

**DESIGN JUSTICE PRINCIPLES AND DO-IT-YOURSELF ASSISTIVE  
TECHNOLOGY: CASE STUDY**

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# Abstract

In this project, we focus on the Principles of Design Justice, as developed by the Design Justice Network, a community committed to challenging structural inequalities of design. Our thesis research project is aligned with the premise of user-centered design and the situated knowledge in third paradigm of HCI. We examine some of the current processes for Do-It-Yourself Assistive Technology (DIY-AT) development and deployment using the works of Makers Making Change (MMC). MMC connects the makers of DIY-AT devices to people who need AT devices. We also examine the impacts of the ongoing COVID-19 pandemic on the need for DIY-AT and the challenges it might have caused. Our findings include MMC's positive impact regarding DIY-AT service delivery, engaging local makers into making DIY-AT, and a modest job in integrating Design Justice Principles. The findings of our study also suggest an increase in the demand for AT due to the pandemic.

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# Chapter 1

## Introduction

### 1.1 Makers and Making

The process of making is associated with creativity and innovation as it includes active thinking, learning, putting the learning into action, and inventing different things. Making encourages the enthusiasts to become creators in multiple areas such as art, science, technology, craft, education, and gadgets. Makerspaces are the home to this process, whether they are in schools, libraries, community centers, or even at individuals' homes (home makerspaces). Makers can be creators of anything and making is not limited to workshops and garages [4]. The term “maker” can refer to hobbyists, enthusiasts, or students who are hacking current tools or using them to create new products. This creation characterizes makers as a source of innovation [42].

The activities done in makerspaces can have diverse outcomes. Each of the makerspaces may aim for certain outcomes from their activities and members. The outcomes cover a wide range of products, including products associated with art, design, digital fabrication, appliances, vehicles, music, and so on. Some of these outcomes from makerspaces activities fit under the category of Assistive Technology (AT) or more specifically Do-It-Yourself Assistive Technology (DIY-AT). In this research project, we mainly focus on these types of outcomes.

### 1.2 Do-It-Yourself Assistive Technology

Assistive technologies (ATs) can be defined as pieces of technology that help maintain or improve an individual's function and independence for tasks that they could not otherwise be



doing or have difficulty performing [33]. ATs are often viewed as promoting the well-being of their users [33]. Do-It-Yourself Assistive Technology (DIY-AT) refers to the pieces of AT that are created or adapted by non-professionals, such as people with disabilities, family members, friends, caregivers, or other community members [33]. Makers Making Change (MMC) is a program under the direction of the Neil Squire Society, a non-profit organization in Canada. The program has the vision of achieving economic and social inclusiveness for all people with disabilities [52]. MMC defines their mission as:

We connect people with disabilities to volunteer makers to build assistive technologies [53].

They connect the whole process of making to assistive devices by encouraging makers to work towards the making of specific DIY-AT devices. Potential beneficiaries of AT can go through the list of available assistive devices on MMC website and request any of them that matches their needs. A maker, preferably from their local community, responds to the request and builds the device while collaborating with the person who requested the device. The device will then be delivered to its user. If the already available devices does not meet the user’s needs, they can always submit their ideas to MMC forums. MMC has a library of their assistive devices, some examples of which include 3D printed holders for different tools & utensils, 3D printed educational devices kit, and their reputable LipSync, a mouth controlled joystick that allows a person to control a touchscreen device cursor with minimal head and neck movement.

### 1.3 Design Justice Principles

Design Justice Network introduce themselves as “an international community of people and organizations who are committed to rethinking design processes so that they center people who are too often marginalized by design” [20]. They do so by following a set of principles they have collaboratively developed by their team. Practitioners (individuals or organizations) can sign to Design Justice Principles and work according to them. These principles are as following [20]:

1. We use design to sustain, heal, and empower our communities, as well as to seek liberation from exploitative and oppressive systems.
2. We center the voices of those who are directly impacted by the outcomes of the design process.

3. We prioritize design’s impact on the community over the intentions of the designer.
4. We view change as emergent from an accountable, accessible, and collaborative process, rather than as a point at the end of a process.
5. We see the role of the designer as a facilitator rather than an expert.
6. We believe that everyone is an expert based on their own lived experience, and that we all have unique and brilliant contributions to bring to a design process.
7. We share design knowledge and tools with our communities.
8. We work towards sustainable, community-led and -controlled outcomes.
9. We work towards non-exploitative solutions that reconnect us to the earth and to each other.
10. Before seeking new design solutions, we look for what is already working at the community level. We honor and uplift traditional, indigenous, and local knowledge and practices.

## 1.4 Research Questions

There remains a global unmet need for AT devices [71]. The discipline of HCI, alongside several other disciplines (such as Occupational Therapy) has AT design and evaluation as an established area of scholarly work and practice. Problematically, much scholarly activity within HCI understands AT design as design “for” people with disabilities as opposed to design “by” people with disabilities [60]. Harrison, Sengers, and Tatar [30] called for a focus on situated knowledge resulting in special awareness of voices that are marginalized, a call that aligns with the premise of user-centered design [30].

Over the past year, many aspects of our lives have changed due to the global pandemic caused by COVID-19. Bearing witness to these changes invites a moment of reflection about the processes that brought about these changes. For example, disability activists have long advocated for the need for telehealth services and flexible working conditions, including working from home. The obstacles to establishing these processes, previously insurmountable, were overcome during the global pandemic. Studying the Design Justice

principles makes us wonder about how change emerges from underlying factors, only some of which are connected to accountable, accessible processes that the principles advocate.

The MMC program — the work that is being done and the relative success of the program’s various aspects — is of interest and relevance to HCI. These aspects include the quantitative and qualitative aspects of the pieces of DIY-AT technology delivered to users, the methods that have been employed to encourage their supporters (such as their funders and the makers contributing to MMC’s goals), the the degree to which the Principles of Design Justice have been adopted, and the effects of the global pandemic on the makers and makerspaces. The intersection of the MMC program, the Design Justice Principles, and the global pandemic provides a rich domain in which to investigate the promise of community-led AT design and design impact.

Therefore, below are our proposed research questions:

- Q1a:** In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?
- Q1b:** In what ways has Makers Making Change (MMC) been successful in motivating DIY-AT and Home Makerspaces?
- Q1c:** In what ways has Makers Making Change (MMC) been successful in promoting the principles of Design Justice?
- Q2a:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) impacted disabled people?
- Q2b:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) affected the demand for AT?

The outcome of this research project can be used by practitioners who are aiming to design more inclusively and/or incorporate design justice principles into their work. It can also provide a critique of works of designers that do not rethink their design process regarding how it can distribute benefit or burden between different groups of people.

## 1.5 Researcher’s Position

Feminist standpoint theory recognizes that all knowledge is situated in the lived experiences of the researcher [6]. Therefore, I would like to locate my own position for the reader. I am a female person of Persian descent, and I was born in Tehran, Iran and raised in the same city. I moved to Toronto, Canada in 2019 to pursue my Master’s studies as an immigrant, international student. During these years, I have both benefited and been harmed by educational inequality, racism, sexism, capitalism, and ableism. I do not identify as a person with disability, although, the works of my parents with people with disabilities have intrigued me in choosing my area of research and undertaking this project.

It is also noteworthy to mention that I have used the pronoun “we” in this thesis instead of “I” due to the standard academic nomenclature. This “we” refers to our research team consisting of me and my supervisor Prof. Melanie Baljko.

## 1.6 Approach

We have structured the thesis as a reflection on our research question and our goal to answer them. The thesis is organized as follows:

In chapter one, we give the reader a brief introduction about the process of making, makerspaces, and assistive technology. We then describe what we are doing by establishing our research questions and demonstrating what type of knowledge is being created in this project. The next part talks about our rationale and how this project connects to HCI.

In chapter two, we provide a background on the history of makerspaces, their different types, the challenges to sustain them, and the nature of their contributions. We then present an overview of some of the valuable literature surrounding AT and DIY-AT, we describe their differences, advantages, challenges, and the way COVID-19 is affecting them. In the end of this chapter we introduce Makers Making Change and Design Justice Network and give a brief background on their work.

In chapter three, after discussing the research questions in more details, we elaborate on qualitative document analysis (QDA), its iterative process, and how we use it for quantitative analysis. We describe our work for the first two phase of QDA which are corpus development and coding the target documents. Corpus development identifies the set of our target documents required for our analysis, discuss assigning unique identifiers to them and preparing them for our next step. Code development and application describes the tools we

are using for our analysis and how we are assigning our developed codes to different text segments of our documents.

In chapter four, we analyze the application of the codes that we have developed in chapter three and investigate emergent trends. We will then describe how our work relates to our proposed research questions and how we can answer these questions based on our previous analysis.

Chapter five concludes and summarizes the work that we have done and discusses further directions this project can take.

# Chapter 2

## Background

In recent years, the discipline of Human-Computer Interaction has undertaken extensive work on makerspaces, Assistive Technology (AT), and Do-It-Yourself Assistive Technology (DIY-AT). In this chapter, we elaborate on making and makerspaces, assistive technology, and Do-It-Yourself assistive technology. We will then talk about the works of Makers Making Change and Design Justice Network. We will be taking use of the previous research projects to answer some of the fundamental questions prior to our research.

### 2.1 Making and Makerspaces

Making and makerspaces have been part of the Human-Computer Interaction (HCI) and much of their focus have been around individual creativity and craft communities, but they have also been considered as a revolution in design and manufacturing [66]. Making has been involved in the lives of humans since the early days of building hunting tools and different artifacts and mankind has evolved through the practice of making. The emergence of modern technologies has had a significant impact on making. Before individuals had access to modern technologies, the majority of physical goods came from the manufacturing economy [4]. Manufacturing has been the domain of major corporations and experienced specialists due to the expertise, equipment, and expenses associated with mass production. Nowadays, with the use of technology and the possibility of digital making, many physical products are first designed on screens and can be shared online. Therefore, as this process can be performed on a regular computer, almost everyone can participate in making.

Our questions regarding the makerspaces can be divided into four main categories. Our first category is related to what a makerspace is and what its different types are. Second

category is about the stakeholders and users of makerspaces. Third category talks about how the makerspaces come into existence and how they are being sustained. Our last category is related to the nature of the maker community contributions thus far. We will be answering the above questions in the following sections: characterization of different makerspaces, stakeholders and users of makerspaces, makerspaces lifecycle, and characterizing makerspaces outputs and activities.

### **2.1.1 Characterization of different makerspaces**

We need to know what a makerspace is in order to discuss their types and to gather further information about them. Makerspaces are informal sites for creative production in art, science, and engineering where people of all ages blend digital and physical technologies to explore ideas, learn technical skills, and create new products [62].

Most makerspaces have an openly accessible space and provide people with facilities that can be shared by everyone [66]. Some of these resources are digital fabrication and open electronics. People having access to these technologies and facilities, can result in a compelling effect on personal manufacturing [66]. Makerspaces can make it easier for people to enter the world of making and enable everyone to create their individual solutions to problems or even bring their products to market [66].

The concept of a Techshop started in 2006 in California and refers to a chain of for-profit makerspaces. They bill themselves as part prototyping and fabrication studio and as part learning center. The makers/members who join the Techshop pay monthly fees which is the main resource of support for the makerspace [43]. A FabLab refers to a small-scale workshop offering digital fabrication, as started from MIT's Media Lab. They define a FabLab in their own words as “a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. It is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to invent.” [43]. The concept of a hackerspace started off as places in the community where a group of computer programmers could collectively meet, work, and share infrastructure. They would “hack” technology and try to innovate new purposes for it [43].

Hacklabs were predecessors of makerspaces [72] and they were originally spaces for the micropolitical practice of alternate life pathways that emerged in parallel to the ascendant regime of capitalist globalization in the wake of the collapse of the vague utopics of late 1960s counterculture [14]. Oppressed and marginalized people also have their own design

sites and communities, but they have been ignored, pushed to the side and made to seem less important [14]. She refers to these sites as subaltern design sites.

#### **2.1.1.1 Privileged vs Subaltern Design Sites**

Many design sites, such as hacklabs, makerspaces, hackathons and the likes of them, are incorporated and promoted by larger institutional, cultural, political, and economic regimes. Costanza-Chock marks these design sites as privileged due to them being raced, classed and gendered [14]. Some examples of privileged design sites are Techshop, FabLab, and Hackerspace.

Subaltern design stand in contrast to privileged sites, and include local auto workshops, cellphone repair shops, audio stores, and sites that focus on design practices that have been raced, gendered, or coded as less valuable. In some cases, women, femmes, and other oppressed people practice their design operations within microsites such as their home. Home Makerspaces (HMSs) are a form of subaltern design microsite in which design practices are carried out.

Although the activities performed in subaltern design sites can be focused on “high-tech” tools and practices, namely computers and software development, they can also be centered around “everyday” technologies [14]. For example, working in an autoshop requires complex technical skills. Costanza-Chock [14] also talks about the history of Jamaican sound system as another example of subaltern design sites, she describes how Jamaican studio innovators created different music recording techniques. Another example of these sites could be Vigyan Ashram, a makerspace empowering youth in rural India through education and hands on skills with technical expertise.

Costanza-Chock [14] also values the importance of design sites where marginalized design practices are carried out and she acknowledges the fact that many important sociotechnical practices come from small-scale interactions within the space of the home, family, and within communities. These practices have usually been coded as less valuable or not recognized as technology [14]. Agricultural knowledge that is exchanged in sites such as community gardens or farms also counts as an example of practices within the space of the home [14].

Marginalized people working within larger institutions can carry out instances of these unnoticed design practices on the margins of those institutions [14]. They may create support networks within their own group and share a wide range of knowledge including design practices [14].

According to Costanza-Chock [14], design and maker cultures that arise from working



class or are centered around women or people of color are not as recognized as the ones centered around white, cisgender, heterosexual men. The former receives less resources, visibility, validation, and respect in addition to being invisibilized.

It is noteworthy that none of the subaltern sites and privileged sites are utopias and both of them can contribute to power dynamics [14]. A local autoshop for example may be a knowledgeable center regarding technical skills and sharing them between the working class men while simultaneously reproducing heteropatriarchal norms of excluding women from this technical knowledge [14]. On the other hand, such design site can also be challenging these norms. Design Justice highlights the value of local knowledge and practices and acknowledges that they have been marginalized and have not received proper attention and respect.

## **2.1.2 Stakeholders and users of makerspaces**

### **2.1.2.1 Maker vs Citizen Designer**

As we will be making use of the term "maker" in this document, we feel the need to clarify the distinction between a "maker" and the commonly-used term of "citizen designer". According to Anderson [4], makers can be creators of anything and making does not just apply to workshops and garages, it can also represent activities such as cooking and gardening. He believes that we are all born makers and this is evident through fascination of children with drawings and different crafts. According to Bean and Rosner [7], makers are people who are learning the technical and conceptual competencies required to contribute to the surrounding world. The Make Community describes makers as hobbyists, enthusiast or students and mentions that they are also a source of innovation as they are creating new products and producing value in the community [42]. Makers can come from different backgrounds and have diverse skill sets and interests.

There are two main views of the term of 'citizen designer'. The first view defines the term as professional designers who are aware of their roles as citizens and act in society's best interest whenever opportunities arise. Designers therefore, are professionally, culturally, and socially responsible for the effects their design has on citizenry [31]. However, some in the field acknowledge that there are limitations to the extent to which designers can implement a truly holistic view of citizenship, and there can be a dichotomy between citizen and designer [19]. The second view of citizen designer is about the integration of citizens' ideas and wishes in the process of urban design, a benefit of which would be the opportunity of crowdsourcing opinions of citizens and getting feedback from a city's inhabitants [54].

### 2.1.2.2 Makers and other Stakeholders

For creating a makerspace, it is essential to establish a good understanding of the stakeholders and users community. The stakeholders of makerspaces can vary, depending on the type of the makerspace. For makerspaces in schools for example, the stakeholders are teachers, students, administrators, parents, and school staff [32]. The stakeholders of community makerspaces can be municipalities or governments officials, makerspaces staff (educators, coordinators, etc.), students, teenagers, university students, providers of the equipment, maintenance people for repairs, and community volunteers.

Makerspaces can have different groups of users, such as students, teenagers, and young adults. The parent of the students and teenagers might also be users if they join their children and do collaborative projects in the makerspace. Adults can use makerspaces for both entertainment and professional purposes. The educators/teachers and supervisors working at the makerspaces can be users as they will be using the equipment and space while teaching people how to use them. Other than the groups that use makerspaces as discussed, there are platforms that people can put up their skills and help with the making based on their expertise and they consist of people from different backgrounds and professions. These people can be disability professionals, teachers, librarians, educators, students, and designers [52], [44].

Making and makerspaces, like every other activity and site, can face operational, sustainability, and other challenges. Makerspaces require an ecosystem of resources such as space, tools, and labour. Finding a suitable and dedicated space to house a makerspace can be difficult when bringing a makerspace into existence [22]. In addition to that, the technology is evolving everyday, resulting in new tools and devices. Having the most current tools and technologies in the makerspace can be another challenge in sustaining operations. Another aspect to consider is be the outcomes of making. It is generally understood that many of the products made in a makerspace will end up in landfill sites and, in order to avoid this problem and the trivialization of making, educators should move toward learning that is more meaningful and contextualized instead of a quick demonstration project approach that is typically associated with makerspaces [34]. Lastly, sustaining a makerspace can be costly and these sites will face a low budget problem, for which there has been attempts to handle it through recycling but this itself also leads to the challenges of recycling process [34].

### 2.1.3 Makerspaces Lifecycle

Yu [72] divides the makerspace history into three main periods of embryonic period, transition period, and outbreak period. The embryonic period, in the 1870s-1990s, is identified with several events marked as key dates in the history of makerspaces. Examples include the Ladies Social Society, Canadian Handicrafts Guild, Chaos Communications Club, and a tool lending library in Ohio. The transition period, during the 2000s-2010s, is the period when makerspaces begin to be associated with academic institutions, beginning with MIT and then officially appearing in libraries. The evolution of technology and DIY culture led to a focus on STEM in these spaces. The outbreak period, referring to the current period, is regarded as starting in 2011 when the Fayetteville Free Library in New York State became the first public library to create a makerspace in the United States. The Toronto Tool Library (TTL) was founded in 2012 and partnered with Toronto Public Library in 2015 to open a new tool library. Afterwards, the making continued and expanded to more universities. To this date, the makerspaces are still growing and spreading further and into more communities and play more apparent roles in people's lives [72].

Considering the expansion of makerspaces and the barriers they are facing, we looked for ways that makerspaces have sustained themselves. These ways can mainly fit into categories of attracting participants, community volunteers and expertise, and donations [55]. They try to attract participants by marketing through social media, and advertising events. They also evaluate their space and share the results of how successful they are in order to encourage new participants to join them. Makerspaces use formal and informal recruitment tactics to attract mentors for 21st Century Community Learning Centers (CCLC) from partner agencies such as museums, faith-based organizations, universities, and art organizations. Guest makers, teachers within a school or the expertise of old and new members of a makerspace can serve in mentor roles [55]. Regarding the donations aspect, makerspaces can also host events and give community members the chance of donating the extra equipment and tools they no longer need. They can sell some of their creations or even start taking custom orders of 3D printing. Finally, there is always the option of crowdfunding campaigns for funding purposes of well-defined needs [55].

Despite the ways mentioned above, makerspaces cannot always succeed in handling these challenges and therefore may become inactive. Below are some reasons that can cause privileged makerspaces to stop operating. The provision of equipment, resources, and tech can be costly and maintaining these equipment and replacement of their components can

lead to additional expenses [16]. Another reason concerns issues of proper staffing and scheduling, especially for makerspaces within the library or school, which add to the ongoing responsibilities of their current personnel. Staff and patron training are necessary aspects of makerspaces, but are not always readily accessible [16]. There are also environmental challenges such as neatness, noise, and maintenance as the whole process of making has the potential of damaging existing furniture or it can include loud equipment requiring a dedicated space with noise reduction features. Safety and liability issues are a primary consideration in a makerspace although it can be challenging to fulfill it due to the potentially hazardous equipment on site [16]. As an example, Toronto’s MakeWorks announced in July 2019 that it will close and their main reason is economics-based. Apparently, they tried hard to find a suitable business model but ultimately it proved to be too difficult and they had to close the workshop [9].

Although subaltern design sites are clearly not immune to the above challenges, there are additional circumstances to challenge their existence. These makerspaces can suffer by not receiving their required resources and recognition and they may not receive the proper validation and respect. The subaltern design sites and their design products could also be marginalized under colonialism and capitalism. Costanza-Chock [14] argues that the history of capitalism is in large part a history of the extraction of design practices that used to take place in family and community microsites and their subsequent systematization, rationalization, and modification to fit the requirements of mass production such as the transformation of the home-based clothing design and production to a globalized industry of fast fashion. Subaltern communities may intentionally avoid recognition in order to shield their practices and innovations from mainstream visibility, in order to avoid incorporation and appropriation [14]. In addition to that, subaltern innovators might be harmed by the various arms of the industrial complex due to systematically unequal policing [14].

Despite these challenges and barriers that cause disruption in the activities of makerspaces, there have also been initiatives to support them. Recently, there has been a move toward intentional diversification of makerspaces, especially regarding gender. Examples of this are Liberating Ourselves Locally, Double Union, and a new wave of intersectional feminist spaces dedicated to design and making [14]. Launching design events, elaborating possible design challenges, and calling for design solutions is another initiative that has proven impactful regarding encouraging communities to contribute. An interesting consequence of this has been the evolution of some of these projects into start-ups. Some governments are also trying to be more transparent and provide citizens with more public administrative data

while actively seeking ideas from public to integrate into government services and citizen’s quality of life [14]. Regarding the subaltern or local design sites, there has been initiatives such as supporting local organizers in multiple cities to run Cooperative Economy Discovering Technology fairs (co-op DiscoTechs) [14]. Providing free software and infrastructure for cultural production in these design sites are other effective strategies. In Venezuela, urban social movements pushed the state to change telecommunication laws to allow community radio and TV stations [14].

#### **2.1.4 Characterizing makerspaces outputs and activities**

Activities done in makerspaces can lead to various types of products and creations, which we will discuss through examples from prior research projects. Li and Todd [40] studied the desired outcomes of a makerspace from young people’s perspective and stated that the most desirable outcomes were tangible products rather digital ones, such as creations made from Lego. This is mostly because these creations were addressing individuals’ needs or were entertaining to them. Among their sixteen participants fifteen of them reported their products were made for play rather than practicality and only one reported preference over practicality. In [34] the author states that the built products are usually associated with a broader contexts such as STEM, STEAM, project- and problem-based learning, design thinking, and innovation. Meaningful making also encourages the makers to apply critical thinking to their designs and go beyond simply creating objects. There are multiple other creative examples of projects undertaken in makerspaces in [8] that originate from community organizations, museums, and schools including “Paper Electronic Storytelling” and “Bike-Powered Smoothie Maker”.

Maker community contributions are often distributed using open source approaches, such as Creative Commons licensing. Many maker community contributions thus far are available on different websites. Make Community website [44] covers a wide range of projects from ad blockers, smart locks, and backyard wind power to macramé. The nature of their contributions can range from useful everyday devices to products associated with arts, crafts, and entertainment. Some of the mentioned categories on their websites are craft & design, digital fabrication, drones & vehicles, education, home, science, and technology. There are also different boards for appliances & gadgets, food & beverage, fun & games, furniture, gardening, and lighting, which confirm that any creation counts as making. However, can any maker start working towards the production of the required products?

Makers Making Change (MMC) provides insightful information regarding this question of purpose-driven making. Makers Making Change (MMC), an initiative within the Neil Squire Society (a nonprofit organization; see section 2.4 below) focuses on making assistive technology (AT). The way Makers Making Change has offered the work, is that it all starts with a device request or idea, a project, or a design challenge. This is followed by submission of solution ideas by potential makers. If approved (by supervisors or admins of their network), one can build a prototype of their solution ideas and put the device into work, get feedback, and apply the changes. If the product is a large-scale product that can be used by many, there is the possibility of signing contracts with companies.

As they focus on AT devices, MMC recommend a set of skill and some requirements to their potential makers. They have an educational resource on their website that encourages the potential makers to have a list of suggested necessary skills such as soldering, designing and printing assistive technology, and 3D printing [51]. They admit that as makers they understand that one wants to do something to solve the issue when they see a problem and that anyone can build anything for themselves, but it is important to put this effort into initiatives that are impactful, necessary, and relevant for our communities. It would be preferable to have expert input and review on the initiatives so that makers can work on solutions that can make a real difference.

MMC is similar to Tetra Society, which is a nonprofit organization that focuses on finding solutions to environmental barriers faced by people with disabilities, and they recruit volunteers who work with clients to design and build assistive devices that are custom-made for the individuals [69]. MMC and the Tetra Society are different from others in the field through their use of community-based makers. There are service providers such as CanAssist, an organization of University of Victoria, which include a team of professionals who are dedicated to helping people with disabilities [12]. CanAssist develops customized technologies for people with disabilities. In order to request technologies from them, they must be unavailable commercially and through other providers [13].

## 2.2 Assistive Technology

The construct of Assistive Technology as a category of technology typically has been defined via two different approaches: one approach defines AT in terms of the technology's purpose and the other approach defined AT in relationship to mainstream technology.

In the first approach, Assistive Technology (AT) has been defined as any device or system

that increases the ease and safety of performing a task, or allows individuals to perform a task that they would otherwise be unable to do [33]. Assistive Technology Industry Association (ATIA) defines AT as any item, piece of equipment, software program, or product system that is used to increase, maintain, or improve the functional capabilities of persons with disabilities [5].

Assistive technology devices refer to a broad range of products. According to [5], AT devices can be low-tech such as communication boards made of cardboard or high-tech such as special-purpose computers for mobility impairments, visual impairments, or specific learning disabilities. AT includes both computer hardware and software; hardware such as special switches, keyboards, and pointing devices and software includes screen readers and communication programs. Devices such as prosthetics, mounting systems, and positioning devices also count as AT. Assistive technology can also refer to specialized learning materials, curriculum aids, and specialized curricular software. Many other technologies such as electronic devices, wheelchairs, walkers, braces, educational software, power lifts, pencil holders, eye-gaze and head trackers fit into the category of Assistive Technology.

In another approach, the construct of Assistive Technology as a category of technology can also be defined in relationship to mainstream technology. The design of mainstream technologies can be understood as a process that results in a particular framework of action, which defines a device's function and use. Mainstream technologies are usually valid across a relatively homogeneous group of users [25]. Assistive technology on the other hand, usually does not aim to design for a homogeneous group of users and values the differences between users. Therefore, AT devices are best customized for their individual users. In order to accomplish this, these devices need to be configured by a group of professionals and a network of modest institutions for the benefit of users [25].

### **2.2.1 Inclusion of AT into the lives of its users**

Previously, we talked about the types and benefits of AT, but we have to acknowledge that there are still a number of barriers to people with disabilities who are trying to successfully include AT into their lives.

According to Alper and Raharinirina [2], there are a number of barriers related to the implementation of AT. Despite the growing body of knowledge around accessibility, assistive technology is still unavailable for many groups. One reason for this could be limited financial resources [2]. Other primary barriers include high cost of the equipment and lack of funding

to access the devices, as well as lack of knowledge around AT for families of individuals with disabilities [2]. Professionals' lack of information about technology, lack of ongoing support, and eligibility issues are among the main obstacles surrounding Assistive Technology [2].

Even in the cases that people with disabilities have the required assistive technology, the issue of abandoning that device persists. Abandonment refers to disuse of a previously obtained device [70]. Some reasons for AT device abandonment are lack of consideration regarding the needs of person with disabilities, selection of device done by family members, complication of the device regarding the setup and programming, lack of technical support, and unreliable technology [2]. The abandonment of AT devices has a negative effect both on the individual and on national health care system [70]. This means that the user's need remains unmet and that the health care team has failed in providing the proper AT equipment [70].

Most policies and procedures for assessing the need for assistive technology devices and services are based on a deficit model, which is similar to the 'referral, identification, and placement' model for special education [23]. The need for AT and how to measure it can come from multiple resources, especially physicians referring patients to AT, and schoolteachers referring students in need [70].

Mainstream technologies have been trying to include better accessibility features, but World Health Organization (WHO) states that across the world there is still an unmet global need for assistive technology and there are many people in need of assistive technology devices that do not have access to it [71]. There are currently one billion people who need one or more assistive products and to date, only one in ten people in need has access to assistive products [71].

Examples of this unmet global need include the 200 million people with low vision who do not have access to assistive products for low-vision and the 75 million people who need a wheelchair (where only 5% to 15% of those in need who have access to one) [71]. Hearing aid production currently meets less than 10% of the people in need, which is 466 million individuals experiencing hearing loss. Assistive technologies in low-income countries can be unaffordable and this could be a major reason that people in need do not have the assistive products they require [71]. Also, although low-income countries have the highest prevalence of disability-related health conditions, they suffer from the lowest supply of health care workers skilled in assistive technology and over 75% of these countries have no prosthetic and orthotics training programmes. Therefore, we are still far from meeting the need for AT applications.



## 2.3 Do-It-Yourself Assistive Technology

Hook et al. [33] define Do-It-Yourself Assistive Technology (DIY-AT) as the creation and adaptation of AT by nonprofessionals, including people with disabilities and their families, friends and caregivers. Hamidi et al. [29] characterized DIY-AT as a mode of commons-based peer production and part of the knowledge commons that seeks to increase accessibility and that is customizable for each user and sometimes costs less than commercially available alternatives.

There are multiple institutions and companies that work in the area, they provide assistive technology for those in need and they also post resources for DIY-AT on social media. Some examples are provided below.

- Instructables: their website has step-by-step guide towards making process of different projects. Some of these projects fit into the category of AT such as "Piu! Voice Assisted Gamepad" and "Sitting Volleyball Aid" and other projects such as "Light-Up Card" and "Scratch Off Cards" fit into categories of art and craft [36].
- PACER's Center – Simon Technology Center: Simon Technology Center (STC) aims to make technology more accessible to children and adults with disability [56]. They have a variety of services to help children, families, and professionals [56].
- Alina Health - Courage Kenny Rehabilitation Institute: they provide technologies to help maximize one's independence [1]. They have a team of occupational therapists, speech therapists, assistive technology practitioners (ATP) and a certified registered ergonomist (CRE) helping individuals with their assistive technologies [56].
- Individual works: there are also many individuals working in the area of assistive technology, namely, Zebreda Dunham who has various projects such as Eating Assistant and Pulley Spoon [73].
- Makers Making Change: Makers Making Change (MMC) is an online platform providing a disruptively low-cost alternative to commercially available assistive technologies [64]. They have a wide range of assistive devices on their website and people can choose from and request their selected devices.

### 2.3.1 DIY Technology and COVID-19

Over the past year, people were faced with numerous challenges due to the pandemic caused by the COVID-19 virus. Based on the resources on MMC's website, the need for assistive technology devices was not exempt from changing due to the circumstances. Therefore, they have developed a new section dedicated to COVID-19 pandemic and response from makers and AT users [50]. With the goal of being relevant in a time of crisis, they have created sections for both Personal Protective Equipment (PPE)/medical devices and non-medical devices [50]. Examples of the former are clear masks for those with hearing problems, 3D printed face shields, and 3D printing of components of medical devices and accessories [47]. Hands-free door openers, social distancing lanyards for people with visual impairments, and ear savers are examples of the latter category [48].

DIY respirators and other medical devices were often discussed during the pandemic, particularly in the first wave. Undoubtedly, manufacturing medical devices has a strict design process, which the makers should handle if they want to contribute to their production. Health Canada has provided a list of standards for face shields and face masks and they have announced that anyone who wishes to manufacture, import or sell a 3D printed Class I medical device in Canada requires a Medical Device Establishment Licence (MDEL) with some exceptions applied [26].

MMC has a webpage dedicated to COVID-19 resources in which they explain the safety measures AT makers and people with disabilities should pay attention to. They recommend people with disabilities to request the devices with contact-free delivery, use alcohol-based cleansers to disinfect touched surfaces during handling of the package, and to disinfect their received assistive device with proper cleansers suitable for the material [49]. They recommend makers to follow their provided guidance on printing, building and packaging the assistive technology [49]. They also provide information about cleaning and sanitization of the builds, which includes an understanding of cross-contamination, best cleaners to use for different materials, and standard methods of sterilization.

Additionally, Makers Making Change introduce some impactful projects during this time which include protective face shields, hands free lever door opener, home made cloth mask, and home made hand sanitizer [49]. Some other design initiatives are open source ventilators and hands free door opener for round shaped knobs [49]. There are also projects that makers should avoid. First, makers should not start making 3D printed masks due to the limitation of these masks to filter out airborne versions of the virus [49]. They should also avoid making

ventilator components, as it has a strict design and production process [49].

### 2.3.2 Prior Research in DIY-AT

There has been extensive research on DIY-AT, its products, and the challenges regarding its making process. Previous works have identified that customizing the commercial assistive technologies and the design of privately manufactured devices are promising methods to avoid the problems caused by one-design-meets-all products [46]. There are manifold HCI research projects that have investigated the applicability and quality of DIY-AT products. We will take a deeper look into some of these projects.

Hurst and Tobias [35] discuss how a large percentage of Assistive Technology devices end up abandoned and this leaves the needs of many people unaddressed. They offer the possibility of DIY-AT leading to more adaptation and adoption by empowering users to make their own custom-build Assistive Technology [35]. They also illustrate how it is possible to build custom Assistive Technology devices that are less expensive. Based on their conducted interviews, users of AT devices had easily achievable modification ideas and they were also interested in being involved in the process of building devices [35].

Hook et al. [33] conduct a qualitative study, exploring the challenges of making DIY-AT for children with disabilities. Their study reveals challenges regarding barriers to participation, scope of ongoing DIY-AT practice and challenges that makers and users of DIY-AT face, they also offer solutions for further research in the area.

Buehler et al. [11] examine Thingiverse, one of the largest online communities that support the open-source sharing of designs which can be used to build physical objects. Many of the designers in this online community have no formal training or expertise in building Assistive Technology devices. Buehler et al. discuss the motivations and skills of DIY-AT designers and why they share their inventions on Thingiverse [11].

One of the reasons for DIY-AT popularity is its ability to eliminate some of the existing challenges in building of AT and putting it into use. AT is usually developed to address the needs of a target user group and therefore, can fail to meet the needs of individuals [33]. Many of the AT devices need to be modified before they can be effective for their users. DIY-AT, on the other hand, has the potential to be customized to fit the specific needs of individuals, unlike AT that may only provide an approximate response [33].

As we discussed earlier, in many cases in which people with disabilities are provided with assistive devices, there is a high rate of AT device abandonment. DIY-AT can also

be a solution to this problem, as they are tailored version of AT devices and built for individuals' needs. DIY-AT in some cases can be cost-effective and less expensive compared to commercially available AT devices. Process of building a DIY-AT device can involve people with disabilities in the activity of making [46], which can result in an increased feeling of empowerment and agency in addition to increased investment in the product itself and support community building [29]. The development of DIY-AT also provides its users with the opportunity of refining the device based on changes in user's needs or circumstances [33].

Despite its benefits, the process of designing and building DIY-AT has also its own challenges. Among the wide range of projects related to DIY Assistive Technology, some are studying the challenges in this field. Rajapakse et al [59] talk about how challenging it is to find different communities with the necessary skills of building these technologies and to bring them together. Hook et al. [33] go through the challenges that children with disabilities and their care network face while using AT or DIY-AT. They found the key barriers to participation in the production of DIY-AT to be self confidence in practicality of the device; apprehension to invest time without the guarantee of a useful outcome; and other aspects such as aesthetics, robustness, and safety of the device [33]. Meissner et al. [46] describe that making itself is a complex and time-consuming process especially for novice makers and different disabilities can cause difficulties for each step of this process. For example, limited dexterity makes it harder to work with tiny components of a circuit or being partial-sighted can cause complications while working with CAD software apps with numerous small icons [46]. This study reveals findings based on strategies participants used to overcome or simplify these challenges. They also identify several potentials for empowerment of the participants [46]. According to Hamidi et al. [29], challenges of DIY-AT can also be related to the environment in which the product is being made. They explore the possibilities and challenges of DIY-AT in Western Kenya, and reveal the most important factors of deploying a DIY-AT product in the East African context. These factors include “using approaches that support end-user appropriation, creating supportive local infrastructures, and engaging multiple stakeholders” [29].

One of the platforms with a rich library of DIY-AT is Makers Making Change with more than 100 pieces of assistive devices ready to be requested or made on their website.

## 2.4 Makers Making Change

Makers Making Change (MMC) is a new, non-profit initiative by the Neil Squire Society with the vision of achieving economic and social inclusiveness for all people with disabilities. It is an assistive technology program that is funded by the Google Foundation, the Government of Canada, and the Vancouver Foundation [64]. They are committed to creating an international community of makers who support people with disabilities within their communities by creating accessibility solutions [64].

The mission and guiding vision for Makers Making Change is available on their website. MMC mission is to “connect people with disabilities to volunteer makers to build assistive technologies” [53]. Their guiding vision at Neil Squire Society is to “achieve economic and social inclusiveness for all people with disabilities” [52]. The available process on their website includes a device request by people in need and suggestions of solutions or prototypes posted by makers. Developing and delivering affordable open source assistive technologies and enabling community-based development are among the goals of this program [52].

MMC has a library of their assistive technology devices all available on their website and users can directly request, download their related files for making, or review the device. Their top three most frequently requested devices are provided below.

- **LipSync:** The LipSync is a mouth controlled joystick that allows a person to control a touchscreen device cursor with minimal head and neck movement. It was first designed and released by Neil Squire society. What makes LipSync distinct among other similar projects, is the low cost of it.
- **Pen Ball:** This is a customizable 3D printable writing aid. The pen ball can benefit anyone having difficulty holding a pen or pencil directly and makes it easier to grip any writing utensil. One advantage of the pen ball is that the diameter of the ball and the writing utensil diameter can be customized to fit the user’s need in the best possible way. Usage: A pen or pencil is inserted through the pen ball and is fixed in place by tightening a screw. The ball is held in the hand to make it easier to write.
- **3D Printed Educational Devices Kit:** This kit contains multiple devices that help people with disabilities with their everyday living and learning tasks. These devices assist people with arthritis, limited finger dexterity or other disabilities. Some of its devices are palm pen holder, dice spinner, bottle opener, and key turner. This kit

can be used as a great educational resource into the world of 3D printed Assistive Technology for schools.

In this project, we will take a deeper look into MMC's projects, solutions, and their whole process of fulfilling the requests of people with disabilities.

## 2.5 Design Justice

Design Justice Network introduce themselves as “an international community of people and organizations who are committed to rethinking design processes so that they center people who are too often marginalized by design” [20]. They work in line with a set of principles that were originally developed in 2015 and are continuously refined. There are multiple ways one can get involved with Design Justice Network: people can become signatories of Design Justice principles, become members of the network, attend different events, join or start a working group, and join or start a local node [21]. Organizations can also become members.

In the following paragraphs we will be discussing some of the other frameworks. Tech for Good [67] was founded by Beatrice Pembroke, Cassie Robinson, and Abby Schlageter. They believe that “tech” itself is neither good nor bad and that it is the intentions of using technology that defines this, therefore, we need to intentionally use technology for better social and environmental changes [67]. They want technology to be used as a means to provide us with better products and services in addition to protecting our planet. Tech for Good's mission is “to grow a global movement for Tech for Good, to increase demand from entrepreneurs, civil society, corporates, funders, policy makers and consumers” [67].

Telus is promoting inclusion and accessibility through their Tech for Good program. This program helps people with disabilities who need assistance in using their phones. According to Telus, this program is “primarily educational in nature and provides customized training and support to help improve the quality of life, independence and personal empowerment of people with disabilities”.

Technological stewardship for the engineering community provides a set of principles including seeking purpose, taking responsibility, expanding involvement, widening approaches, advancing the understanding, realizing diversity, deliberate values, and shared action [65].

I chose the Design Justice Network for my thesis due to its elaborate principles that are aligned with my own epistemological stance.

### 2.5.1 Design Justice Principles

The principles of Design Justice Network are taken from their website, last updated in summer 2018 and are provided below [20].

1. We use design to sustain, heal, and empower our communities, as well as to seek liberation from exploitative and oppressive systems.
2. We center the voices of those who are directly impacted by the outcomes of the design process.
3. We prioritize design’s impact on the community over the intentions of the designer.
4. We view change as emergent from an accountable, accessible, and collaborative process, rather than as a point at the end of a process.
5. We see the role of the designer as a facilitator rather than an expert.
6. We believe that everyone is an expert based on their own lived experience, and that we all have unique and brilliant contributions to bring to a design process.
7. We share design knowledge and tools with our communities.
8. We work towards sustainable, community-led and -controlled outcomes.
9. We work towards non-exploitative solutions that reconnect us to the earth and to each other.
10. Before seeking new design solutions, we look for what is already working at the community level. We honor and uplift traditional, indigenous, and local knowledge and practices.

## 2.6 Conclusion

In this chapter, we started off by introducing makerspaces and discussing their different types, alongside talking about challenges of creating and sustaining them, their users and stakeholders, and their products and activities. We also talked about Do-It- Yourself assistive technology and assistive technology in general and presented some of the platforms and service providers in this area. We demonstrated an overview of the previous literature on

DIY-AT devices, challenges of the process, and its advantages. We then introduced Makers Making Change and their activities, mentioning some of their main assistive devices. Lastly, we talked about Design Justice Network and their guiding principles. In the next chapter, we outline our research questions and our proposed methodology to answer them.



# Chapter 3

## Methodology

### 3.1 Research Questions

As previously mentioned in (subsection 1.4), we have focused on five main questions presented below:

- Q1a:** In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?
- Q1b:** In what ways has Makers Making Change (MMC) been successful in motivating DIY-AT and Home Makerspaces?
- Q1c:** In what ways has Makers Making Change (MMC) been successful in promoting the principles of Design Justice?
- Q2a:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) impacted disabled people?
- Q2b:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) affected the demand for AT?

#### 3.1.1 Discussion of Research Questions

A question that we were originally interested in was “Q1: In what ways have Makers Making Change (MMC) been successful?”, but we soon realized that this question was a too broad

and too vague question. Success is a complicated construct and there are potentially many aspects that one could choose to determine the ways in which MMC has been successful. One example, which is commonly used in the non-for-profit section, is the percentage of funding dollars spent on program delivery as opposed to the overhead. Instead, we decided to focus on a few specific aspects of “success”: “AT service delivery/facilitation” (Q1a), “motivating DIY-AT and HMSs” (Q1b), and “promoting Design Justice” (Q1c).

**AT Service delivery/facilitation (Q1a)** is taken here to refer to the quantity and quality of pieces of technology that MMC is causing to get into the hands of people who need them. This sense of ‘delivery’ is altered from its typical sense, since MMC is not directly providing the service, but rather is serving as a facilitator (hence the term delivery/facilitation). AT service delivery/facilitation is only one component of MMC’s mission, so this question also requires contextualization of AT service delivery/facilitation relative to the other services that MMC provides.

Quality in AT service delivery/facilitation is a complex construct. We decided to examine quality in AT service delivery/facilitation, as opposed to service delivery more generally, and more specifically with regards to uptake of Design Justice principles within the DIY-AT facilitated pipeline. Although this is a selective perspective on the outcome attribute of ‘quality’, we argue that piece of AT which has not been produced with adherence to principles of Design Justice — even if deemed to be of good quality in a particular use case — is still a piece of AT that has been produced via a process that perpetuates marginalization.

The second attribute, **motivating DIY-AT and HMSs (Q1b)** connects to MMC’s mission to encourage increased capacity for DIY-AT. A key component of this is encouraging the creation of new and the expansion of existing HMSs. Another key component is who is being encouraged. Makers can be people with prior experience related to assistive devices, engineering, medicine, or they can just be hobbyists with an intention to help people with disabilities. We would like to investigate how makers who became ‘activated’ as MMC makers got activated (for instance, solely through encouragements and advertisements of MMC, whether they were already working as volunteers or employees in the MMC network).

The aspect of the **promotion of Design Justice (Q1c)** seeks to look more broadly at MMC’s activities with respect to Design Justice principles, at a level that is more global than within the delivery of specific pieces of AT. Thus, Q1c builds upon Q1a. We focused on these three more specific questions:

- Based on MMC’s previously available activities, to what extent have principles of Design Justice been incorporated into their assistive devices?

- Looking forward, in what new ways could the maker community contribute to incorporating Design Justice principles into practice?
- How is the Design Justice Network advancing its advocacy?

Questions Q2a, Q2b relate to the question “Q2: What have been some of the main effects on DIY-AT of the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH), as necessitated by the COVID-19 pandemic?” We are all aware of the significant impact that the pandemic caused by the COVID-19 virus has had on our lives, businesses, and everyday tasks. This change and the fact that many of MMC makers originate from their local community, piqued our curiosity about the ways that the recent pandemic and working from home has affected local and home makerspaces.

In order to find the answer to this, we needed to consider two main attributes: **access barriers (Q2a)** and **change in demand for AT (Q2b)**. Access barrier attribute reviews the impact of the pandemic and shift to SAH/WFH on people with disabilities regarding the knowledge, time, and resources. We would like to find out whether the pandemic is causing any complications in the process of building assistive devices such as any newly established guidelines. The outcome of change in demand for AT attribute determines whether the current conditions due to the pandemic are resulting in an increase or decrease in the demand for AT.

To investigate these questions, a qualitative document analysis approach will be used. The approach will be discussed in subsection 3.2.2.

## 3.2 Research Approach

Before describing the specific approaches that will be taken for each of Q1a, Q1b, Q1c, Q2a, and Q2b, we will first briefly describe Qualitative Document Analysis in (subsection 3.2.1). We will also talk about the considered documents and why they are useful and then describe how this approach will be used for each of the research questions.

### 3.2.1 Qualitative Document Analysis

Document analysis is an analytical method in qualitative research. According to Bowen [10], it is a systematic procedure used to collect, review, analyze and evaluate documents in order to extract meaning, gain understanding, and produce knowledge.

### 3.2.1.1 Types of Documents Considered

Documents in qualitative analysis can be in many forms such as reports, advertisements, web pages, web archives, books, articles, proposals, summaries, and various other records. The term “document” can refer to any single record that captures specific information and can be stored so that the data is not lost. Documents can be physical or digital. Grey literature refers to the documents that have a status of uncertainty and according to Mahood, Van Eerd, and Irvin [41], this uncertainty can be a result of multiple characteristics such as “not being produced for commercial publication, not available through standard distribution means, no standard bibliographic controls, not peer-reviewed, and ephemeral and historically difficult to find”. The Grey Literature Network Service [27] also gives a definition of grey literature:

Grey Literature is a field in library and Information science that deals with the production, distribution, and access to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing i.e. where publishing is not the primary activity of the producing body [27].

Grey literature is studied as a useful resource in policy and practice [38]. Governments, universities, Non-Governmental Organisations (NGOs), and different businesses produce a rich knowledge base that many of them are grey literature [38]. Grey literature can be a great resource for information and topics that are not included in scholarly articles [38]. It also provides the researcher with a broader perspective and complete view of the evidence compared to when only peer-reviewed materials are used [41].

### 3.2.1.2 Utility of Documents

Documents are useful units of study, as they can serve multiple purposes in a research project. Bowen [10] identifies five main functionalities of documents in different projects:

- Documents can provide useful insight about the background and historical aspects of a research context.
- Documents can be used to raise new questions and demand certain observations as part of the research.
- Documents themselves provide us with specific data about a research project that can be a valuable asset to the knowledge base.

- Documents of a certain research can be compared to track and identify the changes.
- Researchers can analyse documents to verify and confirm different evidences.

The data from the documents needs to be extracted and interpreted in order to be used in the analysis [10]. Document analysis, like every other qualitative research method has its own advantages and disadvantages. Document analysis needs data selection instead of data collection phase which can be time efficient compared to other methods [10]. Some advantages could be the availability of documents, their stability, inclusion of exact names, references, and details in them, and remaining unaffected during the research process [10]. Limitations of qualitative document analysis include insufficient details of a document, difficult retrievability, and a biased selection of documents [10].

After the selection of document analysis as a methodology for the research and gathering a wide range of documents related to the research questions, actual analysing of the documents starts. Document analysis requires the researcher to read through the documents and have a good grasp of the content. Then the researcher can organize the information into categories related to the central research questions [10]. The next step would be the thematic analysis. Thematic analysis refers to searching within the data in order to find the emergent themes and patterns that are considered important regarding the research questions [10]. Next, the researcher can use different codes and their correspondent occurrences to gain a better understanding of how these documents respond to the research question.

### **3.2.1.3 Qualitative Document Analysis (QDA) Process**

A four-phase iterative process of qualitative document analysis (QDA) has been established in prior research [3, 10]:

- (1) Corpus Development (discussed in Section 3.3)
- (2) Code Development and Application (discussed in Section 3.4)
- (3) Analysis and Visualization (discussed in Section 4.2)
- (4) Results (discussed in Section 4.3)

The content of these steps sits at the intersection of thematic analysis and content analysis, and is a qualitative and interpretive approach.

### **3.2.1.4 Quantitative Analysis**

Many of the documents related to the research questions will contain quantitative data. For instance, in the “Assistive Devices Library” on the MMC website is a collection of Assistive

Technology “Projects”, also called “Solutions” or “Devices”. Each project page contains a description of an assistive device, and also has included semi-structured information such as its stage of development (e.g., recently added, prototype, etc), type of disability for which this device would be useful, difficulty level to create the device, who created the design, capabilities needed to execute the design, time to complete the design, cost of materials to execute the design, the usage (e.g., everyday use, recreation and leisure, etc) , and the license attached to the use of the design (e.g., Attribution 4.0 International, Attribution-NonCommercial-ShareAlike 4.0 International, etc.). This information template is used for all assistive devices. There are other types of documents which also contain semi-structured data (for instance, the ”design challenge” documents). Another set of documents that we can extract quantitative data from them are the list of requests for assistive devices and their correspondence responses before and after the pandemic. These request can be in search of a maker to build a certain device, can be in the process of building it, or can be requests that have been already fulfilled.

Once a set of documents of this type are assembled, this quantitative data can be extracted. In the analysis, we plan to use quantitative methods to investigate this and other similar types of quantitative data. This quantitative analysis informs us about the prevalence and frequency of certain behaviors and lets us assign numerical values to occurrences [39]. We will then use descriptive statistics in order to gain an understanding of these behaviours and relate them to the research questions.

### **3.2.2 Research Approaches Employed**

Considering the research questions mentioned in the beginning of this chapter (section 1.4), we needed to select a suitable methodology to address our needs. The approach we will be taking as a means to answer our research questions is Qualitative Document Analysis (QDA) and we will be using it for both qualitative and quantitative analysis. We plan to gather a set of relevant documents. What these documents are, how they can provide answer to each of our research questions, and how we prepare them for our analysis are discussed in (section 3.3).

## 3.3 Phase 1: Corpus Development

### 3.3.1 Document Identification

The first step of our qualitative document analysis is to develop a set of relevant documents and to gather, to organize and to store them. By analyzing the research questions and considering the qualitative document analysis we will be conducting, we developed sets of documents that can be used as the basis for answering each of the research questions. We will describe this process in the following sections.

**Unique Identifier Assignment** In the sections below, we describe different types of documents and discuss their inclusion in the corpus. To systematize the corpus development process, we assign unique Document IDentifiers (DID) codes to documents or sets of documents upon their identification for inclusion. The DID nomenclature will consist of an alphabetic prefix (generally a set of three letters indicating the general document category), followed by a number that more specifically distinguishes among different document sub-groups within a category, followed by additional letters to unambiguously distinguish among specific documents within a given sub-group.

#### 3.3.1.1 Q1a: AT Service Delivery/Facilitation

As described in section 3.1.1, we sought to locate documents that help us understand AT service delivery/facilitation: the quantity and quality of pieces of technology that MMC is causing to get into the hands of people who need them. And, as also described previously, AT service delivery/facilitation is but one type of service delivery under the umbrella of MMC’s mission, so we also sought documents that contextualize AT service delivery relative to MMC’s other activities.

In order to investigate the contextualization of AT service delivery among other services within MMC’s broader work, we sought to find out how MMC defines their goals and mission generally, how they describe the achievement of these goals in relation to the aspect of service delivery, and how the delivery of assistive devices is formulated as a portion of their work.

First, we sought to find MMC mission and goals, as defined by MMC themselves explicitly. We categorize these documents as generally “MMC Mission Documents.” We defined the **DID Schema** MMC1*x* for these types of documents. The MMC website was the primary source for these documents. We identified two such documents: “MMC mission sentence”,

and “MMC guiding vision”.

Additionally, we believed that documents that advertised or communicated MMC’s accomplishments or sought to encourage new members would provide information about the contextualization of services: MMC success stories, testimonials received from their clients, lists of MMC events, and ways of helping within the MMC network as a volunteer. We speculated that these documents could assist us in determining how and to what extent service delivery was contributing to the MMC mission. We refer to these types of documents as “MMC Advertisement Documents” more generally. We searched the MMC and Neil Squire websites for these types of documents. We looked into ‘News & events’ archive sections of both of these websites, and the ‘MMC volunteer’ webpages on the MMC website. We defined the **DID Schema MMC4x** for this category. We identified 10 webpages relevant to this category.

In order to investigate the quantity of MMC assistive devices, we decided to gather the documents that are available on the MMC assistive devices library about the repertoire of ATs facilitated by MMC. The **DID Schema** we defined for this category is **MMC2x**. To this date, this library includes 109 assistive devices that users can build by themselves or request them to be built. Each different AT device has its own document as an entry in the MMC library. We seek to find out how many times each of these devices have been requested and what percentage of these requests have been fulfilled.

In order to investigate quality in service delivery, we sought to examine uptake of Design Justice principles specifically within the AT production pipeline. Thus, all of the documents in category **MMC2x** are also relevant to the quality aspect of service delivery and will be examined.

**Q1a Document Set:** The document set for Q1a consists of “MMC mission statement” (DID schema: **MMC1x**, 2 documents), “Documentation of solutions and designs published on MMC site” (DID schema: **MMC2x**, 109 documents), and “MMC advertisement documents” (DID schema: **MMC4x**, 10 documents).

Table 3.1: List of Document Schema Relevant to Q1a

| Document Schema Category | Document Type(s) |
|--------------------------|------------------|
|--------------------------|------------------|



|   |  |
|---|--|
| <b>DID Schema: MMC1x</b><br>MMC mission documents   | Organization Statements;<br>Webpages       |
| <b>DID Schema: MMC2x</b><br>Documentation of solutions and designs published on<br>MMC site | Entries of the MMC AT<br>Library, Webpages |
| <b>DID Schema: MMC4x</b><br>MMC advertisement documents                                     | Organization News,<br>Webpages             |

Table 3.2: Document names for Q1a and their correspondent DIDs

| <b>Document<br/>DID</b> | <b>Document Name</b>                                     | <b>Ref</b>      |
|-------------------------|--|-----------------|
| MMC1a                   | MMC mission sentence                                     | [MMC1a]         |
| MMC1b                   | MMC guiding vision                                       | [MMC1b]         |
| MMC2a                   | MMC assistive devices library page                       | [MMC2a]         |
| MMC2b –<br>MMC2df       | Each assistive device in MMC library                     | Refer to Corpus |
| MMC4a                   | Become a Chapter Leader or Community<br>Champion for MMC | [MMC4a]         |
| MMC4b                   | Neil Squire testimonials                                 | [MMC4b]         |
| MMC4c                   | MMC volunteer  | [MMC4c]         |
| MMC4d                   | MMC latest requests topics                               | [MMC4d]         |
| MMC4e                   | Becoming a community chapter leader                      | [MMC4e]         |
| MMC4f                   | MMC events   | [MMC4f]         |
| MMC4g                   | MMC design challenges                                    | [MMC4g]         |
| MMC4h                   | MMC latest community/volunteer wanted                    | [MMC4h]         |
| MMC4i                   | Donate (Neil Squire)                                     | [MMC4i]         |
| MMC4j                   | Success stories archive                                  | [MMC4j]         |

The next step includes finding patterns among our extracted data, figuring out the organization's goals and that in what ways they are achieving it and how successful they are in this aspect. We are also aiming to extract quantitative data such as the number of assistive devices that have been requested and then been facilitated to get to the hands of users in need.

### 3.3.1.2 Q1b: Motivating DIY-AT and HMSs

As a means to answer this question, we sought to identify documents that serve to encourage individuals, organizations, and/or the government to join the MMC network, to become a volunteer, to provide funding, or to participate in the DIY production of assistive technologies.

One component of the answer can be found by investigating the ways in which MMC is motivating funders to support their efforts to build capacity for DIY-AT in the community. Our conjecture was that MMC's narrative about the rationale for funds (to the funder audience) would be connected to MMC's motivational narrative to the community. Thus, we sought to identify any documents that describe the funding that MMC has or is currently receiving. We defined the **DID Schema MMC3x** to be used to label documents in this category. We decided to seek these documents from the website of MMC itself and from the Neil Squire Society website. We gathered seven documents related to this category, five of which were located in the News archive of Neil Squire website and the other two documents found within MMC website.

We felt that another useful resource could be information about the makers of different assistive devices on MMC website library, especially documents that provide information on the background, location, and personal motivations of the makers. We would like to know who these people are, how they came to work with MMC, and what motivates them to do so. We went through each of the assistive devices webpage and identified their makers, we then looked up their names on the web. For many of the makers, we were able to find LinkedIn profiles, interviews, or personal webpages on their companies. We defined **DID Schema MMC5x** to label documents related to each of the MMC makers. We located 22 documents related to this category.

**Special Note: Q1a and Q1b Overlap** We felt that another component of the answer could be found by examining MMC's appeals to the community. We believed the

ways that MMC is encouraging community members to assist them can inspire hobbyist makers and therefore affect the growth of HMSs. We discussed the set of documents **DID Schema MMC4x** “MMC Advertisement Documents” in section 3.3.1.1 (i.e., documents in which MMC encouraged people to join their network and to assist them, or encouraged them to provide financial supports, 10 documents in total). Thus, we will be using this same set of documents for the purpose of answering this question Q1b and the question Q1a (see subsection 3.3.1.1).

**Q1b Document Set** The document set for Q1b consists of three main groups: “Documents related to MMC funding” (DID schema: **MMC3x**, 7 documents), “MMC advertisement documents” (DID schema: **MMC4x**, 10 documents), and “list of MMC makers and their origin” (DID schema: **MMC5x**, 22 documents).

Table 3.3: List of Document Schema Relevant to Q1b

| Document Schema Category  | Document Type(s)  |
|---|---|
| <b>DID Schema: MMC3x</b><br>Documents related to MMC funding    | Organization News,<br>Reports of Organization<br>Events, Webpages |
| <b>DID Schema: MMC4x</b><br>MMC advertisement documents         | Organization News,<br>Webpages                                    |
| <b>DID Schema: MMC5x</b><br>List of MMC makers and their origin | Social media accounts,<br>Interview transcript from<br>webpages   |

Table 3.4: Document names for Q1b and their correspondent DIDs

| Document<br>DID | Document Name | Ref |
|-----------------|---------------|-----|
|-----------------|---------------|-----|

|                  |  |                 |
|------------------|--|-----------------|
| MMC3a            | MMC partner opportunities                                | [MMC3a]         |
| MMC3b            | MMC funders  | [MMC3b]         |
| MMC3c            | Google.org Awards Neil Squire Society                    | [MMC3c]         |
| MMC3d            | Neil Squire 25th Anniversary Announcement                | [MMC3d]         |
| MMC3e            | Neil Squire Society Receives Funding                     | [MMC3e]         |
| MMC3f            | Neil Squire RESNA Award                                  | [MMC3f]         |
| MMC3g            | TELUS LipSync Buildathon                                 | [MMC3g]         |
| MMC4a            | Become a Chapter Leader or Community<br>Champion for MMC | [MMC4a]         |
| MMC4b            | Neil Squire testimonials                                 | [MMC4b]         |
| MMC4c            | MMC volunteer  | [MMC4c]         |
| MMC4d            | MMC latest requests topics                               | [MMC4d]         |
| MMC4e            | Becoming a community chapter leader                      | [MMC4e]         |
| MMC4f            | MMC events   | [MMC4f]         |
| MMC4g            | MMC design challenges                                    | [MMC4g]         |
| MMC4h            | MMC latest community/volunteer wanted                    | [MMC4h]         |
| MMC4i            | Donate (Neil Squire)                                     | [MMC4i]         |
| MMC4j            | Success stories archive                                  | [MMC4j]         |
| MMC5a –<br>MMC5v | Each of the MMC makers                                   | Refer to Corpus |

### 3.3.1.3 Q1c: Promotion of Design Justice

Related to this question, some resources that are essential pertain to the Design Justice principles themselves. We sought documents that spoke about the principles, about how Design Justice Network is advocating for these principles, such as by encouraging people to join their network, by encouraging them to support them financially, and by describing their goals & missions more generally. Due to the focus of this set of documents on Design Justice, we believed the Design Justice Network organizational website [20] would be the best place to look for such documents. We defined **DID Schema DJx** to be applied to documents related to Design Justice mission and goals. We located two such documents from Design Justice website: “Update from the Design Justice Network Steering Committee

April 2020 Retreat” [DJ1a] and “2020 Membership Report” [DJ1b]. We also defined the **DID Schema DJ2x** to be used to label documents speaking to Design Justice finances and funding. We located four such documents, two of them from Design Justice website and the other two from the website of their fiscal sponsor, Allied Media Projects.

**Special Note: Q1a and Q1c Overlap** We also sought to gather documents containing information about MMC activities more generally, as a way to investigate the extent to which they are incorporating Design Justice principles into them. The MMC assistive devices library seemed like a natural resource for this information, since these documents have textual information that describe activities in some depth and could potentially provide the basis to investigate the extent to which the Design Justice principles have been incorporated into these design solutions. We discussed the set of documents **DID Schema MMC2x** “Documentation of solutions and designs published on MMC site” in section 3.3.1.1 which consists of 109 documents in total (i.e., documents of each of the assistive devices available on MMC website). Thus, we will be using this same set of documents for the purpose of answering this question Q1c and the question Q1a (see subsection 3.3.1.1).

**Q1c Document Set** The documents set for Q1c consists of “Documentation of solutions and designs published on MMC site” (DID schema: MMC2x, 109 documents), “Design Justice Mission Documents” (DID schema: DJ1x, 2 documents), and “Document related to Design Justice Funding” (DID schema: DJ2x, 4 documents).

Table 3.5: List of Document Schema Relevant to Q1c

| Document Schema Category   | Document Type(s)   |
|--|--|
| <b>DID Schema: MMC2x</b><br>Documentation of solutions and designs published on MMC site | Entries of the MMC AT Library, Webpages                  |
| <b>DID Schema: DJ1x</b><br>Design Justice Mission Documents                              | Organization Statements, Organization Membership Reports |

|   |                                |
|---|--------------------------------|
| <b>DID Schema:</b> DJ2 <i>x</i><br>Document related to Design Justice Funding | Organization News,<br>Webpages |
|---|--------------------------------|

Table 3.6: Document names for Q1c and their correspondent DIDs

| Document<br>DID   | Document Name   | Ref             |
|-------------------|---|-----------------|
| MMC2a             | MMC assistive devices library page  | [MMC2a]         |
| MMC2b -<br>MMC2df | Each assistive device in MMC library  | Refer to Corpus |
| DJ1a              | Update from the Design Justice Network Steering<br>Committee April 2020 retreat | [DJ1a]          |
| DJ1b              | Design Justice 2020 membership report   | [DJ1b]          |
| DJ2a              | Design Justice Network finances   | [DJ2a]          |
| DJ2b              | Donate to the Design Justice Network  | [DJ2b]          |
| DJ2c              | About the sponsored projects program  | [DJ2c]          |
| DJ2d              | Allied Media Design Justice program   | [DJ2d]          |

#### 3.3.1.4 Q2a: Access Barriers

To answer this question, we sought to identify documents that spoke to and reflect the impact of the pandemic and the shift to SAH/WFH on people with disabilities.

Given our focus on MMC, we saw this source as a natural place to search for documents that specifically or explicitly identify the pandemic and its impact on the MMC community. We defined the **DID Schema** MMC7*x* to be used to label any webpages from the MMC website that discuss MMC COVID-19 resources. One such article was located: "MMC COVID Guidance for Makers & Users" [MMC7a].

Given the duration and impact of the pandemic, a number of articles — both scholarly and grey literature — have been published on this topic. We defined the **DID Schema**

PAN1*x* to be used to label any articles that document or discuss the impact of pandemic on people with disabilities. We used the Google search engine to look for documents in this category and most of the relevant results were scholarly published articles. We decided to focus our search on scholarly publications academia in order to seek our answer on the basis of resources that have gone through a peer-review processes. We used the search terms “Impact of Pandemic on Disability” in Google Scholar [61]. We then hand-picked a number of documents based on their titles and relevance, studied their abstract and conclusion section, and chose the ones that we believed will guide us in providing an answer regarding Q2a. We selected documents so that a wide range of impacted groups would be represented, such as people with intellectual disabilities [PAN1a], ethnically diverse families with children with disabilities [PAN1b], people with developmental disabilities [PAN1c], and people with disabilities living in cities [PAN1d]. We located four scholarly documents from our search which were related to this category. The details of these documents are available in table 3.7.

We felt that other makerspaces would be another relevant source of information that would be relevant to this question. We defined the **DID Schema** MAK1*x* for any published statements issued by community makerspaces, for the webpages that capture the makerspaces’ work routine (before & after pandemic), and for any guidelines about “making” in this time of crisis. We located materials from many makerspaces both inside and outside of Ontario. However, public health measures and other pandemic responses differed among provinces and among other jurisdictions (between Canada and other countries), creating the possibility of a very complicated analysis. Thus, we chose to focus on Ontario as a single jurisdiction. We located six makerspaces in Ontario that published work routine information during the pandemic.

**Q2a Document Set:** The document set for Q2a consists of “MMC COVID-19 resources” (DID schema: MMC7*x*, 1 document), “Documents on impact of pandemic on people with disabilities” (DID schema: PAN1*x*, 4 documents), “Documents of makerspaces work routine before and after the pandemic” (DID schema: MAK1*x*, 6 documents).

Table 3.7: List of Document Schema Relevant to Q2a

| Document Schema Category | Document Type(s) |
|--------------------------|------------------|
|--------------------------|------------------|

|   |  |
|---|--|
| <b>DID Schema:</b> MMC7 <i>x</i><br>MMC COVID-19 resources  | Webpages                               |
| <b>DID Schema:</b> PAN1 <i>x</i><br>Documents on impact of pandemic on people with disabilities     | Articles                               |
| <b>DID Schema:</b> MAK1 <i>x</i><br>Documents of makerspaces work routine (before & after pandemic) | Webpages,<br>Makerspaces<br>Statements |

Table 3.8: Document names for Q2a and their correspondent DIDs

| <b>Document DID</b> | <b>Document Name</b>   | <b>Ref</b> |
|---------------------|--|------------|
| MMC7a               | MMC COVID guidance for makers & users  | [MMC7a]    |
| PAN1a               | COVID-19 and People with Intellectual Disability: Impacts of a Pandemic  | [PAN1a]    |
| PAN1b               | Examining the Impact of COVID-19 in Ethnically Diverse Families with Young Children with Intellectual and Developmental Disabilities | [PAN1b]    |
| PAN1c               | In the Time of the Pandemic: Safeguarding People with Developmental Disabilities against the Impact of Coronavirus                   | [PAN1c]    |
| PAN1d               | Disability, Urban Health Equity, and the Coronavirus Pandemic: Promoting Cities for All  | [PAN1d]    |
| MAK1a               | “Newmakeit” makerspace   | [MAK1a]    |
| MAK1b               | “Hacklab To” makerspace  | [MAK1b]    |
| MAK1c               | “The Make Den” makerspace  | [MAK1c]    |
| MAK1d               | “Brampton Library” makerspace  | [MAK1d]    |
| MAK1e               | “Toronto Tool Library” makerspace  | [MAK1e]    |
| MAK1f               | “Diyode Guelph” makerspace   | [MAK1f]    |



### 3.3.1.5 Q2b: Change in Demand for AT

In investigating any increase or decrease in the demand for AT, we sought to gather documents that would capture the impact of the pandemic on the demand for AT.

Due to our focus on MMC, we wanted to investigate potential impacts in MMC-directed requests for assistive devices. We, therefore, created the **DID Schema MMC6x** to label the documents on the MMC website that pertain to device requests over the window of time that includes before and during the pandemic. MMC website has a forum section in which users can find relevant information regarding the requested devices and design challenges (ideas for assistive devices that do not already exist on MMC library). Requests have three subcategories of “Maker Wanted”, “Requests in Progress”, and “Archived Requests” with the timeline of before or during the pandemic. The design challenges also fit under three main subcategories of “Seeking Solutions”, “Solutions in Development”, and “Solutions Seeking Review”. We decided to use this forum to locate these requests and design challenges and therefore identified six documents within this category (DID schema MMC6x).

**Special Note: Q2a and Q2b Overlap** We also believed that documents that identify the pandemic and its effects on MMC community can help us explore the challenges of making the assistive devices. We discussed the set of documents **DID Schema MMC7x** “MMC COVID-19 resources” in section 3.3.1.4 which consists of one document in total. Thus, we will be using this same set of document for the purpose of answering this question Q2b and the question Q2a (see subsection 3.3.1.4).

**Q2b Document Set** The document set for this question consists of “List of devices requested on MMC forums” (DID schema: MMC6x, 6 documents) and “MMC COVID-19 Resources” (DID schema: MMC7x, 1 document).

Table 3.9: List of Document Schema Relevant to Q2b

| Document Schema Category  | Document Type(s)  |
|---|-------------------|
| <b>DID Schema: MMC6x</b><br>List of devices requested on MMC forums | MMC forum content |

|  |          |
|--|----------|
| <b>DID Schema:</b> MMC7x<br>MMC COVID-19 resources | Webpages |
|--|----------|

Table 3.10: Document names for Q2b and their correspondent DIDs

| Document DID | Document Name                             | Ref     |
|--------------|---|---------|
| MMC6a        | MMC forum maker wanted topics             | [MMC6a] |
| MMC6b        | MMC forum requests in progress topics     | [MMC6b] |
| MMC6c        | MMC forum archived requests topics        | [MMC6c] |
| MMC6d        | MMC forum seeking solutions topics        | [MMC6d] |
| MMC6e        | MMC forum solutions in development topics | [MMC6e] |
| MMC6f        | MMC solutions seeking review topics       | [MMC6f] |
| MMC7a        | MMC COVID guidance for makers & users     | [MMC7a] |

### 3.3.1.6 Master List of Document Categories

Table 3.11 presents a list of document categories that we believed would answer our research questions after conducting our analysis. It is shown that each set of documents is used to answer which of the research questions.

Table 3.11: List of Target Documents and their Relevance to Research Questions

|                     | Question Relevance |     |     |     |     |                  |
|---------------------|--------------------|-----|-----|-----|-----|------------------|
| Document Categories | Q1a                | Q1b | Q1c | Q2a | Q2b | Document Type(s) |

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| <b>DID Schema: MMC1x</b><br>MMC Mission Documents   | ✓ |   |   |   |   | Organization Statements;<br>Webpages                        |
| <b>DID Schema: MMC2x, MMC2xx</b><br>Documentation of solutions and designs published on MMC site <sup>1</sup> | ✓ |   | ✓ |   |   | Entries of the MMC AT Library, Webpages                     |
| <b>DID Schema: MMC3x</b><br>Documents related to MMC funding  |   | ✓ |   |   |   | Organization News, Reports of Organization Events, Webpages |
| <b>DID Schema: MMC4x</b><br>MMC advertisement documents   | ✓ | ✓ |   |   |   | Organization News, Webpages                                 |
| <b>DID Schema: MMC5x</b><br>List of MMC makers and their origins  |   | ✓ |   |   |   | Social media accounts, Interview transcript from webpages   |
| <b>DID Schema: MMC6x</b><br>List of devices requested on MMC forums <sup>1</sup>                              |   |   |   |   | ✓ | MMC forum content   |
| <b>DID Schema: MMC7x</b><br>MMC COVID-19 resources  |   |   |   | ✓ | ✓ | Webpages  |

---

<sup>1</sup>Quantitative data will be extracted from these documents

|   |  |  |   |   |  |   |
|---|--|--|---|---|--|---|
| <b>DID Schema: DJ1x</b><br>Design Justice Mission Documents                                 |  |  | ✓ |   |  | Organization Statements,<br>Organization Membership Reports |
| <b>DID Schema: DJ2x</b><br>Document related to Design Justice Funding                       |  |  | ✓ |   |  | Organization News, Webpages                                 |
| <b>DID Schema: PAN1x</b><br>Documents on impact of pandemic on people with disabilities     |  |  |   | ✓ |  | Articles  |
| <b>DID Schema: MAK1x</b><br>Documents of makerspaces work routine (before & after pandemic) |  |  |   | ✓ |  | Webpages, Makerspaces Statements                            |

As it is evident in Table 3.11, these documents also include reports, forum contents, and projects that count as grey literature.

In our project, the documents such as reports, web pages, and forum contents count as grey literature. They give us the benefit of having more relevant documents, although finding and gathering all of them can be difficult.

### 3.3.2 Corpus Preparation

The next step in the process of our document analysis was the actual gathering of the set of target documents. Although we were ultimately successful in this endeavour, we were faced with a few challenges. Most of the documents we needed were online and had to be captured from the websites, which was challenging due to the dynamic structure of MMC website and many of the others. Many of these web pages included text, images, ink to other web pages,

and metadata. The approach that we thought would be the best is storing the documents in Webarchive format. Safari web browser allows us to save and review complete web pages in Webarchive format. This enables us to save all the graphics, HTML files, and links on all web pages. But it is noteworthy that even with this approach some aspects of the document we are trying to capture may still be lost.

After gathering all the target documents, we need to prepare them for the next step of our research, developing the codes and applying them to our corpus.

Table 3.12: Document names and their correspondent  
DIDs

| Document DID   | Document Name  |
|----------------|--|
| MMC1a          | MMC mission sentence                                     |
| MMC1b          | MMC guiding vision                                       |
| MMC2a          | MMC assistive devices library page                       |
| MMC2b - MMC2df | Each assistive device in MMC library                     |
| MMC3a          | MMC partner opportunities                                |
| MMC3b          | MMC funders  |
| MMC3c          | Google.org Awards Neil Squire Society                    |
| MMC3d          | Neil Squire 25th Anniversary Announcement                |
| MMC3e          | Neil Squire Society Receives Funding                     |
| MMC3f          | Neil Squire RESNA Award                                  |
| MMC3g          | TELUS LipSync Buildathon                                 |
| MMC4a          | Become a Chapter Leader or Community<br>Champion for MMC |
| MMC4b          | Neil Squire testimonials                                 |
| MMC4c          | MMC volunteer  |
| MMC4d          | MMC latest requests topics                               |
| MMC4e          | Becoming a community chapter leader                      |
| MMC4f          | MMC events   |
| MMC4g          | MMC design challenges                                    |
| MMC4h          | MMC latest community/volunteer wanted                    |
| MMC4i          | Donate (Neil Squire)                                     |
| MMC4j          | Success stories archive                                  |

|               |  |
|---------------|--|
| MMC5a – MMC5v | Each of the MMC makers   |
| MMC6a         | MMC forum maker wanted topics  |
| MMC6b         | MMC forum requests in progress topics  |
| MMC6c         | MMC forum archived requests topics   |
| MMC6d         | MMC forum seeking solutions topics   |
| MMC6e         | MMC forum solutions in development topics  |
| MMC6f         | MMC solutions seeking review topics  |
| MMC7a         | MMC COVID guidance for makers & users  |
| DJ1a          | Update from the Design Justice Network Steering Committee April 2020 retreat   |
| DJ1b          | Design Justice 2020 membership report  |
| DJ2a          | Design Justice Network finances  |
| DJ2b          | Donate to the Design Justice Network   |
| DJ2c          | About the sponsored projects program   |
| DJ2d          | Allied Media Design Justice program  |
| PAN1a         | COVID-19 and People with Intellectual Disability: Impacts of a Pandemic  |
| PAN1b         | Examining the Impact of COVID-19 in Ethnically Diverse Families with Young Children with Intellectual and Developmental Disabilities |
| PAN1c         | In the Time of the Pandemic: Safeguarding People with Developmental Disabilities against the Impact of Coronavirus                   |
| PAN1d         | Disability, Urban Health Equity, and the Coronavirus Pandemic: Promoting Cities for All  |
| MAK1a         | “Newmakeit” makerspace   |
| MAK1b         | “Hacklab To” makerspace  |
| MAK1c         | “The Make Den” makerspace  |
| MAK1d         | “Brampton Library” makerspace  |
| MAK1e         | “Toronto Tool Library” makerspace  |
| MAK1f         | “Diode Guelph” makerspace  |

### 3.3.3 PDF Conversion

In consideration of the next phase of code development, each of the documents in its webarchive format was converted into a PDF file.

We chose the three following options and applied them to our documents in order to find the best one:

- Convert Webarchive to PDF using Safari browser: Safari can open Webarchives and lets us automatically save these webarchives as PDFs the same way we can do this process with any other web pages.
- Webarchive to PDF converter tools: there are a variety of online tools available to convert Webarchives into PDFs such as websites or extensions and add-ons for browsers.
- Convert Webarchive to HTML: we can use a script to extract the HTML file of our Webarchives and then import the HTML file into Dedoose.

The first option we eliminate after applying it is converting Webarchives to HTML. This is because the outcome is not user-friendly and our documents are complex and contain details in multiple formats, therefore only being able to access their text is not a desirable option for us. Both of the other options can be applied to our documents, but it is noteworthy that for some of the web pages only one of these methods works well. For forums, as an example, only the option of using add-ons properly converts and stores their content. For the documents of all assistive devices available on MMC's website none of this option works and we have to go through the web pages again and manually export them as PDFs.

## 3.4 Phase 2: Code Development and Application

Developing the codes for the documents requires a thorough examination of their content. This is because the researcher should be acquainted with the subject matter in order to detect categories within it and assign keywords and codes to different segments of its text. Mayring [45] calls these segments “units” and defines three main types for document analysis: coding unit, context unit, and recording unit:

- Coding unit: defines the smallest portion of text to which a code can be assigned,
- Context unit: the largest portion of text in the analysis to which a code can be assigned,

- Recording unit: refers to the parts of the material that are relevant for the analysis.

Defining the units of analysis (coding units) for a research project is necessary for inter-subjectivity of the process, making it possible for other researchers to redo the analysis procedure [45]. In this project, our coding unit is phrases of text, our context unit can be as large as a paragraph if necessary, and the recording unit refers to each of the documents in our corpus.

### **3.4.1 Document Analysis Tool Selection**

#### **3.4.1.1 Background**

Analysts often import all documents into qualitative data analysis software in order to develop and apply the codes. We identified a list of possible tools: QCAMAP, QDA Miner Lite, and Dedoose.

##### **3.4.1.1.1 QCAMAP**

Mayring [45] defines QCAMAP as “an open access web application for systematic text analysis in scientific projects based on the techniques of qualitative content analysis”. In order to work with QCAMAP, the user needs to create an account and make a new project. The first step then would be defining a research question and choosing a content analytical technique for that question. QCAMAP gives us three options of inductive category formation, deductive category assignment, and summarizing for content analysis technique. Next, the user is required to define the content analytical unit such as coding unit, context unit, and recording unit. For inductive category formation, users should provide a level of abstraction and define selection criterion.

Next step in document analysis using QCAMAP is uploading the target documents for the analysis. The documents can be upload in text format (encoded in Unicode/UTF-16 LE), word documents (DOCX format), and images (JPG, PNG, and GIF) [45]. The researcher can then enter coding mode and mark different sections of the texts with respect to coding units and assign one of the so far developed categories to the text or create a new category. In deductive category assignment, after coding a certain amount of the documents, the program reminds the user to revise the category system and the coding guideline. After finishing this phase and moving on to the next, the user can no longer change the coding guideline.



#### **3.4.1.1.2 QDA Miner**

QDA Miner is a “qualitative data analysis software for organizing, coding, annotating, retrieving, and analyzing collections of documents and images” [58]. QDA Miner also has integrations with WordStat and SimStat (The former software used for text mining and content analysis, the latter used for statistical analysis).

In order to start the research with QDA Miner, the user can create a blank project or a project with an existing set of documents. The documents imported into QDA can be in many formats including Word, Excel, HTML, XML, SPSS, Stata, NVivo, PDFs, as well as images. The tool then loads the documents and allows the user to use different formatting tools to edit and refine the texts before coding. The user will then create their desired categories and can color-code them. QDA Miner gives the user multiple options to presents all the coding sections in a certain document such as highlighting, dimming, and masking the coded texts. QDA Miner also gives the user the ability to retrieve distinct words or codes in whole documents, sentences, paragraphs, or coded segments. The researcher can also analyze the coding and check the code frequencies in table or chart format.

It is noteworthy to mention that QDA Miner has a free version called QDA Miner Lite, which is a Windows application and offers the basic content analysis and qualitative document analysis features.

#### **3.4.1.1.3 Dedoose**

Dedoose is “a cross-platform app for analyzing qualitative and mixed methods research with text, photos, audio, videos, spreadsheet data and more” [17]. One aspect of Dedoose that makes it distinct in comparison with other document analysis tools is its aim at facilitating mixed methods research. Dedoose allows the researcher to access the traditional qualitative data management, coding, and analysis in addition to easy integration of qualitative and quantitative data.

After creating a project, Dedoose allows the user to import spreadsheet, text, audio, image, video or PDF documents. It also provides the user with features such as sorting and filtering media, editing documents, searching, linking media files to descriptors, coding and excerpting, analysis, and exporting. Dedoose supports weighted coding for mixed method analysis and multiple data visualizations methods for the research project.

### 3.4.2 Tool Selection: Dedoose

For the purpose of this project we decided to use Dedoose due to its certain advantages compared to the previously mentioned software products. Compared to QCAMAP, Dedoose gives us the ability to import PDFs and view the coded sections inside a document. It also has the benefit of analyzing and visualizing our coding and data. Dedoose is also available on macOS which is an advantage compared to QDA Miner Lite. Additionally, one of the most important reasons of choosing Dedoose for our project is the availability of mixed method research support which makes it stand out among other options.

PDFs of all documents have been prepared (as per Section 3.3.3) and were imported in Dedoose. The next steps are developing the codes for each of these documents with respect to our research questions in order to provide an answer for them.

### 3.4.3 Coding Target Documents

As we previously mentioned, starting the code development phase of the documents requires a thorough understanding of their contents. Therefore, all the documents were studied and examined before being imported to Dedoose. We examined each question’s related set of documents with a question-specific coding lens. Although some documents were relevant to two or more questions, they need to be analyzed in distinct ways and with the related question in mind. Consequently, these documents may be studied with separate coding lenses for each of the research questions.

The category and coding system in qualitative document analysis is the central instrument [45]. Also, it makes it possible for other researchers to go through our analysis using our coding system and repeat the process [45]. Below, we will consider each of our research questions and the codes we want to develop for their related set of documents.

#### 3.4.3.1 Q1a: AT Service Delivery/Facilitation

**Q1a:** In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?

Here, we will characterize the qualitative aspects of service delivery by MMC. (As described in section 3.3.1.1, there are also quantitative aspects which are characterized in section 3.3.1.1). Document categories we use to answer this research question are presented in Table 3.11 and include: “MMC mission statement” (DID schema: **MMC1x**, 2 documents),

“Documentation of solutions and designs published on MMC site” (DID schema: **MMC2x**, 109 documents), and “MMC advertisement documents” (DID schema: **MMC4x**, 10 documents).

As described previously, there were two qualitative aspects of service delivery of interest: contextualization of AT service delivery/facilitation, and uptake of Design Justice principles.

First, to investigate the contextualization of service/facilitation, we examined the **MMC1x** and **MMC4x** documents. In the first round of studying these documents it was clear that separate codes should be developed to capture the “missions and goals” themselves, and then separately, the “ways of achieving mission”. To refine the second category, the documents were examined carefully, and a number of observations emerged about the ways in which the mission was achieved. The first observation was the relevance of *maker volunteers*, who are people that join a project or design challenge anywhere in the process and assist with the making. Therefore, these people are a key piece of helping MMC achieving its goals. The second observation was about the range of *providing service*, a range which can include any of the services that MMC provides, such as the events they hold, online request of assistive devices, and connecting people with disabilities with colleges or companies for study and work. If MMC receives responses from the community, this *feedback* can consist of the responses MMC has received from people and companies they have worked with. The *Working Together program* helps people with disabilities to land the job they want by assisting them in developing the necessary skills and connecting them to potential employers. We believe this is well aligned with their mission and therefore, fits under the umbrella of “ways of achieving mission”. *Donations* play an important role in accounting for part of MMC expenses and help them get one step closer to achieving their goal. Thus, for “Ways of achieving mission” the following sub-codes emerged: “maker volunteers”, “providing service”, “feedback”, “working together program”, and “donations”.

This way, we determine whether any aspects of the assistive devices are alongside each of the principles or whether they are ignoring them. Second, to investigate the qualitative aspect of service delivery, uptake of Design Justice Principles, we code the solutions and designs of assistive devices on MMC website (DID schema: **MMC2x**). For this purpose, we create a Dedoose project and import all of the 109 **MMC2x** assistive devices PDFs into it. We then develop the codes based on the ten Design Justice principles which we denote by their short codes: “P1” to “P10”. For each principle, we can potentially assign one of two possible codes: evidence of ‘adherence’; evidence of ‘flout’. This results in a total of twenty codes. Gaps are also significant: if a document does not have any excerpts associated with adhering to a specific principle, this could be a sign of that principle being ignored. But, as

we would like to know if any of the documents are explicitly signalling the flouting of any of the principles, both of these code values are needed.

**Q1a Code Set, Iteration #1** The complete coding hierarchy is presented below:

- Missions and goals
- Ways of achieving mission
  - Donations
  - Feedback
  - Providing service
  - Maker volunteers
  - Working Together program
- Quality of Pieces of Technology
  - P1 - adhere
  - P1 - flout
  - P2 - adhere
  - P2 - flout
  - P3 - adhere
  - P3 - flout
  - P4 - adhere
  - P4 - flout
  - P5 - adhere
  - P5 - flout
  - P6 - adhere
  - P6 - flout
  - P7 - adhere
  - P7 - flout
  - P8 - adhere
  - P8 - flout
  - P9 - adhere
  - P9 - flout
  - P10 - adhere
  - P10 - flout

**Subsequent Iteration** During this phase, while studying the documents and applying the codes, we came to conclusion that a change is required in code development from the first iteration of the process. Related to the sub-code of “Maker volunteer”, we figured out that there are different *types* of volunteer roles that are assisting MMC in the process of achieving their goal, which include: community champion, chapter leader, and volunteers that assist in the making process. Also, MMC is not only receiving donations, but they are also donating to other organizations themselves.

**Q1a Code Set, Iteration #2** Therefore, below is the updated coding hierarchy we come up with. *revisions from Iteration #1 are shown as **bold** and ~~strikeout~~.*

- Missions and goals
- Ways of achieving mission
  - Donations
    - \* **Giving donations**
    - \* **Receiving donations**
  - Feedback
  - Providing service
  - ~~Maker-volunteer~~ **Volunteer**
    - \* **Community champion**
    - \* **Chapter leader**
    - \* **Making**
  - Working Together program
- Quality of Pieces of Technology
  - P1 - adhere
  - P1 - flout
  - P2 - adhere
  - P2 - flout
  - P3 - adhere
  - P3 - flout
  - P4 - adhere
  - P4 - flout
  - P5 - adhere

- P5 - flout
- P6 - adhere
- P6 - flout
- P7 - adhere
- P7 - flout
- P8 - adhere
- P8 - flout
- P9 - adhere
- P9 - flout
- P10 - adhere
- P10 - flout

We decided to use this coding system, at least initially. Potential revisions may be warranted. For example different instances of providing services (as we previously mentioned) could potentially become subcategories of this code. But this leads to complications, as there are items that fit under the umbrella of “providing service” that would not belong to one of these particular subcategories. We can always refine our codes as needed and add subcategories to the items above if necessary.

### 3.4.3.2 Q1b: Motivating DIY-AT and HMSs

For the second aspect of MMC being successful, we are seeking to answer the question below:

**Q1b:** In what ways has Makers Making Change (MMC) been successful in motivating DIY-AT and Home Makerspaces?

As previously mentioned, the set of documents for this question includes “MMC funding related documents” (DID schema: **MMC3x**, 7 documents), “MMC advertisement documents” (DID schema: **MMC4x**, 10 documents), and “list of MMC makers and their origin” (DID schema: **MMC5x**, 22 documents). As mentioned in section 3.3.1.2, the set of **MMC4x** documents are also used in Q1a.

In the first round of studying the documents, we wanted to develop codes that would uncover the makers’ disciplinary backgrounds (e.g., engineering, medical) and to reveal whether they are working with MMC as volunteers or not. Therefore, based on the themes that emerged, we came up with two main categories of “makers background” and “role at MMC”.

The first category itself has three child nodes of “engineering/science”, “medical”, and “activated by MMC”. These subcategories code text segments which are describing the past or current experiences of MMC makers. The “activated by MMC” sub-code was developed to apply to segments which indicate the extent to which a maker was already working in the area prior to their activities at MMC (or conversely, whether they have been solely ‘activated’ as a maker by MMC). The “role at MMC” category also has two child nodes of “paid position” and “volunteer”, determining the nature of the makers relationship with MMC, whether it is paid, solely volunteer or a combination of both.

We also wanted to identify the ways in which MMC is encouraging government, organizations, and even individuals to financially support them. The themes that emerged led us to developing the following codes for this category: “empowering people with disabilities”, “advantages of MMC products”, and “perks and benefits”. The “empowering people with disabilities” category was developed to refer to segments of text in which MMC is encouraging others to support them by extolling the positive impact their work can have on the lives of people with disabilities. The category of “advantages of MMC products” is used for mentions of any benefits of MMC assistive devices relative to other assistive devices, such as those available commercially or through other providers. “Perks and benefits” refers to benefits MMC is providing for their funders.

Last, we felt that we should re-use part of the same coding lens as was used in Q1a for “MMC advertisement documents”, specifically the code “Ways of achieving mission” and its sub-codes.

**Q1b Code Set, Iteration #1** Therefore, here is our coding hierarchy after the first iteration:

- Makers background
  - Engineering/science
  - Medical
  - Activated by MMC
- Role at MMC
  - Paid position
  - Volunteer
- Ways of encouraging to fund

- Empowering people with disabilities
- Advantages of MMC products
- Perks and benefits
- Ways of achieving mission [Overlap with Q1a code set]
  - Donations
    - \* Giving donations
    - \* Receiving donations
  - Feedback
  - Providing service
  - Volunteer
    - \* Community champion
    - \* Chapter leader
    - \* Making
  - Working Together program

**Subsequent Iteration** Further on in our coding process, we found trends of other roles which needs to be added to our coding system (e.g., business and management, design roles, and disability professionals). We also decided to make “Activated by MMC” code a root node so that it is not necessarily related to the maker’s background as makers can have specific related backgrounds but still be solely activated through MMC. While closely studying the documents, we identified other ways that MMC is encouraging others to fund them such as mentioning their current funders which include government contracts and major companies, and sharing their positive results and feedback. Hence, below is the updated coding hierarchy:

**Q1b Code Set, Iteration #2** *revisions from Iteration #1* shown as **bold** and ~~strikeout~~.

- **Activated by MMC**
- Makers background
  - Engineering/science



- Business/management
- Medical/disability professional
- Design
- ~~Activated by MMC~~
- Role at MMC
  - Volunteer
  - Paid position
- Ways of encouraging to fund
  - Empowering people with disabilities
  - Advantages of MMC products
  - Perks and benefits
  - **Feedback/results**
  - **Mentions of current funders**
- Ways of achieving mission [Overlap with Q1a code set]
  - Donations
    - \* **Giving donations**
    - \* **Receiving donations**
  - Feedback
  - Providing service
  - ~~Maker volunteer~~ **Volunteer**
    - \* **Community champion**
    - \* **Chapter leader**
    - \* **Making**
  - Working Together program

#### 3.4.3.3 Q1c: Promotion of Design Justice

We are seeking to find out to what extent has MMC incorporated Design Justice principle. Specifically:

**Q1c:** In what ways has Makers Making Change (MMC) been successful in promoting the principles of Design Justice?

The document categories for this question are “Documentation of solutions and designs published on MMC site” (DID schema: MMC2x, 109 documents), “Design Justice Mission Documents” (DID schema: DJ1x, 2 documents), and “Document related to Design Justice Funding” (DID schema: DJ2x, 4 documents). As mentioned in section 3.3.1.3, the set of MMC2x documents are also used in Q1a. Therefore, we re-used the coding lens for “Documentation of solutions and designs published on MMC site” from Q1a, specifically the code “Quality of Pieces of Technology” and its sub-codes. The other two categories, the documents related to Design Justice and how they are advocating for their principles will be answered through coding and analysis of their membership reports, finances, and steering committee notes. This will help us understand how Design Justice Network is advocating for the incorporation of their principles.

Based on this research question and studying our related set of documents, the codes we develop in the first iteration fit in two main categories of “ways of encouraging” and “whom they are encouraging”. “Ways of encouraging” category itself has two subcategories of “encouraging people” and “encouraging funders”. The first one codes the mentions of how Design Justice Network is encouraging people including their volunteers to help them within the process of connecting people with disabilities to makers. The latter, is related to the financial support that they receive. We will apply this code to text segments about the ways Design Justice is requesting funding and how they are encouraging people to donate. The category of “Whom they are encouraging” includes the subcategories of “Individuals” and “Organizations”.

**Q1c Code Set, Iteration #1** Here is our coding system after our first iteration:

- Quality of Pieces of Technology [Overlap with Q1a code set]
  - P1 - adhere
  - P1 - flout
  - P2 - adhere
  - P2 - flout
  - P3 - adhere
  - P3 - flout
  - P4 - adhere

- P4 - flout
- P5 - adhere
- P5 - flout
- P6 - adhere
- P6 - flout
- P7 - adhere
- P7 - flout
- P8 - adhere
- P8 - flout
- P9 - adhere
- P9 - flout
- P10 - adhere
- P10 - flout
- Ways of encouraging
  - Encouraging people
  - Encouraging funders
- Whom they are encouraging
  - Individuals
  - Organizations

**Subsequent Iteration** Further on, by closely studying and analyzing the documents, we discovered patterns among the ways Design Justice is encouraging people. The codes we have developed based on these patterns include “Goals”, “News”, “Perks and benefits”, “Shop”, and “Transparency”. The “Goals” category applies to the text segments that are encouraging people to join Design Justice Network by describing the goals they have. “News” category applies to mentions of the updates they have on their work or discussing their future plans as ways of encouraging people to join them. “Perks and benefits” refer to the member-only benefits provided by Design Justice Network. The subcategory of “Shop” is related to engaging people by having a store from which they can buy products they like in support of Design Justice Network. Lastly, “Transparency” subcategory applies to encouraging people using transparency regarding the information Design Justice shares with their community.

We also realized that the perspective of “Whom they are encouraging” category is not suitable for this question, as it does not contribute to figuring out the motive, drive, and advocacy of Design Justice Network. Instead, we added a new category of “Inviting to fund” as a means to find out how they present their goals to encourage people or organizations to financially support them (“Goals” subcategory) and what the provided financial support will be used for (“Finances” subcategory). We have also added a new category of “Funders Goals” to apply to the segments describing the goals that their funders have in order to understand how they are aligned with Design Justice Network goals. We refine our coding system and add subcategories and edit the previous coding system to match our second iteration discussions.

**Q1c Code Set, Iteration #2** *revisions from Iteration #1* shown as **bold** and ~~strikeout~~.

- Quality of Pieces of Technology [Overlap with Q1a code set]
  - P1 - adhere
  - P1 - flout
  - P2 - adhere
  - P2 - flout
  - P3 - adhere
  - P3 - flout
  - P4 - adhere
  - P4 - flout
  - P5 - adhere
  - P5 - flout
  - P6 - adhere
  - P6 - flout
  - P7 - adhere
  - P7 - flout
  - P8 - adhere
  - P8 - flout
  - P9 - adhere
  - P9 - flout

- P10 - adhere
- P10 - flout
- **Funders goals**
- **Inviting to fund**
  - **Finances**
  - **Goals**
- Ways of encouraging
  - Encouraging people
  - Encouraging funders
  - **Goals**
  - **News**
  - **Perks and benefits**
  - **Shop**
  - **Transparency**
- Whom they are encouraging
  - Individuals
  - Organizations

#### 3.4.3.4 Q2a: Access Barriers

We are seeking to determine the impact of the pandemic and shift to SAH/WFH on people with disabilities. Specifically:

**Q2a:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) impacted disabled people?

The data that will be used to answer this question will be extracted from: “MMC COVID-19 resources” (DID schema: **MMC7x**, 1 document), “documents on impact of pandemic on people with disabilities” (DID schema: **PAN1x**, 4 documents), “documents of makerspaces work routine before and after the pandemic” (DID schema: **MAK1x**, 6 documents).

In the first round of studying the documents, 4 types of information emerged: “work routine after COVID-19”, “knowledge”, “time”, and “making”. For “work routine after COVID-19”, two sub-codes emerged: “closed” and “open with restrictions”. When looking at the documents, we came across multiple ways makerspaces are dealing with COVID-19 and adapting their work routine to best adjust to the circumstances. We developed sub-codes for these options to indicate the type of adaptation (e.g., masks, pre-arranged bookings, limited hours, and shift from in-person to on-line).

We also identified key information related to knowledge, time, and making, all three of which represent added complications or not.

**Q2a Code Set, Iteration #1** Therefore, here is the first iteration of our set of codes:

- Knowledge
  - Added complications
  - no change
- Time
  - Added complications
  - no change
- Making
  - Added complications
  - no change
- Work routine after COVID-19
  - Closed
  - Open with restrictions
    - \* Masks
    - \* Booking
    - \* Limited hours
    - \* Online methods

**Subsequent Iteration** Further on, we realize the significance of some methods that some instances of makerspaces were using in their work routines, such as online classes and gatherings, some other had curbside pickup available for some of the tools makers may want to borrow. Thus, we refined ‘online methods’ by adding the sub-code ‘Alternate Methods’ to capture these instances. Based on other occurrences, we also decided to add “Limited capacity” as a child node of “Open with restrictions” category. Related to the impact of pandemic regarding knowledge, making, and time, we will also consider impacts with respect to resources needed to complete DIY-AT projects, as some projects were flagged that makers should avoid due to the pandemic. Thus, we created a code “Avoidances” to capture these projects.

By closely studying the documents surrounding impacts of pandemic on people with disabilities, we could anticipate the emergence of several themes around the way in which different *aspects* were impacted. We, therefore, added a coding category relating to aspect of impacts of pandemic on people with disabilities, with sub-codes for physical aspects, mental aspects, social aspects, and equipment aspects. Physical aspects cover the problems caused by the pandemic and the difficulties that people with disabilities face in connection to their physical embodiment. Mental aspects include the effects of the pandemic on mental health and wellness. Social aspects are effects of the pandemic on their social lives and problems relating to their required social attention. Lastly, the equipment aspect relates to the needs people with disabilities have such as a safe place to live, assistive devices, and computers.

**Q2a Code Set, Iteration #2** *revisions from Iteration #1* shown as **bold** and ~~strikeout~~.

- **Impact on people with disabilities**
  - **Physical aspects**
  - **Mental aspects**
  - **Social aspects**
  - **Equipment aspects**
- Knowledge
  - Added complications
  - no change
- Time

- Added complications
- no change
- Making
  - Added complications
  - no change
  - **Avoidances**
- Resources
  - Added complications
  - no change
- Work routine after COVID-19
  - Closed
  - Open with restrictions
    - \* Masks
    - \* Booking
    - \* Limited hours
    - \* ~~Online methods~~ Limited capacity
  - **Alternate methods**

#### 3.4.3.5 Q2b: Change in Demand for AT

We aim to find out whether there has been an increase or decrease in the need for Assistive Technology (AT) due to the COVID-19 pandemic, more specifically:

**Q2b:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) affected the demand for AT?

The set of document categories that are related to this question are “MMC COVID-19 Resources” (DID schema: MMC7*x*, 1 document) and “List of devices requested on MMC forums” (DID schema: MMC6*x*, 6 documents). As mentioned in section 3.3.1.5, the set of MMC7*x* documents are also used in Q2a. Therefore, we re-used the coding lens for “MMC COVID-19 Resources” from Q2a, specifically the codes “Knowledge”, “Time”, “Making”, and “Resources” and all their sub-codes.



**Q2b Code Set** [Overlap with Q2a code set]

- Knowledge
  - Added complications
  - no change
- Time
  - Added complications
  - no change
- Making
  - Added complications
  - no change
  - **Avoidances**
- Resources
  - Added complications
  - no change

**Q2b Quantitative Data** For the documents which fall under DID schema: **MMC6x** (List of devices requested on MMC forums), we will be extracting quantitative data. This was previously mentioned in table 3.11). To accomplish this, we have parsed two types of data from the forums: requests and design challenges. Both of these are community submissions on the forums. We went through them over time and populate a spreadsheet with several attributes, including the timestamp of the request. From this, we tabulated the number of requests for each active month. We can then visualize our data to check for any increase or decrease in number of requests or design challenges over time. Table 3.13 shows these numbers for each months starting from February 2019 to mid-August 2021.

Table 3.13: Raw Data for Monthly Number of Requests  
and Design Challenges

|  | Design Challenges | Requests |
|--|-------------------|----------|
|--|-------------------|----------|

|        | Seeking<br>Solutions | Solutions in<br>Development | Solutions<br>Seeking Review | Maker<br>Wanted | Request in<br>Progress | Archived<br>Requests |
|--------|----------------------|-----------------------------|-----------------------------|-----------------|------------------------|----------------------|
| Feb-19 | 0                    | 0                           | 0                           | 0               | 0                      | 0                    |
| Mar-19 | 0                    | 1                           | 0                           | 0               | 0                      | 0                    |
| Apr-19 | 0                    | 0                           | 0                           | 0               | 0                      | 0                    |
| May-19 | 4                    | 0                           | 0                           | 0               | 0                      | 0                    |
| Jun-19 | 2                    | 2                           | 0                           | 0               | 0                      | 0                    |
| Jul-19 | 1                    | 1                           | 0                           | 0               | 0                      | 0                    |
| Aug-19 | 1                    | 1                           | 0                           | 0               | 0                      | 0                    |
| Sep-19 | 0                    | 0                           | 0                           | 0               | 0                      | 0                    |
| Oct-19 | 2                    | 3                           | 0                           | 0               | 0                      | 0                    |
| Nov-19 | 2                    | 0                           | 2                           | 0               | 0                      | 3                    |
| Dec-19 | 4                    | 1                           | 8                           | 0               | 0                      | 0                    |
| Jan-20 | 1                    | 3                           | 0                           | 0               | 0                      | 5                    |
| Feb-20 | 2                    | 1                           | 0                           | 0               | 1                      | 10                   |
| Mar-20 | 0                    | 0                           | 0                           | 0               | 0                      | 4                    |
| Apr-20 | 0                    | 2                           | 0                           | 0               | 0                      | 2                    |
| May-20 | 4                    | 1                           | 3                           | 0               | 0                      | 9                    |
| Jun-20 | 0                    | 1                           | 1                           | 0               | 0                      | 5                    |
| Jul-20 | 0                    | 2                           | 0                           | 0               | 0                      | 8                    |
| Aug-20 | 2                    | 1                           | 0                           | 0               | 0                      | 3                    |
| Sep-20 | 1                    | 0                           | 1                           | 0               | 2                      | 6                    |
| Oct-20 | 1                    | 0                           | 0                           | 0               | 0                      | 2                    |
| Nov-20 | 3                    | 0                           | 0                           | 0               | 5                      | 14                   |
| Dec-20 | 2                    | 1                           | 1                           | 0               | 4                      | 4                    |
| Jan-21 | 2                    | 1                           | 1                           | 0               | 0                      | 9                    |
| Feb-21 | 1                    | 1                           | 0                           | 0               | 5                      | 15                   |
| Mar-21 | 24                   | 3                           | 0                           | 1               | 5                      | 27                   |
| Apr-21 | 6                    | 3                           | 1                           | 0               | 5                      | 6                    |
| May-21 | 10                   | 0                           | 0                           | 1               | 4                      | 8                    |
| Jun-21 | 4                    | 0                           | 0                           | 2               | 3                      | 2                    |
| Jul-21 | 2                    | 1                           | 0                           | 3               | 9                      | 4                    |
| Aug-21 | 0                    | 1                           | 0                           | 2               | 4                      | 1                    |
| Total  | 81                   | 31                          | 18                          | 9               | 47                     | 150                  |

Table 3.14: Mean Monthly Number of Requests and Design Challenges

|   | Design Challenges |                          |                          | Requests     |                     |                   |
|---|-------------------|--------------------------|--------------------------|--------------|---------------------|-------------------|
|   | Seeking Solutions | Solutions in Development | Solutions Seeking Review | Maker Wanted | Request in Progress | Archived Requests |
| <b>Before pandemic</b><br>Feb-19 to Feb-20          | 1.46              | 1                        | 0.76                     | 0            | 0.07                | 1.61              |
| <b>After the pandemic start</b><br>Mar-20 to Aug-21 | 3.44              | 1                        | 0.44                     | 0.5          | 2.55                | 7.16              |
| <b>Total before pandemic</b>                        | 1.07              |                          |                          | 0.56         |                     |                   |
| <b>Total after pandemic start</b>                   | 1.62              |                          |                          | 3.40         |                     |                   |

Table 3.15: Mean Annual Number of Requests and Design Challenges

|                                      | Design Challenges |                          |                          | Requests     |                     |                   |
|--------------------------------------|-------------------|--------------------------|--------------------------|--------------|---------------------|-------------------|
|                                      | Seeking Solutions | Solutions in Development | Solutions Seeking Review | Maker Wanted | Request in Progress | Archived Requests |
| <b>Year 2019</b><br>Feb-19 to Dec-19 | 1.45              | 0.81                     | 0.90                     | 0            | 0                   | 0.54              |
| <b>Year 2020</b><br>Jan-20 to Dec-20 | 1.33              | 1                        | 0.5                      | 0            | 1                   | 6                 |
| <b>Year 2021</b><br>Jan-21 to Dec-21 | 6.12              | 1.25                     | 0.25                     | 1.12         | 4.37                | 9                 |

## 3.5 Chapter Summary

In this chapter, we elaborated each of our research questions in terms of what they mean and what we are investigating. Then we talked about our use of mixed methods research and what quantitative and qualitative analysis techniques we apply to each of our question as our proposed approach. We presented the list of our target documents required for our analysis and how each of them can provide a response to our research questions. We also described the first two stages of qualitative document analysis, “Corpus Development” and “Code Development and Application”. The next two stages will be discussed in Chapter 4.

# Chapter 4

## Results

### 4.1 Chapter Overview

In this chapter, we present the final two phases of the Qualitative Document Analysis (QDA) study.

This chapter builds upon the prior chapter 3, in which the first two phases of the QDA study were presented. By way of an overview, and to quickly recap section 3.2.1, the Qualitative Document Analysis (QDA) methodology is an analytical method in qualitative research [3, 10] that entails a four-phase iterative process consisting of:

- (1) Corpus Development (discussed in Section 3.3)
- (2) Code Development and Application (discussed in Section 3.4)
- (3) Analysis and Visualization (discussed in Section 4.2)
- (4) Results (discussed in Section 4.3)

In this chapter, we first discuss the analysis of our data (section 4.2), which aims to find the meaning and characteristics of the studied documents, both as social products and as what they represent [3]. Altheide and Schneider [3] count all the previous steps of QDA as part of the data analysis, but they also acknowledge that the main data analysis phase has a special focus on examining the textual and enumerative data that has been extracted. Next in this chapter, we answer our research questions, by contextualizing and synthesizing the insights gained (section 4.3).

The research questions discussed in section 3.1.1 are as follows:

**Q1a:** In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?

- Q1b:** In what ways has Makers Making Change (MMC) been successful in motivating DIY-AT and Home Makerspaces?
- Q1c:** In what ways has Makers Making Change (MMC) been successful in promoting the principles of Design Justice?
- Q2a:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) impacted disabled people?
- Q2b:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) affected the demand for AT?

## 4.2 Phase 3: Analysis and Visualization

In this section we will be focusing on comparing and contrasting the extremes and differences of categories, examining the excerpts (coded segments) from documents, and the visualization of our code development. Here, we will refer to our documents using their assigned DIDs available in table 3.12.

It is noteworthy to mention that we did not assign any of the codes that had their own sub-codes to our excerpts, as we established the sub-codes in a way that they cumulatively cover all the possible options that are related to the them. Also, all of the developed codes are present in at least one of the documents in the sample set, but not all the codes are available in all those documents. This is because both coding categories and documents are developed and gathered to answer certain aspects of a research question and as the questions are analyzed from multiple aspects, not all the categories are relevant to all of the documents.

### 4.2.1 Code Application for Q1a

- Q1a:** In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?

**Q1a Code Set** As mentioned before, the document set for this question consists of “MMC mission documents” (DID schema: **MMC1x**, 2 documents), “Documentation of solutions and designs published on MMC site” (DID schema: **MMC2x**, 109 documents), and “MMC

advertisement documents” (DID schema: **MMC4x**, 10 documents). The criterion that we chose for evaluating the quality of the assistive devices is the extent to which they are adhering to Design Justice principles. In section 3.4.3.1, we described the codes that we have developed for this set of documents. Our coding system consists of three main groups which are all presented below:

- Missions and goals
- Ways of achieving mission
  - Donations
    - \* Giving donations
    - \* Receiving donations
  - Feedback
  - Providing service
  - Volunteer
    - \* Community champion
    - \* Chapter leader
    - \* Making
  - Working Together program
- Quality of Pieces of Technology
  - P1 - adhere
  - P1 - flout
  - P2 - adhere
  - P2 - flout
  - P3 - adhere
  - P3 - flout
  - P4 - adhere
  - P4 - flout
  - P5 - adhere
  - P5 - flout
  - P6 - adhere
  - P6 - flout
  - P7 - adhere

- P7 - flout
- P8 - adhere
- P8 - flout
- P9 - adhere
- P9 - flout
- P10 - adhere
- P10 - flout

We applied these codes to all relevant text segments within the documents. We will now discuss the occurrences of different codes and how they are distributed over the set of documents in our corpus. Figure 4.1 provides an overview of these occurrences for the two code groups “Missions and goals” and “Ways of achieving mission”.

Figures 4.2 and 4.3 illustrate the occurrence of the ‘Quality of Pieces of Technology’ codes (i.e., the extent to which Design Justice principles are incorporated into each of the assistive devices).

**Missions and Goals** The first coding category in figure 4.1 is “Mission and goals”. There were three segments coded from among the “MMC mission documents” (MMC1*x*), which signalled MMC’s mission as: *“connecting people with disabilities to volunteer makers to build assistive devices”* [MMC1a], *“developing & delivering affordable open source assistive devices”* [MMC1b], and *“achieving economic and social inclusiveness for all people with disabilities”* [MMC1b].

**Ways of Achieving Mission** The coding of this category is related to the phrases of the previous category as it includes ways that help MMC get closer to the above goals. Over all the documents in the sample, this coding category was found to apply to 121 coding units occurring in all of the documents except the one with DID MMC1b. As presented in our coding system, “Ways of achieving mission” code has five sub-codes: “Donations”, “Feedback”, “Providing service”, “Volunteer, and “Working together program”. Figure 4.4 shows the distribution of each of the sub-codes in this category.

The “Donations” code family has been applied to a total of 12 excerpts which is equivalent to 10% of the total codes in this category. These coded segments appeared solely in two documents with DID of MMC4b (Neil Squire Testimonials) and MMC4i (Donate (Neil Squire)).

“Feedback” has the largest number of codes in this category with a total of 44 excerpts and has dedicated 36% of the total codes to itself. Over all the documents in the sample,



## Code Application for “Mission and goals” and “Ways of achieving mission”

| Media     | Codes             |                           |           |                  |                     |          |                   |           |                |                    |                     |        | Totals |                          |
|-----------|-------------------|---------------------------|-----------|------------------|---------------------|----------|-------------------|-----------|----------------|--------------------|---------------------|--------|--------|--------------------------|
|           | Mission and goals | Ways of achieving mission | Donations | Giving donations | Receiving donations | Feedback | Providing service | Volunteer | Chapter leader | Community champion | Community volunteer | Making |        | Working Together program |
| MMC4j.pdf |                   |                           |           |                  |                     | 7        | 2                 |           |                |                    |                     |        |        | 9                        |
| MMC4i.pdf |                   |                           |           |                  | 9                   |          |                   |           |                |                    |                     |        |        | 9                        |
| MMC4h.pdf |                   |                           |           |                  |                     |          |                   |           |                |                    | 1                   |        |        | 1                        |
| MMC4g.pdf |                   |                           |           |                  |                     |          |                   |           |                |                    |                     | 3      |        | 3                        |
| MMC4f.pdf |                   |                           |           |                  |                     |          | 1                 |           |                |                    | 1                   |        |        | 2                        |
| MMC4e.pdf |                   |                           |           |                  |                     |          | 2                 |           | 1              |                    |                     |        |        | 3                        |
| MMC4d.pdf |                   |                           |           |                  |                     |          | 1                 |           |                |                    |                     | 3      |        | 4                        |
| MMC4c.pdf |                   |                           |           |                  |                     |          |                   |           | 1              |                    | 2                   | 2      |        | 5                        |
| MMC4b.pdf |                   |                           |           | 2                | 1                   | 37       | 3                 |           |                |                    | 8                   |        | 15     | 66                       |
| MMC4a.pdf |                   |                           |           |                  |                     |          | 3                 |           | 4              | 4                  | 1                   | 3      |        | 15                       |
| MMC1b.pdf | 2                 |                           |           |                  |                     |          |                   |           |                |                    |                     |        |        | 2                        |
| MMC1a.pdf | 1                 |                           |           |                  |                     |          | 3                 |           |                |                    |                     | 1      |        | 5                        |
| Totals    | 3                 |                           |           | 2                | 10                  | 44       | 15                |           | 6              | 4                  | 13                  | 12     | 15     |                          |

Figure 4.1: Code Application for “Mission and goals” and “Ways of achieving mission”

the coding units for this category have been identified in solely two documents with the DID of MMC4b (Neil Squire Testimonials) and MMC4j (Success Stories Archive). 37 out of the 44 coded segments of “Feedback” were located in the latter document. This was the largest number of single code found in an individual document regarding this question.

“Providing service” has a total of 15 excerpts and has been mentioned in seven out of the twelve documents in our sample. The DIDs for these documents are MMC1a, MMC4a, MMC4b, MMC4d, MMC4e, MMC4f, and MMC4j. The details of these documents are provided in table 3.12.

Next sub-code is the category of “Volunteer” which has a total of 35 excerpts and appears in documents with DIDs from MMC1a, MMC4a, MMC4b, MMC4c, MMC4d, MMC4e, MMC4f, MMC4g, and MMC4h.

The last sub-code in this category is the “Working together program” which has a total

## Number of Principles each Assistive Device Adhere/Flout

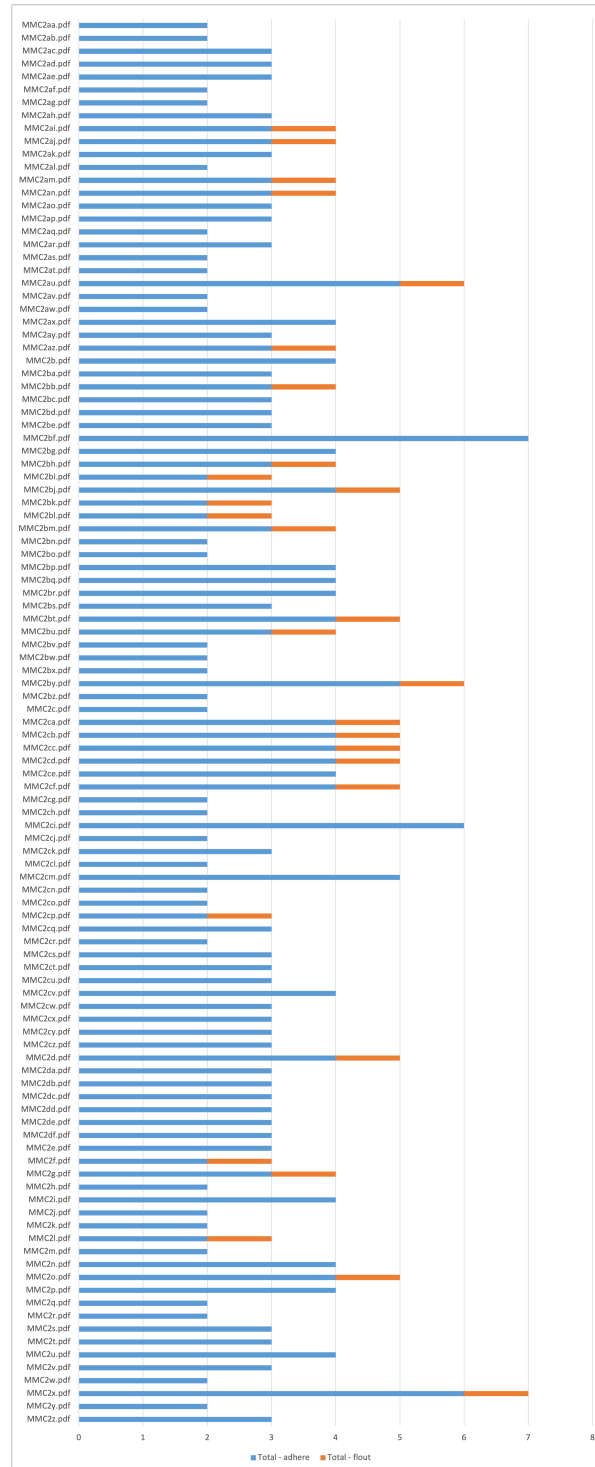


Figure 4.2: Number of Principles each Assistive Device Adhere/Flout

Number of Assistive Devices that Adhere/Flout each Principle

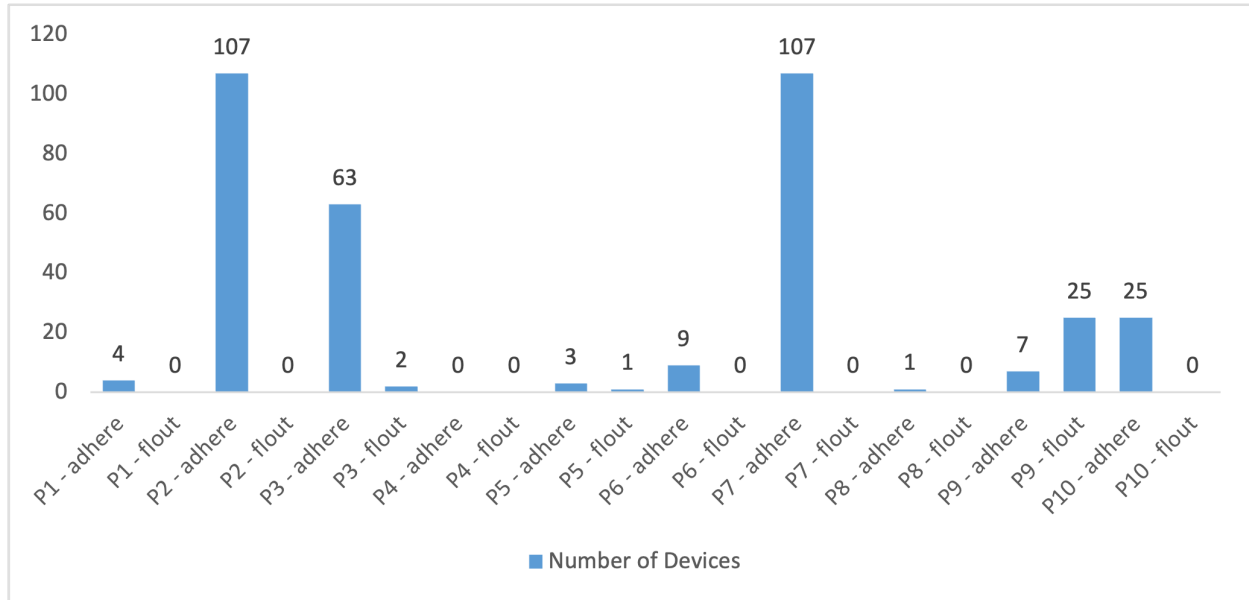


Figure 4.3: Number of Assistive Devices that Adhere/Flout each Principle

Distribution of “Ways of Achieving Mission” Sub-codes

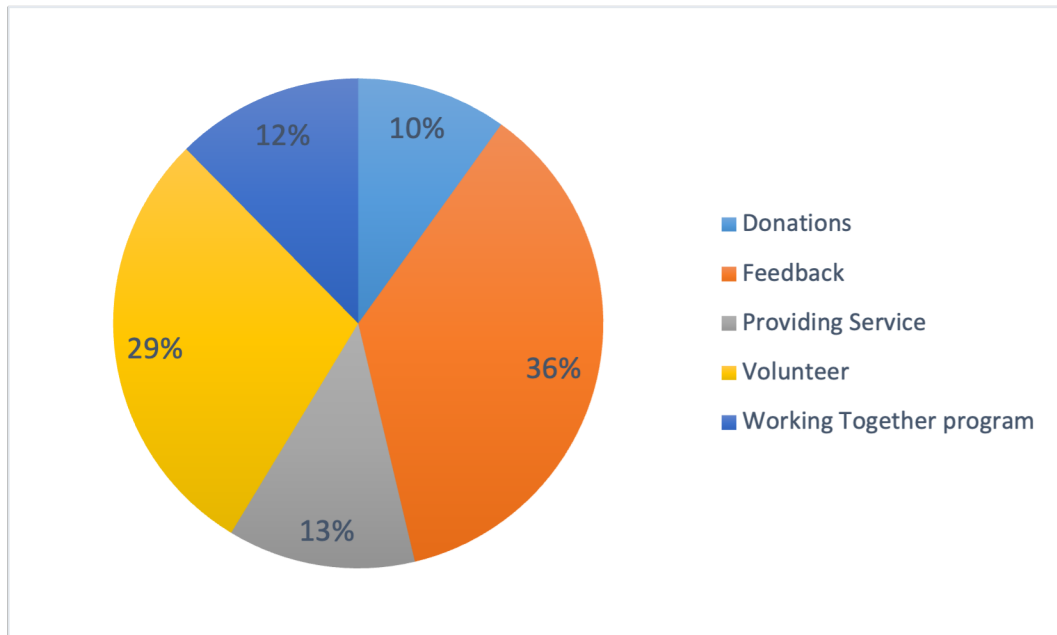


Figure 4.4: Distribution of “Ways of Achieving Mission” Sub-codes

of 15 excerpts. All of the mentions of this code solely appeared in Neil Squire Testimonials document (MMC4b).

The sub-codes for the category of “Donations” and “Volunteer” will now be discussed.

**Donations sub-codes** Excerpts in this category fit under two sub-code groups of “Giving donations” and “Receiving donations”. Among the 12 coded segments of “Donations”, two of them refer to the donations that MMC has given to centres or societies in need which were solely found in Neil Squire Testimonials document (MMC4b). The other ten codes are the mentions of received donations and occurred in the two documents with DIDs MMC4b and MMC4i.

**Volunteer sub-codes** “Volunteer” category itself has four sub-codes. Among the 35 coded segments of “Volunteer”, six of them were coded as “Chapter leader”, four of them as “Community champion”, 13 related to “Community volunteer”, and 12 of them related to “Making”. It is noteworthy to mention that these numbers do not indicate the number of volunteers in each of these groups, rather the number of mentions related to the assistance provided by volunteers in these roles. The distribution of codes for different types of volunteers sub-codes are also presented in Figure 4.5.

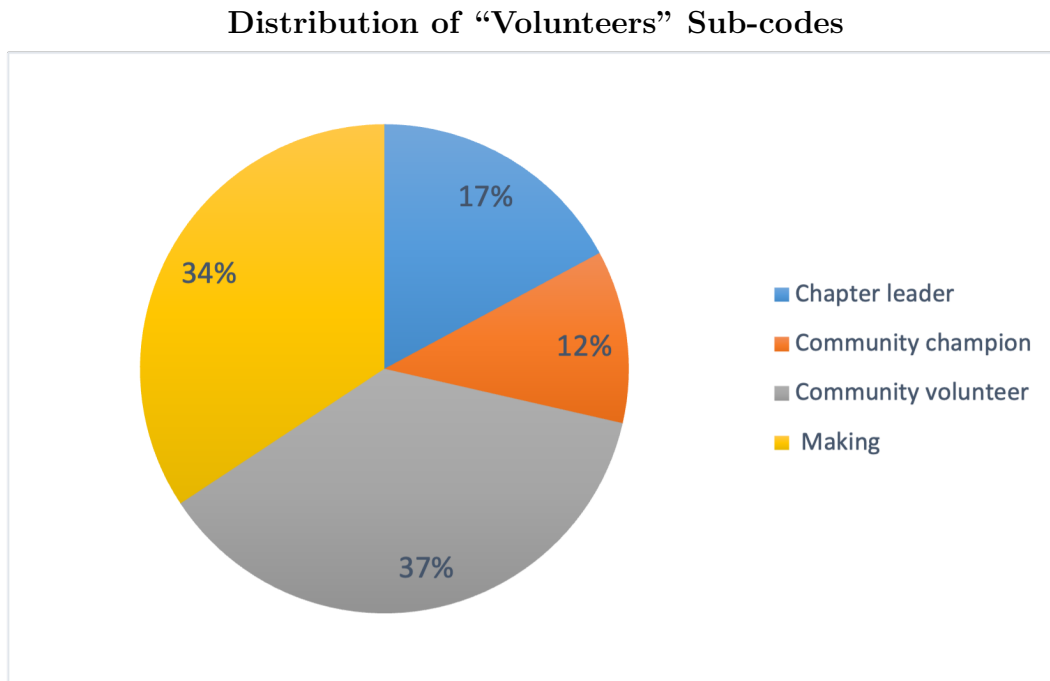


Figure 4.5: Distribution of Different Types of Volunteers

**Quality of Pieces of Technology** The coding category of “Quality of Pieces of Technology” has twenty sub-codes and was applied to 109 documents of assistive devices. Each of the nodes indicates evidence of adherence or flouting each of the design justice principles (P1 to P10). Over all of the documents in the sample, this coding category was found to apply to 630 coding units appearing in all 109 documents with DID schema of MMC2x. But regarding this particular category, we are interested in the presence of the codes and not the number of their occurrences. If a particular “adhere” code for one of the principles is located in one of the documents, we mark that document as adhering to that principle. Lack of adherence code for a specific principle can possibly be a sign of that principle being ignored. We also code segments that are explicitly ignoring any of the principles and mark that document as flouting that principle. Therefore, regarding the presence of the codes, there are a total of 359 segments that provide adherence or flout of each principles in the document sample. Each of the principles and their presence in documents will now be discussed.

**P1: We use design to sustain, heal, and empower our communities, as well as to seek liberation from exploitative and oppressive systems.**

Out of the 359 code presences, four of them were coded as “P1 - adhere” which means that the first principle has been incorporated into the design, implementation, or documentation of solely four of the assistive devices (MMC1z, MMC2au, MMC2bf, and MMC2ci). Two of these documents included statements from the designers saying how important it is to help members of community and empower them and how the design of these devices prioritize healing the marginalized community. The other two went one step further and used contexts that people with disabilities might have problem contributing to them (music production & playing console games) and attempted to seek liberation from the perpetuated marginalization using their designs. Although there were no segments coded as “P1 - flout”, the lack of “P1 - adhere” in the rest of the 105 documents in our sample can be interpreted as a sign of ignoring P1. A possible approach to incorporate this principle into MMC designs could be including people with disabilities in the process of their DIY-AT devices. This approach is aligned with designing “by” people with disabilities instead of designing “for” them and will contribute to the shift from design to co-design [60].

**P2: We center the voices of those who are directly impacted by the outcomes of the design process.**

Among the 109 documents in the sample, 107 (98%) of them were aligned with the second

principle of Design Justice Network. This is because these 107 documents were provided as a direct response to requests made by people with disabilities and have centered their requirements in the design process. These documents were also clear in explaining who their target audience is and what disability this specific device is suited for. The two documents lacking attention to this principle are the ones with DID MMC2k and MMC2c1 which did not specify the target audience. Therefore, we could not identify whether this device centers the voices of people that are directly impacted by the outcomes of the design process. This principle (“P2 - adhere” code) was present in the largest number of documents compared to other principles.

**P3: We prioritize design’s impact on the community over the intentions of the designer.**

We identified instances of the “P3 - adhere” code in 63 (or 58%) of the 109 assistive devices. The segments that we coded as “P3 - adhere” were mentions of affordability, various designs each suitable for different users, and customizable devices which shows an attention to the impact of the designs on the community. We identified occurrences of “P3 - flout” across two of the documents (MMC2cp and MMC2aj). One of these included a statement from the designer focusing on their need while working with children with visual impairments rather than the children’s. The other one was a disclaimer stating the designer company is not responsible for any harm or damage as a result of construction or use of this device. We did not locate any segments regarding adhering (or ignoring) this principle in the other 44 documents.

**P4: We view change as emergent from an accountable, accessible, and collaborative process, rather than as a point at the end of a process.**

For this principle, we found no occurrences of “P4 - adhere” and “P4 - flout” in any of the documents in our sample. Although there were other adaptations of specific devices, there was no evidence that these adaptations are a result of collaborating with users/community and incorporating their feedback. Most of the devices did not have any reviews and there were no responses provided for the ones that did. Therefore, none of the 109 documents in our sample are aligned with this principle.

**P5: We see the role of the designer as a facilitator rather than an expert.**

Among the 109 of the assistive devices, “P5 - adhere” code was present in solely four

of them with DIDs MMC2x, MMC2bf, MMC2bq, and MMC2by. The designer of MMC2x mentioned that the caregivers can customize the shape of this assistive device to better suit the user. This indicates that the designer did not believe their solution is the only right option coming from an expert. The other three acknowledged that their work is a collaborative process and they look forward to receiving feedback from the users in order to improve the device.

**P6: We believe that everyone is an expert based on their own lived experience, and that we all have unique and brilliant contributions to bring to a design process.**

Regarding this principle, only in nine documents in our sample we identified segments relevant to adherence. These documents indicated the importance of others' participation and user feedback, they complemented adaptations made by other designers, and encouraged others to collaborate with their projects. The statements related to these attributes represented that the designers valued the everyone's expertise. The rest of the documents did not include any codes related to this principle.

**P7: We share design knowledge and tools with our communities.**

The signs of adherence regarding this principle was found in the largest number of documents. "P7 - adhere" was found in 107 documents out of 109 and had the same number of appearances as "P2 - adhere". The reason that most of the documents were aligned with this principle is the open source policy that is followed in MMC work. In all those 107 documents, the documentation of the design, how to build the device, and their online resources were fully shared with the community. The other two documents (MMC2bw and MMC2bx) did not include these files and were therefore not sharing their design knowledge and tools with the community.

**P8: We work towards sustainable, community-led and -controlled outcomes.**

Regarding this principle, we found only one instance of "P8 - adhere" appearing in MMC2cm which was inviting the community to participate in improving the design and providing different adaptations. Although, it is noteworthy to mention that MMC in general is encouraging community-led practices, but we were coding the documentations and specific mentions of this encouragement were not present in them. There were also no instances of "P8 - flout" code.

**P9: We work towards non-exploitative solutions that reconnect us to the earth and to each other.**

We marked seven out of 109 documents as adhering to this principle and 25 documents as ignoring it. The mentioned 25 documents included materials for the designs but did not specify whether these materials are sustainable, recyclable, or non-exploitative to the earth.

**P10: Before seeking new design solutions, we look for what is already working at the community level. We honor and uplift traditional, indigenous, and local knowledge and practices.**

The code “P10 - adhere” was present in 25 out of the 109 documents in our sample. These documents mostly included for whom and by whom this device has been initially requested and pointed out the solutions that already exist for their request on MMC library. They also mentioned the original design of some specific assistive device. No documents were openly disregarding this principle, but neither did they acknowledge that there has not been prior work regarding this matter.

**Quantity of Pieces of Technology** This aspect of Q1a involved the extraction of quantitative data from the MMC6x documents (i.e., the List of devices requested on MMC forums). This consisted of three documents with the DIDs of MMC6a, MMC6b, and MMC6c. We used a quantitative approach for this aspect of the question.

In phase 2, we extracted a data set from the the MMC6x documents. The data sets consists of two types of data: ‘requests’ and ‘design challenges’. The raw data was presented in Table 3.13. We will use this raw data towards answering Q1a and Q2b.

For Q1a, we will consider only the ‘requests’ data and not the ‘design challenges’ data. To discuss MMC success regarding the quantity of pieces of technology delivered to users, we compare the total number of initiated requests to the total number of delivered requests, thereby determining the percentage of fulfilled requests.

First, we discuss the subcategorization of the ‘requests’ data (corresponding to final three of the columns in Table 3.13 in section 3.4.3.5). The first sub-category is “Maker Wanted”, which represents the number of devices that have been requested by users to be made, where those requests are still awaiting a maker’s response. Once a maker has agreed to make a requested device, the request state changes from “Maker Wanted” to “Request in Progress”. When the maker builds the device and delivers it to the user, the request will then move from the “Request in Progress” state and into the category of “Archived Requests”. The



time-stamp of each state change can be found on each individual request page on MMC website’s forum, which was used to build the raw data set. This allows us to find the ratio of delivered requests to initiated requests. As shown in Table 4.1 the total number of requests from March 2019 to August 2021 is 206 and the total number of archived requests is 150. Therefore, around 73% of the initiated requests have been fulfilled.

Table 4.1: Fulfillment Rate of Requests

|                   |     |
|-------------------|-----|
| Archived Requests | 150 |
| Total Requests    | 206 |
| Fulfillment Rate  | 73% |

There is a possibility that some of the currently ongoing requests will be fulfilled in the near future and this will change the rate of request fulfillment. Thus, the fulfillment rate may not paint an accurate picture. To resolve the issue, one can take snapshots of the requests that have been initiated but not fulfilled in different time-frames and check their progress.

## 4.2.2 Code Application for Q1b: Motivating DIY-AT and HMSs

**Q1b:** In what ways has Makers Making Change (MMC) been successful in motivating DIY-AT and Home Makerspaces?

**Q1b Code Set** The set of documents for this question, as mentioned in section 3.3.1.2 include “MMC funding related documents” (DID Schema: MMC3*x*, 7 documents), “MMC advertisement documents” (DID Schema: MMC4*x*, 10 documents), and “List of MMC makers and their origin” (DID Schema: MMC5*x*, 22 documents).

In section 3.4.3.2, we described the codes that we have developed for this set of documents:

- Activated by MMC
- Makers background
  - Business/Management
  - Design
  - Engineering/Science

- Medical/Disability professional
- Role at MMC
  - Paid position
  - Volunteer
- Ways of encouraging to fund
  - Advantages of MMC products
  - Empowering people with disabilities
  - Feedback/results
  - Mentions of current funders
  - Perks and benefits
- Ways of achieving mission [Overlap with Q1a code set]
  - Donations
    - \* Giving donations
    - \* Receiving donations
  - Feedback
  - Providing service
  - Volunteer
    - \* Community champion
    - \* Chapter leader
    - \* Making
  - Working Together program

We investigated the document set for this question and coded all the relevant units. Next, we discuss the distribution of these codes and the number of times they have appeared in our documents. Figure 4.6 provides an overview of this information.

**Activated by MMC** The first coding category in figure 4.6 is “Activated by MMC” which identifies whether an MMC maker has started building assistive devices solely because of MMC or not. Therefore, we expect this coding category to only apply to documents in “MMC makers and their origin” (DID schema: `MMC5x`) set. Over all the documents in our sample, this code has been repeated four times and only in three documents with DID of `MMC5h`, `MMC5l`, `MMC5s`. More specifically, among the 22 makers in our document set, only three (or 13%) of them have been solely activated by MMC.

## Code Application for Q1b

| Media     | Codes            |                   |                     |        |                     |                                 |             |               |           |                             |                            |                        |                  |                             |                  | Totals |
|-----------|------------------|-------------------|---------------------|--------|---------------------|---------------------------------|-------------|---------------|-----------|-----------------------------|----------------------------|------------------------|------------------|-----------------------------|------------------|--------|
|           | Activated by MMC | Makers background | Business/management | Design | Engineering/Science | Medical/Disability professional | Role at MMC | Paid position | Volunteer | Ways of encouraging to fund | Advantages of MMC products | Empowering people with | Feedback/results | Mentions of current funders | Perks & benefits |        |
| MMC5v.pdf |                  |                   | 3                   | 1      | 2                   |                                 |             |               | 2         |                             |                            |                        |                  |                             |                  | 8      |
| MMC5u.pdf |                  |                   |                     |        | 11                  |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 12     |
| MMC5t.pdf |                  |                   |                     |        |                     | 1                               |             |               | 1         |                             |                            |                        |                  |                             |                  | 2      |
| MMC5s.pdf | 1                |                   | 2                   |        | 5                   |                                 |             | 1             | 1         |                             |                            |                        |                  |                             |                  | 10     |
| MMC5r.pdf |                  |                   | 1                   |        |                     | 1                               |             |               | 1         |                             |                            |                        |                  |                             |                  | 3      |
| MMC5q.pdf |                  |                   |                     | 1      |                     |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 2      |
| MMC5p.pdf |                  |                   |                     | 1      | 2                   |                                 |             |               |           |                             |                            |                        |                  |                             |                  | 3      |
| MMC5o.pdf |                  |                   |                     | 1      | 11                  |                                 |             | 1             |           |                             |                            |                        |                  |                             |                  | 13     |
| MMC5n.pdf |                  |                   | 3                   |        | 7                   |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 11     |
| MMC5m.pdf |                  |                   | 2                   | 8      |                     |                                 |             |               |           |                             |                            |                        |                  |                             |                  | 10     |
| MMC5l.pdf | 2                |                   |                     |        | 4                   |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 7      |
| MMC5k.pdf |                  |                   |                     |        | 6                   |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 7      |
| MMC5j.pdf |                  |                   |                     | 1      |                     | 1                               |             |               | 1         |                             |                            |                        |                  |                             |                  | 3      |
| MMC5i.pdf |                  |                   |                     |        | 7                   |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 8      |
| MMC5h.pdf | 1                |                   | 7                   |        | 3                   |                                 |             | 1             |           |                             |                            |                        |                  |                             |                  | 12     |
| MMC5g.pdf |                  |                   |                     |        | 1                   | 1                               |             |               | 1         |                             |                            |                        |                  |                             |                  | 3      |
| MMC5f.pdf |                  |                   | 3                   |        | 6                   |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 10     |
| MMC5e.pdf |                  |                   |                     |        | 2                   | 2                               |             |               | 1         |                             |                            |                        |                  |                             |                  | 5      |
| MMC5d.pdf |                  |                   |                     |        | 1                   | 2                               |             |               |           |                             |                            |                        |                  |                             |                  | 3      |
| MMC5c.pdf |                  |                   |                     |        | 4                   |                                 |             |               | 1         |                             |                            |                        |                  |                             |                  | 5      |
| MMC5b.pdf |                  |                   | 3                   |        | 3                   |                                 |             | 1             |           |                             |                            |                        |                  |                             |                  | 7      |
| MMC5a.pdf |                  |                   |                     |        | 6                   |                                 |             | 1             |           |                             |                            |                        |                  |                             |                  | 7      |
| MMC3g.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             | 1                          | 3                      | 1                |                             |                  | 5      |
| MMC3f.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             | 3                          | 2                      | 5                | 4                           |                  | 14     |
| MMC3e.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             |                            | 3                      | 3                |                             |                  | 6      |
| MMC3d.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             |                            | 2                      | 1                | 1                           |                  | 4      |
| MMC3c.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             | 3                          | 2                      | 2                | 1                           |                  | 8      |
| MMC3b.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             | 3                          | 2                      |                  | 2                           |                  | 7      |
| MMC3a.pdf |                  |                   |                     |        |                     |                                 |             |               |           |                             | 8                          | 19                     | 4                | 2                           | 5                | 38     |
| Totals    | 4                |                   | 24                  | 13     | 81                  | 8                               |             | 5             | 16        |                             | 18                         | 33                     | 16               | 10                          | 5                |        |

Figure 4.6: Code Application for Q1b

**Makers background** Over all the documents in the sample, the sub-codes of this category were applied to 126 coding units, occurring in all 22 documents with DID schema **MMC5x**. We have coded all the past and present experiences of makers which were available in our document set. This has resulted in multiple instances of the same sub-code within single documents. There were a total of 34 instances of the sub-code “Business/Management”, 13 instances of “Design”, 81 coded units of “Engineering/Science”, and 8 coded units of “Medical/Disability professional”.

What is of more importance to our research question is the presence of the codes so that we can calculate the distribution of different backgrounds over the community of makers. Among the 22 makers, eight of them have prior experience in “Business/management”. Six of the makers come from the background of “Design”, 17 of them have “Engineering/Science” related expertise, and six of them have “Medical/Disability professional” experience.

Evidently, there are makers that have experience in multiple categories. There is one maker who has experience in all three aspects of “Business/Management”, “Design”, and “Engineering/Science”. There are five makers that have experience in only “Business/ Management” and “Engineering Science”, one in “Business/Management” and “Medical/ Disability professional”, one in “Business/Management” and “Design”, two in “Design” and “Engineering/Science”, three in “Engineering/Science” and “Medical/Disability professional”, one in “Medical/Disability professional” and “Design”.

**Roles at MMC** Here, we will discuss whether the makers are working as volunteer or they are employees of MMC and have paid positions. This category was applied to a total of 21 units, occurring in all documents with the DID schema **MMC5x** but three. For those three makers (DIDs: **MMC5d**, **MMC5m**, and **MMC5p**), we could not identify whether they work as volunteers or not. Among the 22 makers, we coded 14 of them (64%) as “Volunteer”, four as having “Paid positions”, and one mutual between the two sub-codes, who has had both experiences.

**Ways of encouraging to fund** This coding category has been applied to 82 coding units occurring solely in the 7 documents with the DID schema **MMC3x**. Among these 82 units, 18 (or 22%) of them are under the subcategory of “Advantages of MMC products” and have appeared in documents with DID of **MMC3a**, **MMC3b**, **MMC3c**, **MMC3f**, and **MMC3g**. This sub-code has the second largest number of codes under this category. “Empowering people with disabilities” has the largest number of coded segments in this category with 33 (or 40%)

excerpts occurring in all of the documents with DID schema **MMC3x**. Out of the 82 coding units, 16 (or 19%) of them belong to the subcategory of “Feedback/results” occurring in all documents with DID schema **MMC3x** but one (**MMC3b**). The “Mentions of current funders” sub-code was found to apply to 10 coding units appearing in all documents with DID schema **MMC3x** but two (**MMC3e** and **MMC3g**). There are also five occurrences of “Perks & benefits” subcategory solely appearing in document **MMC3a**. This category has the smallest number of coded segments.

**Ways of achieving mission** As discussed earlier, the coding related to “MMC advertisement documents” re-uses some of the coding from Q1a. As discussed in section 4.2.1, the sub-codes of “Ways of achieving mission” have a total of 118 excerpts and appear in documents with DIDs **MMC4a**, **MMC4b**, **MMC4c**, **MMC4d**, **MMC4e**, **MMC4f**, **MMC4g**, and **MMC4h**. The coding information will not be repeated in this section and is available in section 4.2.1.

### 4.2.3 Code Application for Q1c: Promotion of Design Justice

**Q1c:** In what ways has Makers Making Change (MMC) been successful in promoting the principles of Design Justice?

**Q1c Code Set** The coding system that we have developed for this question consists of four main categories. These categories are applied to the **Q1c Document Set** which includes: “Documentation of solutions and designs published on MMC site” (DID schema: **MMC2x**, 109 documents), “Design Justice strategic mission documents” (DID schema: **DJ1x**, 2 documents), and “Design Justice funding related documents” (DID schema: **DJ2x**, 4 documents). The set of Design Justice principles is also a relevant resource for this question which was discussed in section 2.5.1.

In section 3.4.3.3, we described the codes we have developed for this set of documents, which are as follows:

- Quality of Pieces of Technology [Overlap with Q1a code set]
  - P1 - adhere
  - P1 - flout
  - P2 - adhere
  - P2 - flout

- P3 - adhere
- P3 - flout
- P4 - adhere
- P4 - flout
- P5 - adhere
- P5 - flout
- P6 - adhere
- P6 - flout
- P7 - adhere
- P7 - flout
- P8 - adhere
- P8 - flout
- P9 - adhere
- P9 - flout
- P10 - adhere
- P10 - flout
- Funders goals
- Inviting to fund
  - Finances
  - Goals
- Ways of encouraging
  - Goals
  - News
  - Perks and benefits
  - Shop
  - Transparency

We coded the text segments related to the above coding categories. Figure 4.7 shows the number of occurrences for each of these codes in each of the individual documents from the **Q1c Document Set**. Now we will discuss how these codes are distributed among the documents in our sample set.

### Code Application for the Q1c Document Set

| Media    | Codes         |                  |          |       |                     |       |      |                    |      |              |
|----------|---------------|------------------|----------|-------|---------------------|-------|------|--------------------|------|--------------|
|          | Funders goals | Inviting to fund | Finances | Goals | Ways of encouraging | Goals | News | Perks and benefits | Shop | Transparency |
| DJ2d.pdf |               |                  | 2        | 3     |                     | 5     |      |                    | 1    |              |
| DJ2c.pdf | 4             |                  |          |       |                     |       |      |                    |      |              |
| DJ2b.pdf |               |                  | 2        | 3     |                     |       |      |                    |      | 1            |
| DJ2a.pdf |               |                  | 6        |       |                     | 1     |      |                    | 1    | 2            |
| DJ1b.pdf |               |                  |          |       |                     | 13    | 15   | 8                  |      |              |
| DJ1a.pdf |               |                  |          |       |                     | 11    | 7    |                    |      |              |
| Totals   | 4             |                  | 10       | 6     |                     | 30    | 22   | 8                  | 2    | 3            |

Figure 4.7: Code Application for Q1c

**Quality of Pieces of Technology** As discussed earlier, the coding related to “Documentation of solutions and designs published on MMC site” re-uses part of the coding category developed for Q1a. As discussed in section 4.2.1, the sub-codes of “Quality of Pieces of Technology” have a total of 630 excerpts and appears in documents with DID schema MMC2*x*. The coding information will not be repeated in this section and is available in section 4.2.1.

**Funders goals** Over all the documents in our sample set, the category of “Funders goals” was applied to four coding units, only appearing in one document with DID of DJ2c. “Funders goals” was the only available coding category in this document.

**Inviting to fund** This coding category has two sub-codes, which were applied to a total of 16 segments. These coded segments occurred solely in three documents with DID of DJ2a, DJ2b, and DJ2d. Among the 16 coded units, 10 (62% of the total codes in this

category) were coded as being related to “Finances” and six (38%) were related to “Goals” sub-code. The instances of “Finances” codes appear in all three aforementioned documents. The “Goals” sub-code occurred in two documents with DIDs DJ2b and DJ2d.

**Ways of encouraging** The category of “Ways of encouraging” has been applied to a total of 65 coding units, occurring in all the documents but one (DID: DJ2c). Figure 4.8 shows the occurrences of the sub-codes in this category.

The “Goals” sub-code has the largest number of coded segments with a total of 30 occurrences in documents with DIDs DJ1a, DJ1b, DJ2a, DJ2d. The “News” sub-code comes second with a total of 22 excerpts appearing in DJ1a and DJ1b. The other three sub-codes combined, have roughly half of the number of coded segments compared to “Goals” and “News”. Of the total of 65 coded units, eight were coded as “Perks and benefits” (appearing solely in DJ1b), two as “Shop” (appearing in DJ2a and DJ2d), and three as “Transparency” (appearing in DJ2a and DJ2b). Also, the document DJ1b had the highest number of coded units with 36 instances, while each of the others had roughly less than half of this number.

**Distribution of “Ways of Encouraging” Sub-codes**

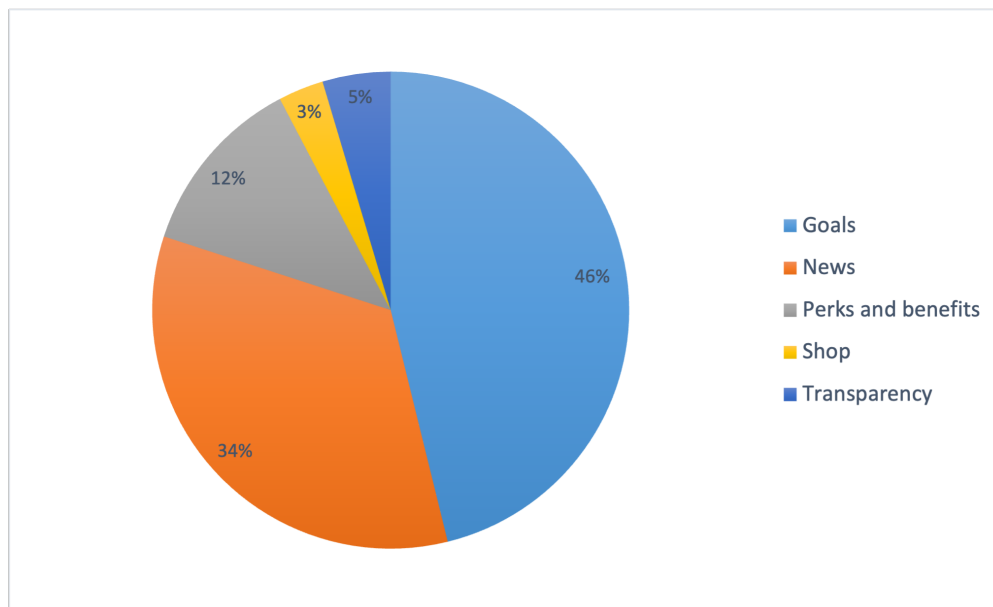


Figure 4.8: Distribution of "Ways of Encouraging" Sub-codes



#### 4.2.4 Code Application for Q2a: Access Barriers

**Q2a:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) impacted disabled people?

**Q2a Code Set** The coding system that we have developed for this question consists of six main groups which are presented below, to be applied to the **Q2a Document Set**: “MMC COVID-19 resources” (DID schema: **MMC7x**, 1 document), “Documents on impact of pandemic on people with disabilities” (DID schema: **PAN1x**, 4 documents), “Documents of makerspaces work routine before and after the start of the pandemic” (DID schema: **MAK1x**, 6 documents). (For details about the code development and meanings, see section 3.4.3.4).

- Impact on people with disabilities

- Physical aspects
- Mental aspects
- Social aspects
- Equipment aspects

- Knowledge

- Added complications
- no change

- Time

- Added complications
- no change

- Making

- Added complications
- Avoidances
- no change

- Resources

- Added complications
- no change

- Work routine after COVID-19
  - Alternate methods
  - Closed
  - Open with restrictions
    - \* Masks
    - \* Booking
    - \* Limited hours
    - \* Limited capacity

All of relevant units within the document were coded, and we now discuss the occurrence and distribution of the coded units over the different coding categories and over the documents within the corpus. An overview is provided in figure 4.9.

Code Application for Q2a

| Media     | Codes | Impact on people with disabilities |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        |         |                  |               |       |        |
|-----------|-------|------------------------------------|-------------------|----------------|------------------|----------------|-----------|--------------------|-----------|----------------|--------------------|------------|-----------|-----------|--------------------|-----------|------|--------------------|-----------|--------------------------|-------------------|--------|------------------------|---------|------------------|---------------|-------|--------|
|           |       | Equipment aspects                  | Financial aspects | Mental aspects | Physical aspects | Social aspects | Knowledge | Added complication | No change | Making process | Added complication | Avoidances | No change | Resources | Added complication | No change | Time | Added complication | No change | Work routine after covid | Alternate methods | Closed | Open with restrictions | Booking | Limited capacity | Limited hours | Masks | Totals |
| PAN1d.pdf |       | 5                                  | 5                 |                | 4                | 11             |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        |         |                  |               |       | 25     |
| PAN1c.pdf |       | 1                                  |                   | 7              | 8                | 3              |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        |         |                  |               |       | 19     |
| PAN1b.pdf |       | 2                                  | 6                 | 16             | 5                | 23             |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        |         |                  |               |       | 52     |
| PAN1a.pdf |       | 4                                  | 1                 | 9              | 3                | 17             |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        |         |                  |               |       | 34     |
| MMC7a.pdf |       |                                    |                   |                |                  |                |           | 31                 | 1         |                | 20                 | 7          |           |           | 22                 | 3         |      | 6                  |           |                          |                   |        |                        |         |                  |               |       | 90     |
| MAK1f.pdf |       |                                    |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          | 1                 | 1      |                        |         |                  |               |       | 2      |
| MAK1e.pdf |       |                                    |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        |         | 1                | 1             |       | 2      |
| MAK1d.pdf |       |                                    |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          | 1                 | 1      |                        |         |                  |               |       | 2      |
| MAK1c.pdf |       |                                    |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          | 2                 | 1      |                        |         |                  |               |       | 3      |
| MAK1b.pdf |       |                                    |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          | 1                 | 1      |                        |         |                  |               |       | 2      |
| MAK1a.pdf |       |                                    |                   |                |                  |                |           |                    |           |                |                    |            |           |           |                    |           |      |                    |           |                          |                   |        |                        | 1       | 1                | 1             | 1     | 4      |
| Totals    |       | 12                                 | 12                | 32             | 20               | 54             |           | 31                 | 1         |                | 20                 | 7          |           |           | 22                 | 3         |      | 6                  |           |                          | 5                 | 4      |                        | 1       | 2                | 2             | 1     |        |

Figure 4.9: Code Application for Q2a

**Impact on people with disabilities** The first coding category in figure 4.9 is “Impact on people with disabilities”, consisting of five sub-codes. Over all of the documents in the sample, this coding category was found to apply to 130 coding units occurring solely in the 4 documents with DID schema PAN1x, which are four scholarly articles. The social aspect

sub-code was the most frequent sub-code for three of the four documents (i.e., PAN1a, PAN1b, and PAN1d). The document PAN1c did not have “social aspects” as its most frequent sub-code, instead “physical aspects” was its most frequent sub-code. However, over all four documents, the sub-code that was applied most frequently was the “social aspects” (54 out of 130 or 41%). For examples, the sentence “social distancing, can lead to life-threatening disruptions in care for those that rely on home health or personal assistants” is one of the excerpts coded as “social aspects”.

The “Mental aspects” sub-code had the second largest number of coded segments (32 excerpts of 130, 25% of the total). Twenty of the coded segments (15%) are found to correspond to “physical aspects” (15%). The codes “equipment aspects” and “financial aspects” both had 12 coded units (each with 10% of the total).

The document PAN1b had the highest number of coded units (52 instances), with the others PAN1a, PAN1c, and PAN1d having roughly half as many (25, 19, 34 instances, respectively).

**Knowledge; Making Process; Resources; Time** Over all of the documents in the sample, these coding categories was found to apply to 90 coding units occurring solely in the 1 document with DID of MMC7a, which is MMC COVID-19 Resources.

Of these 90 coded units, 32 (35% of the total codes in this category) were coded as being related to the knowledge, 27 (30%) related to making process, 25 (28%) related to resources, and 6 (7%) related to the aspect of time. The sub-codes for each of these aspects will now be discussed.

**Knowledge sub-codes:** Among the 32 coded segments of knowledge, 31 segments represented instances in which there was a need for new knowledge, as a result of the pandemic. This segments indicate that makers who want to get involved in building assistive devices have the need to familiarize themselves with this new knowledge. Only one of the segments was coded as ‘no change’, which was a statement about how designing and building medical devices has always been a strict process. This statement alone, can mean that there are not many added complications for makers that have been involved in this process prior to the pandemic, but makers who are new to this process should gain a good grasp of it.

**Making Process sub-codes:** In the category of “making process”, all of the coded segments indicate that there have been new complications in the making process in connec-

tion with the pandemic. This is the result of, for example, an added sanitization step to the beginning and the end of the making process. For some specific projects, more complications are added to this procedure. In total, there were 20 coded segments that represented added complications in the making process. We also coded seven mentions of projects that makers should avoid (despite the increased need for them).

**Resources sub-codes:** Out of the 25 codes related to resources, 22 show us an increase in complication in terms of resources required. This includes the products required for sanitization of different components and parts, the 3D printers, and other equipment. The remaining three are information related to the settings of individual printers such as the flow rate of the filament and the temperature of the print head, which is not a change in resources and users should have always been tuning them to achieve the optimum build quality.

**Time sub-codes:** Regarding the aspect of “time”, there were six coded segments all of which point to time-based complications. These were mostly in connection with the need for the isolation of devices upon receipt by the user and the added time required/suggested for makers. Also, another complication is to first make prototypes, test them, and find for them compatible parts before building a larger number of them. Although, this is not specifically as a response to the pandemic, it is considered more crucial under these circumstances as the goal is to pour our energy into initiatives that are impactful to avoid wasting resources, time, and energy.

**Work routine after COVID-19** Over all of the documents in the sample, this coding category was found to apply to 15 coding units, occurring solely in the 6 documents with DID schema MAK1x, which are documents related to the latest information shared by six different makerspaces about their work routines. Among the six makerspaces, all remained open, with four closed for in-person activities and two remained open for in-person activities. These coded segments indicate that the four makerspaces closed for in-person activities used alternative methods for their work routines, such as curbside pickup and online gatherings. The two makerspaces that remained open, had limited hours and capacity, the requirement of advanced booking, and mandatory masks.

## 4.2.5 Analysis for Q2b: Change in Demand for AT

**Q2b:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) affected the demand for AT?

As noted in section 3.4.3.5, our approach for answering this question consists of both qualitative and quantitative analysis.

**Q2b Code Set** The coding system that we have developed for this question consists of four main categories. These categories are applied to the **Q2b Document Set** which consists of “List of devices requested on MMC forums” (DID schema: **MMC6x**, six documents) and “MMC COVID-19 resources” (DID schema: **MMC7x**, with only one document, **MMC7a**). As discussed earlier, the coding related to “MMC advertisement documents” re-uses some of the coding from Q1a. As explained in section 4.2.4, the sub-codes of “Knowledge”, “Time”, “Making”, and “Resources” have a total of 90 excerpts and appear in document with DID **MMC7a**. The coding information will not be repeated in this section and is available in section 4.2.4. For the analysis of the other documents in the sample, we will be using the extracted data shown in Table 3.13.

### 4.2.5.1 Quantitative Analysis

As described in section 3.4.3.5, the quantitative analysis will consider two sources of data: design challenges and requests. The analysis is based on the raw data that was collected in phase 2 and was summarized in Table 3.13.

**Design challenges: Transitioning through three states** For this part of the analysis, we considered the data that indicated how community-originating requests fit through the development pipeline. The category of “Design Challenges” on MMC website consists of three subcategories of “Seeking Solutions”, “Solutions in Development”, and “Solutions Seeking Review”. These subcategories correspond to the sequential stages of solving a design challenge: as a single design challenge is progressing, it will move through all of these stages.

We will now discuss what each of these stages mean. When a user needs a particular assistive device, they will first look in the library of available devices. When a user does not find the assistive device they require in the library, they have the option to submit their need as a ‘proposed problem’ and can provide initial ideas. Such ideas will initially be in

“Seeking Solutions” category and will be assigned an initial time-stamp. People can start developing solutions regarding the proposed problem, and, if they do so, the state of the design challenge will be changed from “Seeking Solutions” to “Solutions in Development”. When the solution is complete, it needs to be reviewed by professionals; when this happens, the stage of the design challenge will be changed from “Solutions in Development” to the “Solutions Seeking Review” stage. After being reviewed, the solution bundle can be submitted as one of the assistive devices in the MMC library. The time-stamps of each transition are recorded.

**The Development Pipeline** Each of the stages (“Seeking Solutions”, “Solutions in Development”, and “Solutions Seeking Review”) correspond to a sequence of three different pipeline states for a piece of AT being developed. As described above, the time-stamps of each transition are recorded. We have characterized the state of the pipeline by extracting the data of the number of devices in the pipeline, aggregated on a per-month basis, broken down by pipeline state.

Below, in Figure 4.10, we show a comparison of this monthly data for each pipeline state of the AT pieces found in the “Design Challenges” website area.

By comparing the annual means provided in Table 3.15, we see that there was a larger number of design challenges entering the pipeline in the last year (2021) compared to the previous years. The monthly number of items in “Seeking Solutions” category does not have a specific increase/decrease and has been descending for a number of months and ascending for some others, but by comparing the annual means we see a significant increase in the number of items in this category during the year 2021. The number of items in “Solutions in Development” category have also increased in each year, although, the rate of this increase is lower than “Seeking Solutions” category. Lastly, “Solutions Seeking Review” has been the only category among the design challenges with a decreasing number of items.

An alternative way to examine this data is to derive the monthly mean number of design challenges for each of the time periods before and after the start of the pandemic. To support this analysis, the raw data in Table 3.13 was collapsed into two time periods, shown in Table 3.14. The first time period consists of the months February 2019 - February 2020 (we have set the first month of our calculation to February 2019 which is the date of the first post on MMC forum), and the second time period consists of the months March 2020 to August 2021. From this data, we compared two time periods. Figure 4.11 provides an overview of this.

### Number of AT devices in Development Pipeline, Shown by Pipeline State

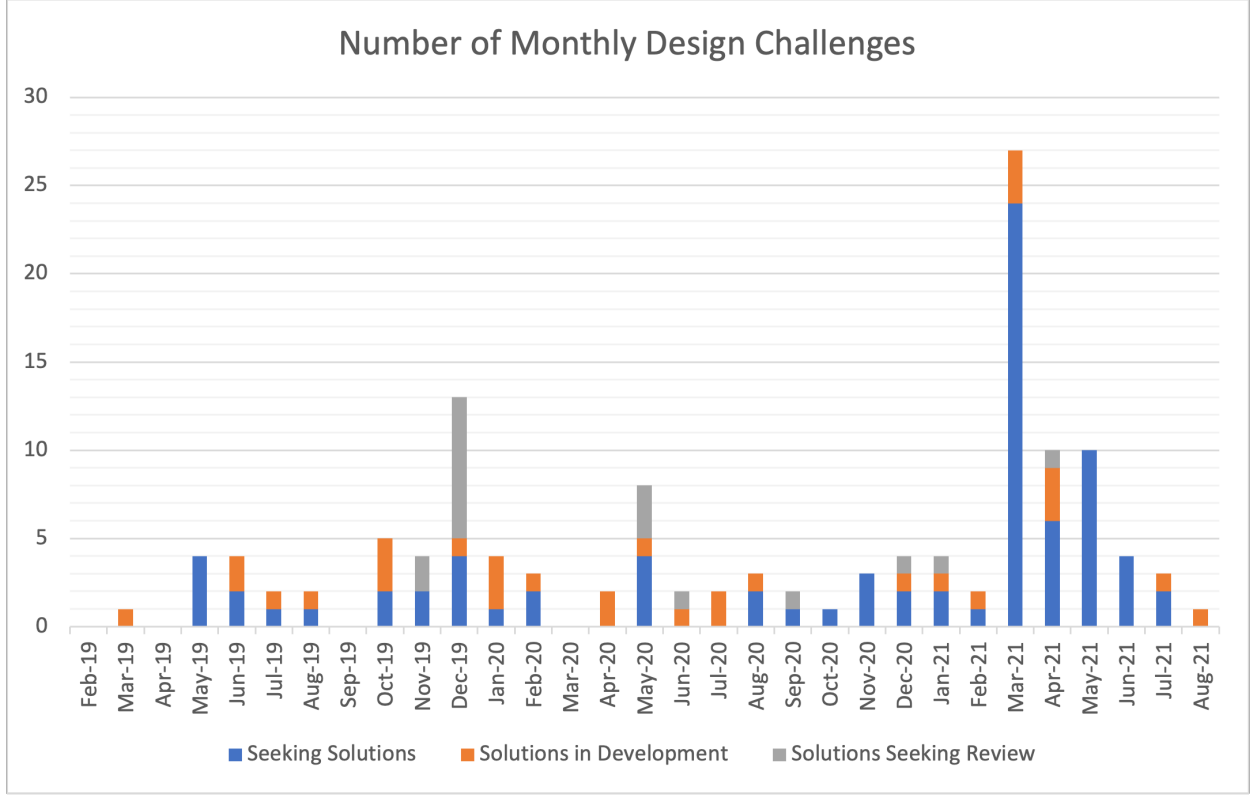


Figure 4.10: Number of AT devices in Development Pipeline, Shown by Pipeline State

By comparing the monthly mean number of design challenges as shown in figure 4.11, we can see a significant increase (135%) in the “Seeking Solutions” category. The average for “Solutions in Development” has remained the same and for “Solutions Seeking Review” this number has decreased (43%).

**Limitations** Another possible approach could be a per-solution analysis in which we record the timestamps of each of the design challenges transitioning into next stages of the development pipeline. We can then calculate the monthly mean of these transitions before and after the start of the pandemic and compare them to gain an understanding of the impacts of the pandemic on the development pipeline of making DIY-AT. We did not undertake this approach in this thesis and it can be addressed in future research (refer to section 5.2).

### Monthly Mean Number of Design Challenges Before & After the Pandemic Start

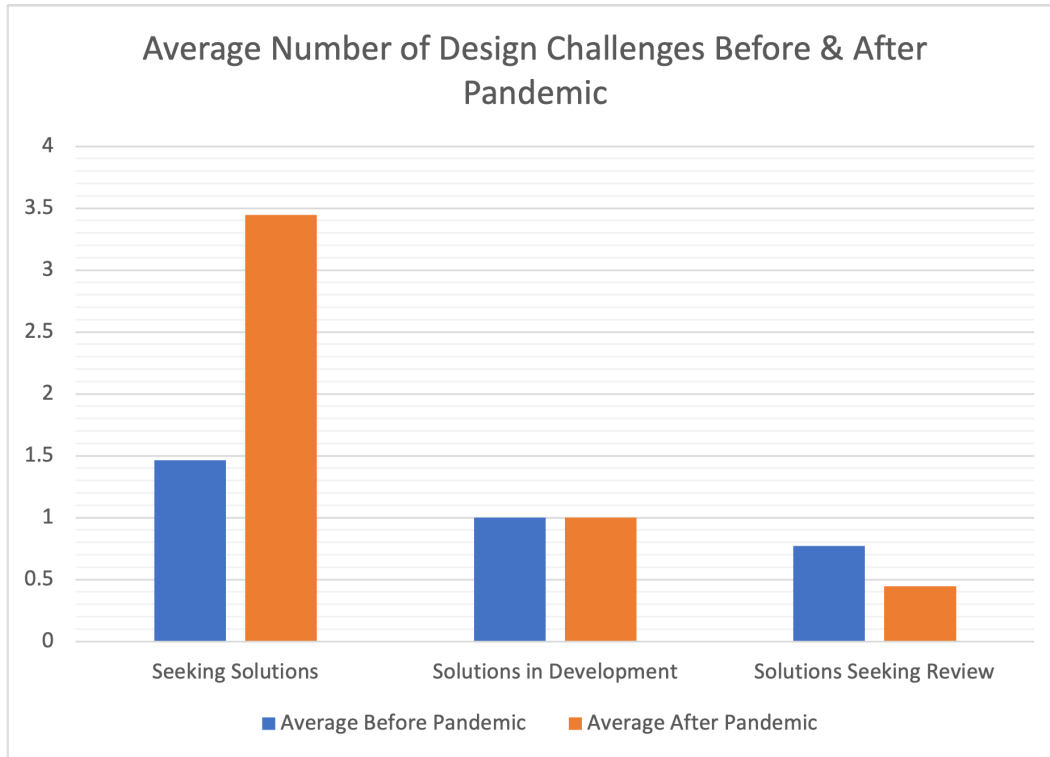


Figure 4.11: Monthly Mean Number of Design Challenges Before & After the Pandemic Start

**Requests: Transitioning through three states** For this part of the analysis, we considered the data that indicated how community members made requests for devices to be made.

The “Requests” data is broken down into the three subcategories of “Maker Wanted”, “Requests in Progress”, and “Archived Requests”. The raw data is provided in Table 3.13. The rate of request fulfillment was calculated and discussed in the analysis for Q1a **Quantity of Assistive Devices** in section 4.2.1 (and therefore will not be repeated). Now, we will use the data to compare the number of requests before and after the start of the pandemic in order to find out its effects on the demand for AT and home makerspaces (HMSs).

**The Requests Pipeline** First, we examine the mean annual number of requests over time provided in Table 3.15. Figure 4.12 shows us the number of monthly requests in each of the subcategories from February 2019 to August 2021. As we get closer to August 2021



in figure 4.12, a higher ratio of initiated requests have remained unfulfilled. For the number of requests in all three categories, we can conclude that there has been a yearly increase from 2019 to 2021. This increase is more obvious in the two categories of “Maker Wanted Category” and “Requests in Progress” based on the information in figure 4.12, but this increase is visible in the mean annual numbers in Table 3.15.

### Number of Monthly Requests in Each Subcategory

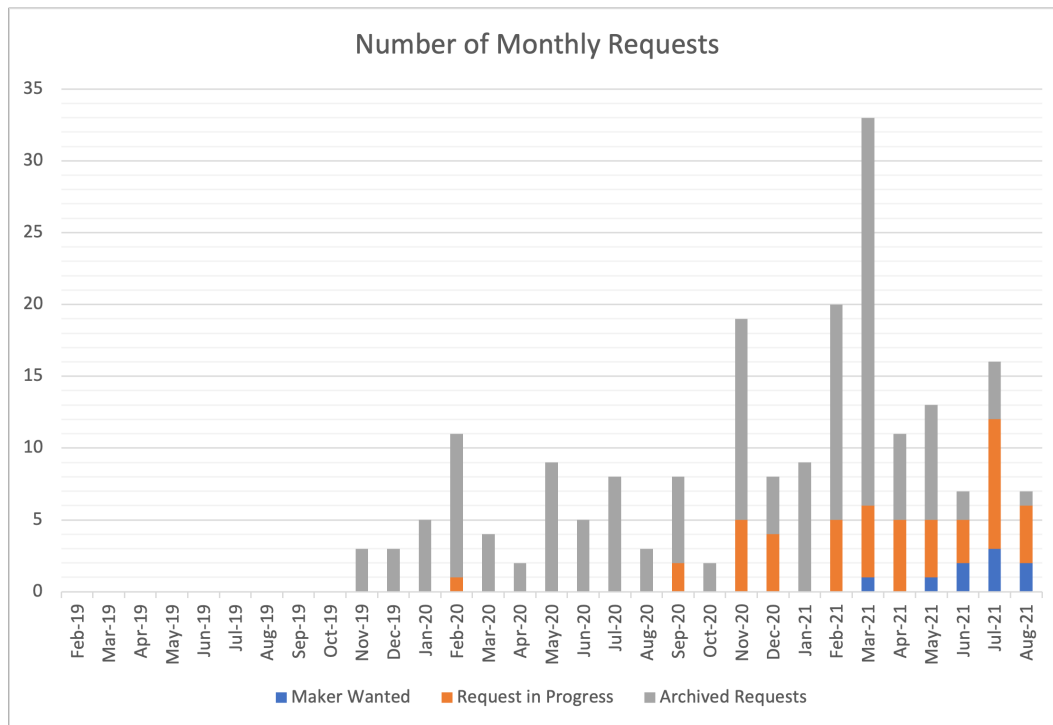


Figure 4.12: Number of Monthly Requests in Each Subcategory

We will now compare the mean monthly number of requests in each category before and after the start of the pandemic provided in Table 3.14. An overview is provided in figure 4.13, which shows a significant increase in the mean monthly number of requests in all three states. The mean monthly number of requests in “Maker Wanted” category from before the pandemic was zero, whereas this number for after pandemic has increased to 0.5. The mean monthly number of requests in “Requests in Progress” state has changed from 0.07 to 2.55 (35.4 times more than before). The “Archived Requests” is the best category for this comparison, as it includes all the fulfilled requests that once existed in the other two subcategories. The average number in “Archived Requests” has changed from 1.6 to 7.1 (3.4 times more than before).

### Mean monthly Number of Requests Before & After the Start of the Pandemic

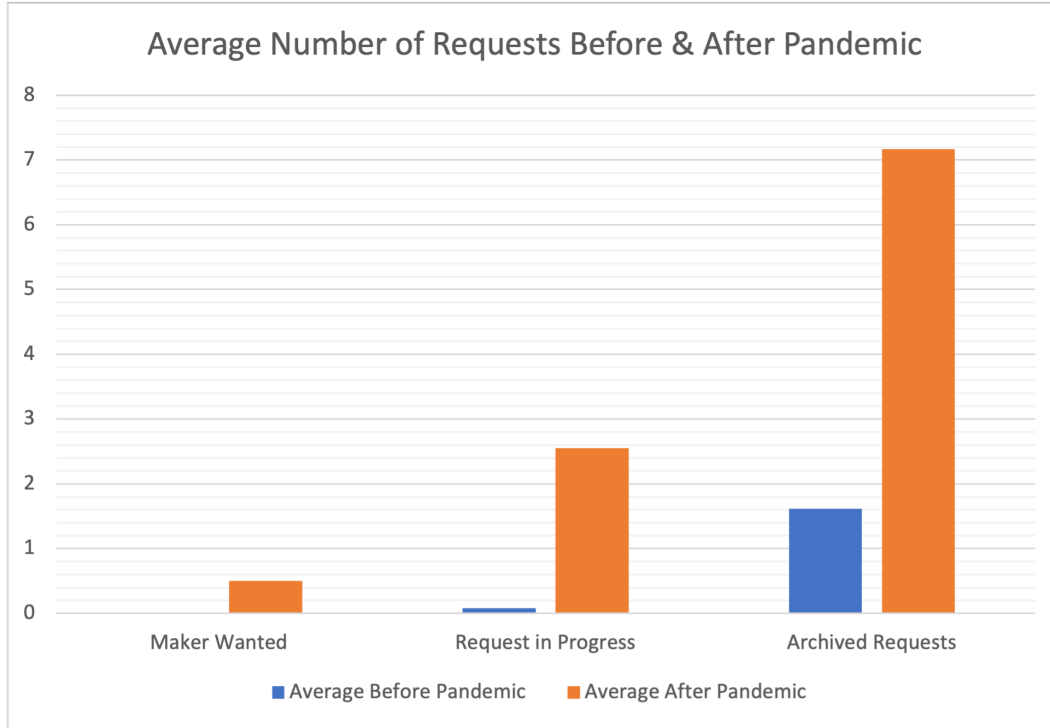


Figure 4.13: Mean monthly number of Requests Before & After the Start of the Pandemic

**Limitations** Another possible approach could be a per-solution analysis in which we record the timestamps of each of the requests transitioning into next stages of the development pipeline. We can then calculate the monthly mean of these transitions before and after the start of the pandemic and compare them to gain an understanding of the impacts of the pandemic on the development pipeline of making DIY-AT. We did not undertake this approach in this thesis and it can be addressed in future research (refer to section 5.2).

## 4.3 Phase 4: Results

In this section, we use our analysis in section 4.2 and discuss what it means and how it provides an answer to each of our research questions.

### 4.3.1 Findings for Q1a: AT Service Delivery

**Q1a:** In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?

The question of assessing AT service delivery/facilitation is complex and nuanced, and we have taken a narrow lens in answering. First, we contextualized AT service delivery/facilitation with respect to MMC’s overall mandate. This serves to provide the organizational context for AT delivery/facilitation. Then, we sought to answer both in terms of the qualitative impact of AT delivery/facilitation at the community level and in terms of a qualitative assessment of pieces of AT themselves (specifically in terms of their adherence or flouting of Design Justice principles). We also sought to examine the number and types of ATs quantitatively. Thus, we answered the question by examining AT delivery/facilitation both qualitatively and quantitatively.

In terms of the contextualization of AT service delivery/facilitation, we found that MMC’s mission is very strongly rooted in AT service delivery/facilitation goals, with dual aspects of **facilitation** (e.g., “*connecting people with disabilities to volunteer makers to build assistive devices*” [MMC1a]) and **delivery** (e.g., “*developing & delivering affordable open source assistive devices*” [MMC1b]). But AT service delivery/facilitation was contextualized within the umbrella goal of **inclusion** (e.g., “*achieving economic and social inclusiveness for all people with disabilities*” [MMC1b]).

#### 4.3.1.1 Quality of MMC Assistive Devices

What has been the impact of AT service delivery/facilitation at the community level, in terms of qualitative impacts? Our analysis shows a positive impact at the community level. There are numerous instances of **positive assertions** from people that have worked with them. This positive feedback, in turn, encourages others to collaborate with MMC, in terms of volunteering and in terms of making assistive devices. Also, potential users can be encouraged by people’s satisfaction with MMC’s work and start requesting the assistive devices that they need from their website.

There are several facets to the volunteerism. For instance, *“The Neil Squire Society works really hard to empower people with disabilities. They put a lot of time and effort into other people’s success.”* -Literacy Program Volunteer [MMC4b] and *“The Neil Squire Foundation [Society] has changed my life! The caring Computer Comfort staff helped me build my confidence and skills enough for me to be able to attend Computer Application classes at Vancouver Community College and volunteer at BCPA once a week.”* -Computer Comfort Participant [MMC4b]. Impact is also shown in the quality of the community of volunteers work (e.g., *“The staff support is absolutely perfect. The moderators are very knowledgeable and understanding. Should we need help they were always there to guide us in the proper direction.”* -Employ-Ability Participant [MMC4b]), and also the nature of the work that this community has been mobilized to do, such as help with events, advertisements, and most importantly making process of assistive devices. Some examples are: *“We are a community of people who leverage, make and support the use of Open Source Assistive Technologies. Our community of active volunteers is for anyone, whether you’re an Open AT Enthusiast, Maker, Disability Professional or someone who thinks what we do is pretty great. Our community has a variety of opportunities for people of all skill levels and backgrounds to participate.”* [MMC4f] and *“Makers Making Change is always looking for volunteers to help us with events, admin support, and tech support. If you are interested in ways you can help beyond making a device, this is where you will find open positions.”* [MMC4h]. But despite the great work volunteers undertake, the issue here is the assumption that volunteers are people without disabilities who are working to provide help to people with disabilities. Among the volunteers themselves, we did not identify any person with disabilities or any signs of MMC encouraging them to participate as volunteers either in events or in the making process of assistive devices. Also, based on our coded excerpts, it is implied that people with disabilities were imagined solely in terms of being the recipients of this program and not its active contributors which is in contradiction to empowering people with disabilities.

Our analysis shows modest quality in terms of uptake of the Design Justice principles in the MMC-facilitated pipeline. One aspect concerns inclusion. The design of many assistive technology devices did not explicitly adopt an anti-oppression lens that Design Justice principles are advocating for. One of the aspects that can lead to perpetuating marginalization is **neglecting the inclusion of people with disabilities** into the design and making process. This relates to disregarding principles that are conducive to a collaborative, community-led design process, that are encouraging of the consideration of the expertise of everyone based on their lived experiences, and that are not restrictive, in terms of seeing the role of the de-

signer as an expert (Design Justice principles one, four, five, six, and eight). This issue is also related to the fact that MMC is specifically designing “for” people with disabilities rather than designing “with” them. This issue is also reflected from one of their goals “*connecting people with disabilities to volunteer makers to build assistive devices*” [MMC1a]. There is no mention here, explicitly signaling that “volunteer makers” refer to people in general and the term is inclusive of people with disabilities as well. Thus, in consideration of the evidence described above, one might conclude that MMC has adopted a stance of designing “for” people with disabilities rather than engaging in design “with” them.

Also in connection to Design Justice principles, the documentation of MMC assistive devices had a lack of attention regarding **sustainability**. Although in many cases, the used material was mentioned, there was a gap related to the preference of choosing sustainable over non-sustainable in the documentations (e.g., *The rod can be made of plastic, wood, or metal* [MMC2o] and *components were printed using PLA plastic* [MMC2au]). These issues are related to Design Justice principles eight and nine. Among the documentation of MMC assistive devices, some instances include references to the devices that already exist and can be used as solutions for particular requests (e.g., “*The project was originally undertaken as part of the TOM Global (Tikkun Olam Makers) Innovation Challenge*” [MMC2by] and “*It was inspired by a post to theATMakers.org page on Facebook asking for a utensil holder that accommodated knives [sic] as well as forks and spoons.*” [MMC2bt]). This is related to Design Justice principle number 10.

Our analysis shows that the other two principles have been incorporated into more of the design solutions as compared to the previously discussed principles. Related to Design Justice principle two, most of the devices are designed directly as a response to requests from people with disabilities and therefore centering their voices and adhering to this principle. Regarding the seventh principle of Design Justice, the knowledge behind making the devices are shared with the community, and the designers’ first priority is the impact of the device on community (e.g., *we consider creating an alternative design if that design would result in a significant cost savings and/or greater customization and personalization.* [MMC2o]).

Thus, considering the above evidence, we can conclude that some of Design Justice principles have been neglected while designing the MMC assistive devices and there are still many possibilities of improvement in terms of incorporating these principles in the process of design and making of AT pieces. However, we encountered a limitation related to our methodology and resources regarding the uptake of the Design Justice principles. Our results are based on the available documentations of these assistive devices and there is a chance

that makers or designers might have taken some of these principles into account but have not reflected them in the documents. This is one of the limitations of our work which can be addressed in further research.

#### **4.3.1.2 Quantity of MMC Assistive Devices**

What has been the impact of AT service delivery/facilitation, in terms of quantitative impacts? Our analysis shows that MMC has had a positive impact in terms of the number of the AT devices they have facilitated to get to the hands of their users. For this aspect, we have considered the ratio of fulfilled requests to the total number of requests. MMC has been able to fulfill around 73% of the initiated requests between Feb 2019 - Aug 2021 (this has been established and explained in section 4.2.1). The rate of request fulfillment is impressive and has a positive impact at the community-level, but some additional aspects should be considered. Many of the initiated requests have been counted as unfulfilled, but they are currently in progress and could be fulfilled in the near future. Initiated requests that do not have any progress yet (at all) constitute only a small part of all unfulfilled requests (16%), and all the unfulfilled requests (whether they have had some progress or no progress at all) have been initiated recently (over the past six months). Therefore, the actual rate of request fulfillment could be higher than 73% (as discussed in section 4.2.1) and it can be determined by examining the same set of ongoing requests after some months to investigate what percentage of them have been ultimately fulfilled. This can be investigated in future research.

#### **4.3.2 Findings for Q1b: Motivating DIY-AT and HMSs**

**Q1b:** In what ways has Makers Making Change (MMC) been successful in motivating DIY-AT and Home Makerspaces?

We sought to answer this question by analyzing it from two main perspectives. First, we sought to contextualize MMC's role in motivating DIY-AT activities by examining their community of makers. Once we realized that continuation of MMC activities (DIY-AT included) is strongly dependent on the funding they receive, we also sought to answer this question in terms of the way MMC has motivated companies/individuals to support them financially.

By studying MMC's community of makers, our analysis revealed the powerful impact of MMC in terms of encouraging people towards DIY-AT activities. Most of the makers were

volunteers, dedicating their free time to designing and making assistive devices while working a full-time job (e.g., *Some devices in our library are designed by our internal engineer team. However, most are created and contributed by community members* [MMC5c]). Our analysis also shows that the makers MMC is attracting consists of people with experience in areas such as (sorted from most common to least common): engineering and science, business and management, design, and medical and disability professionals. Some examples of the credentials of the volunteer makers include *Master’s Degree in Systems and Industrial Engineering* [MMC5c], *Master’s Degree in Special Education with a concentration in Assistive Technology* [MMC5c], *Bachelor of Applied Science with Concentration in Systems* [MMC5a], and *Undergraduate, Electrical and Computer Engineering* [MMC5s].

Our analysis shows that MMC is receiving funding from many well-known organizations. We sought to find the ways MMC is encouraging these organizations to financially support them so that they can continue attracting new members contributing to DIY-AT activities. Our analysis shows that a key way that MMC encourages organizations to provide this funding is by emphasizing their goals: to empower people with disabilities and to achieve economic and social inclusiveness for people with disabilities. This is demonstrated by: *Neil Squire receives funding to empower people with disabilities* [MMC3e] and *Support the growth of an innovative program to help build a community that maximizes accessibility and social inclusion, and make a huge impact on the lives of children and adults with disabilities* [MMC3a]. Another way that MMC makes funding appeals is by emphasizing the value and the advantages of MMC assistive devices in comparison with commercially available ATs, such as affordability, being customizable, and being open-source (e.g., *Our model of releasing it open source will ensure it is an affordable option that can be customized to the specific needs of people with disabilities worldwide* [MMC3c]). MMC also uses other ways to attract funding, one of which is providing them with the results of their work, how they are spending their current funding, and how they have impacted the lives of people with disabilities so far (e.g., *The support of Google.org will enable us to take our LipSync from prototype in our R&D department into the lives of people with disabilities* [MMC3c] and *More than 20,000 Canadians with physical disabilities have benefited from the work of the Society* [MMC3d]). They also mention names of their current funders on their website, which potentially motivates others to financially support them as well (e.g., *It is funded by Google.org, Calgary Foundation, Winnipeg Foundation, Vancouver Foundation, RBC Foundation, Craig H. Neilsen Foundation, and the Government of Canada.* [MMC3a]). Last, MMC offers perks and benefits for their funders, such as featuring the funders events in

all MMC social media channels and mentioning the company’s name and logo in the MMC website (both of which serve to increase community awareness of the funding organization’s philanthropic activities).

Our analysis shows that the funding MMC receives not only sustains their operations, but also is one of the reasons that inspires people to contribute their designs to the MMC assistive devices library (e.g., *As far as I can tell, MMC is the only site devoted to assistive technology that also has a relatively stable funding stream* [MMC5c]).

We can conclude that the way in which MMC has been successful in motivating DIY-AT and Home Makerspaces has been primarily by attracting volunteer local makers in the community and engaging them in the process of making assistive devices.

### 4.3.3 Findings for Q1c: Promotion of Design Justice

**Q1c:** In what ways has Makers Making Change (MMC) been successful in promoting the principles of Design Justice?

We sought to answer this question from two perspectives. The first perspective is to examine the extent to which principles of Design Justice have been integrated into the designs of MMC assistive devices library. The second perspective is much broader, looking at Design Justice Network’s own advocacy of their principles, including the ways in which they encourage other to join them or financially support them. This second perspective gets away looking at Makers Making Change (MMC) as the promoter, in favour of looking at the Design Justice Network as being the promoter.

The first perspective, examining the extent to which principles of Design Justice have been integrated into the designs of MMC assistive devices library, overlaps with the question (Q1a) posed in section 4.3.1 “In what ways has Makers Making Change (MMC) been successful in AT service delivery/facilitation?” as we also discussed the uptake of Design Justice principles into MMC assistive devices for our first research question (Q1a). In the earlier phases of the project, Q1a and Q1c were thought of as more different as questions, but over time, as we probed deeply into Q1a, we found that one effective way to frame the question was by considering ‘success’ in service delivery in terms of close alignment with the promotion of the principles of design justice. Thus, this evolution in Q1a has resulted in an overlap between Q1a and this question, Q1c, and thus in the answers to these two questions. Therefore, we will not repeat the results that are mutual between Q1a and Q1c in this section.



The second perspective looks at the promotion of the principles of Design Justice by the Design Justice Network itself. Our analysis shows the positive impact of Design Justice Network on the community, with more than 2000 members signing on to their principles as of August 2021.

The Design Justice Network invites people/organizations to provide funding for them in two ways: 1) describing their finances and explaining how their funding is currently being spent or will be spent (e.g., *communications work for the Design Justice Network* [DJ2b] and *publication of various zines and literature related to Design Justice* [DJ2b]) 2) explaining their goals and how their practices are meant to challenge structural inequalities (e.g., *supporting, foregrounding and amplifying the voices of marginalized designers and communities* [DJ2d] and *building the design justice movement in local communities* [DJ2d]).

The second way described above — explanation of their goals and how their practices are meant to challenge structural inequalities — is also used as the major way to encourage people to join their network. Design Justice Network also give regular updates about their ongoing work, their advances, and events (e.g., *This workshop explored the question of how to build power and accountability in our organizations using the design justice principles and by engaging with work scenarios drawn from real-life stories. DJN members left having developed strategies and tactics to use in their workplaces, organizations, and communities, around systemic change within these institutions* [DJ1b]). We also identified instances of available perks and benefits Design Justice Network offers to their members such as *invitations to DJN Member Story sharing sessions, and the opportunity for members to lead one themselves* [DJ1b] and *support for local node events, including graphic design, promotion, and organizing #NodesConnect meetings* [DJ1b]. They also encourage people to shop from their store for merchandise and publications. Design Justice Network values transparency regarding their received funding and improving their financial reporting.

In addition to these ways, their fiscal sponsor — Allied Media Projects (AMP) — is also encouraging people to support Design Justice Network by advocating for their goals and principles (e.g., *They [Design Justice Network] are all actively creating the world we need* [DJ2c] and *We believe that uprooting oppressive systems and planting new liberatory ways of being is possible on a global scale through the strategic interconnection of many small-scale efforts* [DJ2c]).

We believe the Design Justice Network principles should be taken into account in design processes, and this requires gaining more publicity surrounding their work, principles, and the potential impacts on the lives of people in marginalized communities. They can coordinate

further events in which they collaborate with organizations working related to design (such as MMC) and incorporate their principles into their actual projects.

#### 4.3.4 Findings for Q2a: Access Barriers

**Q2a:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) impacted disabled people?

As a result of our analysis for this question (discussed in section 4.2.4), we have considered two aspects in answering it. First, we investigated direct impacts of shift to WFH activities on the lives of people with disabilities. Then, given our focus on DIY-AT and its important role in the lives of people with disabilities, we investigated the impact of the shift to WFH on DIY-AT activities. Regarding the latter aspect, we sought to answer this question both in terms of the challenges regarding the making process of DIY-AT devices and in terms of the changes in work routine of makerspaces, which is the home of many DIY-AT activities.

##### 4.3.4.1 Impact on Lives

To investigate the direct impacts of the shift to WFH activities on the lives of people with disabilities, we focused on scholarly articles that discussed the challenges people with disabilities have been facing during the pandemic. This change from in-person activities to work-from-home has been challenging for people with disabilities in the five aspects which we will now discuss. The first major aspect concerns the **social complications** of staying at or working from home which includes both the effects of the pandemic on social lives and the challenges arising from the pandemic due to their required social support from people outside of their own household such as caregivers. Some examples of this aspect include *containment measures, such as social distancing and self-isolation, may be impossible for those who rely on the support of others to eat, dress and bathe* [PAN1d] and *increased caregiving burden and heightened challenges with child behaviour in families of children with intellectual disability disorder* [PAN1b]. The second aspect that our analysis discovered is the **mental aspects** which is related to their mental health and/or the challenges they face due to mental disabilities. Our examples of such issues include *elevate the worry and anxiety in people with developmental disabilities and lead to a relapse of mental illness or the display of behaviors that challenge* [PAN1c] and *quarantine is likely to be difficult for people with intellectual*

disabilities to tolerate and compounded by not understanding its importance and the implications of not adhering to restrictions [PAN1a]. The **physical complications** come next and are related to physical health problems caused by the pandemic in addition to the problems people face due to physical disabilities. Some of these instances we identified are *Persons with disabilities (PWDs) living in cities during the COVID-19 pandemic response maybe four times more likely to be injured or die than non-disabled person* [PAN1d] and *COVID-19 can place PWDs at a higher risk of infection since some may already have compromised immune and respiratory systems and policy responses* [PAN1d]. Next, is the **financial complications** that people with disabilities have been facing (e.g., *costs of home deliveries and/or hiring of private support due to the suspension of public services* [PAN1d] and *families most commonly reported economic concerns about the pandemic* [PAN1b]). The final aspect is the hardships in accessing necessary **equipment** such as proper housing facilities, access to personal protective equipment, or other daily living requirements (e.g., *not everyone with ID has access to technology and elderly carers may not be skilled in using it thus creating a barrier to their family members receiving direct care* [PAN1a] and *PWDs must be supported to meet their daily living requirements, including access to food* [PAN1d]). Although some of these challenges may exist for everyone, the severity and risks are higher for people with disabilities.

#### 4.3.4.2 Impact on DIY-AT Making

What have been the effects of shift to work-from-home on the process of getting DIY-AT devices into the hands of their users? Our analysis shows that this shift has caused difficulties in four main aspects of knowledge, making process, resources, and time. First, due to the added complications regarding the aspect of **knowledge**, makers need to do a thorough research and expand their knowledge before starting to build. This helps makers in terms of the added steps in the making process such as sanitation or being aware of the projects to avoid (e.g., *Connect with local hospitals or agencies to ensure there is a need and they have way to integrate the devices into their supply chain* [MMC7a], *Do not use alcohol. Alcohol can dissolve the filament used in the build* [MMC7a], and *In cases of more immediate deployment use hydrogen peroxide to disinfect as long as the part will not have exposure to internal parts of the body* [MMC7a]). Second, the **making process** itself has become more complicated due to the necessity in following the additional COVID-19 guidance. Some examples of this complications that we identified are *Clean your 3D printer before beginning* [MMC7a] and *Remain sterile through the manufacturing, packaging and delivery process* [MMC7a].

Next, there are also additional **resources** that makers need to be able to fulfill COVID-19 regulatory requirements. Many of these resources are related to sanitization products used for different materials. Some of which include *Gamma radiation* [MMC7a], *Ethanol* [MMC7a], and *Sodium Hypochlorite* [MMC7a]. Lastly, regarding the aspect of time, we identified complications both in terms of extra time needed to complete a build, find compatible parts, and urgency of the matter (e.g., *To prevent wasting a lot of time, or building a large number of unusable parts we recommend starting your projects with an initial test prototype using the desired material and then conducting a test fit to make sure serviceable devices or parts are delivered after the final production* [MMC7a], *Leave the builds for 2 to 3 days in order for the half life of the virus to expire* [MMC7a], and *Difficult decisions may have to be made to address pressing and immediate needs* [MMC7a]). As a result of all the previously mentioned complications that are added to the process, people with disabilities may face a delay in receiving the assistive devices they need. These complications can potentially discourage some of the makers from getting involved in DIY-At activities.

How has the shift to work-from-home affected makerspaces work routine and therefore DIY-At activities? Our analysis shows that this shift has caused closure for in-person activities in many of the more local makerspaces or the ones in rural areas. Although these makerspaces held online gatherings to keep the community in touch or offered curbside pickup for specific tools, it could still be problematic for some people to access what they need in a makerspace. Some of the makerspaces in cities managed to remain open with restrictions such as limited capacity, limited hours, and advance booking. With many makerspaces closed for in-person activities, people that relied on these facilities for their making activities can no longer continue their work. This will also cause an obstacle for people who build assistive devices in makerspaces. With them not being able to continue their work, people in need of those assistive technologies will be deprived of them.

### 4.3.5 Findings for Q2b: Change in Demand for AT

**Q2b:** How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities (as necessitated by the COVID-19 pandemic) affected the demand for AT?

The question of assessing the change in the demand for AT due to the pandemic restrictions is broad and ambiguous, when considered globally. Therefore, given our focus on MMC, we sought to answer the question more specifically by investigating the number of

requests the MMC community has received with the timeline of before and after the start of the pandemic. These include both the orders for devices that people need and that are already available on their website (referred to as “Requests”) and the orders for devices that people need, but are not yet available (referred to as “Design Challenges”).

**How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities affected the quantity of MMC “Design Challenges”?** Our analysis from section 4.2.5 demonstrated a significant increase (135%) in the number of submitted ideas which are still waiting for solutions, whereas, the number of ideas that have a solution in development has remained the same. We also identified a 43% decrease in the number of ideas with a solution waiting to be reviewed. These changes can be seen as indicating an increase in the need for the devices that users need, but are not available on MMC assistive devices library, although many of them are still awaiting a response. This may also be a sign of less activity by MMC, as many new ideas/needs were generated but have not been addressed since the pandemic.

**How has the shift from in-person activities to stay-at-home (SAH) and/or work-from-home (WFH) activities affected the quantity of MMC “Requests”?** Our analysis from section 4.2.5 demonstrated an increase in requests that are seeking makers (“Maker Wanted” category), an increase in requests that are in the process of being made (“Requests in Progress”), and an increase fulfilled requests (“Archived Requests”).

We feel the increase in fulfilled (Archived) requests is the most reliable, in comparison to the other increases. The “Maker Wanted” and “Requests in Progress” categories only show the number of currently remaining requests, and this number decreases as each of the entries transition to the next stage of the development pipeline.

Given the complexity of this question, it is noteworthy to mention that our current information regarding “Design Challenges” and “Requests” is not enough to come to an exact conclusion and more information can assist us in answering this question. There are other variables that can be considered in the timeline of before & after the pandemic start to resolve some of the ambiguities. This is discussed in section 5.2.

Based on the information we had, the analysis we undertook, and the increase in total number of requests after the start of the pandemic, we believe not only the demand in AT has increased, but MMC has also become more active and is adding more devices to its library everyday.

### 4.3.6 Implication of Results to the Discipline

There are a number of implications of our results that can be applied to the discipline or be of use for the stakeholders. Here we discuss some of them and leave more for the future work.

Due to our focus on MMC and their DIY-AT pipeline, first we would like to discuss the implications related to their workflow. We believe that MMC should build a platform into their website — in addition to their forum — through which people and makers can communicate better and to provide a way for the recipients of the designs for their voices to be directly foregrounded at that point. Another idea is related to the idea of “who can be a maker?” and MMC needs to explicitly mention that there are disabled makers in our communities who have special expertise that come from their lived experiences in order to more strongly center their voices. As right now, there is the implication (although not explicitly mentioned) that makers are not people with disabilities and “abled” makers are the ones to undertake the building of assistive technologies. We also encourage that they hold events as a means to motivate more people with disabilities to become makers themselves and provide them with the sufficient information, resources, and help if needed. Another suggestion surrounding MMC’s work would be for them to go through the body of knowledge around existing assistive technologies such as different forums, GitHub, or Thingiverse and to gather this information, credit the creators and include the devices on their website so that it is more easily available to people.

Another implication could be an additional source of evidence that this research projects has provided for the third paradigm HCI and the situated knowledge approach. Harrison, Sengers, and Tatar [30] approach this through the issue of inadequacy of the user as the information processor metaphor, but this project points out the need for situated perspective from a different point of view, the inadequacy of the process, in which the principles are centered and the voices get heard. This source of evidence is focused towards using a “process lens” as opposed to a “structural lens”.

# Chapter 5

## Conclusion and Future Work

### 5.1 Conclusion

In the first chapter of this project, we gave a brief review of the preliminary concepts related to our project, which included making and makerspaces, assistive technology (AT), and Do-It-Yourself assistive technology (DIY-AT). We described Makers Making Change as a platform for facilitating the making of assistive devices and for connecting makers and people with disabilities with one another. We introduced the Design Justice Network, which is a community committed to rethinking design processes and challenging structural inequalities. The Design Justice Network operates according to a set of principles, which we described and which we used as a foundational element of this research project. Next, we described the five research questions we were seeking to answer. Our first three questions examined the success of MMC regarding three specific aspects of “AT service delivery/facilitation”, “motivating DIY-AT and HMSs”, and “promoting Design Justice”. The other two questions investigated the impact of COVID-19 pandemic and the shift to work-from-home on people with disabilities and the demand for assistive technologies (and DIY-AT). These questions are relevant to HCI, as the discipline strives to evolve towards participatory models of digital technology design and to develop effective approaches toward AT design and the urge to conduct such studies has been acknowledged in the third paradigm.

In chapter 2, we dove deeper into each of our preliminary concepts and explored the relevant bodies of research literature in each of those areas. We discussed what constitutes a makerspace, the different types of makerspaces, and the characteristics related to each of these types. We synthesized the research literature about the users and the stakeholders of makerspaces, alongside the activities undertaken in makerspaces and the various types of

makerspace outcomes (in terms of products and creations). We described the typical lifecycle of a makerspace, and the challenges of creating, maintaining, and sustaining them. Next, we reviewed two approaches to defining assistive technology (AT), discussed some AT examples, the barriers related to adoption of assistive devices into the lives of their users, and the unmet global need for assistive technologies. Related to Do-It-Yourself assistive technology (DIY-AT), we presented some of the platforms and service providers in this domain of practice and provided a synthesis of the previous literature on DIY-AT devices, challenges of the process, and advantages of DIY-AT in comparison to AT. We chose Makers Making Change (MMC) as one of the community platforms for DIY-ATs, to be used in our case study, and described some of their well-known assistive devices. Lastly, we talked about Design Justice Network, their guiding principles, and our rationale for choosing this as our framework in this project.

We used a four-phase Qualitative Document Analysis (QDA) as our methodology and explained how it can be used to answer our research questions. For the first phase of our methodology, we identified the documents that could assist us in answering the questions, gathered them and assigned unique identifiers to them. This resulted in a corpus consisting of 171 documents in the forms of webpages, scholarly articles, and other types of documents. In the second phase of our analysis, we selected our document analysis tool, Dedoose, and examined the documents thoroughly and iteratively developed and applied a set of codes to the document set.

In the third phase of our document analysis study, we focused on comparing and contrasting the extremes and differences of the code application and reviewed the occurrences of our codes in the documents alongside visualizing them. Lastly, we used our analysis to discuss how the data provides answers to our research questions. For the first research question — MMC’s success regarding the aspect of “AT service delivery/facilitation” — our findings showed a positive impact at the community level. In response to the second question, we concluded that the way in which MMC has been successful in motivating DIY-AT and Home Makerspaces has been primarily by attracting volunteer local makers in the community. For the third question, we concluded that MMC has done only a modest job regarding the promotion of Design Justice and there are potentials to incorporate Design Justice principles into MMC’s DIY-AT products in the future. Our findings for the fourth question included the social, mental, physical, and financial challenges of people with disabilities caused by the COVID-19 pandemic and the shift to work-from-home. Lastly, our findings included a higher demand for assistive technologies after the start of the pandemic compared to before pandemic, and we also identified the added challenges to the process of making DIY-AT



devices such as added complications related to knowledge, time, and resources.

## 5.2 Future Work and Limitations

In this project, we set out and answered a set of 5 research questions, and the project raised additional questions for future exploration. Here, we discuss the future directions other researchers could take in this research area, as well as the limitations of our work.

**Uptake of Design Justice Principles** We discussed the success of MMC assistive devices in terms of their adherence or flouting of Design Justice principles based on the provided solutions. But a document-based study of these devices implements a specific scope to our analysis. We did not consider the possibility that designers have taken these principles into account beyond the scope of those documents. For further research, we can interview MMC designers and/or makers to gain a better understanding of their thought process and priorities while designing the assistive devices. We can also benefit from their perspective towards incorporation of Design Justice principles into their work.

**Other Criteria for Success Evaluation** In our research, we investigated the quality of MMC’s assistive with respect to incorporation of design justice principles. The success of MMC assistive devices can also be evaluated using other criteria such as, the quality of the devices based on users’ feedback, operational aspects, such as the average time it takes to fulfill a request, and the percentage of funding dollars spent on program delivery as opposed to the overhead. In further research, the feedback from users can be obtained by conducting interviews for users, their caregivers or families, the fulfillment time for a request can be done with a per-solution analysis, and the spent funding can be gathered from governmental documents.

**Additional Information on Fulfilling Requests** Another limitation of work was related to determining MMC’s rate of fulfilling requests. Given the complexity of the matter and with our current information, we cannot determine the exact rate of request fulfillment, and there are other important variables that need to be taken into account in the timeline of before and after the start of the pandemic. Some of these variables include the number of active volunteer makers in MMC community, the time makers dedicate to building AT, the transition time from one stage to the next one, and the degree of MMC’s recognition by

people. These did not fall within the scope of this project and could be addressed in future research.

There are a number of approaches that could be taken in a further request fulfillment investigations. For example, by monitoring the stage for each of the active entries, we can find out which of the requests will eventually be fulfilled and this will change the fulfillment rate we have calculated in our analysis. Or, in another example, depending on the change in transition time, we can decide whether the increase in “Maker Wanted” and “Request in Progress” is indicating less activity by MMC or an actual higher demand. By knowing the number of makers working on each category, we can decide whether the increase in “Maker Wanted” category is a result of makers being occupied with many “Requests in Progress” and that this number will decrease in the future (due to older requests being fulfilled and the newer ones being in progress). Another approach related to the fulfillment rate of requests and design challenges could be a per-solution analysis. In this approach, we could monitor the state of each of the entries in design challenges and requests. We could record the time these entries have entered each of the stages in the development pipeline and calculate the time it takes to transition from one stage to the other. We could then calculate the monthly mean of these transitions before and after the start of the pandemic. By comparing these values, we could then come to a more reliable conclusion regarding the impact of the pandemic on the demand for AT (and DIY-AT) and the development pipeline of its making.

**Methodological Limitations** Some limitations of our work were related to our choice of methodology, Qualitative Document Analysis. The process of gathering the corpus is thoroughly dependent on the researchers and it is their decision to stop the search for and gathering of the documents. Our current corpus of documents has provided data on the context of our research question and assisted us in seeking the answers. However, there could still be additional documents (that were not uncovered by our process) that speak to our research questions and shed light on uncertain parts of our answers. Another limitation of our work was assessing the inter-coder reliability of our project. Our research question and the approach we undertook to answer them were complex and nuanced, therefore, the process of familiarizing a new researcher with this process would be time-consuming and complicated. Therefore, we did not undertake the assessment of inter-coder reliability which can be addressed further on in the process.

**Inequality of Access** By analysing the whole workflow of Makers Making Change and getting more familiar with the process of making, its participants and recipients, we realized that the assumption is the existence of an already built community of makers. Although that is true about the community of MMC makers, there could still be many other potential makers from diverse backgrounds in the communities who are not being encouraged to become makers or that they do not have access to the required resources. For example, the access to resources and materials for an older woman in a third-world country such as my grandmother could be much more limited compared to a man in Northern America. This problem can result in the negligence of many creative and innovative ideas in the realm of making. We would like to acknowledge that the issue of inequality of access to means for making — material and knowledge — exists and is of great importance, but was unfortunately outside the scope of this projects and therefore, was not coded and addressed here specifically.

**Further Implications** In section 4.3.6, we discussed a number of implications of results to Makers Making Change and to the discipline of HCI. Here, we would like to address the fact that there are remaining implications that were not addressed in this project in detail.

The analysis performed in this project was specifically related to the design of assistive technologies. The chosen framework, Design Justice Principles, on the other hand is related to all design processes in general. The result of our project can help design practitioners modify this framework in order to better fit their specific areas of design. Design Justice Network can also plan and run workshops to help enthusiasts with incorporating their principles into actual projects in the industry or academia.

Lastly, the results discussed in 4.3, point out the power imbalance in the world of making, the Makers Making Change organization, and design processes. We would like to acknowledge these issues and state that further analysis and a different coding lens is required in order to identify the instances of the power manifest and provide possible solutions.

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