

Digital Design Marginalization: New Perspectives on Designing Inclusive Interfaces

J AISIE SIN

TAGLab & Faculty of Information, University of Toronto, Canada

RACHEL L. FRANZ

Information School, University of Washington, Seattle, WA, USA

COSMIN MUNTEANU

TAGLab & Institute of Communication, Culture, Information and Technology, University of Toronto Mississauga, Mississauga, Canada

BARBARA BARBOSA NEVES

Monash University Melbourne, Victoria, Australia

We conceptualize Digital Design Marginalization (DDM) as the process in which a digital interface design excludes certain users and contributes to marginalization in other areas of their lives. Due to non-inclusive designs, many underrepresented users face barriers in accessing essential services that are moving increasingly, sometimes exclusively, online – services such as personal finance, healthcare, social connectivity, and shopping. This can further perpetuate the “digital divide,” a technology-based form of social inequality that has offline consequences. We introduce the term Marginalizing Design to describe designs that contribute to DDM. In this paper, we focus on the impact of Marginalizing Design on older adults through examples from our research and discussions of services that may have marginalizing designs for older adults. Our aim is to provide a conceptual lens for designers, service providers, and policy makers through which they can use to purposely lessen or avoid digitally marginalizing groups of users.

CCS CONCEPTS • Human-centered computing-HCI theory, concepts and models

Additional Keywords and Phrases: Digital Design Marginalization, Older Adults, Marginalizing Design, Inclusive Design, Digital Inclusion, Digital Exclusion, Digital Inequality, Digital Divide, Social Exclusion, Social Marginalization

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.

1 INTRODUCTION

Across numerous domains in the modern information society, essential life services, such as public services, are increasingly being migrated to digital, online, or mobile-only spaces. Brick-and-mortar stores are expanding into or exclusively switching towards e-commerce solutions. Established financial institutions have been progressively replacing their in-person services, such as those offered through existing physical branches, with digital alternatives such as mobile and online banking, which offer digital solutions for payment, banking, investments, insurance, and more recently, cryptocurrency management.

Users of the newer digital solutions experience many advantages, including increased ease of access to those services due to the overcoming of physical- and time-related barriers. Yet, the design of these systems can create access barriers for others. In other words, these systems can digitally exclude people, such as some groups of older adults (those aged 60+). For example, a website that uses complicated layouts, menu controls that require dexterity in operating a mouse, or dense passages of text can be categorized as not “user-friendly” for some older adults. Similarly, a mobile banking app that forgoes the use of textual information in favor of images and icons (or other elements that are non-compliant with assistive technologies, like screen readers) to convey its content [67] may appeal to the app’s brand identity but is not inclusive of blind or low-vision users, of which consists of not only older adults but people from other age groups as well. Finally, many photocentric social media platforms have the potential to help older adults’ stay connected and reduce their risk of social isolation, however they are designed with information workflows that might not match some older adults’ mental models [2].

These design decisions can actively create barriers that prevent such user groups from accessing and participating in services that continue to transition to online- or mobile-only formats. When it comes to older adults, these barriers leading to non-use and non-adoption of these digital services can result in negative impacts on these users’ non-digital lives. Such social consequences include a loss in their ability to access the same quality of service at banks, increased social stigma, and a decrease in their sense of self-efficacy and social belonging [53].

As a design community, we have frameworks such as inclusive design, universal design, accessibility, and ability-based design to conceptualize approaches to be attentive of user needs. These frameworks motivate and aim to serve as lens for satisfying usability and user-friendliness requirements by creating designs that are digitally inclusive. These frameworks have been applied towards design solutions and practices for understanding and improving technological inclusivity for older adults (e.g. [7,12,24,47,59,61]).

However, these frameworks do not (nor is it their goal to) fully reflect upon, capture, or address the digital designs or design processes that may negatively impact users beyond the immediate use of the design, extending to aspects such as the users’ social well-being or economic status. Thus, sometimes the same technologies designed to bridge technological divides can lead to further marginalization. For example, mobile devices have been touted as democratizing internet access [45]; this is primarily because they are more affordable and for many are the only means of getting online [68]. As a result, existing design frameworks may suggest that digital products should be first-and-foremost designed to be mobile-friendly, if not even mobile-only. However, mobile access to services often fall short of PC-alternatives [45]. This means that those with only mobile-access to the internet become a “second class” of digital citizens based on their

technological capabilities, usage patterns, cross-platform skills [45]. These differences can reinforce and exacerbate inequities in digital skill sets, online participation, and content creation [45], and these online digital inequalities can result in offline social inequalities [53].

To highlight the consequences-laden impact of design on additional, indirect, and long-lasting social consequences on aspects such as social well-being, we conceptualize and formally define in this paper the notion of **Digital Design Marginalization (DDM)**. DDM refers to the process where a digital interface design excludes certain users and contributes to marginalization in other areas of their lives, through means such as social exclusion, lowered self-efficacy, and social stigma. In turn, a digital interface with a **Marginalizing Design** renders the members of this user group as second class in not only the use of that digital interface, but also in society as well. When a DDM lens is not applied throughout the design process, it enables practices that may lead to designs that actively ignore, exclude, or push certain groups to the margins.

DDM, which focuses on the social consequences of a digital design, can be applied in conjunction with existing design frameworks, which have focused on making digital designs more inclusive. The DDM framework is situated in ongoing discourses about reflective practice, and thus can be used in conjunction with disability studies, action research, and community-based participatory research (CBPR). Namely, the DDM supports: the commitment of and increasing call towards the role of reflexivity in action research [18,31]; the increased need for reflective practice as evidenced by key research in CBPR [15]; and the need to take care of risks of exacerbating participants' vulnerability, as supported by Sensitive HCI [62].

The DDM framework conceptualizes how marginalization by design can be caused even by designers with the “best of intentions” but otherwise unaware of their role in such issues. As illustrated by the case studies in Section 5, even research mindful of inclusive design principles, such as co-design, sociotechnical systems approaches, and accessible design, can lead to unintended consequences and thus DDM. As evidenced by the two case studies we present in Section 5, even researchers who are already experienced in inclusive frameworks may still omit design aspects that could potentially marginalize users. The DDM thus helps us reflect on these issues more holistically. That said, the aim of the DDM is to help not only those who are trained in existing inclusive design frameworks but also designers who are new to these frameworks. One of the DDM's aims is to help designers avoid such consequences when DDM is embedded from the onset in designers' practice as a reflective guide. For designers, DDM can serve as a lens through which to reflect on (and revise) existing practices that may lead to designs that actively ignore, exclude, or push certain groups to the margins. For practitioners and researchers alike, DDM can become a new basis on which to reflect on their practices and research, as we will demonstrate through the case studies in this paper in Section 5. Lastly, for HCI and social science scholars, DDM can also be a lens through which to investigate questions of technology adoption and the societal impact of technology on people's lives.

We ground this proposal of DDM in a critical analysis of the current research body of design knowledge and practice. Concretely, we contribute:

- A theoretical proposal to conceptualize this dynamic and consequences-laden exclusion as “digital design marginalization” (DDM), outlining design decisions and practices that cause DDM as forms of “marginalizing design” (Section 4);
- An illustration, through case studies of prior research, of how digital design marginalization framework can identify gaps in the design process that can lead to marginalization (Section 5);

In our age of “technological solutionism” [44], it becomes all the more important that we call for a stronger recognition of the active role design has in perpetuating the “digital divide.” It is important to emphasize that the goal here is not to oppose efforts to support technological innovations. Rather, it is to try to recognize marginalizing effects of design to certain groups of users beyond the direct use of the technology that is being designed. We claim that we need a new theoretical framework that will guide this understanding, help our community conceptualize and contextualize the marginalizing effects of design, and ultimately support a cultural shift in how we approach designing interactive interfaces. We propose and apply the DDM framework primarily on designs for older adults (people aged 60+) as this is our primary domain of expertise, and as such can serve as a starting point or as an exemplar. This provides us with a lens through which to reflect on the marginalizing aspects of designs. We illustrate this reflection through two case studies from our own research [25,46–48]. Following ‘curb cuts’ principles, we believe that the DDM framework can be applied to other user forms of human diversity with respect to ability, language, culture, and gender to critically analyze one’s designs, and we encourage further work to be done to study such applications.

2 THE ROLE OF DESIGN IN MARGINALIZATION

Historically, design has played a (often underacknowledged) role in marginalizing people or reinforcing existing inequalities, regardless of whether these effects were intentional or out of “negligence”. An example is the parkway to Jones Beach State Park (advertised at the time of its opening in 1929 as a “beach for everyone”) in the U.S. state of New York [1]. The architecture of the overpass bridges spanning the parkway offered low clearance to the vehicles on the parkway [10,66] and prevented public buses from easily reaching the park. This parkway’s design has been called racist [1,66] because it made it harder for those of lower socioeconomic status in those times, namely African Americans who could not afford the luxury of access to cars, to visit the beaches.

The parkway is a historical example of the marginalizing effects of design and often referenced in Science and Technology Studies. It is a valuable and emblematic case even if it does not take place in the digital space. Such examples complement more recent digital examples, one of which is the issue of marginalization through the introduction of digital-only payments in stores. Cashless retail stores in San Francisco, California have recently been ordered to accept paper currency instead of exclusively using electronic/digital payments as a way to avoid marginalizing socioeconomically disadvantaged users [63]. Further examples of designs of digital systems that reinforce inequality include face-tracking webcams that fail to recognize those of darker skin tones [65], and a recent example in 2019 which sees a legal case where the website and mobile app for pizza ordering was not compatible with screen readers, thus excluding blind or low-vision users from using them [67]. In the latter example, these users were still able to access the analog alternative of calling the pizza restaurant to place an order, but this method placed additional burdens on these users and excludes them from other forms of interaction. Not only does this legal case, as well as the restaurants’ insistence to dispute the case, present a poor user experience for certain users, but it also reinforces existing social inequalities.

In all of these cases, potential users are not only pushed away and ultimately excluded from the *online digital* features or versions of a service, but these design-based factors also reinforce existing *offline social* inequalities based on belonging to an identifiable group (based on age, race, ability, etc.). In other words, such cases of design further perpetuate the “digital divide” (a technology-based form of inequality which produces negative online and offline consequences) and further reinforce existing offline social inequalities. The design of these digital systems has actively created situations of exclusion which contributes to creating new or further perpetuating existing social inequalities.

Many barriers to ensuring fair access to digital resources still exist for many potential users, including people experiencing lower literacy or socioeconomic conditions [26]. There is research dedicated to incorporating inclusive design approaches, such as by supporting collaboration across users of different literacy levels [54], or directly aiming to increase digital literacy skills [13]. However, we are still falling short of eliminating all barriers. For instance, even accessibility options like screen readers have limitations such as the difficulty in navigating long texts [3] and the need for users to have a good mental model of their assistive software [60] – a task that can be difficult for, as an example, some older adults who are living with cognitive impairments. Furthermore, technologies designed to bridge technological divides can sometimes lead to further marginalization. As mentioned in the Introduction, mobile device penetration has been touted as democratizing internet access, yet it risks creating an “under class” of digital citizens based on a number of factors relating to mobile being an inferior form of Internet access [45].

While the existence of digital divides and digital exclusion have been studied, there is not yet a framework grounded in critical theory that captures the dynamic relation between marginalization and design. Given the rapid pace at which new digital designs are being introduced, we must ensure a deeper understanding of how certain groups can be marginalized through design.

3 DIGITAL DESIGN MARGINALIZATION & MARGINALIZING DESIGN

Prior to or even during the construction of a product or service, decisions on the design of the product are made by designers, practitioners, or policy makers. As we have argued and evidenced earlier, these decisions can actively contribute to both digital inclusion and digital exclusion. The latter manifests in a number of ways, such as in situations where the needs of certain user groups are not included in the final design or the design process. However, in many cases, such decisions can go beyond the digital context – in such cases the act of being digitally excluded by interface design may lead to those user groups being socially excluded or relegated.

To help ground our definition of digital design marginalization, we turn to the definition of (social) marginalization by Dwivedi et al. [19]. Dwivedi et al. saw marginalization as the “intended or unintended relegation of individuals, groups, or entire nations by limiting their access to the benefits of globalization.” This marginalization results in the social consequence of exclusion due to inaccessibility and non-participation. To define digital design marginalization, we map the definition by Dwivedi et al. for the social space onto the space of interfaces and digital service design, specifically the space of human-computer interaction. Here, we see digital design marginalization as the intended or unintended relegation of users by limiting their access to the benefits of a digital service or system. This marginalization also results in the social consequence of exclusion due this time to digital inaccessibility and non-participation (in other words, due to digital exclusion).

Thus, we propose a formal conceptual definition of digital design marginalization as follows:

Digital Design Marginalization is the pushing of a defined group of users (such as older adults) away from a digital or online service or system, whether intentional or not, and the direct result of how the digital interface of the service or system is designed, which originates both digital and social exclusion. This exclusion has additional, indirect, and long-lasting social consequences on that particular user group.

In operational terms, digital design marginalization can be seen as “marginalization by design.” More specifically:

Digital design marginalization occurs when the decisions about the design of a digital system or service have consequences extending beyond such users being excluded from using that particular system or service to users experiencing additional negative social consequences. These consequences may include increased barriers to using the non-digital equivalent of that system or service, diminishing of the ability to interact with other digital systems or services, or additional difficulties in

engaging with essential services or experiences (social, personal, financial, administrative, etc.) that were previously accessible to them. The impact of digital design marginalization may be measured in the degradation of the users' quality-of-life (socioeconomic status, health, personal well-being, etc.).

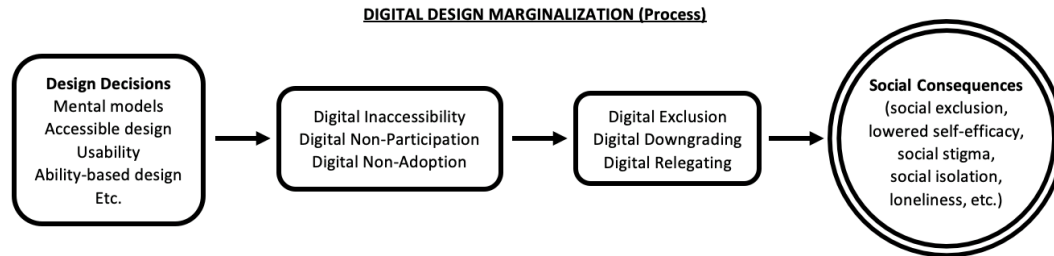


Figure 1 A flowchart visualization of the conceptualization of Digital Design Marginalization. When design decisions lead to digital inaccessibility, non-participation, and non-adoption, digital exclusion results. Digital exclusion has offline consequences in the form of social consequences, such as social marginalization, social exclusion, lowered self-efficacy, and social stigma. This process spanning from design decisions to social consequences is Digital Design Marginalization.

Figure 1 is a flowchart visualization that captures the definition of digital design marginalization. We have proposed the digital design marginalization as a conceptual framework that aims to provide a critical lens of the design and the design process. Digital design marginalization pushes identifiable groups of users away from the design. In turn, a digital interface design that renders this user group as second-class in not only the use of that digital interface, but also in society (in other words, a design that causes digital design marginalization) is “Marginalizing Design.”

We carefully chose the term “pushing away” to explain digital design marginalization, instead of other possible choices such as “excluding,” in order to better highlight the non-binary nature of digital design marginalization. That is, some members of any given user group may be able to overcome the marginalizing effects of a newly-designed service or system, and not be outright “excluded”. The difference between “pushing away” and “excluding” is important because even when members are not outright excluded in a new design, they can still be pushed away and thus experience the marginalizing effects. By choosing the word “pushing away”, we are also encouraging designers and similar decision-making stakeholders to avoid taking on a “victim-blaming” perspective and assuming that it is up to the members of an affected user group to actively seek ways to overcome barriers to a service or system.

4 EXISTING CONCEPTUALIZATIONS OF INCLUSION AND MARGINALIZATION

To help situate our definition of digital design marginalization, we now look at the broader conceptual space of inclusion and marginalization. By anchoring in these existing conceptualizations, one will become better equipped to survey the barriers and consequences of design that may not be inclusive of underrepresented user groups such as older adults.

4.1 Conceptualizations Within the Social Sciences

Technology can exclude certain users from critical digital services based on factors such as age, ability, and language. Many formalize inequality in access to and advantages of technology [56]. Yet, none of these terms frame the issue in relation to the social consequences caused by the design of the technology. The terms within the social sciences that

address various forms of technological disparity include but are not limited to those outlined under the following subheadings.

4.1.1 Digital Divide & Digital Inequality

The digital divide is the recognition that there is an uneven distribution in the availability, use, and impact of information communication technologies. Digital inequality has surfaced as one of the most prominent forms of inequality and cannot be analyzed apart from offline circumstances and consequences [53]. Many conceptualizations of the digital divide are used [38,51], with the most common one being a three-level definition of the digital divide.

The first-level digital divide asks, “who can and cannot access the internet?” The first level of the digital divide pertains to the physical access to a digital product or service, based on properties such as access to the network or necessary hardware [20]. Recognition of the digital divide was raised through a series of reports issued by the United States National Telecommunications and Information Administration [8,20,21]. These reports mobilized scholars, politicians, and local communities to inquire whether information communication technologies can address the needs and integration of low-income people into the information society. Inequalities of the first-level have been observed across factors [9,29] such as age [40], education [21], race [34], gender [6], income [27], and rural residence [58]. The first-level digital divide is sometimes framed in terms of the differences between the “haves” and “have-nots”, or between users and non-users.

The second-level digital divide pertains to inequalities in terms of users’ motivations, skills, and purpose of using a digital product or service [29]. The second-level digital divide pertains to inequalities that exist amongst those who have formal access to the Internet [17]. For example, even when someone can go online, their ability to make use of this resource is dictated by their autonomy of use, skill, and social support in using the technology. Such is the case with older adults [30]. DiMaggio & Hargittai [17] identified five dimensions that factored into a user’s ability to find information on the web; they were technical means (software, hardware, connectivity quality), autonomy of use (location of access, freedom to use the medium for one’s preferred activities), use patterns (types of uses of the Internet), social support networks (availability of others one can turn to for assistance with use, size of networks to encourage use), and skill (one’s ability to use the medium effectively).

The third-level digital divide asserts that use of digital products and services are more beneficial to some people than others in terms of what they can achieve by using these products and services [16]. The implication is that those who already have many resources on hand tend to derive more benefit from going online and using digital products and services. The benefits that are derived are based on social, cultural, economic, personal, and political factors.

4.2 Conceptualizations Within the Design Community

The terms mentioned in the previous subsection are used primarily in political and popular contexts when addressing concepts related to the digital divide. Several more terms exist which are specific to design in the digital space, such as the ones in the following subheadings.

All of these terms attempt to tackle important aspects of the “digital divide” through the lens of design. They are also a testimony to the efforts of the design community to address issues of discrimination and the negative social impact of non-inclusive design. However, none of these terms specifically reflect upon or address the mechanisms by which digital design itself contributes to the widening of the digital divide and the perpetuation of digital inequality. In addition, none of these terms have been sufficient to address the active, non-neutral role that digital design plays in extending both digital and social inequalities.

The term **digital exclusion** refers to the lack of access to, and use of, digital technologies by a particular individual or group of people [69]. When this term first emerged, it was used with respect to disparities between developed and developing nations. Now it is mostly applied to contexts within individual nations, an example being the difference between those who have access to the Internet (the “haves”, who are included) and those who do not have access to the internet (the “have-nots”, who are excluded) [56]. Digital exclusion is linked to people’s social, economic, and cultural contexts, and cannot be analyzed apart from offline circumstances and consequences [53], and factors include being older, unemployed, and less likely to live in a household with children [32], all of which can characterize older adults.

In contrast, **digital inclusion** is an approach to narrow the digital divide by tackling issues of digital exclusion and access [32]. The idea was that access to digital resources would increase social inclusion, and thus it was important for the government to support digital inclusion. Digital inclusion attempts to tackle the challenge of the digital divide by ensuring that all individuals and communities, especially those who are most at risk of being marginalized, will have access to and can benefit from the use of information communication technologies. Digital inclusion has a positive relationship with social inclusion when it comes to older adults [32,33].

The design space also has an interpretation of the **Digital Divide**. Nielsen [22] identify three stages to the digital divide that are of concern to designers; they are the ‘economic divide,’ the ‘usability divide,’ and the ‘empowerment divide.’ The economic divide relates to issues of access (much like the aforementioned first level divide). The usability divide pertains to skills to use digital services (much like the aforementioned second level divide), with a focus on digital literacy and accessibility. In the case of older adults, the usability of touch-based graphical user interfaces is often a concern due to a gradual decline of fine motor ability that can occur in later life. Another usability issue leading to furthering digital divides is the mismatch between the mental models of designers and that of older adults also leads to lower levels of technology adoption in older adults; this is shown in a study highlighting differences between older and younger adults’ use of photo close storage applications [2]. The empowerment divide relates to peoples’ use of the opportunities provided by technology. The empowerment divide regards participation inequality and the role of users’ understanding of digital designs and how that may factor into their lives. For example, users tend to not understand their own biases towards selecting the first search result they come across, regardless of the quality of content provided by that result [22]. Educating users so that they can form a proper mental model of how the search engine functions can prevent users from being at the mercy of design decisions made by others [22].

Universal design is a term coined by Ron Mace [41], who established The Center for Universal Design in 1989. With origins in architectural and industrial design [70], universal design aims to build products that are accessible to everyone, regardless of age, disability, or other factors. A commonly cited example of universal design is the “curb-cut” effect, which refers to the design of sidewalk ramps which benefit not only people who use wheelchairs but also other people who are operating other objects on wheels, such as strollers, shopping carts, and luggage. Providing older adults with products designed for universal design options can improve their daily living [11,36].

Finally, **inclusive design** is a term used widely in design industries for the development of digital products. It is an approach to design that recognizes and accounts for the full range of human diversity when thinking about design research, processes, and impact [70]. Unlike universal design, inclusive design reserves the freedom to take a one-size-fits-one approach. However, like universal design, inclusive design practices are known to benefit more than simply the intended audience. For example, high-contrast designs aimed at improving accessibility of digital products for older adults by accounting for vision loss can also help those who are suffering situational and temporary problems such as reflections of sunlight from glass screens [50].

4.3 Related Conceptualizations: Algorithmic Bias

Algorithmic bias concerns the role of the design of procedures used in computer systems in producing unfair outcomes for disparate groups of people. The bias has often reflected existing social inequalities based on factors like race [49] and ability [37]. Attention to algorithmic bias has been on the rise, especially with the emerging potential of “big data” [14] and the growing use of AI algorithms in the design of sensing technologies [37]. Concerns about algorithmic bias surround the inclusivity of the datasets and their potential to further marginalize disadvantaged groups [5,28,35]. It has had implications in the capacity of existing sensing systems to serve people with physical disabilities [37], the financial and housing crisis of 2008 [52], search algorithms’ negative biases towards already marginalized populations [49], and the wellbeing of those of low social and economic status [26]. Algorithmic bias serves as an example of how technology, even if well-intended, can not only exclude users, but actively bring negative social, cultural, economic, and personal consequences through the active discrimination of identifiable user groups.

Algorithmic discrimination focuses on the societal consequences of the design of procedures used, for example, in AI systems. The consequences of algorithmic discrimination can serve as a “lessons learned” about the path and necessity of scrutinizing technology from a very wide and thorough inclusion/exclusion perspective for their social consequences. While algorithmic discrimination is outside the scope of our research, which focuses on design, it serves as a valuable perspective in the discussion of digital design marginalization.

4.4 Design Dimensions: Marginalization and Inclusion

Dwivedi et al. [19] defines marginalization in the context of globalization as the “intended or unintended relegation of individuals, groups, or entire nations by limiting their access to the benefits of globalization.” The result of marginalization is exclusion due to inaccessibility and non-participation. There are multiple aspects through which one can be marginalized; these include but are not limited to age, ability, sexuality, race, and socioeconomic status. The affected group reaps fewer benefits and feels less important than those who hold power [19]. This in turn results in a number of psychological and social impacts including social isolation, hopelessness, limitation to access to resources, stereotype threat [57], and internalization of the negative messages.

Coping with marginalization is burdensome for the individuals who experience it. Despite individual strategies to minimize the negative impact of marginalization, this is a structural issue. Addressing marginalization relies on the contributions and actions of all members of society. This includes advocacy, changes in public policy, and increased self-awareness of our societal positions and roles.

There are several areas of (non-digital) service design from where we can draw lessons and guidance with respect to avoiding marginalization, with one being the example of Moses’ overpass bridges towards the Jones Beach Park as recounted in the earlier in this paper [1,10,66]. Dimensions of marginalization and inclusion continue to be relevant today and across contexts. More recent critical analysis of the design of urban spaces has been emphasizing the effective use of participatory and inclusive design practices in order to bridge the divide and prevent marginalization through design (e.g. [4,23]). Avoiding marginalization is also relevant in contexts such as designing education [43]. The issues of design include not only access and digital literacy (e.g. as outlined by [55]), but also how the associated product or services are delivered. This encompasses services for older adults as well, from inclusive care [64] to inclusive (person-centred) health service delivery [42].

It is outside the scope of this paper to extensively survey all aspects of social inclusion and of social marginalization, as this is a broad space. Rather, we provide an overview of this space to situate our contribution. Inclusion is an important aspect of the design of any new service or system (whether digital or not). We have provided these examples as a means

to conceptually frame marginalization and to anchor our proposed definition of digital design marginalization and its relevance to the space of designing for older adults in the following two subsections. Through this, we aim to highlight how design can be not only an approach against marginalization, but also act as an agent of marginalization.

In the next section, we provide case studies of applications of the digital design marginalization framework to our research on technology for older adults, illustrating how to recognize and prevent digital design marginalization.

5 OLDER ADULTS AND DIGITAL DESIGN MARGINALIZATION

We now return to our proposed framework of digital design marginalization and reflect on its practical applicability through a case study reflection. We show how the digital design marginalization framework can more clearly articulate the marginalization effects that novel (as in case study 5.1) and existing interactive designs (as in case study 5.2) have on older adults. Our aim is twofold: first, to concretize the concept of digital design marginalization, and second, to motivate further investigations of case studies, causes, and prevention and reduction strategies, especially in the context of older adults' use of digital technologies.

Our reflections are on case studies for the population of older adults through the lens of our own expertise (older adults and later life). We hope that our reflections can serve as examples for other researchers and practitioners on how to apply this framework to their work with underrepresented groups that are marginalized with respect to interaction design. We also hope that they can also serve as examples of moving beyond the 'positive bias' of research that often prevents the publishing of 'negative results' or negative unintended consequences.

5.1 Case Study: The Accessible Communication App Project

5.1.1 Project Summary

The first case study draws on our development of InTouch [46–48], which is a communication app for older adults and relatives. Research shows that creating opportunities for social connectedness can help alleviate and prevent both loneliness and social isolation in later life. Thus, we created an accessible tablet-based communication app developed with and for older adults at risk of loneliness and social isolation. The app supports asynchronous communication and allows users to send and receive multimedia messages (pre-set text, video, audio, and picture messages). In addition, its interface offers large non-textual touch icons (no typing, only swiping/tapping) to accommodate users with motor and visual impairments. The group of focus were older people vulnerable to loneliness and social isolation in later life, namely those who were frail, lived in care homes, and struggled with standard technology due to motor issues or lack of digital experience.

Two studies were conducted in care homes in a large metropolitan area in Canada to evaluate the feasibility of this app to enhance social connectedness (meaningful social interaction) among older people. The first study was conducted in a long-term care facility with 'oldest old' people (aged 80+). The sample included five Chinese Canadians and five study partners (relative or friend). The research design was based on a long-term mixed methods approach that encompassed pre-, mid-, and post-deployment stages over the period of two months. The second study was conducted in a retirement home with a sample of 12 residents and their study partners for a period of three months. Participants in the second study had more diverse cultural backgrounds, including British and Latin American. For both studies, methods included interviews, psychometric scales, usability and accessibility tests, field observations, and log analysis. Findings showed that this app was a feasible tool to enhance frequency of social interaction and social connectedness, although the latter was only observable for participants who had family and friends living in different provinces or

overseas. The studies provided rich understandings of technology adoption, use, and its diverse social and technical outcomes in later life.

5.1.2 *Analysis Through the Lens of Digital Design Marginalization*

This case study involves our own project and design. This app's design, when analyzed through the lens of digital design marginalization, reveals some examples of marginalizing design in the design process that needs to be accounted for in future iterations of the app. We switch to first-person plural nouns here as they are told by the co-authors. The first-person also serves to emphasize the act of reflecting on one's designs.

Inadequate consideration of all social actors/agents interacting with the technology and the primary user.

For some participants, different intergenerational expectations and practices of digital communication, such as reply time or preferred types of messages, led to tensions with relatives. Older participants preferred to receive text and send audio messages, which conflicted with their relatives' preferences to send picture messages. Furthermore, relatives often had expected reply times that were sooner than that of the participants' expectations, and this mismatch in expectations resulted in a decrease in the quantity of messages that participants received.

In this case, our design choices did not sufficiently consider all the social groups that would interact directly or indirectly with the technology. In addition, the app was designed for older people, but their family or staff members were not involved in the design process. The social consequence of our design choice was the resulting tension between participants and their relatives. Our design was marginalizing as it risked enhancing social isolation and loneliness among participants.

Examination of this finding from the lens of marginalizing design prompts us to consider mapping all social actors/agents involved in the interaction with the technology and the participant in iterations of this app or similar apps. In other words, through the digital marginalization framework, we are encouraged to increase the focus on social contexts.

Inadequate understanding of the mental models related to digital literacy in later life (rather than simply categorizing users vs. non-users or low vs. high usage). We assumed that participants with some digital literacy would be able to understand better how the app worked. Yet, for some who had used computers and email before, the messaging system on the app was unclear because it did not meet their mental models of prior technology.

In this case, our design choices were based on our assumptions around participants' mental models of technology. The social consequence of our design choice was that participants with higher levels of digital literacy felt some sense of inadequacy. Our design was an example of a marginalizing design because it risked lowering participants' sense of self-efficacy.

Fortunately, because our team was there 'in situ' for 2-3 months, we were able to help them overcome that period. If this had not been the case, it might have resulted in non-adoption or the social consequences of lowered levels of digital self-efficacy and confidence. Consideration of these findings from the lens of marginalizing design suggests that a better understanding of different levels of digital mental models would have been useful before deployment. In order to accomplish this, preliminary field work and research to better understand participants' existing mental models of technology would have been key.

Not accounting for potential accessibility issues beyond software. While we knew that the hardware used was standard (since our users didn't want a special hardware, wanting to use tablets they see their family using) and not as accessible or adjusted to our participants as the software, we did not account for an array of possible issues regarding both the technology and the social settings of our participants. As one example, the limitation of using standard hardware,

such as iPads, was that our participants could not find the on/off button on the iPad case due to issues of sensitivity loss in their fingertips. As another example, one care home had security issues that required us to lock participants' tablets to their beds, adding cables and locks that further affected the accessibility of the technology.

In the process of designing the app, we did not adequately consider the limitation of using standard hardware. This resulted in an adaptation period for many of our participants. This incident is an example of digital design marginalization because it had the social consequence that some participants realized how excluded they were from standard technology, which in turn enhanced their sense of frailty and exclusion.

We employed several techniques to counteract design barriers such as painting on/off buttons, testing cables and tablet covers, and ensuring participants that difficulties using the app was not their fault. However, consideration of this consequence from the lens of marginalizing design suggests that we should have further accounted for potential accessibility issues beyond software. Engaging staff members here could have helped as well since they have a better understanding of their locales and settings.

Not brainstorming negative unintended consequences and devising a risk assessment plan and a mitigation plan. While the app led to mostly positive outcomes for participants, there were a few unintended negative outcomes. In addition to family tensions, we found enhanced awareness of frailty (e.g., participants realizing that they struggled to lift the tablets to record videos or when recording audio messages that their voice did not sound good), lack of privacy (e.g., participants realizing that they did not have a private space), and institutionalization (e.g., they could not take pictures or videos that were satisfying to them because they were always in the same space and could not freely go anywhere).

In this case, we did not elaborate on the potential unintended consequences of the technology or the project. The social consequence was a rise in family tensions and enhanced awareness of loneliness among some participants because of low engagement of family members. Our design was marginalizing as it risked enhancing social isolation and loneliness in the participants.

Examination of these social consequences from the lens of marginalizing design prompts us to consider preparing a mitigation plan for negative outcomes. A 'risk assessment' instrument would have helped us to overcome issues that can affect ethically our conduct and our responsibility and duty of care as researchers.

In sum, even though inclusion, accessibility, and empowerment of older people was the basis of this project, we still encountered unintended consequences and DDM outcomes.

5.2 Case Study: Accessibility Features on Smart Devices

5.2.1 Study Summary

The second case study [25] was provided to us with permission by the authors. Older adults want to be able to use the mainstream technology that younger age groups use. However, older adults might have functional impairments (e.g., sensory, motor, cognitive) that make interaction with mainstream technologies difficult. Mainstream technologies often have accessibility features that make it easier for individuals with functional impairments to provide input and interpret system output. Older adults with functional impairments might be able to use mainstream devices more effectively if accessibility features are activated. However, there is a lack of information on how and when older adults, especially those who are experiencing ability changes, use accessibility features.

An interview study was conducted in which 14 older adult participants were asked about their adoption and use of their smart devices, their awareness of accessibility features, and their perceptions of the features when activated. A

close social tie of the older adult participant was also interviewed to acquire an outside perspective of the older adult's perception and use of accessibility features. A little over a month after the interview study, participants were asked if they were still using accessibility features activated during the study or if they had explored alternative accessibility features.

The primary findings were that: (1) Some older adults do not perceive themselves as needing accessibility features because they associate these features with disability; (2) Accessibility features are difficult to discover, locate, and use; (3) Accessibility features do not accommodate hesitance to use trial-and-error; and, (4) Accessibility features do not easily accommodate combinations of impairments.

5.2.2 Analysis Through the Lens of Digital Design Marginalization

This case study is an evaluation of an existing system, namely, accessibility features on smart devices. This case study is an example of how even the best intentions can lead to unintended consequences. Even when we try to make a design inclusive (by incorporating accessibility features), if we are not considering far-reaching consequences, there is the risk that users are marginalized in other aspects of their lives – in this case, their social interactions and status in society. These risks are revealed upon analyzing the study's findings through the lens of digital design marginalization.

Labelling the features as “accessibility” features. The name “accessibility” for these features were problematic in two ways. First, as reported by two of the participants in the study, sometimes assistive technologies are perceived as oversimplified (“dumbed down”), limited in what they could do, and were stigmatizing and patronizing. This was to the extent that being able to use mainstream devices would lead to a sense of social inclusion and one of the participants expressing that she hoped to never need to use accessibility features due to their negative associations with disability. Secondly, due to this reputation for accessible features, some people with ability changes may not see themselves as needing accessibility features as they do not perceive themselves as disabled (even though the features would benefit them).

In this case, the design gave users two choices, and both led down paths of digital design marginalization. The first option was to use the regular, non-accessible interface. This would lead to exclusion from the smart device completely and from the services (such as communication) offered by the device, and risk the user feeling socially isolated. The second was for the user to use the accessibility features which the users saw as a degradation and perceived loss of social status. This in turn risks increasing the users' sense of social isolation due to (perceived) stigma attached to the use of accessibility features. Here, the recommendation is for designers to rethink usage of the term “accessibility” and to reframe them in terms of their usefulness separate from a user's disability status.

Reliance on social support for use. The second most common reason that participants did not explore accessibility and related features after the initial set was activated during the interview study was the lack of social support. Participants reported that they would request social support to train, coach, or reinforce them when trying new features on their devices, and the same went for accessibility features. This predicament posed a dilemma because while older adults relied on social support, technological designs risked burdening the social support available to older adults. Social support in this context is not only informational, but consists of emotional and practical support, encouragement, reliance and reassurance.

In this case, a design that induces concerns about the loss of social status (due to the label of “accessibility”) but also requires social support for adoption would result in one of two outcomes. The first is the non-adoption of the design, in which case the older adult misses out on the use of the smart device for purposes such as communication, games, and reading. The second outcome is the risk that the use of the design (which is now made accessible through technical

support from family members, peers, etc.) may result in older adults no longer seeking social interactions with those who offered them technical support due to (perceived) stigma attached to the use of “accessible” features as suggested by the participants. Both of these paths are examples of digital design marginalization in action, and thus the design is marginalizing.

6 DESIGN PRACTICES VIEWED THROUGH THE LENS OF DIGITAL DESIGN MARGINALIZATION

Through the two case studies we presented in the previous section, we explored the application of the digital design framework on a novel design (section 5.1) and a pre-existing design (section 5.2). Both of these cases involved previously published projects on which we have now applied the digital design framework to surface issues that were not evident before. In these cases, the digital design lens reveals problems related to social consequences of digital inequality (sections 5.1), social stigma (section 5.1), social isolation (section 5.1 & 5.2), loneliness (section 5.1 & 5.2), lowered self-efficacy (section 5.2), and increased sense of frailty (section 5.2).

For the project in section 5.1, because the app was a novel design, we also discussed means to prevent further digital design marginalization in future iterations of this app or implementations of related apps. For example, we suggest increased focus on social contexts, increased preliminary field work and research, increased engagement of community members, and brainstorming of negative unintended consequences to derive risk assessment plans and mitigation plans.

These considerations match calls for attention to contextual factors and a more holistic approach to designing for older adults [39]. The case study of section 5.2 demonstrates the combination of considerations of marginalizing design for social consequences with considerations of accessibility. Analysis through the digital design marginalization framework in section 5.2 demonstrated the importance of considerations of stigma and access to social support when it came to accessibility features. From the analysis of the study, we found that a design can become marginalizing with respect to causing social withdrawal if it does not account for differences in perceived level of stigma and access to social supports.

We offered our reflections to demonstrate the potential of the digital design marginalization framework to help trigger, as it did for us, strategies that avoid the creation of marginalizing designs. That said, the focus of this paper is on formalizing the theoretical framework of digital design marginalization. Thus, it would be too speculative to propose concrete solutions for avoiding designs that marginalize users. But, as shown, not only does design play an active role in causing digital design marginalization, it can also play an active role in addressing it. We consider proper practice and reflection of theoretical and methodological design approaches that can help us further study and address digital design marginalization. To this end, we encourage designers to actively seek out appropriate design methods for their user groups that can expose potential points of digital design marginalization.

Here, we have used digital design marginalization as a lens to view the research and design of technology for older adults in various domains. By viewing the design process itself through the lens of digital design marginalization, one can identify previously unseen gaps in the research and creation of designs that are fully inclusive of target user populations. In a pragmatic sense, viewing designs in terms of their capacity to be marginalizing designs can more easily reveal the shortcomings of design in terms of its degree of inclusivity. To a lesser, yet still significant, extent these discussions also present future directions for research into digital design marginalization.

7 CONCLUSION

“Despite [older adults’] increasing numbers the world seems to be designed against the elderly. ... And when companies do design things specifically for the elderly, they tend to be ugly devices that shout out to the world “I’m old and can’t function!” We can do better.” – Don Norman [50]

“Interface features and changes that young designers take for granted as effortless may in fact make significant inroads upon older users’ cognitive capacity.” – Hawthorn [30]

In this paper, we have discussed the active role that design decisions for digital interface designs can have in not only online digital exclusion but also the offline social “pushing away” of marginalized groups such as older adults. These design decisions can be made by designers with the best of intentions but otherwise unaware of their role in such issues and also by those who, as illustrated in our case studies, are mindful of inclusive design principles. Our hope is to shed light on the responsibility of design in digital products and services, since design decisions can have lasting and serious social consequences on dimensions such as the social well-being of underrepresented users (e.g., older adults, in the exemplars we have selected for illustration). Thus, we aim to encourage and provide designers with means to avoid unintended consequences and marginalization by design.

To do this, we started by outlining the state of today’s information society in industrialized countries: that many essential services are increasingly being migrated online and that, as a result, certain populations are being excluded. We have discussed the benefits of existing frameworks – such as inclusive design, accessibility, and ability-based design – and their limitations to capture the social consequences of design. To address the consequences-laden impact of design on additional, indirect, and long-lasting social consequences, we proposed the concept of Digital Design Marginalization (DDM). DDM refers to the process in which design choices lead to consequences that extend beyond the direct use of the digital interface. Such consequences include social exclusion, lowered self-efficacy, and social stigma. We applied the DDM framework to prior research as case studies to demonstrate the potential of DDM to surface serious design problems that were not previously identified.

We focus on the demographic of older adults, partly because having intimate access to the two case studies (with the authors’ permission) allowed us to reflect on the marginalizing aspects of design for this population. Doing this through the lens of our own expertise (in the research space of designing for older adults and the contexts of later life) also enabled our reflection to go beyond the ‘positive bias’ of research that often prevents the publishing of ‘negative results’ or negative unintended consequences.

However, it is important to recognize that digital design marginalization can be applied to a broad range of contexts where marginalization occurs. Our examples of design of technology for older adults serves to illustrate how the digital design marginalization concept can be applied to a specific context, but the principles involved can be generalized to design at large and, much like inclusive design, decrease the marginalizing effects of designs on other user groups beyond older adults as well [50]. Our hope is for the DDM framework to be disciplinarily expanded for the benefit of all (following the principles of the ‘curb cut’ effect). We invite other communities to apply and refine this framework to their own areas of expertise or lived experiences in the context of, for example, forced migration, rural/urban divides, and socioeconomic disadvantages.

Digital design marginalization is not simply about digital exclusion; it is about the introduction of new social inequalities or the reinforcing of existing ones. It is about inadvertently treating the people who cannot use these digital systems and services as inferior. In the short term, it is a message to users pushed away by a marginalizing design that they do not matter. In the long term, digital design marginalization can also prevent them from participating in the space or service and have enduring impact on their well-being and social inclusion. The concept of digital design

marginalization urges designers and policy makers alike to critically consider throughout the entire design process the role that the design of digital systems plays in people's online and offline lives. When embedded from the onset in designers' practice as a reflective guide, the digital design marginalization framework can help designers avoid broader reaching negative and unintended consequences. With proper recognition and attention paid to the design of digital systems and services, there is promise that the design community can progressively avoid creating marginalizing design and prevent digital design marginalization.

REFERENCES

- [1] Michael Adno. 2017. Robert Moses's Jones Beach. *Curbed NY*. Retrieved September 17, 2020 from <https://ny.curbed.com/2017/6/21/15838436/robert-moses-jones-beach-history-new-york-city>
- [2] Benett Axtell and Cosmin Munteanu. 2019. Back to Real Pictures: A Cross-generational Understanding of Users' Mental Models of Photo Cloud Storage. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 3, 3: 1–24. <https://doi.org/10.1145/3351232>
- [3] Valentina Bartalesi and Barbara Leporini. 2015. An enriched ePub eBook for screen reader users. In *International Conference on Universal Access in Human-Computer Interaction*, 375–386.
- [4] Christoph Becker, Ruzanna Chitchyan, Leticia Duboc, Steve Easterbrook, Birgit Penzenstadler, Norbert Seyff, and Colin C. Venters. 2015. Sustainability Design and Software: The Karlskrona Manifesto. In *2015 IEEE/ACM 37th IEEE International Conference on Software Engineering*, 467–476. <https://doi.org/10.1109/ICSE.2015.179>
- [5] Cynthia L Bennett and Os Keyes. 2019. What Is the Point of Fairness? Disability, AI and The Complexity of Justice. *arXiv preprint arXiv:1908.01024*.
- [6] Bruce Bimber. 2000. Measuring the gender gap on the Internet. *Social science quarterly*: 868–876.
- [7] Robin N Brewer and Anne Marie Piper. 2017. xPress: Rethinking Design for Aging and Accessibility through a Voice-based Online Blogging Community. 1: 17.
- [8] Ronald H Brown, David J Barram, and Larry Irving. 1995. Falling Through the Net: A Survey of the 'Have-Nots. *Rural and Urban America*.
- [9] Erik P Bucy. 2000. Social access to the Internet. *Harvard International Journal of Press/Politics* 5, 1: 50–61.
- [10] Robert A Caro and Robert A Caro. 1974. *The power broker: Robert Moses and the fall of New York*. Alfred a Knopf Incorporated.
- [11] Kelly Carr, Patricia L Weir, Dory Azar, and Nadia R Azar. 2013. Universal design: A step toward successful aging. *Journal of aging research* 2013.
- [12] Nai-Ching Chi, Olivia Sparks, Shih-Yin Lin, Amanda Lazar, Hilaire J. Thompson, and George Demiris. 2017. Pilot testing a digital pet avatar for older adults. *Geriatric Nursing* 38, 6: 542–547. <https://doi.org/10.1016/j.gerinurse.2017.04.002>
- [13] Vinayagum Chinapah and Jared O. Odero. 2017. Towards Inclusive, Quality ICT-Based Learning for Rural Transformation. *Journal of Education and Research*: 107–125. <https://doi.org/10.3126/jer.v5i0.15733>
- [14] Kate Crawford. 2013. The hidden biases in big data. *Harvard business review* 1, 1: 814.
- [15] Christopher A Le Dantec and Carl DiSalvo. 2013. Infrastructuring and the formation of publics in participatory design. *Social Studies of Science* 43, 2: 241–264. <https://doi.org/10.1177/0306312712471581>
- [16] Alexander J. A. M. van Deursen and Ellen J. Helsper. 2015. The Third-Level Digital Divide: Who Benefits Most from Being Online? In *Studies in Media and Communications*, Laura Robinson, Shelia R. Cotten, Jeremy Schulz, Timothy M. Hale and Apryl Williams (eds.). Emerald Group Publishing Limited, 29–52. <https://doi.org/10.1108/S2050-206020150000010002>
- [17] Paul DiMaggio, Eszter Hargittai, and others. 2001. From the 'digital divide' to 'digital inequality': Studying Internet use as penetration increases. *Princeton: Center for Arts and Cultural Policy Studies, Woodrow Wilson School, Princeton University* 4, 1: 4–2.
- [18] Lynn Dombrowski. 2017. Socially just design and engendering social change. *Interactions* 24, 4: 63–65. <https://doi.org/10.1145/3085560>
- [19] O Dwivedi, Renu Khator, and Jorge Nef. 2007. *Managing development in a global context*. Springer.
- [20] United States Economics, Statistics Administration, United States National Telecommunications, and Information Administration. 2000. *Falling Through the Net: Toward Digital Inclusion: a Report on Americans' Access to Technology Tools*. US Department of Commerce, Economic and Statistics Administration.

- [21] United States Economics, Statistics Administration, United States National Telecommunications, and Information Administration. 2000. *Falling Through the Net: Toward Digital Inclusion: a Report on Americans' Access to Technology Tools*. US Department of Commerce, Economic and Statistics Administration.
- [22] World Leaders in Research-Based User Experience. The Power of Defaults. *Nielsen Norman Group*. Retrieved September 17, 2020 from <https://www.nngroup.com/articles/the-power-of-defaults/>
- [23] Guido Ferilli, Pier Luigi Sacco, and Giorgio Tavano Blessi. 2016. Beyond the rhetoric of participation: New challenges and prospects for inclusive urban regeneration. *City, Culture and Society* 7, 2: 95–100. <https://doi.org/10.1016/j.ccs.2015.09.001>
- [24] Azadeh Forghani, Carman Neustaedter, Manh C. Vu, Tejinder K. Judge, and Alissa N. Antle. 2018. G2G: The Design and Evaluation of a Shared Calendar and Messaging System for Grandparents and Grandchildren. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*, 1–12. <https://doi.org/10.1145/3173574.3173729>
- [25] Rachel L Franz, Jacob O Wobbrock, Yi Cheng, and Leah Findlater. 2019. Perception and Adoption of Mobile Accessibility Features by Older Adults Experiencing Ability Changes. In *The 21st International ACM SIGACCESS Conference on Computers and Accessibility*, 267–278.
- [26] Shikoh Gitau, Gary Marsden, and Jonathan Donner. 2010. After access: challenges facing mobile-only internet users in the developing world. In *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*, 2603. <https://doi.org/10.1145/1753326.1753720>
- [27] Susan Goslee and Chris Conte. 1998. *Losing ground bit by bit: Low-income communities in the information age*. Benton Foundation.
- [28] Anhong Guo, Ece Kamar, Jennifer Wortman Vaughan, Hanna Wallach, and Meredith Ringel Morris. 2019. Toward Fairness in AI for People with Disabilities: A Research Roadmap. *arXiv preprint arXiv:1907.02227*.
- [29] Eszter Hargittai. 2002. Second-level digital divide. *First Monday*, ISSN 1396-0466. Retrieved July 28, 2020 from http://www.artefaktum.hu/kozgaz/Hargittai_Second-Level%20Digital%20Divide.htm
- [30] D Hawthorn. 2000. Possible implications of aging for interface designers. *Interacting with Computers* 12, 5: 507–528. [https://doi.org/10.1016/S0953-5438\(99\)00021-1](https://doi.org/10.1016/S0953-5438(99)00021-1)
- [31] Gillian R. Hayes. 2011. The relationship of action research to human-computer interaction. *ACM Transactions on Computer-Human Interaction* 18, 3: 15:1-15:20. <https://doi.org/10.1145/1993060.1993065>
- [32] Ellen Helsper. 2008. *Digital inclusion: an analysis of social disadvantage and the information society*. Department for Communities and Local Government.
- [33] Ellen J Helsper and Anna Gal  cz. 2009. Understanding the links between social and digital exclusion in Europe. *World wide internet: Changing societies, economies and cultures*: 146.
- [34] Donna L Hoffman and Thomas P Novak. 1999. Examining the Relationship of Race to Internet Access and Usage Over Time. *Nashville, Tenn: Vanderbilt University*.
- [35] Ben Hutchinson, Vinodkumar Prabhakaran, Emily Denton, Kellie Webster, Yu Zhong, and Stephen Denuyl. 2020. Unintended machine learning biases as social barriers for persons with disabilities. *ACM SIGACCESS Accessibility and Computing*, 125: 1–1.
- [36] Jeff Johnson and Kate Finn. 2017. *Designing user interfaces for an aging population: Towards universal design*. Morgan Kaufmann.
- [37] Shaun K Kane, Anhong Guo, and Meredith Ringel Morris. 2020. Sense and Accessibility. 14.
- [38] Mun-Cho Kim and Jong-Kil Kim. 2001. Digital divide: Conceptual discussions and prospect. In *International Conference Human Society@ Internet*, 78–91.
- [39] Bran Knowles, Vicki L Hanson, Yvonne Rogers, Anne Marie Piper, Jenny Waycott, and Nigel Davies. 2019. HCI and Aging: Beyond Accessibility. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–8.
- [40] William E Loges and Joo-Young Jung. 2001. Exploring the digital divide: Internet connectedness and age. *Communication research* 28, 4: 536–562.
- [41] R Mace. 1997. *About the center: Ronald L. Mace*. Retrieved from The Center for Universal Design at NCSU: <http://www.ncsu....>
- [42] Brendan McCormack and Tanya McCance. 2016. *Person-centred practice in nursing and health care: theory and practice*. John Wiley & Sons.
- [43] Mary E. Morningstar, Karrie A. Shogren, Hyunjoo Lee, and Kiara Born. 2015. Preliminary Lessons About Supporting Participation and Learning in Inclusive Classrooms. *Research and Practice for Persons with Severe Disabilities* 40, 3: 192–210. <https://doi.org/10.1177/1540796915594158>

- [44] Evgeny Morozov. 2013. *To save everything, click here: The folly of technological solutionism*. Public Affairs.
- [45] Philip M. Napoli and Jonathan A. Obar. 2014. The Emerging Mobile Internet Underclass: A Critique of Mobile Internet Access. *The Information Society* 30, 5: 323–334. <https://doi.org/10.1080/01972243.2014.944726>
- [46] Barbara Barbosa Neves, Rachel L. Franz, Cosmin Munteanu, and Ron Baecker. 2018. Adoption and feasibility of a communication app to enhance social connectedness amongst frail institutionalized oldest old: an embedded case study. *Information, Communication & Society* 21, 11: 1681–1699. <https://doi.org/10.1080/1369118X.2017.1348534>
- [47] Barbara Barbosa Neves, Rachel L. Franz, Cosmin Munteanu, Ronald Baecker, and Mags Ngo. 2015. “My Hand Doesn’t Listen to Me!”: Adoption and Evaluation of a Communication Technology for the ‘Oldest Old.’ In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI ’15*, 1593–1602. <https://doi.org/10.1145/2702123.2702430>
- [48] Barbara Neves, Rachel Franz, Rebecca Judges, Christian Beerhmann, and Ron Baecker. 2019. Can Digital Technology Enhance Social Connectedness Among Older Adults? A Feasibility Study. *Journal of Applied Gerontology* 38, 1: 49–72. <https://doi.org/10.1177/0733464817741369>
- [49] Safiya Umoja Noble. 2018. *Algorithms of oppression: How search engines reinforce racism*. nyu Press.
- [50] Don Norman. 2019. I wrote the book on user-friendly design. What I see today horrifies me. *Fast Company*. Retrieved September 17, 2020 from <https://www.fastcompany.com/90338379/i-wrote-the-book-on-user-friendly-design-what-i-see-today-horrifies-me>
- [51] Pippa Norris and others. 2001. *Digital divide: Civic engagement, information poverty, and the Internet worldwide*. Cambridge university press.
- [52] Cathy O’Neil. 2016. *Weapons of math destruction: How big data increases inequality and threatens democracy*. Broadway Books.
- [53] Laura Robinson, Shelia R. Cotten, Hiroshi Ono, Anabel Quan-Haase, Gustavo Mesch, Wenhong Chen, Jeremy Schulz, Timothy M. Hale, and Michael J. Stern. 2015. Digital inequalities and why they matter. *Information, Communication & Society* 18, 5: 569–582. <https://doi.org/10.1080/1369118X.2015.1012532>
- [54] Simon Robinson, Jennifer Pearson, Matt Jones, Anirudha Joshi, and Shashank Ahire. 2017. Better together: disaggregating mobile services for emergent users. In *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services - MobileHCI ’17*, 1–13. <https://doi.org/10.1145/3098279.3098534>
- [55] Jennifer Rowsell, Ernest Morrell, and Donna E Alvermann. 2017. Confronting the digital divide: Debunking brave new world discourses. *The Reading Teacher* 71, 2: 157–165.
- [56] Neil Selwyn. 2004. Reconsidering Political and Popular Understandings of the Digital Divide. *New Media & Society* 6, 3: 341–362. <https://doi.org/10.1177/1461444804042519>
- [57] Claude M Steele and Joshua Aronson. 1995. Stereotype threat and the intellectual test performance of African Americans. *Journal of personality and social psychology* 69, 5: 797.
- [58] Sharon Strover. 2001. Rural internet connectivity. *Telecommunications policy* 25, 5: 331–347.
- [59] Afroza Sultana and Karyn Moffatt. 2019. Effects of Aging on Small Target Selection with Touch Input. *ACM Transactions on Accessible Computing* 12, 1: 1–35. <https://doi.org/10.1145/3300178>
- [60] Mary Frances Theofanos and Janice Redish. 2003. Bridging the gap: between accessibility and usability. *interactions* 10, 6: 36–51.
- [61] Jenny Waycott, Sonja Pedell, Frank Vetere, Elizabeth Ozanne, Lars Kulik, Alan Gruner, and John Downs. 2012. Actively engaging older adults in the development and evaluation of tablet technology. In *Proceedings of the 24th Australian Computer-Human Interaction Conference on - OzCHI ’12*, 643–652. <https://doi.org/10.1145/2414536.2414633>
- [62] Jenny Waycott, Greg Wadley, Stefan Schutt, Arthur Stabolidis, and Reeva Lederman. 2015. The Challenge of Technology Research in Sensitive Settings: Case Studies in “ensitive HCI.” In *Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction (OzCHI ’15)*, 240–249. <https://doi.org/10.1145/2838739.2838773>
- [63] Julia Wick. 2019. Newsletter: Essential California: Why San Francisco banned cashless stores. *Los Angeles Times*. Retrieved January 8, 2021 from <https://www.latimes.com/newsletters/la-me-ln-essential-california-20190508-story.html>
- [64] Paul Willis, Tracey Maegusuku-Hewett, Michele Raithby, and Penny Miles. 2016. Swimming upstream: the provision of inclusive care to older lesbian, gay and bisexual (LGB) adults in residential and nursing environments in Wales. *Ageing and Society* 36, 2: 282–306. <https://doi.org/10.1017/S0144686X14001147>

- [65] 2009. *HP computers are racist*. Retrieved September 17, 2020 from <https://www.youtube.com/watch?v=t4DT3tQqgRM>
- [66] 2017. The True Measure of Robert Moses (and His Racist Bridges). *Bloomberg.com*. Retrieved September 17, 2020 from <https://www.bloomberg.com/news/articles/2017-07-09/robert-moses-and-his-racist-parkway-explained>
- [67] Domino's and the Web are Failing the Disabled. *Wired*. Retrieved September 17, 2020 from <https://www.wired.com/story/dominos-and-the-web-are-failing-the-disabled/>
- [68] Newswire | Smartphones: Still Room to Grow in Emerging Countries | Nielsen. Retrieved September 17, 2020 from <https://www.nielsen.com/us/en/insights/article/2013/smartphones-still-room-to-grow-in-emerging-countries>
- [69] What is Digital Exclusion | IGI Global. Retrieved September 17, 2020 from <https://www.igi-global.com/dictionary/digital-exclusion/7615>
- [70] Inclusive Design Research Centre. Retrieved September 17, 2020 from <https://legacy.idrc.ocadu.ca/about-the-idrc/49-resources/online-resources/articles-and-papers/443-whatisinclusivedesign>