is often not the case and the disabled may have to give up their travels, destinations, or seek complex alternative routes (Ashford, 2022; Herbst, 2024).

With the addition of newer technology such as mobile devices, there have been numerous amounts of assistive technology programs added to the Android and Apple App Store for disabled users to download to their mobile devices. These assistive applications can help with a wide array of disabilities including auditory, sensory, visual, mobility, and more (UKS Mobility.com ltd, 2015).

Important challenges in AI's role for accessibility have drawn attention during recent discussions. These challenges include inaccuracies in AI-generated outputs such as alternative text and captions along with biases stemming from ableist training data. Integrating human oversight, leveraging truly all-embracing datasets, as well as adhering to strictly moral AI Practices, importantly zeroes in on the role these elements play in guaranteeing accessibility technologies effectively meet the vastly diverse needs of people with disabilities (Funk, 2024).

CURRENT SOLUTIONS TO THE PROBLEM

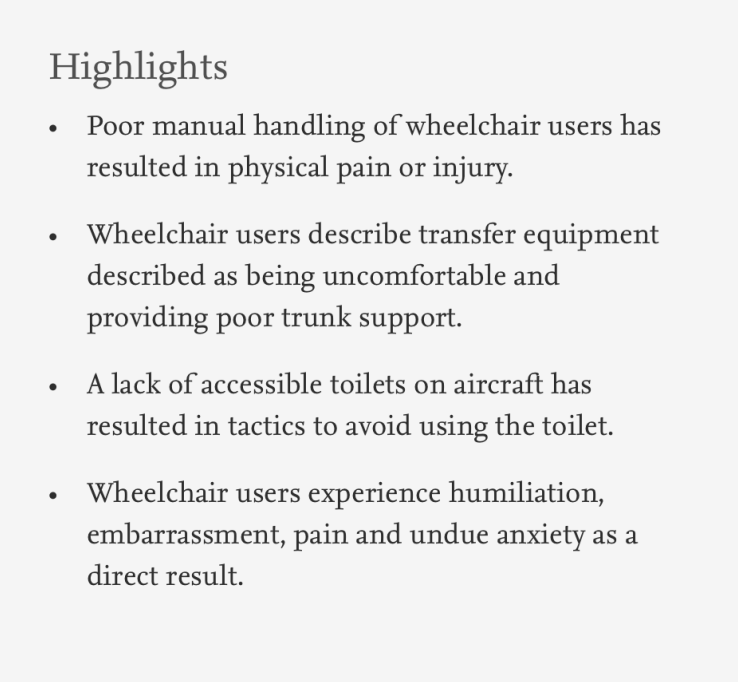
Research Studies

There was a study in Spain on the integration of mobility and parking solutions for people with disabilities (Ferreras et al., 2015). The authors

developed an integration of different modern information and communication technologies (ICTs) solutions and developed SIMON, an enhancing European Parking Card for disabled individuals with contactless technologies that integrates mobile solutions to help support better user identification. This proved to help with parking in urban areas where it is often difficult for people with disabilities to find parking due to lack of accessible information on routes, transportation alternatives, and parking availability (Ferreras et al., 2015). Lack of accessible information on routes, transportation alternatives, and parking availability closely ties to the urban parking challenges faced by people with disabilities. Proper parking space design, ramps, along with access aisles, importantly improve disabled people's mobility, as shown by reports concentrating on universal accessibility principles (Antipova et al., 2020).

Andrew Davies and Nicola Christie in the U.K. conducted an exploratory study of the experiences of wheelchair users as aircraft passengers and discovered the difficulties that they encounter (Davies & Christie, 2017) (see Figure 11 on next page). Wheelchair users reported a lack of accessible toilets on aircrafts as well as the transfer equipment being uncomfortable (Davies & Christie, 2017) (see Figure 11). The Urban Planning Institute of the Republic of Slovenia, Europe developed a toolkit for detecting and eliminating the barriers that people with disabilities face in the built environment (Kerbler, 2012).

The study by Apostolidou and Fokaides (2023) highlights the transformative role of mobile applications in enhancing accessibility for disabled individuals within buildings. These apps provide real-time navigation assistance, information about accessible entrances and elevators, and personalized features tailored to different disabilities. The authors emphasize the importance of incorporating user-centered design principles to ensure these apps meet the diverse needs of their users. Challenges such as maintaining data accuracy and overcoming technical limitations like indoor GPS inefficiencies are also addressed.



Highlights

- Poor manual handling of wheelchair users has resulted in physical pain or injury.
- Wheelchair users describe transfer equipment described as being uncomfortable and providing poor trunk support.
- A lack of accessible toilets on aircraft has resulted in tactics to avoid using the toilet.
- Wheelchair users experience humiliation, embarrassment, pain and undue anxiety as a direct result.

Figure 11 *-Davies and Christie, 2017, Highlights of research from study: An exploratory study of the experience of wheelchair users as aircraft passengers – implications for policy and practice.*

Mobile Applications

One of the changes to society that has made a significant difference to the community is the creation of assistive mobile applications for the disabled. Often developers have found certain problems that needed to be addressed – moreover focused within metropolitan cities – and focused their design within their app to address the needs of the disabled. For this final research the six most used mobile applications: Access Earth, WheelMate, Wheelmap, Waze, Google Maps, and Roll Mobility were the focus. Only two of these applications –

Waze and Google Maps - are considered a navigational application for everyday users.

CURRENT MOBILE APPLICATIONS FOR NAVIGATION FOR THE DISABLED

Access Earth

After booking a "wheelchair accessible" hotel that ended up having stairs to access the hotel, a software engineer and wheelchair user Matt McCann – CEO and Founder of Access Earth – developed an app that allows people with mobility issues to rate restaurants, hotels, businesses, and tourist attractions around the world based on their accessibility (Wanshel, 2016, para. 2; Access Earth, n.d.).

Users can input data into the app and others can agree or update the information for businesses/hotels/restaurants for their accessibility around the world. Matt McCann told the Huffington Post that,

> "By allowing users to have a voice on this topic, we hope that this will further push the issue of accessibility and help improve standards across the globe. Ultimately, we want to change the accessible tourism market and become a 'TripAdvisor for Accessibility,' giving people who have accessibility issues a more equal experience of travel" (Wanshel, 2016, para. 4).

WheelMate

WheelMate is both a free smartphone app and a web application that gives disabled users an instant overview of the nearest disabled toilets and parking spaces (Coloplast, 2012, para. 3). Finding an accessible bathroom can be a problem for the more than 2.7 million wheelchair users in the U.S. and making even simple day trips to an unknown place can be a major planning

issue (2012, para. 4). This application gives the user the location of the closest accessible bathroom and parking spaces within a certain area (Coloplast, n.d.).

Wheelmap

A German developer named Raul Krauthausen (see Figure 12) is the figurehead of wheelmap.org. Created and launched in 2010, in Germany – and later developed more for other countries – the application allows users to rate buildings, bathrooms, transportation, hotels, restaurants, etc. on their accessibility (Beuth, 2011, para. 1-5).

Figure 12 *- Photo of Wheelmap creator and developer Raul Krauthausen*

Wheelmap is based on Open Street Map, a project that collects geospatial data for everyone to use (Beuth, 2011, para. 4). Wheelmap.org was the first original project in 2010 before being later developed into a mobile application. It was an online map where volunteers around the world could gather and register wheelchair accessible places (para. 2). There were multiple benefits to the launch of Krauthausen's application by allowing those who use wheelchairs to rate businesses and buildings all over the world on their accessibility (para. 4). On the other hand, it gently pressured businesses to make their buildings more accessible to the public because attention was being highlighted online about them to remove the barriers (para. 5).

Waze

This application allows users to input data as they travel along their navigated path such as road errors, traffic, construction, police, objects on the road, animals on the road, and more (Waze, n.d.). Faculty at the Department of Mechanical and Industrial Engineering from the University of Gadjah Mada in Indonesia studied users and their preference of the Waze application over Google Maps (Trapsilawati et al., 2019, pp. 38-43). Their findings revealed that users had more trust in the Waze application partly because of the user input data features (p. 42). This study suggests that if users are more involved in the development of the application process, they are more likely to trust its results.

Google Maps

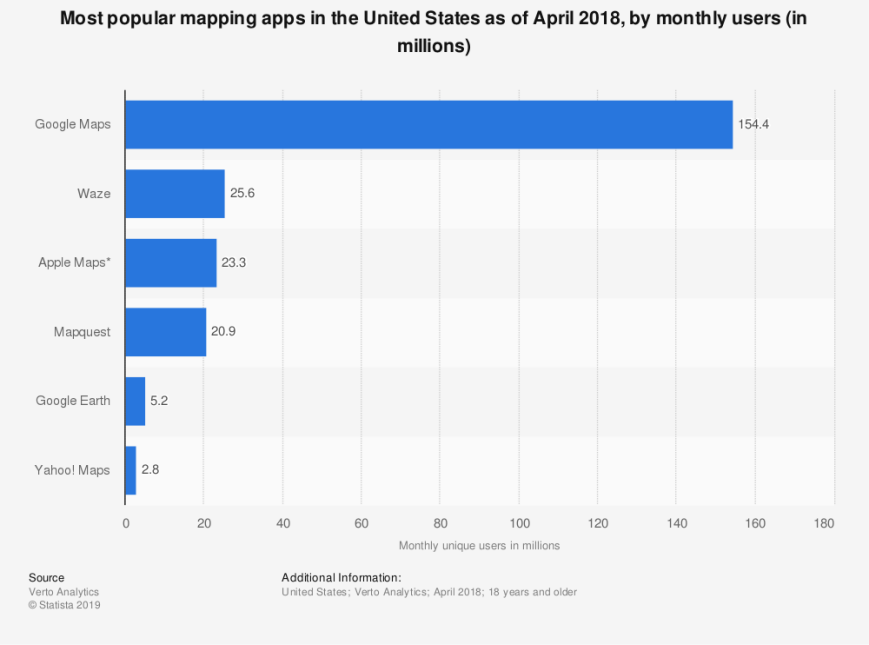


Figure 13 *- Most popular mapping app in the U.S. as of April 2018 Statistic graphic provided by Verto Analytics*

Google Maps is by far the most popular navigational app in the world with it having over 154.4 million users as of 2018 (see in Figure 13) (Clement, 2019, para. 1). And as of May, 2020, they released a new update to their Google map system that the entire disabled community has been asking the company to add to their mobile application for the past decade. People can now turn on the "Accessible Places" feature to have wheelchair accessibility information displayed in their Google Maps (Blair-Goldensohn,

2020, para. 3). This new feature will allow individuals to know if a place has accessible seating, entrance, restrooms, or parking (Statt, 2020, para. 2). Google Maps has been on the market since 2005 and they have clearly been dominating on research and navigating since (Gibbs, 2015, para. 7). Google has information on 15 million places and counting (Blair-Goldensohn, 2020, para. 4).

Roll Mobility

Roll Mobility is the newest assistive mobility navigation app on the market. It is a community-driven accessibility tool designed to make life easier for people who have mobility issues. The app provides reliable information on the accessibility of restaurants, public spaces, businesses, trails, and parking spaces (WeFunder, 2023). The application was founded by Shane Blandford and Joe Foster. The mobile application rolled out on January of 2023 (Roll Mobility, 2023). This application was not included in the initial SUS questionnaire because it was developed in 2023, a few years after the initial SUS Questionnaire and the Walk-a-mile were completed.

GAPS IN RESEARCH

The *Access Earth* application, originally created in the United Kingdom, has recently been adapted worldwide, yet not many people in the U.S. know about the app. Some U.S. data has been entered into the application for mobility issues, but CEO and Founder Matt McCann told the Huffington Post that they do have plans to further the apps assistive technology to add sensory and cognitive disability criteria in the future (Wanshel, 2016, para. 13). The app is also more focused on the destination and items within a certain location and does not offer navigation within the application (McCann, n.d.).

For the mobile assistive application *WheelMate,* there is not as much crowdsourced user inputted data. The origin of the applications development

was to design a free application to make finding clean, accessible restrooms and parking spaces easier and more convenient (Vantage Mobility, n.d., para. 10). The current mobile application only lists some information and is not as well versed for both metropolitan and rural areas. It is more about parking and bathrooms, and less about accessible ramps or how to get to the location of the bathroom or parking spot. The current application could use more development from both the users and the original designers.

The assistive application called *Wheelmap* is also new (only released in the U.S. as of Sept 4th, 2019) and there has not been as much development. Additionally, users cannot click on the actual business establishment on the application to access their website or location information. Another area for improvement is the universal need for instructions. The designer originally came up with the idea of a traffic light symbol for rating the items (red bad, yellow cautious or ok, and green good). These ratings however will not apply to everyone and their specific type of disabilities as some are more mobile in their wheelchairs than others (*handout for mappers – news von wheelmap.org*, Wheelmap, n.d.).

Another area where the *Wheelmap* application could use improvement is the ability to plan a route. So far, you can only look at current issues on the map and rate them, but you cannot plan a "drive" or directions from one place to another to see the issues you might run into. This is where this application would benefit the most and will be of the most concern in the upcoming days for research. There are similar applications that allow you to plan such a route (like *Open Route Service*) but this is only available in Europe for disabled individuals and is not fully utilized in the United States (Open Route Source, n.d.).

The crowdsourced data entry navigational application known as Waze (see Figure 14 on next page) is only for driving and does not incorporate the addition of a walking or on foot navigational guide. This technology could be

Figure 14 *- Image of iPhone with Waze navigational application open.*

easily integrated into the existing application for a walking/rolling method for limited mobility individuals as the mass crowdsourced application is in the top five best navigation applications in the world (Collins, 2019, para. 17). Waze was of such popularity that Google bought the company in 2013 (Cohan, 2013, para. 1). If an application is updated constantly by its users, it can be more effective than the typical navigational application and will prove to be immensely popular and helpful (para. 4).

Google Maps newest addition was supposed to be a very exciting release for the disabled community; however, the integrated feature is not automatic. You have to go into settings, accessibility, and turn on accessible place, before you even see the icon (Southern, 2020, para. 20). Then once the wheelchair icon appears, it is grey and hard to see (reference to Figure 15). The listed features are also not as helpful as you would imagine. The information for Google Maps is crowdsourced user-inputted data. This user-inputted data is typically helpful, except the majority of Google Map users are individuals who are not disabled, who do not use

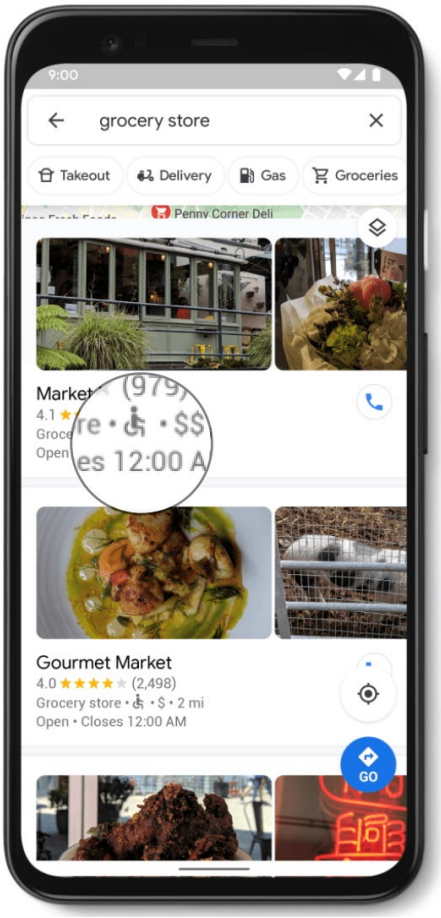


Figure 15 *- New Google Map feature highlights wheelchair accessible places - zoom showing google wheelchair icon*

the accessibility features, nor will they take the time to input extra data for the disabled community without a return incentive. Seeing as this feature was released as of May 2020 it is going to take some time for the disabled community to help input correct data and truly help Google better integrate the feature within their mobile application. Google claims the app will help to "Benefit Everyone" as Sasha Blair-Goldensohn a Google Software Engineer said in Googles Article release calling it a "better map for everyone." We can only hope that this will be the case for the future of this application.

Although Roll Mobility seems to have the most promise among the newer applications, it is still in the early phases since it was only released in 2023. It was created to address the current gap in available information but it is still quite new. Unfortunately, since it was only developed in 2023, it is still attracting new users. They had only acquired 25 thousand users within the first 6 months with data for 93 thousand places (Wefunder, n.d.). In order for the mobile application to be truly helpful, the developers still need more people to use the application and input data because as it stands there is not enough current data on the mobile app for the United States in smaller cities and rural areas for it to be an effective assistive mobile application.

All of these applications rely on user crowdsourced data input and do not collaborate. They would benefit more if their collected data was shared among the applications as the data would be more extensive. Another benefit would be if these applications allowed the user to plan their route.

In the context of research on mobile applications accessibility, there remains a notable gap in studies focusing on the United States, particularly in rural versus metropolitan areas. While significant work has been done on mobile applications within buildings, research has largely overlooked the broader navigation challenges within towns or cities (Apostolidou & Fokaides, 2023). Matos et al. (2023) attempted to address this gap by examining mobility application accessibility in Europe, focusing on approaches and challenges.

They emphasize the need for effective methodologies, particularly driven by the implementation of the Web Accessibility Directive in Europe. However, they identify limitations in current evaluation methods, including the absence of specific guidelines for mobile applications, and the lack of comprehensive automated tools. Although their study makes valuable contributions to improving mobile accessibility evaluations, its applicability remains limited to Europe (Matos et al., 2023).

FOCUS OF PROPOSED RESEARCH

Alison Kafer once said, "To eliminate disability is to eliminate the possibility of discovering alternative ways of being in the world, to foreclose the possibility of recognizing and valuing our interdependence" (Hamraie, 2017, p. 223). Most disabled individuals rely on themselves through means of public transportation as a way of interdependence (Rosenbloom, 2007, p. 519). Unfortunately, there are still barriers that the disabled individual must overcome to achieve this mobility independence especially when it comes to traveling or visiting a new city (Cerchiai & Lieberman, 2018, para. 16).

Through the development of an empathic solution to the wicked problem of lack of navigational access, the final project focused on the current experiences faced by those who have limited mobility when using assistive mobile applications. The student researcher hopes to add to the body of knowledge that the other applications are missing, as well as help to improve navigation for the individuals in more rural areas.

By merging the understanding of the current applications available, the student researcher hopes to help improve the combined and existing knowledge of the lack of access for the limited mobility disabled users in both navigation and accessibility which will further allow for future development in the field of assistive technologies for the wheelchair users and other mobility-impaired access users in both rural and metropolitan areas.

METHODS

PURPOSE

The purpose of this research study was to understand the experiences that the limited mobility disabled community face while navigating both rural and metropolitan areas while using assistive mobile applications (apps). The student researcher focused on the analysis and understanding of current assistive mobile applications for the disabled previously mentioned in the literature review (Access Earth, Wheelmap, and WheelMate, Google Maps) (see Figure 16).

Figure 16 *- Mobile apps for disability access; logos from the Apple App Store; featured from left to right: Access Earth, Wheelmap, WheelMate, and Google Maps.*

Both the effectiveness and problems associated with the current applications were tested. It also adds to the body of knowledge via design-thinking strategies such as walking-a-mile in a wheelchair through video journal, which can help to empathize more understanding of using the applications in a real-world setting.

SAMPLE/SUBJECTS OF RESEARCH

A purposive sampling technique was used for this study. Participants for this study met a certain selective criterion in order to participate. The first part of this study, Group 1, completed an online questionnaire and for that part of the research, the purposive sampling was from a random pool of limited mobility disabled individuals within five private Facebook groups, *IS-ABLED (for people in wheelchairs & disabilities), chat for all disability people*, *So? I use a Wheelchair?*, I USE A WHEELCHAIR, Yes I Have A Life, and *WHEELCHAIR AND MOBILITY AID USERS GROUP*. These support groups are aimed at supporting those with limited mobility issues, which mainly focus on individuals in wheelchairs. To participate in the online questionnaire,

participants had to be a part of these private Facebook groups, use a wheelchair part-time or full-time, or have another physical mobility assistive device – such as a scooter, cane, walker, or require other physical mobility assistive devices – and have access and used assistive mobile applications for limited mobility access for disabled navigation. Criteria of questionnaire takers was of the following: that they be United States (U.S.) residents, use an assistive mobility device – such as a walker, scooter, cane, or wheelchair full-time or part-time – and have familiarity with the selective mobile applications – Access earth, WheelMate, Wheelmap, and Google Maps – to participate.

INSTRUMENTS

Instruments for Stage 1

The number of individuals who participated in the online questionnaire was open to a timeframe of 2-weeks, and the number of people who par-took in the questionnaire within that time frame was reported within the study (original projection was 20+). The student researcher surveyed their use of mobile applications. Individuals who chose to participate in the study would select the mobile application(s) at the start of the questionnaire. The demographic and statistics of the individuals surveyed at the end of the System Usability Scale (SUS) Likert Scale Survey were reported as a group finding and not individuals to protect anonymity. Each participant was assigned a number in the order that they completed the questionnaire and their identity remained confidential. Participants who par-took in the questionnaire are known as Group 1.

This sample was the best choice for this study as it proved to be the most accurate for the use of the applications for which they were designed. These users have first-hand experience

Figure 17 *- SUS Likert Scale example*

using these applications and were able to give an honest and unbiased opinion on how they work. It also helped to have a selection of participants from all over the U.S. as this was the main cause for concern for these applications, and the technology for the applications can vary based upon which city or rural area you use them in.

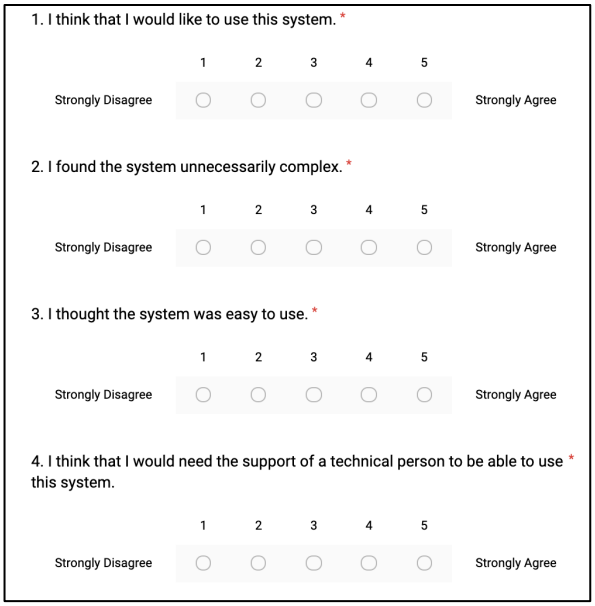


Figure 17 *– Sus Likert Scale Example*

For the first part of this study, an online questionnaire (SUS), see link below and Appendix A, was used. This questionnaire was developed by the student researcher using Google forms and contained 25 questions for the surveyors to answer.

Link to online SUS: https://docs.google.com/forms/d/e/1FAIpQLSecU9FiBITtzFNAKqmO5H4RNTIJAv7BzthFJVWIi5otLLIR-w/viewform?usp=sf_link

Specifically, the questionnaire consisted of 10 Likert-scale questions (see example in Figure 17) pertaining to the app the individual used (i.e., either Access Earth, Wheelmap, WheelMate, Google Maps). These questions measured the participants subjective feedback of their experience when using the assistive mobility app for disabled navigational access. Five open-ended questions continued exploring the user experience with apps, and the last section of the questionnaire consisted of demographic questions (see Appendix E). The first part of the questionnaire included the online consent form (Appendix B).

Instruments for Stage 2

Figure 18 *- Walk-a-mile with mobile app testing figure*

Stage 2 consisted of the following design-thinking methods: walk-a-mile immersion, video journaling, and think-aloud-testing. For walk-a-mile immersion, the student researcher traveled in a wheelchair in both a rural and metropolitan area to gain a sense of empathy for people through firsthand experience (see Figure 18). During the walk-a-mile immersion, the student researcher recorded the journey (video journaling). The journaling was an activity that invited people to view the personal experience that was recorded and allowed the student researcher to re-review the experience as a means of data collection later on in the study. The think-aloud testing happened throughout the entire walk-a-mile and video journaling to assess the mobile applications and navigation through the rural and metropolitan area. This think-aloud testing acted as a format for the student researcher to be the test subject where she narrated her experience while performing tasks within the mobile applications. Each of the mobile applications were used to assess a journey in a rural and metropolitan city, and positive and negative experiences that did arise while using the technology were recorded.

PROCEDURE/ STAGES OF STUDY

This study was broken down into stages of looking, understanding, and making to re-evaluate and give the research the opportunity for further growth. Looking was performed through the collection of data for the SUS. The understanding and making methods were performed through the walk-a-mile methods of immersion, video journaling, and think aloud testing.

STAGE 1

System Usability Survey (SUS)

This study was conducted first with a sample subject pool of selective purposive volunteer questionnaire takers from five private Facebook groups, *IS-ABLED (for people in wheelchairs & disabilities), chat for all disability people*, *So? I use a wheelchair?* and *WHEELCHAIR AND MOBILITY USERS GROUP*. This study was submitted as a virtual Facebook post to the five private Facebook groups (see example of Facebook post in Figure 19 and Appendix F). From these five groups, people of particular criteria were asked to fill out a SUS using a Likert scale and answer open-ended questions.

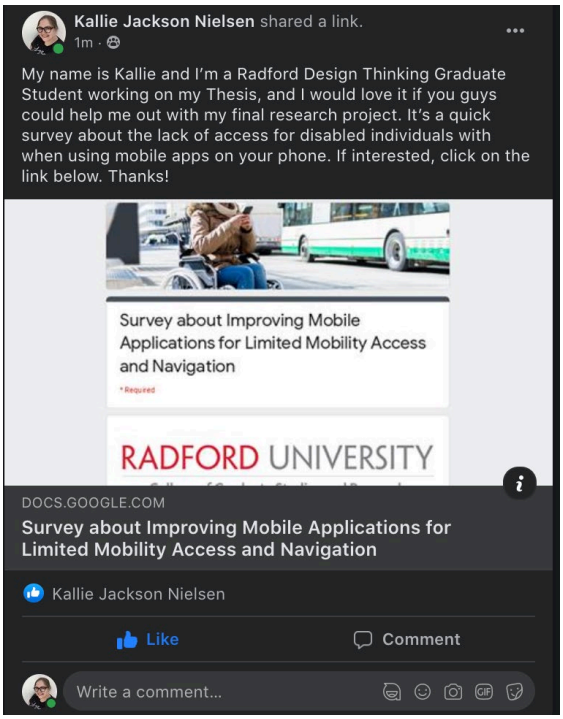


Figure 19 *- Facebook post of recruitment for online questionnaire (SUS)*

This data was collected through a cross-sectional time frame and means. Through this questionnaire, anonymous individuals answered short online questions rating the use of each of the mobile applications and their effectiveness.

STAGE 2

Walk-a-Mile Immersion/Video Journaling/Think-Aloud Testing

Stage two consisted of the student researcher participating in an immersive walk-a-mile experience through a means of video journaling and think-aloud testing of the mobile applications and navigation of both rural and metropolitan areas via a wheelchair. The wheelchair for this study is a Tracer SX Manual Wheelchair by Invacare with an 18" seat width (seen in Figure 20).

Figure 20 *- Image of Tracer SX Manual Wheelchair by Invacare*

The location for which this study was conducted was a purposeful and convenience sampling selection and data was collected on a cross-sectional time frame of one day for each location. The study was in the convenience sampling of the student researcher's location of a rural area of Ruckersville, Virginia. The second location was in another convenience sampling of an area that is 30-45 minutes away from the first location and was the metropolitan area of Charlottesville, Virginia. The student researcher conducted a typical journey within these locations (see Figure 21 on previous page).

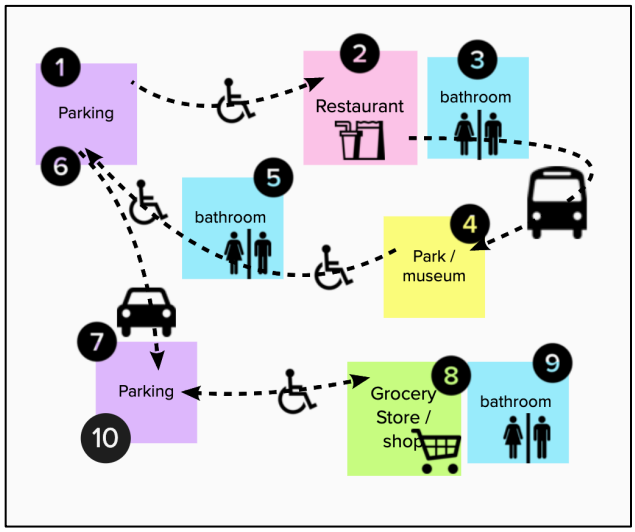


Figure 21 *- Mind map of planned walk-a-mile journey*

The journey consisted of a plan such as this:

1. Find disabled parking with WheelMate and Wheelmap.

2. Find accessible restaurant with Access Earth and Wheelmap, and Google Maps.
3. Find out if the bathroom in the restaurant is rated accessible with all three mobile applications. If not, find the nearest accessible bathroom.
4. Find an accessible Park and/or Museum in Access Earth and Wheelmap, then find an accessible bus or car route to take you there.
5. Find an accessible bathroom within the park and/or Museum along the route to the disabled parking with WheelMate, Google Maps, and Wheelmap.
6. Head back to parking and put the wheelchair in car and find an accessible shop/store as well as find accessible parking at the location.
7. Drive from one accessible parking spot to another at the next location.
8. Unload wheelchair and make sure that location is wheelchair accessible.
9. Check to see if the bathroom in the store is accessible with WheelMate, Google Maps, and Access Earth and use it.

The student researcher video recorded these experiences within a 4-hour time period (8 hours total), taking into consideration all video was edited for later viewing by the research team. The student researcher did not put herself in any danger while completing this task and remained true to the walk-a-mile, while maintaining health safety practices for COVID-19 and privacy both for others and herself where necessary.

The recording technology used for this study was a Canon digital SLR EOS Rebel T7 camera, a GoPro Silver 7, and the student researcher's typical cellphone at the time (an iPhone SE), and an old iPhone 5C. The student researcher also used assistive devices to hold the technology while navigating to help with the filming process which was done solely by the student researcher and her assistant. The device used to help attach the phone to the wheelchair is called a tablet clamp stand (see Figure 22). The camera views and recordings were as follow:

Figure 22 *- Tablet Clamp Stand (image and product from 5Below.com)*

- iPhone 5C: recorded the student researcher's facial responses, reactions, comments while navigating the overall experience. The phone was attached to the tablet clamp stand to better stabilize the device for recording while the wheelchair was in motion and to fully capture the student researcher's face.
- iPhone SE: recorded the screen capture of the mobile applications while in use. It gave a screen view of what was happening with the mobile applications while coordinating in the video with the other iPhone
- GoPro Silver 7: this camera was strapped to the armrest of the wheelchair. This gave the viewer an immersive experience as to the journey of the student researcher navigating terrain both in the rural area and within the metropolitan area. This also gave a walk-a-mile experience to the viewers.
- Canon Digital SLR EOS Rebel T7 Camera: This camera was worn around the student researcher's neck (as well as her video

assistant) and was used to take pictures of issues, ideas, or key points discovered within the walk-a-mile journey. The images taken with this device are available in the Appendix.

INTERNAL VALIDITY

The initial part of this study allowed for randomization of individuals across the United States with a range of disabilities to express their opinions – within the private Facebook groups – about these applications and their experience with navigation while using them. The use of the Likert Scale allowed these individuals to express their opinion without being misled or guided toward a specific answer, while the open-ended questions allowed for more true depth in their responses. The questionnaire was pilot tested with the student researcher's thesis committee to improve content validity.

DATA ANALYSIS

The closed-ended questions from the online questionnaire (SUS) were analyzed using descriptive statistics in the form of frequencies and percentages. The data from the open-ended questions were analyzed using affinity clustering. The student researcher read through the comments several times and noted repeated words and phrases on sticky notes. These sticky notes were then clustered into themes on a digital mural board (see Figure 23). Data from the walk-a-mile, video journaling, and think-aloud testing were recorded and viewed by the research team to observe common struggles and experiences.

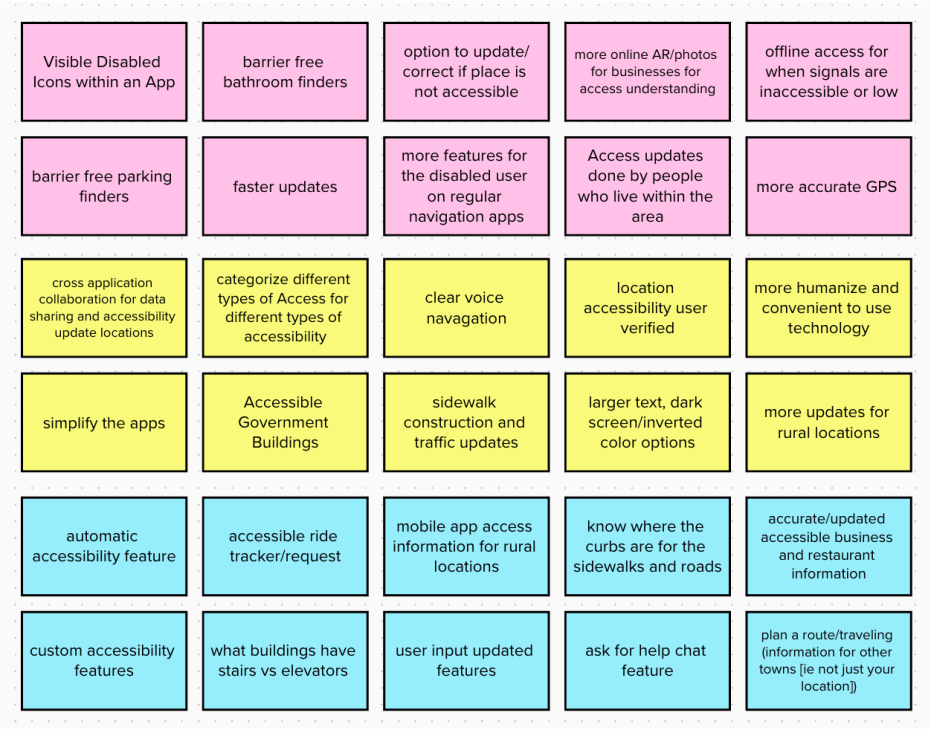


Figure 23 *- Digital post-it notes from open-ended questionnaire*

RESULTS

ONLINE QUESTIONNAIRE (SUS)

For this investigation, the student researcher aimed to assess the effectiveness and user satisfaction of assistive mobile applications for individuals with disabilities, specifically focusing on navigation applications. A total of 51 participants responded to the questionnaire, providing both

quantitative and qualitative data across various aspects of their experiences (full results are viewable in Appendix D). The findings are summarized below, categorized into usage patterns, user experience, application effectiveness, and suggestions for improvement.

Assistive Mobile Application Usage

Participants reported using several assistive mobile navigation applications, with Google Maps being the most popular, used by 36 individuals. Other applications reported include Wheelmap (15 users), WheelMate (8 users), Access Earth (8 users), (see Figure 24) and a few other lesser-known apps. A small number of participants (1) indicated that they did not use any assistive mobile applications for navigation. Interestingly, when asked to clarify the "other" apps used, 19 participants provided responses, with notable mentions including Google Maps, I Access, Waze, and other regional or lesser-known apps. This suggests that some participants may not have followed the initial instructions carefully, leading to confusion about which apps should be listed under this category.

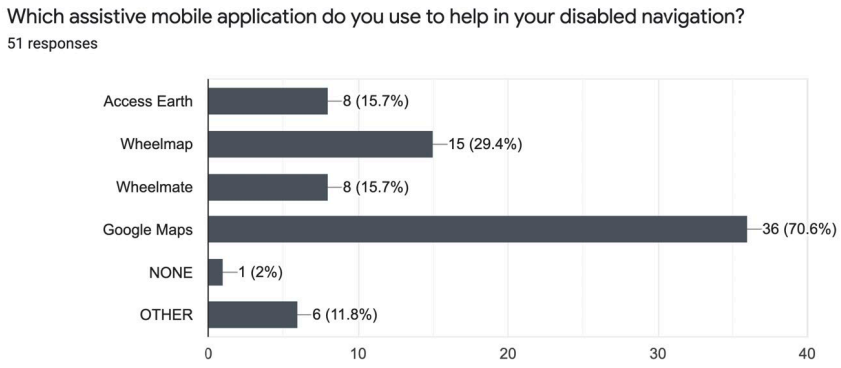


Figure 24 *- Open-ended questionnaire answers regarding use of assistive mobile applications for navigation*

User Experience and Application Perception (Likert Scale Responses)

A significant portion of the questionnaire focused on assessing users' perceptions of the applications they use, based on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Key findings include:

- Preference for the Application: Most respondents expressed a positive view towards the applications. Specifically, 23 out of 51 participants agreed (rating 4) that they would like to use the application again, while 16 expressed neutral views (rating 3).
- Complexity of the Application: On the complexity scale, 16 participants found the application easy to use (rating 4), while 18 participants found it somewhat complex (rating 3), and 7 participants rated it as very complex (rating 1). This indicates that while some users were satisfied with the simplicity of the application, others experienced difficulties.
- Ease of Use: The majority of respondents (23) felt that the application was easy to use (rating 4). However, 16 participants felt the application was neither easy nor difficult to use (rating 3), and 7 participants found it difficult.
- Need for Technical Support: A majority (19) of participants felt that they would not need technical support to use the application (rating 2), suggesting that the applications are generally user-friendly.
- Function Integration: The integration of various functions within the applications was rated positively, with 20 participants rating it a 4, indicating that they felt the functions worked well together.
- Consistency Issues: Some inconsistencies were noted, with 14 participants agreeing that the application had some inconsistencies (rating 2) and 15 participants neutral (rating 3).
- Learning Curve: Most users felt they could quickly learn to use the applications, with 22 participants rating it 4 (agree) and 13 rating it 3 (neutral).

- Cumbersome Experience: A small proportion (10 participants) found the application cumbersome (rating 1), while 17 participants gave a neutral rating.
- Confidence and Familiarity: Confidence in using the application was generally high, with 17 participants rating it 4 (agree), and 18 participants feeling somewhat confident (rating 3).

Benefits and Challenges

Participants provided a range of benefits and challenges associated with using the applications in the open-ended questions. Despite the open format, there were significant commonalities among responses. Below in Figure 25 & Figure 26 are the top three answers given for benefits and challenges.

- Benefits: Many participants noted convenience, accuracy, and efficiency as key advantages (see Figure 25). The ability to find accessible routes and locations, such as wheelchair-friendly public transit and accessible restrooms, was highlighted frequently. Other benefits included improved independence, time-saving features, and user-friendly interfaces, particularly in larger cities.

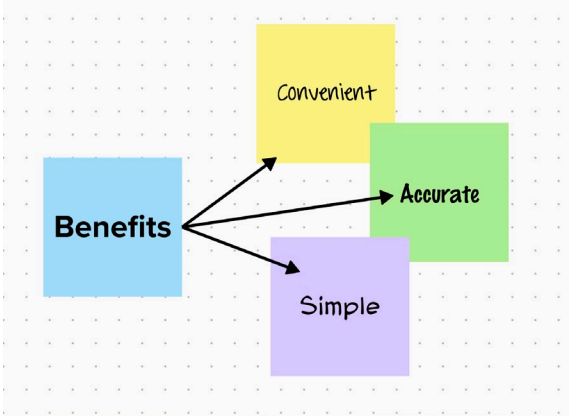


Figure 25 *- Top three answers given for benefits for accessible apps (results from open-ended questionnaire)*

- Challenges: The primary challenges reported included inaccuracies in GPS positioning, lack of up-to-date information, and occasional discrepancies between the advertised accessibility features and the actual conditions on the ground (see Figure 26). Users expressed frustration with inaccessible locations or the failure of the apps to reflect real-time changes in accessibility.

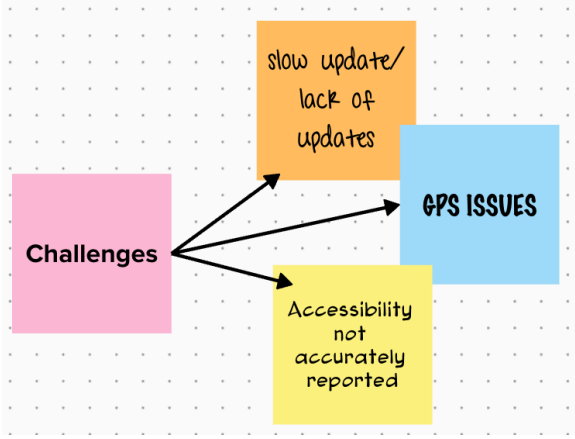


Figure 26 *- Top three answers given for challenges for accessible apps (results from open-ended questionnaire)*

Suggestions for Improvement

Several themes emerged from the suggestions for improvement:

- Accuracy and Updates: Many respondents suggested that the apps need to be more accurate, particularly regarding accessibility information. There was a call for frequent updates to ensure that businesses and locations are correctly categorized (see Figure 27).

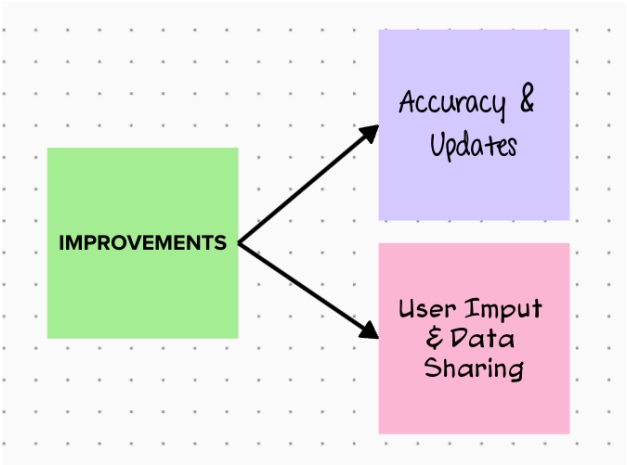


Figure 27 *- Top four responses for suggested improvements (from open-ended questionnaire)*

- User Input and Data Sharing: There was a desire for more user-driven content and the ability to provide updates for locations in

real time. Participants also recommended that the apps integrate more data from various sources and share information across different platforms (see Figure 27 on previous page).

- Expanded Features: Additional features were requested, such as improved voice navigation, better integration of public transportation accessibility, and the ability to navigate rural areas more effectively.
- Accessibility for Smaller Cities: Respondents expressed concern about the lack of information for smaller towns and rural areas. Many suggested that the apps should provide more comprehensive coverage for these regions.
- App Interface and Usability: Users recommended simplifying the app interface, improving its design, and addressing issues like small icons and difficult navigation.

Demographics and Other Data

The demographic data collected from the questionnaire reveals a diverse group of respondents in terms of gender, race, age, and mobility device usage. A majority of participants identified as male, with females comprising a significant portion as well, while a smaller number identified as transgender. Racially, the respondents were predominantly White, but the sample also included individuals from various other ethnic backgrounds, including Black, Hispanic, and Asian.

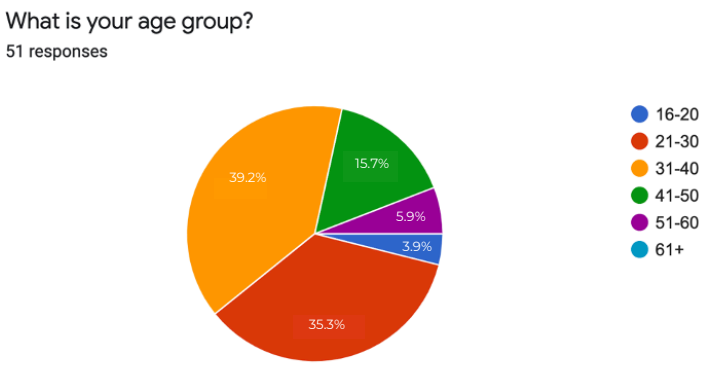


Figure 28 *- Demographic of ages from open-ended questionnaire*

Participants mainly concentrated within the 21-40 age range, with few over the age of 50 (see Figure 28 on previous page). This indicates that the questionnaire captured a younger, middle-aged demographic particularly well in the context of assistive mobility device use.

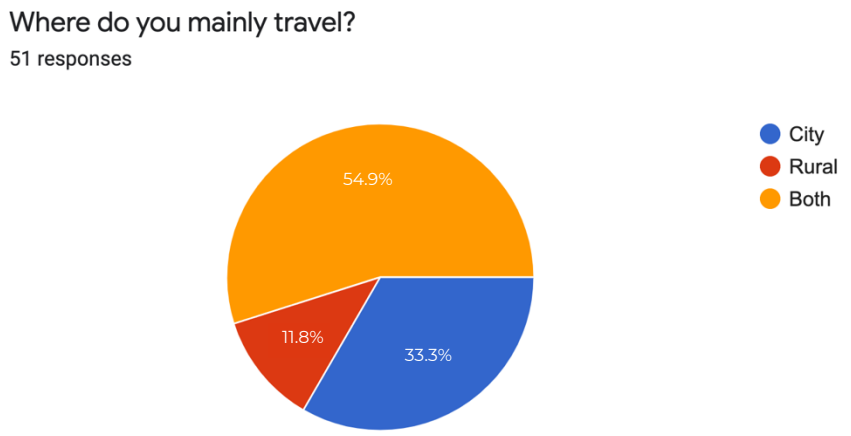


Figure 29 *- Accessible travel location open-ended questionnaire*

When considering travel habits, the majority of participants reported traveling in both rural and urban areas, indicating a varied range of mobility challenges across different environments (see Figure 29). The geographic distribution of respondents spans several U.S. states, with notable representation from California and Hawaii, and a broad spread across other regions.

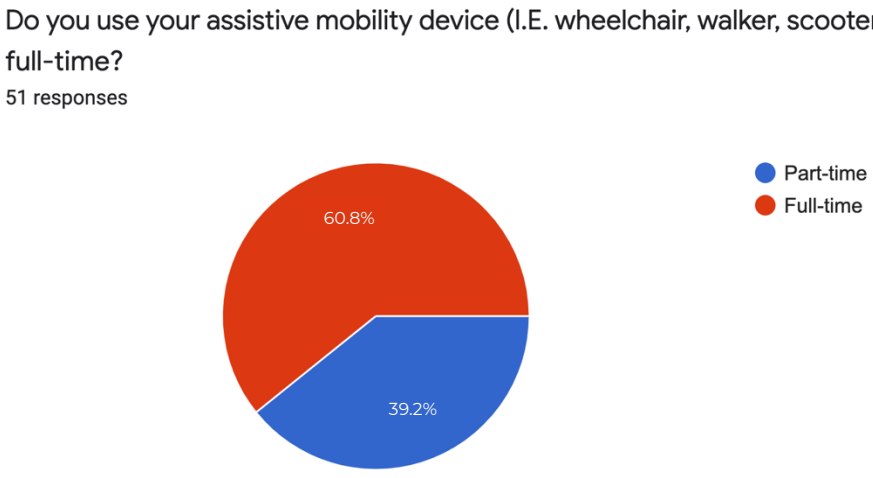


Figure 30 *- Assistive mobility device usage from open-ended questionnaire*

Regarding mobility device usage, most participants reported using their devices full-time, while a smaller portion used part-time (see Figure 30 on previous page).

The questionnaire also captured a range of experience with assistive devices, with participants reporting varying lengths of use from under a year to over two decades. This broad span of experience highlights a diverse range of needs and challenges in navigating the built environment with assistive mobility devices.

Overall, the data reflects a varied and diverse group of individuals who are using mobility aids in different geographic and social contexts, and with varying levels of experience. This broad representation helps provide insights into the challenges faced by people with disabilities and how these challenges might vary by age, geographic location, and device usage.

General Impressions and Additional Comments

The questionnaire collected a diverse range of demographic data, including participants' ages, genders, and mobility device usage, providing a broad representation of individuals with disabilities. The majority of respondents were between the ages of 21-40, with many using mobility aids full-time. The sample also included individuals from various regions across the U.S., with most traveling in both urban and rural areas, reflecting the varied challenges faced by people with disabilities in different environments.

While participants generally viewed assistive mobile navigation apps as valuable tools to enhance independence, they identified a need for improvements in data accuracy, user interface design, and app functionality. Although many users expressed satisfaction, they emphasized that app effectiveness could be improved, particularly in smaller cities and rural areas where accessibility information is limited.

The questionnaire results reveal that while assistive navigation apps offer convenience, users continue to encounter challenges related to accuracy, usability, and accessibility. The feedback indicates that while apps like Google Maps are widely used, specialized apps like Wheelmap are less common. Furthermore, the data suggests that, despite generally favorable ratings, issues with app complexity and ease of use persist. These findings underscore the importance of continuous updates and user input to improve functionality, particularly in less urbanized areas where accessibility information is often lacking.

WALK-A-MILE

Introduction to the Walk-a-Mile Experience

The walk-a-mile video immersion was conducted in two distinct phases as part of this final research project, aimed at evaluating the experiences faced by individuals with limited mobility access in both urban and rural settings. The first phase focused on an urban experience in Charlottesville, Virginia, filmed during the pandemic in 2020. The second phase took place in 2022, capturing the rural experience in Ruckersville, Virginia. Links to both the full-length feature film and the edited short version are provided below.

Link to full online version of video: https://youtu.be/1GT4yw713ws
Link to short edited video: https://youtu.be/FpkiRzUJL8o

Phase 1: Urban Walk-a-Mile

Figure 31 *-Wet cobblestone incline in Charlottesville, Virginia (photo from walk-a-mile)*

Figure 32 *- Ground barrier at coffee shop entrance in Charlottesville, Virginia (taken during walk-a-mile)*

During the urban walk-a-mile in Charlottesville, the student researcher encountered significant difficulties in navigating with mobility applications in real-time. The challenging terrain and adverse weather conditions further complicated the usability of the apps, hindering effective navigation (see Figure 31). On several occasions, the student researcher had to relocate to sheltered areas to attempt using the applications, as weather conditions such as rain or snow obstructed my ability to interact with them effectively. Of all the mobile applications tested, Google Maps proved to be the most user-friendly and useful, though it still had limitations. For instance, it failed to identify a small hump in the pavement that prevented me from easily accessing a coffee house (see Figure 32). There were quite a few steps that blocked entry for disabled individuals among

Figure 33 *- Step barrier to shop in Charlottesville, Virginia (taken during the walk-a-mile)*

many stores in the outdoor downtown urban area (see Figure 33). Additionally, pandemic-related obstacles, such as a table placed in a doorway to encourage hand sanitizing, blocked access to essential areas like restrooms, highlighting how temporary safety measures can inadvertently create significant barriers.

Phase 2: Rural Walk-a-Mile

The rural walk-a-mile experience in Ruckersville presented its own unique set of challenges. Upon arriving at the first location, which was marked as accessible on Google Maps, the student researcher discovered that the ramp leading into the building was exceedingly steep, and the door, which was propped open, created an additional barrier to entry (see Figure 34). This required outside assistance, which often feels disempowering for wheelchair users. It underscored how seemingly minor design flaws—like a steep ramp—can significantly impact accessibility for individuals with mobility impairments.

The second location was more accessible, albeit still challenging to navigate. The restaurant staff provided helpful guidance, but the broader rural environment posed additional difficulties. Ruckersville, for instance, has no

sidewalks, forcing pedestrians to walk on grass or in ditches—an impractical and unsafe option for individuals with mobility impairments. Furthermore, at the first location, the gravel parking lot at Jack Shop Kitchen presented a significant obstacle. The wheelchair wheels became stuck, rendering it nearly impossible to move. A paved parking lot would have drastically improved accessibility and usability for individuals relying on mobility aids.

Figure 34 *- Barrier created by propped open door to restaurant in Ruckersville, Virginia (photo from walk-a-mile)*

Mobile App Usability and Challenges

Using mobile apps for navigation during both the urban and rural experiences revealed several usability challenges. Although Google Maps was the most reliable app, it still had limitations, such as failing to recognize minor obstacles or environmental changes like temporary constructions or pandemic-related restrictions. Other apps also presented challenges, including lack of real-time updates or incomplete information about accessibility features like ramps or door widths. This seems to re-affirm the responses from the questionnaires, the gap between app capabilities and the real-world conditions that users with mobility impairments face.

Weather and Environmental Factors

Figure 35 *- Wet wheelchair ramp in rain at restaurant in Ruckersville, Virginia (photo taken during walk-a-mile)*

Figure 36 *- Wheelchair wheel stuck in gravel parking lot at restaurant in Ruckersville, Virginia (photo taken from walk-a-mile)*

The weather played a significant role in this study, particularly the rain. These adverse and unpredictable weather conditions hindered the outdoor navigation, forcing me to try to stay inside to avoid slipping or becoming stuck (which was apparent in the gravel parking lot at Jack Shop Kitchen). The rain also made it exhausting to navigate with the mobile device as the student researcher was constantly trying to wipe the screen and the student researcher's glasses to be able to see, and was having to over-exert herself to use the wheelchair during the wet weather (see Figure 35). This was evident during both the urban and rural walk-a-mile experiences, where adverse weather made it difficult to use the mobile apps efficiently. Furthermore, environmental factors such as construction zones, rough terrain, or obstructions that were not

accounted for in the apps added to the complexity of navigating both urban and rural areas (See Figure 36 on previous page).

Public Transportation and Accessibility Barriers

An additional challenge during the metropolitan walk-a-mile experience involved the local public transportation system. Using the CAT bus tracker app, the student researcher observed that the bus driver may have deliberately skipped the stop because of the wheelchair. The driver's decision may have been influenced by a desire to stay on schedule, underscoring how time constraints can lead to discriminatory practices. The same experience can be seen in the rural walk-a-mile video when the student researcher is exiting the restaurant, where the gentlemen leaving before me did not hold the door open for me (see Figure 37). This accessibility barrier (not having an automatic door) proved to be a common theme among locations both rural and metropolitan. This overall experience illustrated how public transportation systems and individuals can inadvertently marginalize people with mobility impairments, further complicating efforts to navigate urban and rural areas.

Figure 37 *- Man, not holding the door for wheelchair at Café in Ruckersville, Virginia (taken during the walk-a-mile)*

App Limitation and Lack of Feedback Mechanisms

A key limitation of the apps tested is the lack of mechanisms for reporting accessibility issues. Although users can leave individual reviews for

specific locations, there is no system in place to report broader accessibility concerns, such as the absence of sidewalks or the difficulty of navigating a particular neighborhood. This lack of feedback channels means that the apps cannot adequately reflect the real-world accessibility barriers that users with mobility impairments encounter. Without these features, the applications fail to offer comprehensive, reliable support for individuals navigating both urban and rural areas.

Conclusions and Key Takeaways

The walk-a-mile immersion highlighted several crucial insights into the effectiveness of current mobile applications for individuals with mobility impairments. While some applications, like Google Maps, provided useful tools for navigating urban areas, they were limited in their ability to address more complex accessibility issues in rural environments or unexpected situations. The study results reinforce the importance of continuous improvement in mobile applications to better serve the disabled community, emphasizing the need for real-time, dynamic updates and enhanced user-feedback mechanisms to improve accessibility across diverse environments.

REFLECTIONS

LIMITATIONS

Weather had a tremendous impact on this study. For the disabled community, weather could influence access to the outdoors. If there was snow or rain, there was a likely chance that someone would stay inside to avoid slipping or getting stuck. Part of the research had to be scheduled during a specific time frame to ensure good weather and the best outcomes for both filming and participation. It would have been more beneficial to document this process in all seasons, as there are different limitations related to weather throughout the year. Having documentation of those issues and how to

address them would have certainly added to the overall body of knowledge. The walk-a-mile, while helpful as part of the data collection, was only conducted by the student researcher. This limits the generalization of the findings.

There was also a limitation to only surveying individuals who had limited mobility and used assistive mobility devices, such as scooters, wheelchairs, canes, and walkers. While anyone could use these applications, the disabled community would benefit if more people, both disabled and non-disabled, contributed to them. The more the application is used, the more data can be gathered to better serve the community. Therefore, limiting participation to only those who used wheelchairs restricted the research collected on the overall usability and effectiveness of each application.

Another limitation of this study was the time frame for the walk-a-mile. Had the walk-a-mile been conducted over a longer period, perhaps a week, more obstacles and issues might have arisen. There is always a flux of construction and issues that change on a day-to-day basis, and these are precisely the challenges these applications aim to address. The unexpected is what users cannot plan for, and a single day was not enough time to fully understand what it is like to use a wheelchair in a rural or metropolitan city. This would have made for an extremely long filming and editing process, potentially taking months to evaluate and edit for proper research, thus adding to the study's limitations.

Finally, the student researcher herself could present a limitation to the study. Being previously diagnosed as a disabled American, the student researcher could have had a bias regarding what should be considered acceptable accessibility. Nevertheless, the researcher remained neutral regarding the walk-a-mile mobile applications for the study and had not experimented with them in the field prior to the research.

ONLINE QUESTIONNAIRE (SUS)

The Likert scale used for system usability assessment in this research provided a straightforward and quantifiable way to gauge user satisfaction and identify areas of improvement. However, its limitations became apparent, as it tends to oversimplify complex user experiences, potentially overlooking context-specific challenges. While the Likert scale effectively captured overall user sentiments, it failed to acquire the full range of usability concerns, especially those that were nuanced or multifaceted. These strengths and weaknesses highlight the need for supplementary qualitative data to offer a more comprehensive understanding of user experiences.

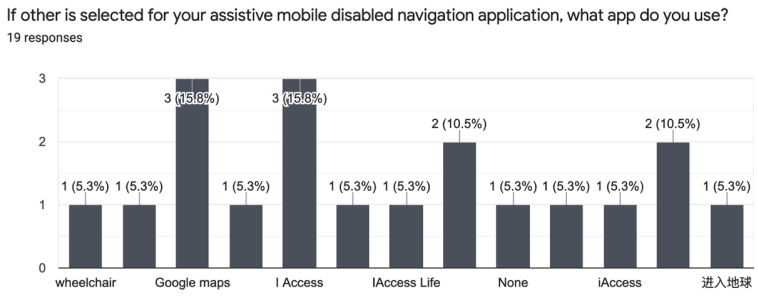


Figure 38 *- 19 responses to selection of other (when there should only be 6) in the open-ended questionnaire*

In conducting the online questionnaire, a common challenge was participants not fully following the provided directions, which impacted the accuracy of the responses (see Figure 38). In particular, users sometimes skipped questions or provided responses that deviated from the expected format. This issue highlights a significant limitation of using Likert scales and questionnaires in general: respondents' misinterpretation or disregard of instructions can lead to unreliable data. Such discrepancies emphasize the importance of clear guidance and potentially complementing quantitative data with more targeted qualitative feedback for a fuller understanding of user experiences.

Collecting and organizing the System Usability Scale (SUS) data and demographic information posed significant challenges, particularly due to the

complexity of the data and participant responses. The raw questionnaire data required careful sorting and categorization, which was time-consuming and prone to inconsistencies. Participants sometimes misunderstood or ignored directions, complicating data analysis further. Additionally, transforming demographic information into readable and meaningful insights required careful attention to detail, ensuring that the responses were correctly interpreted while avoiding potential biases. This process highlighted the difficulties in managing large datasets and the need for efficient data organization techniques.

WALK-A-MILE

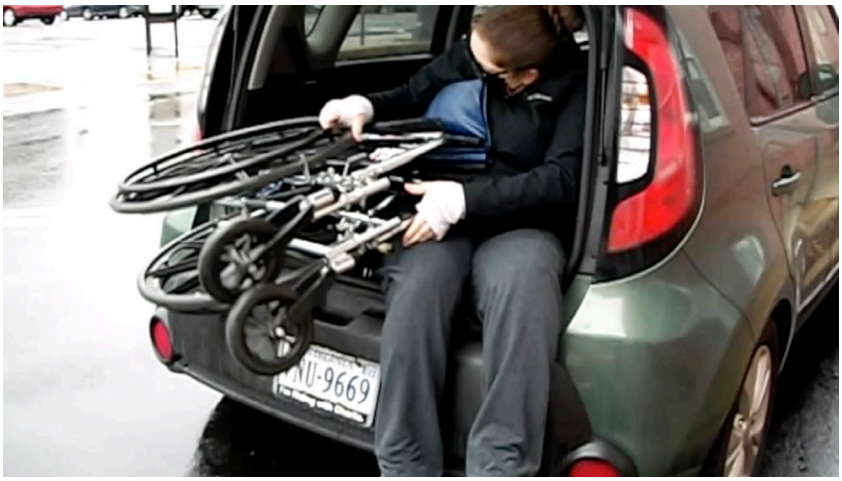


Figure 39 *– Loading wet/dirty wheelchair into trunk of car (taken during walk-a-mile)*

Reflecting on this experience, the student researcher underestimated the impact of weather and the physical exhaustion involved in navigating with a wheelchair (see Figure 39). As a result, the walk-a-mile activity was cut shorter than initially planned. Nonetheless, this exercise highlighted the limitations of the mobile applications tested. Google Maps was the only somewhat effective tool for rural navigation, while the other apps appeared to be tailored for metropolitan environments, failing to meet the needs of users in rural areas.

The use of mobile navigation apps revealed several significant challenges related to real-time navigation, accessibility, and the limitations of current app functionalities. The apps, while generally useful, were difficult to

navigate, especially when compounded by environmental factors such as difficult terrain and adverse weather conditions. A particularly notable limitation was that Google Maps, despite being the most user-friendly, failed to account for small but important obstacles, such as minor changes in terrain or temporary barriers like pandemic-related tables. These temporary measures, although intended for safety, often created unintended barriers, underscoring the need for more comprehensive and adaptive navigation tools.

Figure 40 *– Steep wheelchair ramp at restaurant in Ruckersville, Virginia (photo from walk-a-mile)*

Further challenges emerged during the rural walk-a-mile experience, where inaccessible routes, such as steep ramps and doors blocked by propped tables (see Figure 40), emphasized how minor design flaws can create significant hurdles for individuals with mobility impairments. Addressing these issues is essential to ensure a building complies with ADA standards, particularly for newer facilities constructed within the past 20 years. These issues were not adequately reflected in the navigation apps, highlighting a critical gap in their ability to provide accurate and inclusive information for users with disabilities.

In addition, public transportation services, such as the local free trolley/bus, exhibited discriminatory practices when a bus driver may have deliberately bypassed a stop to maintain the schedule, further marginalizing individuals with accessibility needs. This experience illustrated how time

pressures can lead to neglecting the needs of disabled individuals, further compounding the barriers to mobility.

The rural environment posed its own set of challenges, including the absence of sidewalks and unsafe pedestrian pathways, which were not represented in any of the apps tested. This lack of consideration for broader infrastructure issues—such as gravel parking lots and inaccessible streets—underscores the need for better reporting mechanisms within apps that could allow users to document and report real-time accessibility issues. Currently, the lack of such functionality, along with the inability to provide feedback on town-wide accessibility, represents a critical gap in the mobile app landscape for users with mobility impairments.

In summary, while mobile apps like Google Maps provide valuable assistance, there is a clear need for improvements in app accuracy, the integration of real-time accessibility data, and more inclusive design features that account for the full range of mobility needs, including feedback mechanisms that enable users to report both temporary and permanent barriers. Interestingly, these findings support the more current work of Apostolidu and Fokaides (2023) who also discovered that a number of accessibility apps for buildings need improved accuracy and timelessness through real time updates. While not a major focus of this study, results also alluded to the themes of humiliation and embarrassment, like Davies and Christie's (2017) investigation on individuals using wheelchairs in airplanes. Missing the bus, not having access to restrooms, and exhaustion via navigation may leave those with mobility issues feeling degraded. As argued by Ronn Daniel (2023), standards and norms of construction do not always take into consideration the opposite, the non-standard, and can discount an entire population, the disabled.

CHALLENGES, ADAPTATIONS, AND LESSONS LEARNED IN FINAL RESEARCH EXECUTION

This final research project was initially conceived as a thesis. However due to factors beyond the student researcher's control such as the pandemic along with challenges related to her chronic health conditions, the scope and format of the project was revised. The student researcher's ability to conduct research with disabled people was obstructed by the pandemic, leading to a decision that was made to shift the participant pool from disabled students at Radford University to online graduate students specializing in design thinking. After months of outreach and discussions with the Director of the Center for Accessibility Services, the researchers struggled to secure student participation. After careful consultation, it was agreed that a condensed version of the "Walk-a-Mile" video could still be engaged with meaningfully by the design thinking students, which was intended to help them empathize with the experiences of disabled people, as well as participate in the associated workshop.

Certain components of the initial research were removed due to time constraints and limited participation. The student researcher spent a much larger time editing the nearly two-hour "Walk-a-Mile" immersion video into a shorter, more controllable format, which caused delays. Due to lack of prior experience with professional video editing, online resources – including YouTube and Google – were heavily relied upon to learn the necessary skills. The initial video was produced using Apple iMovie, while the final shorter version was created using Adobe Premiere Pro. The student researcher's ability to meet the original project timeline was greatly affected by the wide-ranging time required for filming and editing.

Delays were further exacerbated by the challenges posed due to the student's chronic health conditions. Under these circumstances, the student

researcher strongly advise against people facing chronic health challenges taking on a thesis project with such ambitious methods.

The student researcher divided the original methodology into four key sections: (1) the System Usability Survey; (2) the engaging “walk-a-mile” experience along with think-aloud testing & video journaling; (3) the online interactive student workshop featuring methods such as the bullseye diagram, statement starters, and visual the vote; and (4) the online final critique, which would incorporate feedback from storyboarding along with schematic diagramming exercises based on data from the previous sections. These steps could have led to the development of a mobile navigation app designed for people with limited mobility if the need arose.

Finally, after careful consideration, the thesis committee and Student researcher decided that transitioning to a final research project would be a more practical and time-effective approach. This decision allowed for a more feasible completion of the project while still maintaining its core objectives.

To elaborate on the walk-a-mile, creating a feature-length film as a beginner in video editing posed significant challenges, especially when tasked with managing multiple complex elements such as a four-square viewing format, numerous photos, and different audio tracks. As a novice, navigating these components required an immense amount of time and effort, given the steep learning curve and the lack of experience with professional editing software and techniques. The difficulty was intensified by the need to manage and synchronize the various layers of media, ensuring that each element was well-timed and cohesive within the larger narrative structure. This broad-ranging skillset can sometimes be demanding when even working in a group setting. The degree program prepares people to do design work, but that design work will usually have a team to do some of these other technical pieces like video editing, where solo thesis work does not. So, it is important for students to scope their research in a way that either complements their

skillset or solely uses methods covered in the course work that can be completed by a single student in a reasonable time frame.

Efficient editing workflows were unfamiliar, causing important time management issues that led to extended hours on tasks which an experienced editor would have found more straightforward. Balancing the different aspects of the project proved to be especially difficult, as we adjusted photos with corresponding audio and adjusted the pacing to maintain viewer engagement.

Further complicating the project was the decision to condense the feature-length film into a short 10-minute video for easier consumption. This editing process required making difficult decisions about what to include and what to cut, all while ensuring that the shortened version still conveyed the core message and maintained a logical flow. The reduction in length added additional pressure, as the project required not only technical editing skills but also a strong sense of narrative structure and pacing—skills that are honed with professional video editing experience.

In retrospect, the student researcher would not recommend that students take on such an ambitious project as part of their graduate study final project, especially as a single component. It would require many years of work, greater experience in video production, a team effort, and an understanding of time management that can only come with practice and experience. The difficulty was heightened by the pandemic setting, which presented unique challenges such as limited access to filming locations, social distancing protocols, and logistical constraints, all of which added to the complexity of the project.

Learning Opportunities

Despite the multiple limitations encountered in this study, the student researcher gained invaluable insights into the real-world barriers faced by individuals with limited mobility. Through innovative methods such as walk-a-

mile immersion and video journaling, the research not only highlighted accessibility challenges but also provided a firsthand understanding of the emotional and physical impact of these obstacles. The process highlighted the critical need for empathy-driven research in understanding the unique experiences of disabled individuals, especially in navigating both urban and rural environments with assistive technologies.

Skill Development

This project was an opportunity for the student researcher to hone a variety of research and analytical skills. Employing methods like surveys, system usability testing, and immersive experiences, the researcher enhanced their ability to gather and synthesize complex data. The iterative process of evaluating mobile applications and documenting accessibility challenges in real time developed problem-solving skills and critical thinking.

In particular, the walk-a-mile video required the researcher to develop professional-level video editing skills, ensuring the footage effectively communicated the accessibility challenges and user experience issues observed during the study. This process also demanded critical thinking to determine the most impactful way to present findings, connect them to broader accessibility concerns, and engage the audience meaningfully. These new skills, along with the overall research experience, will undoubtedly inform future work in both academic and professional settings.

Broader Implications

The findings from this research highlight the importance of user-centered design principles in creating more inclusive technologies. The study revealed that while existing assistive mobile applications like Google Maps offer some accessibility features, significant gaps remain, particularly in areas like real-time updates and rural coverage. By uncovering these issues, the research advocates for a shift towards designing solutions that prioritize the

diverse needs of disabled users. It also reinforces the idea that inclusive design benefits all users by fostering greater accessibility and usability across different contexts.

Future Significance

This research underscores the critical role that adaptive technology and user-driven innovation play in promoting independence for individuals with disabilities. The study's findings point to the urgent need for advancements in real-time data integration, collaborative app design, and coverage expansion to underserved areas. Furthermore, this work advocates for ongoing collaboration between app developers, policymakers, and the disabled community to ensure that future solutions are both practical and impactful. Continued efforts in this domain can pave the way for a more equitable future, where mobility and access are no longer barriers but enablers of opportunity

Reflections on Accessibility and the Path Forward

Even though this project encountered multiple limitations, The student researcher gained a deeper understanding of the challenges faced by individuals with limited mobility. The walk-a-mile experience provided firsthand insight into barriers like uneven terrain, inaccessible restrooms, and unreliable navigation tools. Engaging with participants highlighted the diverse needs of users and reinforced the importance of user-centered design.

This research illuminated both progress and ongoing challenges in accessibility. Current apps reflect broader societal gaps in inclusivity, emphasizing the need for collaborative efforts among designers, developers, and policymakers. By prioritizing user needs, we can work toward a future where mobility is no longer a barrier but a pathway to independence and inclusion.

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APPENDIX

Appendix A - SUS (Online Questionnaire)

Radford University
College of Graduate Studies and Research
Department of Design

COPY OF ONLINE SURVEY

Copy of survey can be viewed at:
https://docs.google.com/forms/d/e/1FAIpQLSecU9FiBITtzFNAKqmO5H4RNTIJAv7BzthFJVWli5otLLIR-w/viewform?usp=sf_link

Survey of Assistive Mobile Applications used for Navigational Access

This survey is for limited mobility users, (part-time or full-time use of wheelchair, walker, cane or scooter) only please. Complete this survey rating your use of the assistive mobile applications for disabled navigation. If you use more than one of these applications, please indicate which application you use in the survey below.

SECTION 1

1. Which assistive Mobile Application do you use to help in your disabled navigation?

❒ Access Earth
❒ Wheelmap
❒ Wheelmate
❒ Google Maps
❒ None
❒ Other

2. If other is selected for your assistive mobile disabled navigation application, what app do you use?

_____

_____

SECTION 2

Survey Questions

This section of the survey measures people's subjective and objective feedback of their experience with the assistive mobile applications for disabled navigational access.
For the App(s) that you selected above please answer the questions below rating from 1 (Strongly Disagree) to 5 (Strongly Agree) for the application that you use the most.

1

1. I think that I would like to use this application.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

2. I found the application unnecessarily complex.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

3. I thought the application was easy to use.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

4. I think that I would need the support of a technical person to be able to use this application.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

5. I found the various functions in the application were well integrated.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

6. I thought there was too much inconsistency in this application.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

7. I would imagine that most people would learn to use this application very quickly.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

8. I found the application very cumbersome to use.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

9. I felt very confident using the application.
   - ❒ 1 Strongly Disagree
   - ❒ 2
   - ❒ 3 Neutral
   - ❒ 4
   - ❒ 5 Strongly Agree

10. I needed to learn a lot of things before I could get going with this application.
    - ❒ 1 Strongly Disagree
    - ❒ 2
    - ❒ 3 Neutral
    - ❒ 4
    - ❒ 5 Strongly Agree

SECTION 3

Open Ended Questions

This section of the survey consists of open-ended questions pertaining to your experience while using navigational mobile applications. *Please give a short response to each of the questions below.*

1. What are some of the benefits you have experienced while using this(these) app(s)?

   _____

   _____

   _____

2. List some of the problems you have encountered while using the app(s).

_____

_____

_____

3. What are some improvements that you would like to see made to assistive mobile navigational access applications?

_____

_____

_____

4. What did you find complicated about using the app(s)?

_____

_____

_____

5. Is there anything else that you would like to comment about concerning assistive mobile navigational applications?

_____

_____

_____

SECTION 4

Demographic Portion of Research Survey

This area of the survey is for statistical data purposes. It is completely optional to complete but highly recommended. It would help in determining what percentage of users participated in the survey.

1. What is your gender?
   - ❒ Male
   - ❒ Female
   - ❒ Transgender

- ❒ Prefer not to say

2. What is your race?
   - ❒ American Indian or Alaska Native
   - ❒ Asian
   - ❒ Black or African American
   - ❒ Native Hawaiian or Other Pacific Islander
   - ❒ White
   - ❒ Hispanic or Latino
   - ❒ Other

3. What is your age group?
   - ❒ 16-20
   - ❒ 21-30
   - ❒ 31-40
   - ❒ 41-50
   - ❒ 51-60
   - ❒ 61+

4. Where do you mainly travel?
   - ❒ City
   - ❒ Rural
   - ❒ Both

5. What U.S. States do you mainly live/Travel in and use the apps for?

   _____

   _____

6. Do you use your wheelchair part-time or full-time?
   - ❒ Part-time
   - ❒ Full-time

7. How many years have you used your assistive mobility device (I.E. Wheelchair, Walker, Scooter, or Cane)?
   - ❒ Less than 1 year
   - ❒ 1-3 years
   - ❒ 3-5 years
   - ❒ 5-10 years
   - ❒ 10-20 years
   - ❒ 20+ years

SECTION 5

Option for Future Participation in Research Critique

This information is kept completely private and will not be shared with anyone or a third-party company. If you have any questions or concerns you can contact Dr. Jeanne Mekolichick, Institutional Officer and Dean, College of Graduate Studies and Research, Radford University, jmekolic@radford.edu, (540) 831-5958, or the Student Researcher, Kallie Jackson Nielsen at knielsen4@radford.edu

If you would like to further contribute to the research of this study and would like to participate in the open-ended research critique at the end of this survey, please be sure to check the yes box at the end of these questions and leave your email. You will only receive one email from Kallie Nielsen at knielsen4@radford.edu prompting for further research and your email will NOT be given to anyone else. This is for sole graduate research purposes and your individual information will remain private.

Would you like to be included in further research for this study at a later date?

- ❒ YES
- ❒ NO

Link to Email

In order to maintain privacy and collect user's emails for the final critique of research for the study you will copy the link below and paste it into a new browser after completing this study. If you choose to participate in the final research, your email will be kept private and will remain on a password protected device, on a private server, in a locked office, in a private location.

** Copy and paste this link into a new window/tab BEFORE hitting submit. PLEASE NOTE! Please be sure to ONLY copy the link and past into a new window or all of the survey data will be lost and will not be submitted. After you have copy and pasted into a new window/tab you can hit submit on this page. PLEASE DO NOT FORGET TO HIT SUBMIT!**

https://docs.google.com/forms/d/e/1FAIpQLSfEfkw1aA72XiB6bgmyWf3gIT-IWKqmkGmmXdrlfzIWIlg5_w/viewform?usp=sf_link

Appendix B - SUS Online Consent form

College of Graduate Studies and Research
Department of Design

Radford University Online System Usability Survey Consent Form

You are invited to participate in a research survey, entitled *"Survey about Improving Mobile Applications for Limited Mobility Access and Navigation."* The study is being conducted by Kallie J. Nielsen, MFA candidate of Graduate Research Studies, Department of Design, Design Thinking program, Radford University, 801 East Main St. Radford, VA 24142, knielsen4@radford.edu and the Primary Investigator Dr. Joan Dickinson, of the Department of Design, College of Visual and Performing Arts, Radford University, 801 East Main St. Radford, VA 24142, jidickins@radford.edu.

The purpose of this study is to examine how to improve current assistive mobile applications for the disabled while helping to improve disability access and navigation through using design thinking methods. Your participation in the survey will contribute to a better understanding of *disabled individuals understanding of mobile applications and their ease of usability and/or lack of navigation.* We estimate that it will take about 5-10 minutes of your time to complete the questionnaire. You are free to contact the investigator at the above address and phone number to discuss the survey.

This study has no more risk than you may find in daily life.

One of the questions we will ask you as part of this study may make you feel uncomfortable. You may refuse to answer any of the questions, take a break or stop your participation in this study at any time.

The research team will work to protect your data to the extent permitted by technology. It is possible, although unlikely, that an unauthorized individual could gain access to your responses because you are responding online. This risk is similar to your everyday use of the internet.

A limited number of research team members will have access to the data during data collection. Identifying information will be stripped from the final dataset.

Your participation in this survey is voluntary. You may decline to answer any question and you have the right to withdraw from participation at any time without penalty. However, if you withdraw from the study your answers will be removed from the research and you will no longer be a part of the research data and study. If you wish to withdraw from the study or have any questions, contact the investigator listed above.

If you have any questions or wish to update your email address, please send an email to knielsen4@radford.edu. You may also request a hard copy of the survey from the contact information above.

This study was approved by the Radford University Committee for the Review of Human Subjects Research. If you have questions or concerns about your rights as a research subject or have complaints about this study, you should contact Institutional Officer for Research for the College of Graduate Studies and Research, Dr. Jeanne Mekolichick, Institutional Officer and Dean, College of Graduate Studies and Research, Radford University, jmekolic@radford.edu (540) 831-5724.

If you agree to participate, please type "***I agree***" in the fill in box below. Then continue to the survey on the next page.

Thank you.

Appendix C - SUS online consent for email capture (document copy)

RADFORD UNIVERSITY

College of Graduate Studies and Research

Department of Design

Consent for Email Capture for Participation in Final Critique

Please enter the email address below that you wish to be contacted at for the final critique. Please note that your email will remain private and will only be viewed by the researchers of this study.

You will only be contacted once with information pertaining to the research critique.

Your email will be stored on a password protected file, on a password protected MacBook Pro, on a private server, in a locked office till the end of the study and up to 3 years. After the end of the study or 3 years, the information will be deleted.

If you have any questions or wish to update your email address, please call Kallie J. Nielsen at (423) 716-0604 or send an email to knielsen4@radford.edu. You may also request a hard copy of the survey from the contact information above.

This study was approved by the Radford University Committee for the Review of Human Subjects Research. If you have questions or concerns about your rights as a research subject or have complaints about this study, you should contact Institutional Officer for Research for the College of Graduate Studies and Research, Dr. Benjamin Caldwell, Institutional Officer and Dean, College of Graduate Studies and Research, Radford University, bcaldwell13@radford.edu, (540) 831-5724.

If you agree and want to be emailed about participating in the final critique please enter a valid email address below at which you can be contacted, then hit submit.

Email Address

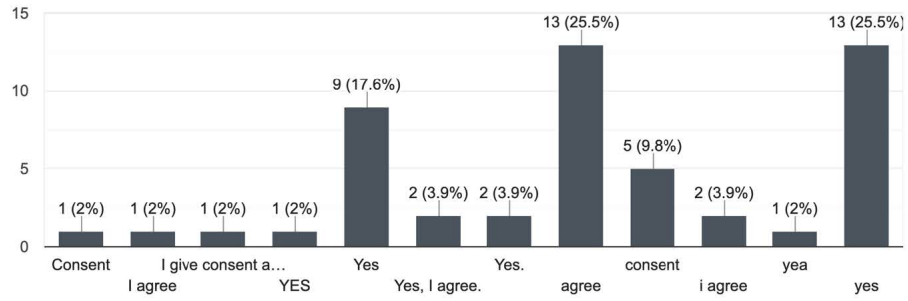
Appendix D – Results of System Usability Survey

Questionnaire for Improving Mobile Applications for Disability Access and Navigation
DATA COLLECTED

OVERALL SUMMARY OF 51 RESPONCES

Radford University Online Consent Form

Do you give consent and agree to participate in this online survey?
51 responses

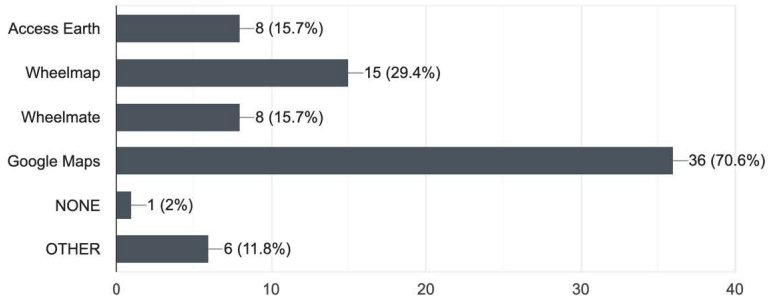


1

SURVEY OF ASSISTIVE MOBILE APPLICATIONS

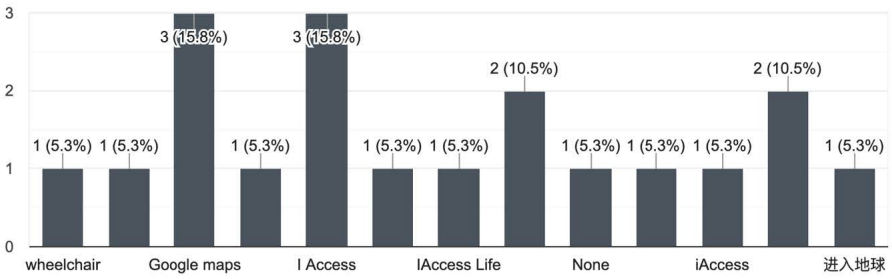
Which assistive mobile application do you use to help in your disabled navigation?

51 responses



If other is selected for your assistive mobile disabled navigation application, what app do you use?

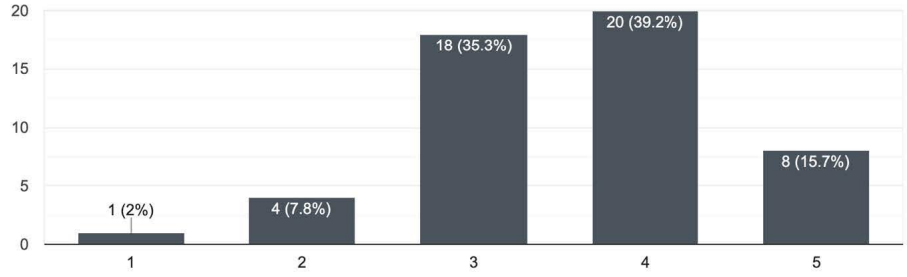
19 responses



Survey Questions

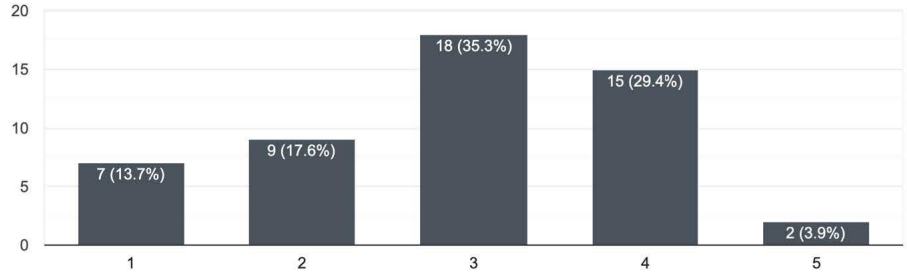
1. I think that I would like to use this application.

51 responses



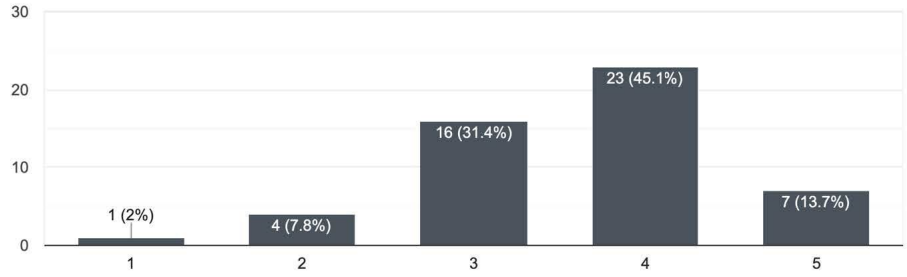
2. I found the application unnecessarily complex.

51 responses



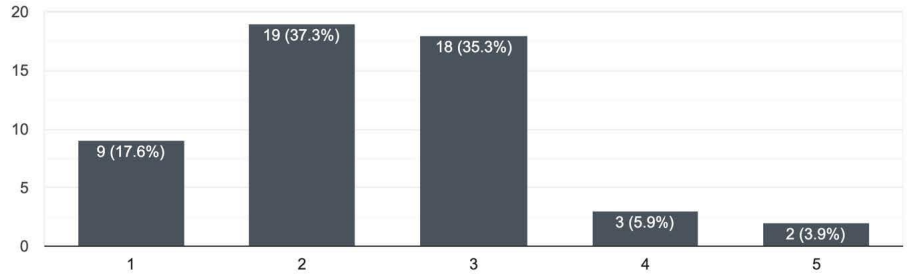
3. I thought the application was easy to use.

51 responses



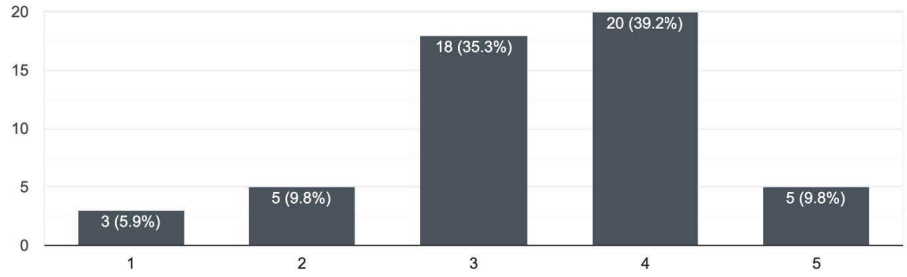
4. I think that I would need the support of a technical person to be able to use this application.

51 responses



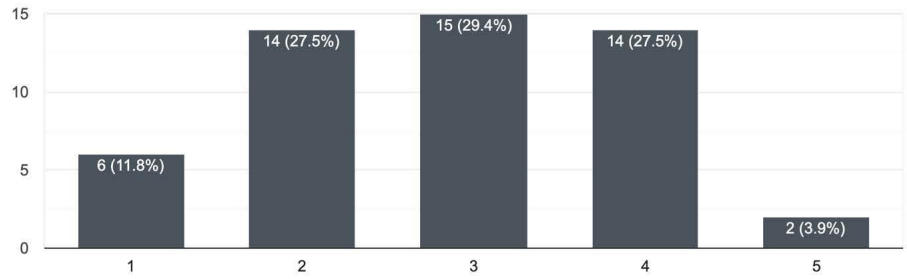
5. I found the various functions in the application were well integrated.

51 responses



6. I thought there was too much inconsistency in this application.

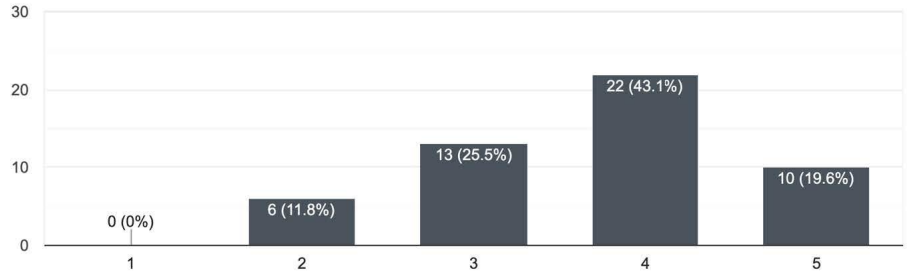
51 responses



5

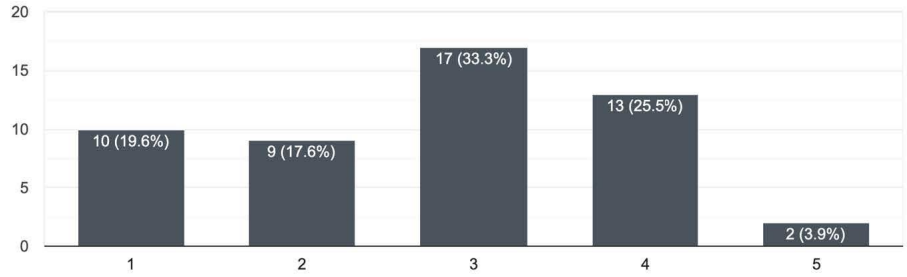
7. I would imagine that most people would learn to use this application very quickly.

51 responses



8. I found the application very cumbersome to use.

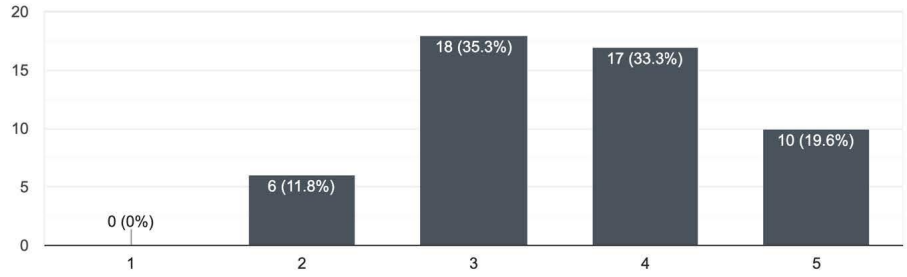
51 responses



6

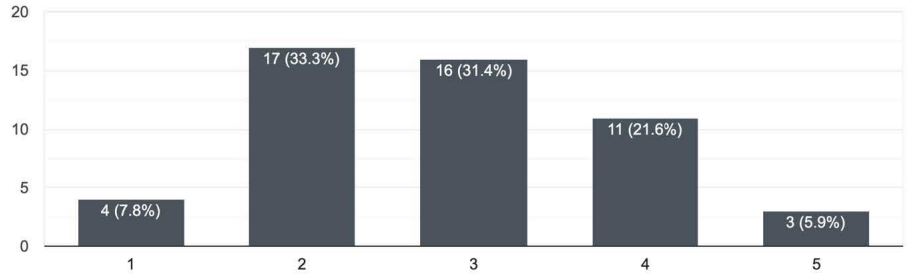
9. I felt very confident using the application.

51 responses



10. I needed to learn a lot of things before I could get going with this application.

51 responses

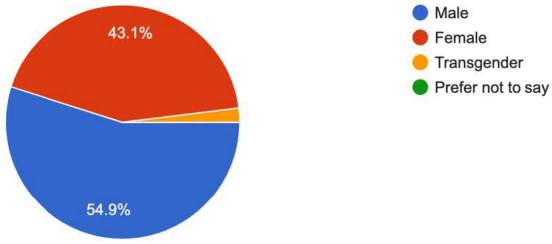


7

Demographic Portion of Research

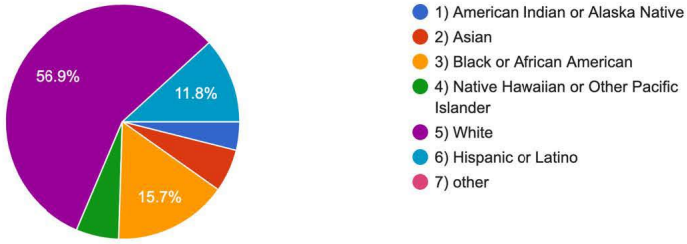
What is your Gender?

51 responses



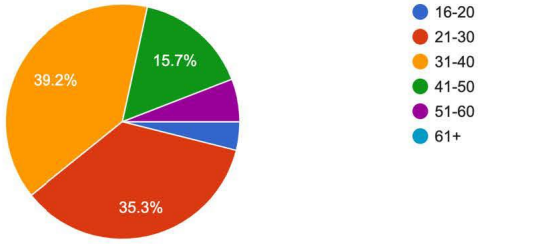
What is your race?

51 responses



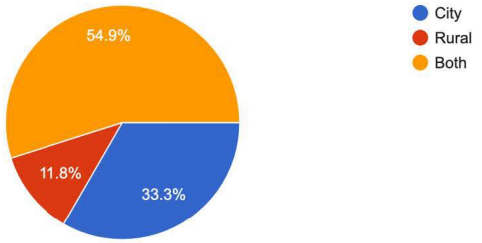
What is your age group?

51 responses



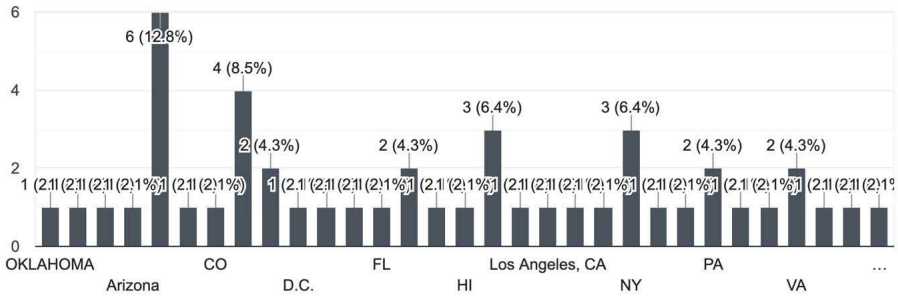
Where do you mainly travel?

51 responses



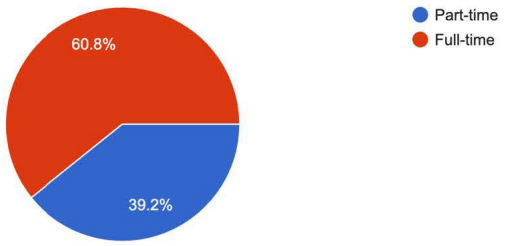
What U.S. States do you mainly live/travel in and use the apps in?

47 responses



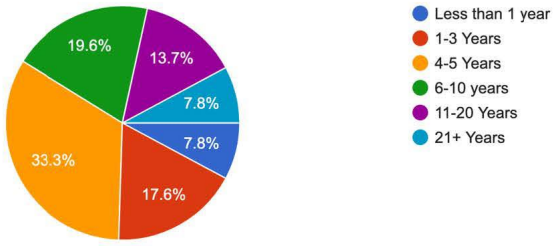
Do you use your assistive mobility device (I.E. wheelchair, walker, scooter, cane, etc.) part-time or full-time?

51 responses



How many years have you used your assistive mobility device (I.E. wheelchair, walker, scooter, cane, etc.)?

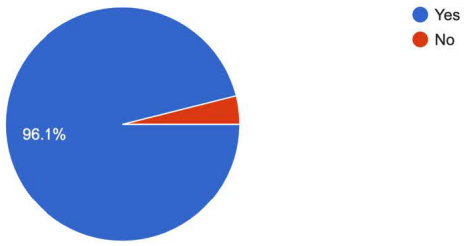
51 responses



Option for Future Participation in Research Critique

Would you like to be included in further research for this study at a later date?

51 responses



Appendix E – Open ended Questions from Online Questionnaire (SUS)

Open Ended Questions and Responses

QUESTION -What are some of the benefits you have experiences while using this(these) app(s)?
RESPONSES:

its quick to use and most people are familar with it
It tries to give an accessible route.
I was lost in London everyone was busy not ready to show me direction, Google map assisted me a lot
being able to find a bathroom and accessible restaurant
Accurate location
Simple and accurate
Convenient and quick
Very accurate navigation
convenientSafety accurate
accurate
Accurate, simple, convenient and easy to use
convenient
simple
It keeps me from getting lost
More convenient travel
Nearby supermarkets, restaurants, hotels, etc., can be quickly searched
More convenient transportation
More convenient travel
Can display wheelchair-friendly public transit interchanges on Google maps.
Navigate to where I want to go.
It's very helpful for me to be able to travel alone
Convenient and efficient
The application is very easy to use, it just took me a couple of minutes to master the most basic functions
Convenient and quick
Wheelmap gives me better positioning for GPS
It is somewhat convenient.
Both apps are pretty convienient and fast
I can find the places I can't find.
Super quick and Convenient compared to the other apps

1

loads fast and is easy to use
mostly accurate and fairly simple
It has a lot of information for when traveling to a big city
its convenient
nice app to have for finding accessible restrooms and parking
I can look up places plus it gives driving directions too.
IAccess Life has helped me find more accessible places than any other app.
Google is a reasonably simple app to use and is effective for what it is.
mostly easy to use
i like how there is a bunch of information populated for Nashville, but its not always correct
Nearby supermarkets, restaurants, hotels, etc., can be quickly searched so that is nice
I like how I can display accessible public transportation on google maps and accessible restaurants on I Access.
its easy to search nearby businesses, restaurants and hotels fast.
It keeps me from getting lost
Honestly, not alot. Its nice to have a navagation app for the car, but once i get on foot it gets to be a hassel. It would be nice if the app was accurate 100% of the time or even 90% but is more wrong than it is right.
it's nice to know if a restaurant is gonna be accessible or not
It helps me a lot to get where I want to go.
It is convenient for me to travel alone and reach the destination faster.
These apps helped me get back my independence
None so far.
It's nice to have access at my fingertips of accessible locations.
when i'm in a city its much easier to use then when i'm back in my hometown

QUESTION: List some of the problems you have encountered while using the app(s).
RESPONSES:

the disabled info is tiny and isnt populated for every location. also not alot of information for issues along route on foot.
The route isn't always accessible or it's just plain dangerous. For example, it once told me to go down steps.
Giving you long rotation while shortcut is available you spend a lot of time and get tired especially when stranger at a place,
sometimes the places listed as accessible are not. so like they are not updated oftenn
Sometimes there are deviations
Update slow
NO
No problems
Update slow
no problem
Updates are a little slow and sometimes the signal isn't very good
Meet with difficulties
It's a little bit complicated
In the process of using railway ticket, there will be a verification code including graphic verification code, slider verification code and other forms, I find it very difficult
The program card
It's hard to find out whether there are accessible elevators in supermarkets
The program card
The program card
Lack of clear instructions and signs can cause people with disabilities to waste a lot of time and effort, especially when it is inconvenient to travel to an unfamiliar place.
In some places the location is not so clear.
Can on occasion
Occasionally caton
None
Don't want to answer
sometimes the positioning on Wheelmate isnt accurate
it has a bad network and sometimes it is somewhat awkward to figure out how to use it
not alot of problems in the City
Finding barrier-free bathrooms and parking is difficult while traveling.
Google Maps, Wheelmate, Wheelmap position GPS are almost always slightly off and IAccess is updated more often

sometimes there is no signal for navigation
slow updates and signals are sometimes bad
dont have much info for when traveling to the country
the disabled icon is sooooo small on Google
don't like how you have to be in a location to edit or add something. that isnt helpful;
The wheelchair icon is far too small on the screen to see, there is hardly ANYTHING listed for where I live, and honestly, it took forever to load.
Google Maps is not always correct about places being fully accessible.
The grey accessible icon is hard to see. At first, I did not even know Google had integrated the features into the app.
gps is off about location alot
Would be nice to know what areas of Nashville are TRUELY accessible, I really enjoy supportin local businesses but most of them are in older buildings and they havent been retrofitted for wheelchairs. A lot of them are accessible once you get inside but I've had to have people carry me to get inside or up a couple of steps and its really not ideal.
It's hard to find out if the restaurant provides accessible restrooms
Lack of clear instructions and signs can cause people with disabilities to waste a lot of time and effort, especially when it is inconvenient to travel to an unfamiliar place.
Bathrooms are hard to find, especially ones that i can use in my wheelchair properly.
It's hard to find out whether there are accessible elevators in supermarkets
It takes me a long time to plan out a trip because i always have to double check if the businesses is truely accessible.
google maps isn't always accurate. Sometimes it will say a place is accessible, and then there are stairs going up to the main entrance.
No problems at the moment.
There was only about 3 businesses that show up for where I live with the apps, and I can never seem to find an accessible washroom.
no problems
Cannot find any accessible places for where I live.
The GPS is quite not right for either of the apps.
no places listed for my area

QUESTION: What are some improvements that you would like to see made to assistive mobile navigational access applications?
RESPONSES:

more features for the disabled user
I feel like if the publishers would get wheelchair users to actually navigate said course, like how they used the Google car to create a driving route.
Snap shot so that you do not get lost even if no internet access
no user friendly IE user input information more
Sometimes there are deviations
Updated accurate reporting
To be more accurate
Have you found any problems so far
Constantly updated
Enhanced AR features
Update fast network well
Be more informative
Be more informative
Hopefully, there won't be too many captchas.
More convenient to use
Hope businesses to improve barrier-free information, improve the degree of facilities.
The program is more convenient and more user-friendly
Some cities don't have "barrier-free access" options. I hope every city will have this feature
Voice navigation is clearer and more accurate.
Improve software running fluency
Resolve the fluency of software operation
It should have a dark theme so as not to strain your eyes at night.
Be human
more accurate GPS positioning and more updates
Simpler interface with more integrated functions. Perhaps more access and uploaded data for rural locations.
Set up Categorized Navigation
Make google more accessible. It is not accessible even with the new update.
More people need to use IAccess in order for it to be a better application.
I would like it to automatically shut down when I power off the phone.

they need to update the report from time to time
simplify them
id like Waze to start incorporating some disabled features
It'd be useful to change your location in the app to another location in another city instead of the one you're currently in. Could help when planning a trip.
Perhaps, having someone update Google Maps would represent more accurate information for smaller cities and towns.
I would like Google Maps and IAccess Life to collaborate.
Google should require business who are already on their mobile application to be re-evaluated as to if their business is accessible; because unfortunately, some businesses are claiming that they accessible and they are not.
often it does not account for traffic or construction for sidewalks
Maybe if i could ask a local via chat that would be a nice feature.
Hopefully, there won't be too many captchas cause that can be really annoying when trying to use an app on the go.
A ton of cities, especially small towns, don't have more barrier free access options available to disabled visitors.
Would be nice to have an app to let the bus know I'm riding so it won't skip me. Would also like to know what gov building are accessible, cause usually they are not and google say they are.
Would like traffic and construction updates for walking
If a business is listed as accessibly by Google then the ADA should certify if their business is truly accessibly, because 75% of the time it is not wheelchair accessible.
Google needs to make more updates for smaller towns. My town only has like 6 places listed as accessible and really only 2 of them are actually accessible. Google should really check their facts before publishing info like that to the public.
Optimize the voice broadcast function.
Remote areas should be more detailed and precise.
make them more intelligent
Google should add more accessible places for small towns.
It would be nice if both apps would share their data with each. Sometimes Google will say a place is accessible and I Access will say it is not. I call and find out it's accessibility and end up traveling there to find out they are not accessible. It can be a BIG waste of time.
easier to use, and make it more available in more places

QUESTION: What did you find complicated about using the app(s)?
RESPONSES:

not much
You can encounter other places are not step free along the journey like train stations
to many icon types to remember and the apps dont really share data or information across platforms
Sometimes there are deviations
Nothing too complicated
NO
It's very easy to do without learning it
Nothing too complicated, just get familiar with it
no
It's not too complicated
no
Too many things to choose from
When you're in a wheelchair, the bus is a hassle.
There's nothing complicated about it
It's hard to find out if the restaurant provides accessible restrooms
Not complicated.
It's not complicated and easy to use
The operation is simple and not complicated
No
Don't want to answer
it can be a complex operation to use the app
It never seems to have a lot of information for small towns when I travel.
not alot
It's not as easy when traveling outside of big city.
no problems with it so far
not complicated, familiar. Familiar with the good and simple; fairly good operation.

it was overwhelming at first
none
This app will probably be more helpful whenever we are in the larger cities we are traveling to, but for small its not helpful;
Everything!!!!
There was a lot to learn at first but, once I got used to using IAccess Life it was easy, Google still has a lot of improvements it needs to make as it's nearly impossible to use.
It is a good program, however, it needs to be updated more often and by people who ACTUALLY live in the area.
it isnt the same for in town or city
Alot of places on google maps say they are accessible but when you get there, its not.
n/a
It is harder to navigate in small towns, than it is in big cities.
there is nothing complicated about it
Goole maps is well integrated but sometimes it can run me into a curb, or area that is not accessible even tho it claims to be.
it took me a while to figure out how to turn on and use the disabled feature. Why is it not already turned on automatically?
sometimes the GPS is off and when i'm trying to navigate it can take FOREVER to load.
It is not that complicated.
The user input function doesn't seem to work for the Wheelmap app, I've tried so many times to update information for my town but nothing.
N/A
Nothing the app was easy to use, it just had zero information for where I lived.
A lot of the information provided is incorrect. A lot of government buildings are not accessible even though Google thinks it is.
the app was simple to use.

QUESTION: Is there anything else that you would like to comment about concerning assistive mobile navigational applications?
RESPONSES:

they should be more about access for everyone not just cars
It should have optins for informal settlement navigations options
wish that google has more information for rural area when i travel for work
no
Very good have can continue to update strengthen
NO
Hopefully the pronunciation will be a little better
Learn about road conditions and report updates
satisfied
Update the report from time to time
no
Not yet
Temporarily no
Some cities don't have "barrier-free access" options. I hope every city will have this feature
No.
It is of great help to us disabled people. I hope it will be better and better
This software is very practical
No
Don't want to answer
make it more simple operation
Add more apps, not much for disabled navigation and I'd like to see more.
more integrated features
in city, google is good. Outside of city google is bad. Even sometimes in city google is still wrong about location and if building is accessible.
I really want all mobile apps to share data, to help improve each other and allow wheelchair users to be rewarded.

they need to update the signal to update the status.
they need to be simpler, more user friendly, and updated more often for BOTH city folks and those who live out in the sticks.
not right now
wish it had more features
They should have tested the application in small towns before they released it to the public!
It would be nice for both applications to have more user input for rural locations as when traveling out of a big city, there is hardly anything there.
Google should require business who are already on their mobile application to be re-evaluated as to if their business is accessible; because unfortunately, some businesses are claiming that they accessible and they are not.
it needs to be updated more often
just be certain that your app is truely accessible before you slap that term or logo on there. Alot of people depend on the help of others to get around and it would be nice to be more independent.
n/a
A ton of cities, especially small towns, don't have more barrier free access options available to disabled to visitors.
Businesses should improve barrier-free information provided to the public, and improve access to their facilities.
Accessible apps should be easier and better than regular apps. Basically Google should be taking all the guess work and problem solving out for you. Maybe if they had more user input features like Waze or Wheelmap that would help, but even Wheelmap has a bunch of problems with updates.
it would be nice to have a feature to ask a question, like if your travlin to a town, and you wanna ask a local but nobody is around, but they would have to have an answer like insta messanger. Ya know quickly.
I think that the technology is there, but it could be a lot better. Maybe they should invest their money into improving the apps they have instead of trying to make self driving cars cause we ain't there yet.
The app is very good, GPS could use to be updated more often.
When it works its nice, but when ya really need it to do what you want it to do, it does not get the passing grade.
They are all great apps, but they need updating.
Maybe Google should focus more on smaller towns and less on big ones.
DC is always very crowded and Public transport is very key for travel but the bus will skip you if it full, it would be nice if you could inform the bus on ur phone that you are gonna be on its route and not left waiting in the rain.
I would like the option to chat with a real person and ask them about the town i'm in. Locals usually know more than big corporations.

Appendix F – Photos from Walk-a-Mile


Spice
LATTE


3436
kcals

Appendix F – Facebook Post