A CRITICAL, EMPIRICAL, AND REFLEXIVE INVESTIGATION OF HCI'S PROMISE OF DEMOCRATIZATION IN THE MAKING PHENOMENON

by

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ABSTRACT

JOHANNA OKERLUND. A Critical, Empirical, and Reflexive Investigation of HCI's Promise of Democratization in the Making Phenomenon. (Under the direction of DR. DAVID WILSON)

Many endeavors in the field of Human-Computer Interaction (HCI) align themselves with the promise of the democratization of technology production, a promise that has yet to be fulfilled due to gaps in access and underlying power dynamics. HCI has recently seen new glimmers of the promise of democratized technology production in the making phenomenon. In this dissertation, I present a normative theory project grounded in my experience of starting and running a university makerspace that engages with the concept of democratization directly. To construct and develop the Normative Theory of Human-Centered Making (NTHCM), I derived a definition of democratization, developed an argument for a shift in values to better meet that definition, and conducted a series of empirical studies to understand how the theory relates to practice. I then used feminist utopianism as a definition of democratization to evaluate the theory and reflect more broadly on the merits and challenges of this theory in light of HCI's promise of democratization.

Overall, I found that while the NTHCM is grounded in a definition of democratization and grounded in relation to maker practices, it does not guide towards or capture democratization to a sufficient extent, nor does it relate directly enough to maker practices to shed light on how to shift them. However, it is useful nonetheless as a reflective lens for makers, makerspace leaders, and HCI researchers on maker practices and contexts. I also found that feminist utopianism, the construct I had planned to measure the NTHCM against, has merit as an alternate way of pursuing some of the same goals as the NTHCM. I reflect on the similarities and differences between the NTHCM and feminist utopianism and discuss how underlying assumptions I had made while developing the NTHCM may have gotten in the way of its ability

to relate to maker practice or to fulfill the promise of democratization. Contributions include insights about the merits of the NTHCM as a reflective lens for maker leaders and HCI researchers, insights about the merits of feminist utopianism to guide maker leaders and HCI researchers towards the promise of democratization, and insights about underlying assumptions of HCI endeavors that may be in the way of fulfilling the promise of democratization.

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LIST OF ABBREVIATIONS

CMC Computer-mediated communications

DIS Designing Interactive Systems conference

DIY Do-it-yourself

DIY-AT Do-it-yourself assistive technology

HCD Human-Centered Design

HCI Human-Computer Interaction

HHP Helping Hand Project

IoT Internet of Things

PD Participatory Design

STS Science and Technology Studies

CHAPTER 1: INTRODUCTION

New technologies and innovations are often introduced with optimistic narratives. Many of these either explicitly or implicitly cite the promise of democratization: The Internet, for example, promised to promote increased dialogue [145], provide a place where everyone was considered an equal [184], and enable citizens to be more informed [109]. For various reasons, these narratives are being called into question. We see that discourse on the Internet is polarized and radicalized [55], the data that was collected for the purpose of customization are being sold to advertisers for micro-targeting [193] and are being used to reinvent racist forms of surveillance [37]. Additionally, we are seeing that even explicit democratizing efforts are not reaching everyone in society [10, 89, 185]. While technologies are certainly capable of influencing social and political arrangements [190], critics point out how the general assumption that the technology itself will drive social change is incorrect [10, 88, 138].

The field of Human-Computer Interaction (HCI) and neighboring fields that study and design interactive systems often cite or claim to be pursuing the promise of democratization, particularly the democratization of technology production [16]. Some of the ways HCI research and design aligns with this promise includes involving end users or previously forgotten populations in the design process and celebrating or supporting instances of end user empowerment [124].

However, none of these HCI endeavors have lived up to this promise of democratization. Researchers have pointed out ways even the most noble Participatory Design efforts do not escape various biases of the leaders [14, 20], how difficult it is to truly design with people of different cultural backgrounds [152, 176], how easy and problematic it is to impose a Western definition of progress as though it were universal

[157], and how HCI research often takes an a-political approach to political problems such as democratization [73, 124, 163].

A recent version of the democratization narrative in HCI research emphasizes a renewal of democratic ideals embodied in the activities of makers, makerspaces, hackerspaces, and other related aspects of the making phenomenon [16]. HCI rhetoric typically portrays users as helpless and frustrated until they are saved and empowered by HCI-designed systems [51]. The emergence of makers affords HCI researchers new opportunities to spread empowerment by spreading *maker* empowerment: designing tools and supporting the maker phenomenon to turn more users into makers. Makers are also celebrated in HCI research due to their material engagement and technological outputs. We might recognize many of the artifacts coming out of makerspaces as devices we would see in HCI-related conferences such as CHI or UIST [125]. This means that makers are different from the typical users that HCI research studies because the already empowered makers are able to make the same types of artifacts for themselves [163]. In some ways, the making phenomenon embodies the vision of democratized technological production that HCI imagines creating [16].

However, this promise of democratization in HCI through the making phenomenon has also fallen short due to systemic barriers that prevent many from participating, incorrect assumptions about technology's ability to solve social problems, the imposition of narrow definitions of progress, and the avoidance of looking into the political aspects of making [16, 163]. Thus, the question this dissertation asks is about HCI's promise of the democratization of technology production: What does it look like to truly pursue this goal? Why is it so difficult? What needs to change for HCI research to make commendable progress towards this goal?

To shed light on these questions, I describe a theory project that is grounded in my experience of starting and running a university makerspace as well as leading several other maker-related contexts. Throughout this theory project and in the context of

leading various makerspace contexts, I directly confronted the topic of democratization relative to the making phenomenon, considered different ways that local making endeavors did or did not align with the promise, and uncovered tensions I felt as a leader of various making contexts attempting to align local efforts with those broad goals. The questions and decisions I faced as a makerspace leader are analogous to questions HCI faces in general, which makes this experience as a makerspace leader an appropriate object of study to shed light on the broader questions about democratization in HCI.

1.1 Thesis Statement, Research Questions, and Contributions

This dissertation documents a project that aimed to develop a normative theory that would guide makers and maker leaders on how to shape their efforts toward the broader goal of democratization. The overarching question this project aims to shed light on is about HCI's promise of democratizing the production of technology:

> Overarching Research Question: What does it look like for HCI researchers to pursue the promise of democratization? Why is it so difficult? What needs to change for HCI to make progress towards this goal?

This is a broad question and is difficult to answer directly. I thus focus on a similar question in the context of the making phenomenon:

> What does it look like for HCI researchers to pursue the promise of democratization in the context of the making phenomenon? What is in the way of that promise being fulfilled?

This still a broad question and difficult to answer directly. To answer it, I focus specifically on the practice of making and makerspace leadership, engaging with the promise of democratization directly and investigating what it means to try to pursue it:

> Specific Research Question: What should makers and makerspace leaders do or think about to better align their efforts with the promise of democratization?

To answer this question, I describe a theory project that was grounded in and informed by my experience of starting and running a university makerspace, as well as several other maker-related contexts. The goal of the project was to develop a normative theory, which I call the Normative Theory of Human-Centered Making (NTHCM), that would guide makers and maker leaders on how to shape their efforts toward the broader goal of democratization. Figure 1.1 illustrates the different levels these research questions live at, with each narrower and more specific. The theoretical and empirical investigations of this dissertation primarily live at the lowest level, focusing directly on the making phenomenon, and secondarily at the second level, drawing upon HCI research periodically to answer that question. Figures 1.2 and 1.3 further illustrate the difference between the two lowest levels of the triangle. In order to answer questions about HCI's promise of democratization in the making phenomenon, I first needed to understand how to pursue that goal from within the making phenomenon itself. Several chapters of the dissertation focus primarily on this question and the immediate relevance of the findings is limited for HCI more broadly. However, the aggregate insights from these findings about democratization as it applies to makerspace leaders allow for broader reflection on HCI's pursuit of democratization. This discussion culminates in the discussion chapter (Chapter 8).

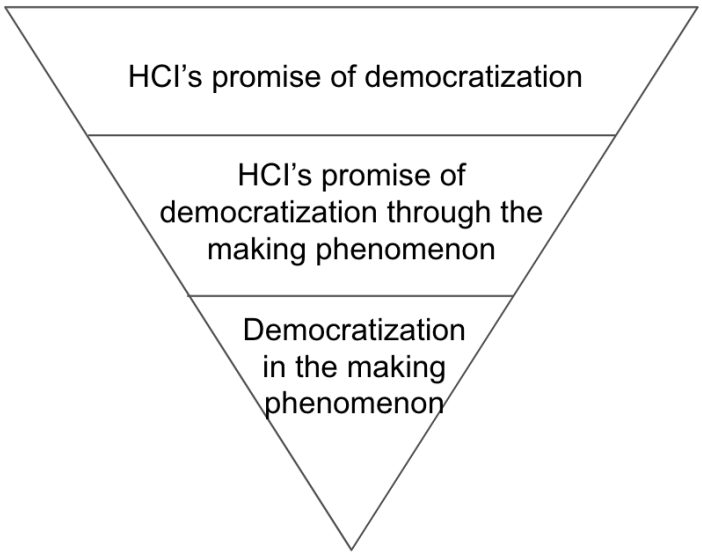


Figure 1.1: Levels of Research Questions

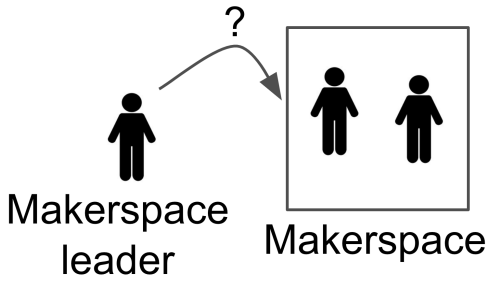


Figure 1.2: Focusing on what makerspace leaders should do towards the promise of democratization in the making phenomenon

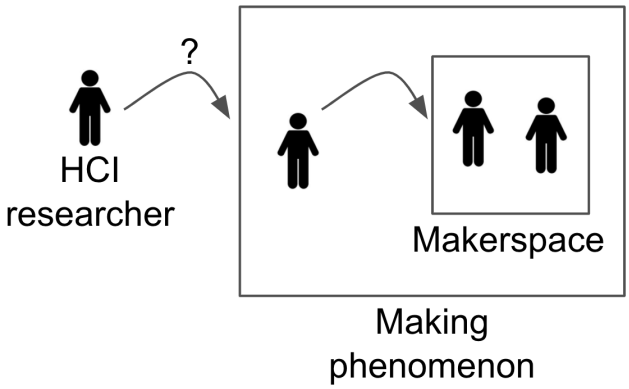


Figure 1.3: Using insights about what makerspace leaders should do towards the promise of democratization in the making phenomenon to shed light on implications for HCI

The hypothesis that drove the normative theory project was as follows:

> Driving Hypothesis: The NTHCM, which calls for a shift in the values of the making phenomenon to more closely resemble the values present in HCI research and design endeavors, is theoretically grounded, relates to existing maker practices and contexts, and there is reason to believe that adopting the theory will bring the making phenomenon closer to the promise of democratization.

This hypothesis drove the work I present in Chapter 3, where I construct the theory, Chapters 4-6, where I develop the theory based on empirical investigations of maker practice, and Chapter 7, where I evaluate the theory relative to the promise of democratization.

Ultimately, I conclude that this hypothesis is not the best answer to the research question. I show that while the NTHCM is helpful in some ways, for example, as a reflective lens that can shed light on the extent to which various maker contexts and activities align with different narratives of making, it neither fully captures the concept of democratization, nor does it relate directly enough to the practice of making or maker leadership. In the process of determining the extent to which the NTHCM shows promise for aligning local maker efforts with the broad promise of democratization, I considered feminist utopianism as a particular definition of democratization. During this process, it became clear that feminist utopianism was less suited as an evaluative measure of the NTHCM and better suited for consideration as a fellow traveler. I then discuss the similarities and differences in approach between the NTHCM and feminist utopianism, shedding light on some of the underlying assumptions I had made when developing the NTHCM that limited the extent to which it could contribute to guiding endeavors toward fulfilling making's promise of democratization. I reflect on those differences in light of HCI's pursuit of democratization through re-

search and design efforts related to the making phenomenon, which is where I provide support for the thesis of this dissertation.

> Thesis Statement: HCI endeavors that pursue the promise of democratization through research and design efforts related to the making phenomenon require moving beyond several underlying assumptions of typical HCI practice: assumptions about how the endeavor will scale, assumptions about HCI's role in driving the effort, and assumptions about how theory and praxis relate.

The primary contributions of the dissertation are the following:

- I introduced the idea of Human-Centered Making and developed the Normative Theory of Human-Centered Making. I used literature to derive and ground the definition of the theory and empirical studies to develop an understanding of how it manifests in the making phenomenon and the merits it offers for makers, makerspace leaders, and researchers.
- I use the results of an empirical study and a reflective analysis to discuss the merits of feminist utopianism as a definition of democratization for the making phenomenon and a guiding construct for makerspace leaders.
- I reflect on the underlying assumptions I made throughout the project to provide insights about different ways of engaging with the idea of democratization in the making phenomenon and a discussion about what this means for HCI's pursuit of democratization.

1.2 Methodology

The primary contributions of this dissertation are theoretical. The main project centered around developing a normative theory grounded in a theoretical argument

and developed based on the results of several empirical studies. I describe more specifically the methodology of each chapter throughout and I describe my general methodological approach here.

The empirical studies employ more traditional HCI methodologies, using methods such as interviews, observation, and qualitative data analysis. These empirical studies do not aim to provide empirical support that the Normative Theory of HCM is correct; rather they help investigate necessary questions about what how the concepts relate to actual maker practice. Some of the insights from these studies are directly relevant for maker leaders and researchers and also form the basis of broader reflections I make about the NTHCM and the promise of democratization in the making phenomenon and in HCI.

The research draws upon Humanistic HCI [15], which makes contributions to HCI using methods of inquiry and techniques from the humanities such as essays, close reading, and critical analysis. While HCI research tends to range in methodologies such as research by design and A-B experimentation, many of these endeavors fit within the category of rationalist research. Rationalist HCI aims to generalize and abstract human behavior and technological design elements to achieve a more methodological approach to design [192]. Rittel and Webber point out how there are some problems, coined as "wicked problems", that are too complex to be solved with traditional design or any existing approach [160]. Humanistic HCI aims to uncover nuance, read deep into one instance or circumstance, and embrace subjective viewpoints. Since democratization is a broad concept that is difficult to measure, Humanistic HCI is a reasonable approach. Some of the points I make throughout the dissertation belong to this epistemology. For example, in Chapter 3 as I am justifying the choice of values for the definition of HCM, the fact that I am able to use those values to make a certain argument supports the choice.

Additionally, I draw upon reflexive ethnography and autoethnography, which are

methodologies that derive research insights from personal experience [144, 57]. The reflexive aspect means that the researcher discloses their stance and rather than trying to remove subjectivity, they discuss how their insights were influenced by their goals, background, assumptions or other aspects of their positionality [161]. Autoethnography is when the researcher studies their own experience such as a time when they used a particular technological device themselves [74]. Autobiographical design is also a related and relevant methodology where the researcher describes a design process for themselves. A guiding principle of autobiographical design is that the researcher is able to better articulate nuances of the conditions or constraints they are designing for than if they were designing for someone else under those conditions [144]. While at times I describe a design process I performed, I was not designing maker contexts for myself, so autoethnography is partially relevant. Autoethnography does not always have a design component to it, since an autoethnographic account might document the experience of not having a cell phone for a certain period of time [129]. I do, however, draw on aspects of these epistemologies throughout the dissertation, using my experience setting up and running a makerspace to provide insights about the challenges and opportunities for HCI to pursue the promise of democratization by supporting the making phenomenon.

1.3 Scope of Relevance and Terminology

Making is a broad term used to refer to many activities that arguably include hacking, crafting, maintenance, repair, and craft [39, 103, 107, 108]. Failure to include one of these additional practices runs the risk of erasing the participation of a certain demographic or minority group. For example, many have argued that "making" should also include hacking, repair, craft, reappropriation etc. for full inclusion. Cultural context also makes a difference, as Lindtner et al. and Bardzell et al. have conducted long-term ethnographic studies of makers in Taiwan and China and discuss how the supposed global sentiment of making as democratizing is very western and making

brings a very different promise to those different regions [21, 126, 123]. Following an example from Bardzell et al. [16], I use making as an umbrella term to roughly cover all these activities and likely others, but I purposefully do not define the bounds of what I include when I discuss making. In this research, I refer to general the rise of Makerspaces, Fab Labs, and the broader wave of engagement in making and digital fabrication as the "maker phenomenon", focusing on this trend from a Western, US-based perspective. While I do refer to "making" or "makers" as a homogeneous group, it is important to note that there can be substantial variation in the range of practices, values, and goals [16].

As I do not define the bounds of making, I also do not define the bounds of the making phenomenon. Because I am concerned with the broad impact of the phenomenon, when I discuss what is or is not happening, I mainly focus on the core of the phenomenon or the mainstream spaces and contexts that are associated, though it is difficult to define what constitutes the core versus the margins [183]. I choose the word "phenomenon" rather than the colloquial "movement" because the Maker Movement is something else discussed by and typically associated specifically with Make media [24].

Some have pointed out that some of making's supposed universal hallmarks of "democratization" and "empowerment" are in reality an imposition of Western ideology on a global phenomenon that is not homogeneous [123]. "Making" is often presented without discussing the local nuances and cultural differences that cause different instantiations of making or different opportunities, promises, and pitfalls. With this in mind, because this dissertation focuses on the concepts of democratization and empowerment, my claims and insights are relevant to individuals and contexts that already align or desire to align their endeavors with these concepts. While I often discuss the NTHCM in terms of democratization, democratization is a concept that lives outside of the actual definition of theory. It is possible that the NTHCM might

be relevant and applicable in contexts that do not align with democratization and empowerment. However, evaluating the theory against measures in other contexts and other than democratization and empowerment is out of scope of this dissertation.

I often use "HCI" as a noun, referring broadly to the field of HCI as a whole, its disciplinary commitments, or broad tendencies. While HCI is a diverse field, there are certain broad tendencies that do not have a more specific locus such as a set of researchers or branch of HCI research. For example, I refer often to HCI's promise of democratization, which is both an explicit framing some HCI researchers attach to their endeavor as well as an underlying goal in HCI research that does not claim that goal explicitly. This is a convention that is also adopted in other HCI literature [16, 51, 123, 163].

1.4 Context and Self-Disclosure

This work was done in the context of the University of North Carolina at Charlotte (UNCC), a large public university in the southeast United States. This research was grounded in the experience of setting up and managing a university makerspace, which was initiated by a faculty member in the College of Computing and Informatics (CCI), who was also one of my dissertation advisors. Our makerspace (Figure 1.4) has an emphasis on digital fabrication equipment, programmable electronics, and textiles. It is open to students, faculty, and staff from all departments for personal, research, or class projects. A team of 4-7 paid student workers run training sessions, workshops, and facilitate the space during open hours. Since Spring 2016 when we began sorting out the machines, policy, and opening the doors, my role was second-in-command to the faculty director. I oversaw many of the day-to-day operations including checking in with the student staff, training new staff, creating and updating training material for the makerspace users, and updating policies as needed. I also spent several hours a week in the space getting to know the users, making note of the vibe of the environment, seeing what problems arise that staff might not be aware

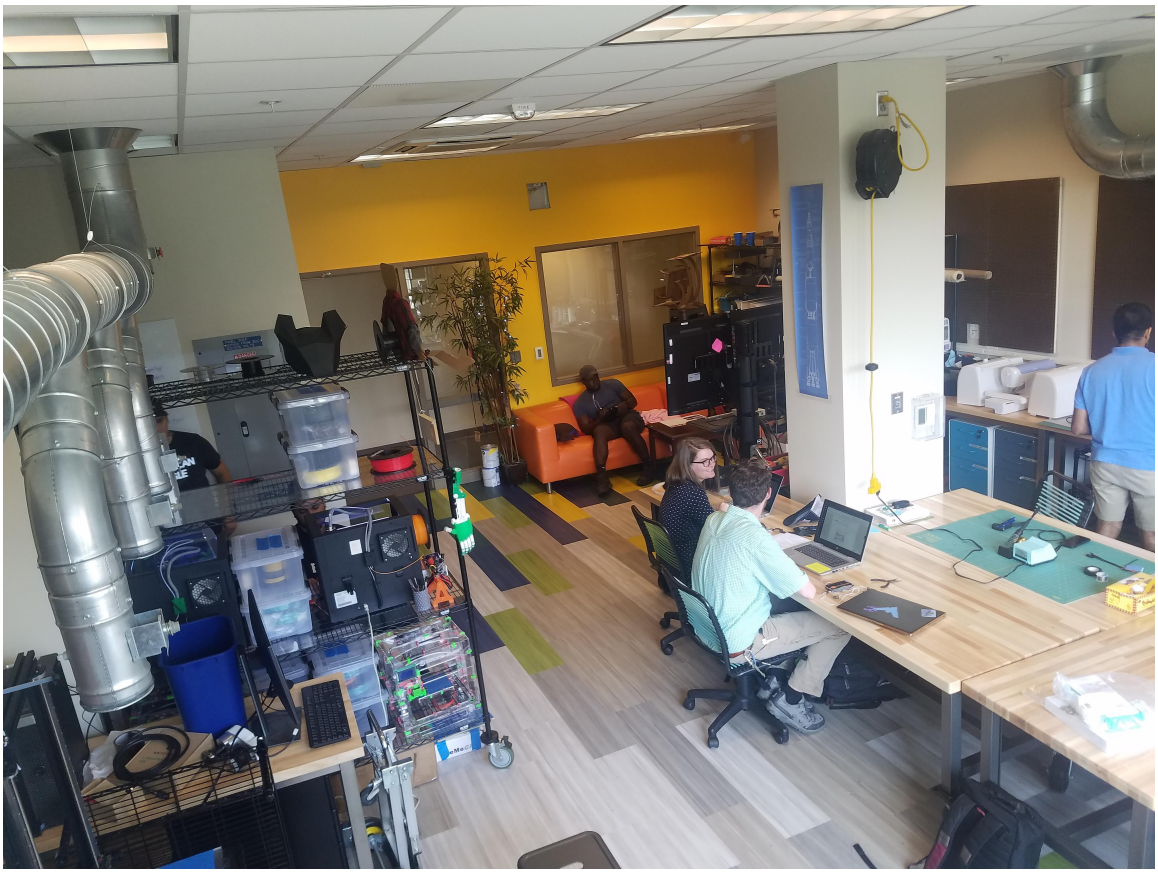


Figure 1.4: UNCC CCI Makerspace

of to bring to our attention, and trying to do some making of my own. While the space itself was not the direct object of research in this dissertation, I used it often to reflect on what happens in it, how we talk about it, and my own relationship to it. I detail some of the specific questions I faced and approaches I tried in later chapters.

The research presented in this dissertation was influenced by my feminist stance, driven in part by an activist instinct and informed by scholarly works of feminist theory, which I discuss at various points throughout. The project was started because of a desire to rectify the apparent injustice that makerspaces only fulfill their promise of radical inclusion for a narrow representation of the overall population. Some of my initial endeavors, documented in the first few chapters, were in line with parasitic resistance, which involves "incrementally redirecting the host's resources from inside" as defined by Fisher and discussed by Lindtner et al. [124, 77]. I was working within

the bounds of a typical makerspace, but aimed to resist some of the problematic norms by shifting the values and rhetoric in specific ways. I disclose my standpoint at various points in this dissertation, reflecting on the responsibility and power dynamics at play associated with positions of authority such as being a makerspace leader and an HCI researcher. In later stages of the project, I engaged directly with feminist utopianism, a feminist theory-informed perspective on how radically better futures emerge participatorily, using this as an evaluative measure and a source of guidance for design endeavors.

Throughout this project, I did not engage deeply with the topic of race or with bodies of critical theory that unpack other sources of oppression. It could be argued that overturning a certain oppressive power structure, such as gender-related oppression, invites emancipation from other forms of oppression as well. However, without an explicit and holistic consideration of these other factors, such as the critical race theory-informed approach necessary to reduce blind spots in HCI research to complicity of racial injustice [147], we do not know for sure.

1.5 Road Map

- In Chapter 2, I discuss related work in different research areas that this dissertation contributes to: 1) HCI's commitment to democratization 2) HCI's understanding of the making phenomenon. While I draw on and discuss other relevant literature throughout the dissertation, this chapter focuses on these agendas that I view as fellow travelers in that they have similar goals, but different approaches.

- In Chapter 3, I discuss the construction of the NTHCM. I first ground the need for such a theory in specific questions I encountered when starting and running a university makerspace. I then derive a set of criteria for democratization based on critiques of the making phenomenon. I argue that when a particular

value system (consisting of individualistic, artifact-based, and internal-facing mindsets and practices) is prominent, these criteria for democratization are not likely to be met. I then draw on common practices in HCI research and design to derive a complementary value system (consisting of collective, interaction-based, and external-facing mindsets and practices) and argue that when these are present, the endeavor is more likely to make progress towards the promise of democratization. I use these arguments to construct the definition of the Normative Theory of Human-Centered Making (NTHCM) which argues for a shift in the values discussed above. I provide definitions and examples to support the concept.

- Chapter 4, 5, and 6 present empirical studies aimed to develop an understanding of the theory and the values of HCM based on how they relate to makerspace practice. Chapter 4 presents the results of an interview study with participants of Statement Making, a digital fabrication fashion show. The purpose of the study was to understand how the values of HCM manifest and how they relate to each other in practice.

- Chapter 5 presents the results of an empirical study that uses the NTHCM to reflect on student learning in a semi-structured capstone course centered around using advanced HCI methods in the area of 3D printing prosthetic devices for others. The purpose of the study was to understand if the NTHCM is useful for maker leaders as a reflective lens.

- Chapter 6 presents the results of an interview study with maker leaders and an autoethnographic reflection, aimed to understand how the NTHCM can help drive or guide maker practices.

- In Chapter 7, I present the results of additional theoretical investigations, returning to the literature to find an updated definition of democratization to

use for deeper analysis of the potential outcomes of applying the NTHCM. I argue the appropriateness of feminist utopianism and proceed to use feminist utopianism as a lens in the context of Statement Making, the same context studied in Chapter 4. Ultimately, this investigation sheds light on some of the shortcomings of the NTHCM and shows the value of feminist utopianism in and of itself.

- Chapter 8 is the discussion, where I summarize the findings about the NTHCM, including reflecting on the extent to which it is well-grounded, relates to maker practices and contexts, and shows promise for democratization. I reflect on feminist utopianism in similar terms, showing how although I intended it as an evaluative measure of the NTHCM, it has merit and value towards similar ends as the NTHCM. I then reflect on the NTHCM and feminist utopianism together in terms of how they relate to the promise of democratization in different ways and what the merits and shortcomings of each mean for HCI's pursuit of the promise of democratization in the context of the making phenomenon.

CHAPTER 2: RELATED WORK

This related work section highlights the work in different research areas that this dissertation contributes to: 1) HCI's pursuit of the democratization of technology production and 2) HCI's understanding of the making phenomenon. While I draw on and discuss relevant literature throughout the dissertation, this chapter focuses on these areas where I make contributions.

2.1 HCI's Pursuit of Democratization of Technology Production

In this section, I discuss different ways HCI research has pursued the democratization of technology production, either explicitly or implicitly. For each type of endeavor, I discuss what the endeavor looks like, what challenges it faces or what critiques are present, and how that research makes progress towards HCI's goal. I focus mostly on the broad research that relates to the making phenomenon, though there are related areas of HCI research that also fit into the agenda of the democratization of technology production such as Value-Sensitive design, which aims to systematically take into account users' values [83] and ICTD or HCI4D, which focus on marginalized communities [48]. Also, any research that aims to increase the usability or functionality of web applications falls into the category of democratized technology production since researchers have pointed out that the advent of Web 2.0 means the Internet is as much about making content as it is about consuming it [86].

There is also a broader question of the relationship between HCI research and the promise of democratization. Since claiming the inherent democratic nature of technology has been pointed out as naïve or technosolutionist [138], the application of these narratives is often narrow [126] and HCI's vision has yet to come to fruition

[16], one might wonder if perhaps HCI needs to consider a set of goals other than democratization. However, Schuler points out how technology is inextricably linked to human social and political systems, including democracy itself [170]. Democracy has many forces working against it, so unless technologists are careful and deliberate, technology will likely work against the interest of democracy. Schuler's view on democracy, similar to political theorists such as Dewey [59], is that a democratic society requires decisions to be made democratically at all levels and democracy needs to be part of all aspects of life [170], which includes decisions about the production of technology. While the topic of democratization in HCI research in recent years is often political and societal in nature, the ideas of democratization can be traced back to HCI's foundational agenda of empowering users by saving them from the tyranny of unusable or frustrating systems [51]. Because technology impacts many aspects of personal and community life, to truly empower the user, we must continue to figure out how to design such systems in a participatory and democratic way.

2.1.1 Participatory Design

In order to position HCI's support of the making phenomenon in the broader context of democratization in HCI research, I first discuss HCI research agendas for Participatory Design (PD), which is one of the most prominent branches of HCI related to the democratization of technology production. Participatory Design aims to conduct design endeavors in a fertile region "in between" the design world and the user's world where both agents have impact over the design [140]. Designers know that achieving this requires more than just "adding users and stirring" [140] since each user is different, has different needs, and speaks a different language, so researchers work to develop different techniques such as story telling and card activities that can break down the barriers between the designer and user. The foundation of PD was fundamentally democratic, initially focusing on processes to include people in the design of systems that impacted them in the workplace [71].

Bannon and Ehn point out how even mainstream HCI research has largely accepted the aspects that PD endeavors have argued as important such as the use of prototypes to bridge gaps in the design process and the belief that the end users have the right to participate in and drive endeavors that will impact their life [14]. However, they point out how the conditions under which those aspects were first articulated have changed, which means HCI researchers' understanding of how to commit to them needs to be renewed. For example, while early PD was primarily concerned with creating artifacts, modern approaches to innovation include *social innovation*, which is less object-focused. Work is needed to understand how a PD approach can be appropriated to situations where the activity does not center around an object [14, 97]. Bødker and Kyng critique the state-of-the-art PD endeavors as failing to make progress on the "big issues", pointing out how endeavors often see achieving participation itself as the "good" of the project, how these endeavors are typically a-political, and how prioritizing participation limits the technical ambition to what all participants can conceive of [30]. They draw attention to a handful of endeavors that embody aspects of a renewed view of PD, one of which was the Fablab@school.dk project, which brought digital fabrication into the classroom in response to a needed reform of the educational standards. The incorporation of the technology involved many stakeholders, including administrators, students, parents, and educators participatorily exploring what digital fabrication could bring to the curriculum [30]. Bardzell summarizes additional challenges of PD including how the designer needs to configure the participation and roles beforehand, which undermines the extent to which participation is democratic, and how PD efforts are expected to leave the local participants satisfied, which complicates the ability for the endeavors to satisfy broader concerns such as climate change [20].

Overall, these challenges of PD remain largely unsolved. While HCI endeavors continue to work to address them, other HCI endeavors seek the promise of democ-

ratization in other other ways, such as through supporting the making phenomenon, as discussed in the next section.

2.1.2 The Making Phenomenon

HCI researchers discuss the making phenomenon as a new way to further research agendas related to empowerment and democratization. Several authors have explicitly framed their research on making as furthering HCI's agenda of democratization and empowerment since these values are also often discussed in the making world [16, 125, 155, 163, 174]. By studying makers, understanding the "maker ethos", and spreading maker empowerment by helping more people achieve maker practices and mindsets, HCI research makes progress towards goals of empowerment and democratization [16]. In this section, I explore some of those research endeavors to discuss how specifically these goals manifest in their research, as well as some of the outstanding critiques of the making phenomenon that limit the extent to which HCI research has made progress towards the goal of democratization.

One of the reasons HCI researchers focus on the making phenomenon is because making can be seen as embodying aspects of the democratization of technology production. Not only do maker enthusiasts themselves cite democratization as one of the driving goals of makerpsaces [135], there is also other evidence that aspects of HCI are reflected in the making phenomenon. For example, we might well recognize many of the artifacts coming out of Makerspaces as artifacts we would see in CHI or UIST conference papers (e.g., Internet of Things (IoT) devices for the home or interactive wearables [56, 61]) [105, 125]. The exciting thing about these devices coming out of the maker world is that they are the end result of people making things for their own needs and desires, rather than waiting for someone else to do it for them. HCI researchers have also pointed out how makers are different from the typical users that HCI studies: makers are already empowered since they have the mindset towards, ability to use, and relationship with technology, tools, and materials to make things

for themselves [163]. The making phenomenon thus represents a glimmer of an empowered society engaged in democratized technological practice that HCI imagines creating [16].

One type of research contribution in HCI towards this agenda is recognizing ways the making phenomenon embodies this vision of democratization. For example, Tanenbaum et al. discuss how individual makers exhibit their own types of resistance to the tyranny of typical forms of mass production by choosing to make rather than purchase and argue that the endeavor of Do-it-yourself (DIY), which was typically seen as recreational, should be seen as democratized technological practice since it brings together pleasure, utility, and expression [174]. Hui and Gerber recognize that makerspaces embody social conditions that would provide opportunities for the democratization of entrepreneurship [105]. Lindtner et al. and Hui et al. point to innovations makers are creating that resemble the types of products HCI endeavors focus on [105, 125].

Tanenbaum et al. ask whether this insight into makers as empowered individuals who engage in democratized technological practice means HCI design endeavors are obsolete [174]. They suggest this is not the case since HCI researchers can shift design efforts to design for creativity, hackability, and mixed manufacture. Roedl et al. similarly investigate the rhetoric in HCI research around makers, showing how the emergence of the making phenomenon represents a discursive shift in the subjects of HCI research from the helpless user to the empowered maker [163]. One type of agenda that is born from this shift is HCI endeavors that aim to understand makers and the "maker ethos" for the purpose of spreading maker empowerment [163]. A large body of HCI literature thus focuses on technical design to enable makers, including the development of digital fabrication tools that embed the knowledge of the materials, the machines, or of expert fabricators to make fabricating objects with certain properties or functionality easier [22]. Baudisch and Mueller provided an

extensive summary of all the work that has been done in this area and the larger agenda these individual projects are working towards [22]. For example, these tools might help users fluidly shift between physical and digital representations [80], convert models into interlocking pieces [133], convert models into wireframe for faster prototyping which can speed up iteration cycles and decrease frustration [139], allow for incremental printing while modeling [156], design functional chairs by sketching [167], or easily add interactivity to 3D printing objects [168]. These are all designed for personal fabrication, considering the experience between one user and the tools that will help them create the objects they want to make. While not all of these papers directly cite democratization in the form of access or material empowerment as goals, they are in line with Roedl et al.'s notion of material empowerment [163] since they paint a picture of progress in the form of enabling makers to create different types of artifacts more easily.

So far, this is an optimistic narrative: the making phenomenon embodies a number of aspects that represent the promise of democratization, so HCI researchers can pursue HCI's broad agenda of democratization by designing tools to support makers and spreading maker empowerment. Roedl et al. take a more critical look at HCI's agendas for making, pointing out some blind spots. Like Cooper and Bowers [51], Roedl et al. performed a Foucaldian Discourse Analysis on HCI papers that study and discuss makers, aiming to uncover the hidden discursive rules that have influenced how and why HCI researchers discuss makers the way they do [163]. Roedl et al. point out that while the treatment of empowerment and democratization in HCI is typically rather a-political, the discussion of makers as empowered subjects is actually a rather significant challenge to prior discussion in HCI research of the "naive user" [163]. Roedl et al. also point out how makers do some things that in HCI research are typically not seen as positive such as re-appropriating tools for other uses. They point out how HCI researchers tend to design for specific use and if the users do something

unexpected, that indicates failure on behalf of the designers since it shows they did not study the users closely enough to know their needs and design something that did not need re-appropriation [163]. To argue that re-appropriation and other maker activities should be a matter of concern and an object of study in HCI, "authors have repeatedly positioned maker culture within a narrative of democratic populism and technosocial progress" [163]. Roedl et al. point out how this rhetorical strategy adopted by HCI authors to legitimize the study of making within HCI is strikingly similar to the one that Cooper and Bowers pointed out that HCI researchers used in the beginning to legitimize itself as a field [163]. Both use empowerment and/or democratization as the broader narrative to justify certain endeavors. While HCI research in general has evolved beyond the framing of users as helpless in order to justify HCI research, as evidenced by the study of makers as empowered subjects in HCI, HCI research on making is younger and has not moved very far beyond the narratives it used to legitimize the study of making.

Roedl et al. go on to discuss some specific blind spots in HCI research on making. There are two types of maker empowerment: 1) material empowerment, where makers have the ability to shape materials and use tools to accomplish various goals and 2) socially progressive empowerment, where makers embody democratic attributes such as open source and resisting consumer culture [163]. Roedl et al. also point out that while some HCI researchers discuss both of these types of empowerment, HCI overall typically considers democratization and empowerment in a rather apolitical way, which allows HCI research to "continue to portray itself as contributing to social progress through technological development in support of makers while sidestepping the need to consider structural socioeconomic issues or engage in controversial public debates" [163]. In other words, by focusing on material empowerment by building tools for makers and limiting the definition of socially progressive empowerment to aspects that mostly concern individuals, such HCI research has a blind spot to larger

problems such as how the making phenomenon is entangled with corporate interests and designed obsolesence, which complicates the narrative of making as a sustainable alternative to mass production. Roedl et al. admit that there is a growing number of critical perspectives on making, and that number has grown since their paper was written, but that the "energy" with which research endeavors take on the material dimension is much greater than the political aspects of the social dimension [163].

Similarly, Bardzell et al. group critiques of making around three main issues: 1) how spaces fail to live up to their claimed values of inclusion, 2) technosolutionist ideas that the technology associated with a makerspace itself will solve problems, and 3) how narratives of making tend to be based on Western-centric ideas of democracy [16]. While a common value and promise of making is being "radically inclusive", some researchers and community members have pointed out that many do not live up to that promise [9]. It is not enough to simply claim to be open to anyone and expect democracy to emerge [9]. Gershenfeld et al. discuss the promise of Fab Labs to transform society, but note that for the technology to achieve that promise, there is much societal infrastructure that must be put in place [88]. They point out that in past technological revolutions in communication and computation, the technology makes leaps and society struggles to catch up, meaning that inevitably, the great promise falls short. Technology will not drive social change, but it can be leveraged; technology and society should be envisioned and shaped together. Lindtner et al. similarly discuss technosolutionism in making, using examples of individuals who have been empowered through making, though it was more than just the tools that instigated that empowerment [123].

Overall, as Bardzell et al. point out, HCI's agendas for the making phenomenon are entangled waves of optimism, criticism, and new informed optimism [16]. The informed optimism does not express that making will solve things for us, but that making can be leveraged to achieve the vision of democratization. The outstanding

problem is that we still do not know how to work towards that or know what it looks like. In the next section, I summarize some of the HCI endeavors that have made progress towards the promise of democratization with these critiques in mind.

2.1.3 Contributions in HCI Towards the Democratization Agenda

A number of HCI endeavors have sought to take these critiques in mind and make new types progress towards democratization. I summarize these examples, primarily focusing on the making phenomenon or other user-driven innovation, that explicitly engage with the concept of democratization to illustrate what an HCI contribution that makes progress towards democratization might look like. In general, Bardzell et al. suggest adopting a number of new HCI research agendas in making towards democratization including considering social justice more directly, exploring alternate making ecologies, and engaging with more precise definitions of words that are used as rhetoric.

One type of contribution to the agenda of democratization involves investigating various sites of participation to ground the concept of the democratization of technological production in practices that are emerging. For example, Freeman et al. study indie game developers to understand an understudied category of user in the context of end-user innovation: the "middle-tier pro-amateur" user, who is neither a top-down innovator, nor a bottom-up hobbyist [82]. They illustrate how understanding the democratic practices of this type of user when they work in small teams can help the broader pursuit of democratization by drawing attention to how nuances in democracy-related behaviors, such as how decisions are made in the team, affect successful innovation.

Lindtner et al. and Bardzell et al. also perform long-term ethnographic work in Taiwan, China, and Indonesia to understand alternate narratives around and practices of making [21, 126, 123]. For example, Lindtner et al. point out how citing the promise of democratization in the context of making imposes a Western narrative as though

it were universal [123]. Their ethnographic work seeks to "reconstitute the utopian vision of making" by understanding what making means to people in Taiwan and China [123]. They use glimmers of those narratives to "speculatively imagine" visions of the future of making without relying on Western notions of democracy, access, or individuals [123]. The end result relates to democratization in a way: they suggest that the making phenomenon in Taiwan functions as a "workshop for discovering ways that a democratized technology can contribute to a social vision of a lasting, self-sufficient, and sovereign society, yet divided, even extremely divided, on what that vision should entail and how to bring it into being" [123]. However, the authors "de-center[ed] [their] own HCI theoretical predispositions as Western academics" to get to that point. Like Freeman et al. [82], one of their contributions is in the form of drawing attention to how making practices relate to democratization in different ways or using making practices to articulate new visions of making. However, Lindtner et al.'s primary contribution is the suggestion that HCI researchers need to similarly de-center their expectations and positionality to make progress towards less narrow conceptions of democratization.

Similarly, Lindtner et al. suggest other techniques for HCI to understand forms of democratic participation that it would otherwise miss due to assumptions about what democratization looks like [124]. They position these suggestions in relation to a paradox of intervention: Some democratizing endeavors in HCI start small and intend to scale up, but often the politics at the small scale are so small that they are barely noticeable. Other democratizing endeavors in HCI attempt to start large, but run into the problems that come with attempting to solve complex social problems with technological solutions [124]. Lindtner et al. thus offer three analytic strategies from feminist and critical theory for HCI researchers to use: "noticing differently", "walking alongside", and "parasitic resistance" [124]. Noticing differently, for example, means "to acknowledge and simultaneously step out of familiar frames of reference"

and parasitic resistance happens when someone is "dependent on a host yet pursues independent goals, including goals that go against the interests of the host", which offers an alternative to the limiting narrative of the individual lone "countercultural hero" [124]. These techniques can be used to shed light on forms of democratic participation that we might not otherwise recognize.

Björgvinsson et al.'s contribution to HCI's research agenda of democratization is a new definition of democratization, based on a critique of von Hippel's innovation-based definition of democratization as the ability for individuals to create novel products before the industry can [28, 187]. Björgvinsson et al. study the activities of Malmö Living Labs, a long term open-ended participatory endeavor which conducts "design experiments" and "attempt[s] to connect disparate parts of the city and to build bridges between groups and competences," focusing more on infrastructures than objects and more on the less tangible aspects of innovation [28]. Based on their interpretation of these activities, they argue for a different definition of innovation, which is not about the ability to create objects, but rather about the possibility to create infrastructures that have value to the people who are participating [28]. Overall, their contribution is a suggestion to shift the focus of democratizing efforts from the product to the infrastructure. Green and Kirk study the dynamics of the maker network in the entire city of Newcastle, UK and similarly suggest that a focus for design should be supporting infrastructure to support interconnectedness at such a scale [91].

Tanenbaum et al. also offer a contribution in the form of a new definition of democratized technological practice, arguing that democratization needs to provide opportunities for pleasure, utility, and expression, not just one of those aspects and that HCI researchers pursuing democratization need to be sure to consider situations from all of those angles [174].

In line with a call for HCI researchers to adopt more robust definitions of democracy

[16], another type of research contribution towards democratization uses formal notions of democracy as a guide or a lens for analysis or endeavors. For example, Lodato and DiSalvo use Dewey's notion of publics to distinguish between different kinds of hackathons [128]. While some hackathons orient themselves with social issues, there is rarely the opportunity for publics to form, which would be an indication of real civic action. They say the benefit of such issue-oriented hackathons is the material participation. Their work illustrates the use of political theory to shed light on the more political aspects of participation in particular making-related spaces. Le Dantec et al. aimed to broaden participation in technology in a way that "goes beyond simply increasing the rolls of technology users", but rather to engage with a notion of democratization that "involves bringing different social groups into discourse about technology, its place in society, and its potential for enabling action, facilitating connection, and providing access to information" [119]. They describe their engagements with two publics, the homeless public and the care provider public, exploring the boundaries and relations of the publics in the context of the design of a community resource center. While this represents commendable engagement with political theory and benefits to the local participants, Lindtner et al. cite Le Dantec et al.'s work as an example of an endeavor that takes place at a scale that is so small, the politics are hard to see [124].

Many of these contributions are generative in that they do not fully answer the question of how HCI researchers should pursue the promise of democratization, but rather provide suggestions for how HCI endeavors should adjust the way they engage with or look for democratization. This dissertation ultimately contributes something similar: suggestions about underlying assumptions HCI researchers make that get in the way of the promise of democratization being fulfilled.

This literature also reflects a gap that prompted this research project, particularly the lack of insight about what makers or makerspace leaders could do to better align

with HCI's vision of democratization. One thing that is missing is a way to consider the theory of democratization during the practice of making and the practice of makerspace leadership. Understanding different types of participation and democratic endeavors related to making have already emerged in other places does not necessarily provide direct guidance on what should be happening in a different place. I reflect more on the need for this type of guidance in Chapter 3.

2.1.4 Other Mentions of Democratization

For completeness, I highlight other ways the concept of democratization manifests in HCI research.

Technology Enabling Democratic Society - A more political notion of democratization and technology involves considering how technology can contribute to a more democratic society and more participation in democracy. More of these discussions happen outside of HCI, for example in the work by Habermas [92] and Ess [76]. HCI endeavors in this area have focused on the design of platforms for dialogue [132], negotiating perspectives surrounding a particular issue [54], studying patterns of use of social media [118, 137], the formation of publics and allowing for collective action [110], and how technology contributes to threats to democracy such as the spread of fake news [79].

Some have pointed out how doing work in this area, particularly in the form of design and intervention, is rather difficult for HCI researchers given the type of knowledge and nature of the effort required to make these things happen. Joyojeet Pal discusses design for democracy and other HCI research that brands itself as in line with the "CHI4Good" tagline or with goals of "leveling the playing field" [152, 153]. Pal points out how issues that are tackled in design-for-good hackathons are much more complex than is communicated and traditional HCI methods need to be adapted and expanded to be able to tackle these problems.

Access to a skill - In many instances, democratization is synonymous with access

to a certain skill. In these cases, technology is seen as a mediating factor in providing that access, or democratizing that skill. For example, Tao et al. designed a system for creating self-folding structures, with the title of their paper being "Demonstrating Thermorph: Democratizing 4D Printing of Self-Folding Materials and Interfaces" [175]. Interestingly, the word democratization only appears in the title, nowhere else in the paper. In fabrication and making research, the term is also often used in this way meaning access. Baudisch and Mueller present an extensive literature review on advances in research on fabrication and points out how digital fabrication "holds the promise of democratizing a whole range of fields preoccupied with physical objects" [22]. In this case, the claim is that digital fabrication provides people access to skills that were typically difficult to obtain and thus the ability to participate in many different domains. Another HCI endeavor aims to give users tools such as Scratch, Kodu, and Etoys that enable them to participate in the production of digital media [159]. All of these endeavors that fall under the umbrella of democratizing access to a particular skill focus on skills related to technology and media. So while the authors do not explicitly frame them under the umbrella of democratizing the production of technology, they are arguably implicitly part of that same agenda.

2.2 HCI Research on the Making Phenomenon

While considering the maker as an already-empowered end user and the makerspace as a site of democratized technological production may have legitimized the study of the making phenomenon in HCI, and while many of HCI contributions on making cite these broader agendas, there are other outcomes and goals in HCI research on making. I summarize some of those here. While this dissertation primarily focuses on studying the making phenomenon as it relates to democratization, it also makes contributions to some of these other areas.

2.2.1 Understanding Makers and Making

A number of HCI endeavors seek to understand makers, their practices, and the interactions that happen in makerspaces. These endeavors fit into a number of different broader HCI agendas: 1) Identifying opportunities for the design of tools or experiences, which is a common format for HCI research through design endeavors. Some of these design opportunities also contribute to the second agenda, 2) Spreading democratization by empowering makers or broadening participation in making and, 3) Identifying opportunities for HCI researchers to adopt aspects of maker practice as an upgrade to how HCI researchers conduct design.

Towards these agendas, HCI researchers have looked into use cases of these spaces, finding a wide range of practices such as entrepreneurship [9, 105, 125], IKEA hacking [165], DIY assistive technologies for others [106], and use as a social space [9, 42]. Many makers are drawn by the desire to help people or "do good" and participate in activities such as 3D printing prosthetics for children [154]. Kuznetsov and Paulos conducted one of the largest surveys of makers, studying participants in online sharing communities, to understand their practices, motivations, and values [115]. They found, for example, that some of the top motivations for contributing to projects online included self-expression, learning new skills, personalizing things, and solving problems [115].

An example of studying makers in order to understand how to cultivate those qualities in others is Hartmann et al., who describe how hackers tend to combine different hardware and software components to create "mashups" and often use hot glue to combine components rather than designing clean dove tail joints from the beginning [94]. They characterize this type of design as "opportunistic" since it involves incorporating existing artifacts and they suggest opportunities for HCI design to support such acts such as helping Makers switch fluidly between styles of Making [94]. Similarly, through observation of makers exhibiting these behaviors, Bardzell et al. developed

an understanding of adhocism as solving problems and making adjustments when they arise as opposed to starting with a full plan and executing it [17]. They suggest that perhaps helping non-Makers cultivate an adhoc attitude could be a source of empowerment [17].

An example of an HCI endeavor that aimed to find opportunities for design is Hudson et al., who investigated a group of people they call "Casual Makers", who are people who use walk-up-and-use 3D printing services at places like libraries [104]. They wanted to know the workflows, challenges, and motivations of this group of users. They found that there were common misconceptions such as 3D modeling unprintable objects and that the casual makers had a heavy dependency on the staff of the 3D print centers, even though the staff tend not to be highly trained in digital fabrication either [104]. They suggest a few considerations for designers to incorporate into the design of 3D printing tools such as to integrate 3D modeling with 3D printing workflows and to integrate more expert knowledge into the software [104]. Bousseau focuses on how novices sketch and prototype artifacts by hand in a controlled design setting [33]. They observed that the novices utilized a wide range of sketching techniques and spent a lot of time manipulating the physical materials. From this, they suggest a number of design principles for CAD software for novices such as helping novices understand fabrication challenges and nuances [33]. Makerspaces also present opportunities for HCI researchers to explore the design of systems to support situational awareness. Stark et al. drew on literature on novice makers along with interviews with expert makers to design a system to support makers in real time [172].

One thing that is notable from this body of literature is that while there are plenty of mentions of the promise of making at a societal level [105], there are few studies of making at a broad scale. Most endeavors focus on the depth and nuance within a makerspace or individuals. One of the goals of this dissertation was to bridge the gap between the broad societal promise and local individual maker practices.

2.2.2 Critical Understanding of Making and Addressing Critiques

As discussed above, making is critiqued as being technosolutionist and not as broadly inclusive as promised. I discuss how HCI researchers have sought to understand making in a way that draws attention to alternate narratives, calls into question dominant narratives that have been pointed out as problematic, and sheds light on ways making can be emancipatory.

Some researchers explore alternate making experiences, for example that combine digital and physical making to expand making such that more diverse gender identities can relate to it [114, 39, 113]. Many of these target the tools and materials, pointing out that electronics can be perceived as gendered and more readily adopted by masculine identities [9]. In addressing what other barriers might bar women from entry, Toupin et al. and Toombs et al. both indicate that it is not a lack of skill, but rather structural, psychological, or cultural differences that make women less likely to show interest in Makerspaces than men [182, 181]. Solutions to this bias and to broadening participation sometimes involves expanding the materials offered by the makerspace to include non-electronic materials [90] or creating experiences that use a hybrid of textile crafts with electronics to disrupt both masculine and feminine maker identities, inviting a new way of identifying with the experience [101, 38].

HCI research has also focused on understanding how making relates to identity. Whelan points out how the identity "Maker" is easier for some to connect to than others due to gendered technological practice [189]. They point out that while Make was meant to include all forms of Making, it tends to favor more technological practices, thus de-legitimizing the inherent difference in feminine technological identities. They suggest that advocates of Making move away from the "identity-centric rhetoric" [189]. Fox et al. study self-identified Feminist Hackers and the Feminist Hackerspaces they created [81]. Most notable was the way they chose the technologies that would go in the space, for example, choosing weaving and other non-technical tools that tend

not to be associated with hacking. What this does is it provides access and recognition for these feminized tools by framing them as "hacking culture, not devices", i.e. hacking the notion of what does and doesn't count as hacking [81]. Toupin also investigates the relationship between Feminist Hackers and the Feminist Hackerspaces in which they reside [182]. They find that the Hackerspaces and their "boundaries offer both safety and a platform for political resistance" [182]. Marshall and Rode critique both Fox et al. [81] and Toupin [182] for having a heteronormative and binary notion of technical gender identities, with the feminine identity as being inherently non-technical [131]. They suggest deconstructing gender identity based on the Socio-Technical Gender Model for the Co-Construction of Gender and Technical Identity by Rode and Poole [162] and that doing so would allow room for non-binary gender identities [131].

None of these examples, however, has shed light on a holistic or systemic way to address the critiques of making as being exclusive or concrete guidance for makerspace leaders.

2.2.3 Makers and Designers

While the making phenomenon and the field of HCI are separate entities, there are often ways in which the bounds between specific practices or mindsets in the two domains are not well-defined. For example, HCI researches have found evidence of elements of design thinking in makers. Desjardins and Wakkary summarize the notion of everyday design, which is about how everyday people can be engaged in aspects of design as they use tools and objects around them creatively [58]. These individuals are often the subjects of ethnographic studies conducted to understand how HCI researchers can design systems that support these non-expert designers in their practice [53, 58, 177, 179].

Thanapornsangsuth has students who were new to making participate in formal need-finding and design with the goal of having them see making as something they

can use to help people [178]. Bowler and Champagne present a set of questions that can help makers be more mindful or critical about their practice [34]. In my past work, I studied volunteer makers who create prosthetic devices and found ways Human-Centered Design and Participatory Design would be helpful practices for the makers to adopt [150].

In addition to looking at ways makers engage or might engage in activities that resemble design, HCI researchers have also considered adopting aspects of maker practice themselves. For example, Kuznetsov and Paulos, who extract a set of values that the expert amateur lives by (open sharing, learning, and creativity over profit and social capital) and suggests considering embedding these values into other every day practices and suggests HCI practitioners work closely with this group of expert amateurs. They hope that their work "serves to import DIY culture into CHI and vice versa" [115]. A panel at CHI on research agendas for Making poses the question of how Making can inform HCI practice explicitly, asking "How does DIY making and hacking affect HCI practice?" and "How can we better include making approaches into HCI education beyond just its deep engagement with physical materials and hardware?" [11]. Much of the literature discussed in Section 2.2.1 could also similarly fit into this HCI agenda of learning about the making phenomenon in order to adopt aspects as part of HCI research and design practice.

This dissertation contributes to this area of understanding ways that practices within the making phenomenon and formal HCI research and design endeavors are not completely distinct. Specifically, the concept of Human-Centered Making is a particular type of making context or endeavor that embodies some of the values of HCI research and design endeavors. My contributions in this area include the definition of the concept, empirical investigations of how these values manifest in maker mindsets and practices, insights about the conditions under which these mindsets and practices might emerge, and discussion about whether promoting or reflecting on the

presence of these mindsets and practices is helpful towards the broader agenda of the democratizing technology production.

CHAPTER 3: THEORY CONSTRUCTION

In this chapter, I describe how I constructed the definition of Human-Centered Making (HCM) and the Normative Theory of Human-Centered Making (NTHCM). This project was grounded in my experience as a makerspace leader and aimed to provide a specific type of guidance I needed. To illustrate the gap this theory aims to fill, I begin by discussing some of the dilemmas and questions I faced when starting and running a university makerspace. These reflections are reflexive in nature as my main goal was to address some of the critiques of the making phenomenon as being exclusive and technosolutionist, but I needed to consider my own standing in relation to the making phenomenon: what is within my domain of control and responsibility? What is at my disposal for design? In what ways can I intervene? In the first part of this chapter, I discuss how I came to ask these questions and what lead me to the conclusion that I needed to intervene in the making phenomenon, as well as why it was unclear how to do so.

I then discuss how I decided to develop a normative theory, the Normative Theory of Human-Centered Making (NTHCM), that calls for a shift in values in the making phenomenon. The normative theory aims to guide makers and maker leaders towards mindsets and practices that are more likely to contribute to making's overall promise of democratization of technology production. The NTHCM provides this guidance in the form of calling for a shift in values towards particular values from the field of HCI.

To derive the NTHCM, I read literature on democratization and empowerment and chose relevant criteria that would constitute a definition of democratization. I then used these criteria to discuss prominent values in the making phenomenon that

seem to be in the way of these criteria being fully met. I use these values from the making phenomenon to reflect on HCI research and practice and suggest alternate complementary values. These two sets of values form the basis of the definition of HCM and the NTHCM, which I discuss and provide examples of.

I draw upon several methodologies in this chapter. I first draw upon reflexive ethnography [161] to articulate the motivation behind this research, specifically using my experience as a makerspace leader to shed light on a need for research about a certain type of guidance for makerspace leaders. The construction of the NTHCM, which aims to fill this gap, in some ways follows a trajectory similar to Lindtner et al., whose research agenda was working towards a new articulation of the utopian vision of making [123]. Lindtner et al.'s work consists of two components: a critique of the present to reveal challenges and opportunities as well as an anticipatory design approach that involves projecting what the future could look like through glimmers that are evident in fragments of the present. The NTHCM is grounded in a critique of the present, based on values that are prevalent in the making phenomenon and an argument that when these values are all-encompassing, they prevent the criteria for democratization from being fulfilled. The NTHCM also represents glimmers of a better version of the making phenomenon that were derived by looking to HCI research and practice for alternate aspects to augment or complement the aspects of the present that were critiqued earlier. In the following section, I present a reflexive narrative from the perpsective of a makerspace leader and use the conclusions to justify drawing from HCI research and practice as a source for such glimmers. However, I also reflect on the broader implications of the assumption that aspects of HCI research and practice are the answer to the challenges of the making phenomenon in the discussion chapter (Chapter 8). Lindtner et al.'s methodology is appropriate broadly because they had some of the same goals I had in terms of articulating how the relationship between the broad promise of making aligns with local maker practices and

mindsets.

3.1 The Need for a Theory to Guide Maker Endeavors Towards Democratization

I here reflect on my experience as a maker leader wanting to develop a makerspace such that it would be more inclusive and how I came across the concept of democratization as a broad goal to align our makerspace with.[1]

When I began assisting with setting up and running a university makerspace in Spring 2016, I approached the project as an outsider to the making phenomenon. While I had experience with various types of making and digital fabrication technologies, I had no direct experience with makerspaces. I continually had a sense of not quite relating to the rhetoric of "everyone is a maker" [44] or the box-like identity of "maker" [189]. I was, and continue to be, in the unique position of being in a leadership position for a space that I would probably not have otherwise found myself in. Perhaps I was ignorant of the potential for makerspaces that only visionary early adopters could see or perhaps my hesitations were justified by critiques such as how the Maker Movement is more of a brand and corporate endeavor than a movement [24]. I was intrigued and excited by the potential, however, I was also sensitive to the critiques discussed in Chapter 2 that makerspaces were not as radically inclusive as promised and I did not want to similarly make assumptions that the makerspace itself would drive social change [16]. My takeaway from the critiques of makerspaces as being exclusive due to legacies of racism and sexism in technological spaces was that the culture of the space needed to be broadened, however I was not sure what that would look like or how to broaden the culture. A driving question throughout my time with the makerspace was thus, "*What is supposed to be happening here? What broader promise should we align our space with and how do we move towards that promise?*" In other words, the question was "*Where are we going? And how do we get there?*"

[1] Some passages in this section have been quoted verbatim from my published work [151].

I began the makerspace project by immersing myself in online maker communities to understand what the making phenomenon was all about, acquiring tools and materials, and developing policies and training materials. While each makerspace has a slightly different equipment profile, we decided on a fairly standard set of 3D printers, laser cutter, sewing and digital embroidery machines, desktop CNC router, e-textiles, and microcontroller electronics. When the space was open, we had student staff members present to oversee activity in the space. Anyone from the UNC Charlotte community was welcome to get trained on the machines and make anything they would like.

Our initial goal was to create an open-ended space that was open to students, faculty, and staff from all departments for creativity, collaboration, informal learning, and community. We saw opportunities for the space to foster informal exploration of concepts introduced in formal education such as tangible interaction design or the Internet of Things (IoT). We figured many of the use cases would emerge and it would become clear over time what particular purpose the space would serve in the university context and society at large. We saw our role as makerspace leaders to be understanding that emerging purpose and supporting and fostering those types of endeavors. In other words, we imagined we would frame the practice and promise of making based on what activities we saw emerging, and use that understanding to guide our actions as leaders of the space.

As the space became more established, it did not become clearer what purpose the space could serve within the university or society at large. A collective purpose connected to the promises of making did not seem to coalesce. Many of the emerging use cases of our makerspace were one-off personal projects such as a gift or a laptop stand, download-and-prints, and students using the space as a homework hangout spot. There was nothing wrong with any of these endeavors, but they did not shed light on the potential for the space or shed light on what we, as makerspace leaders,

should do to develop the space and the community. I also observed that only a narrow population of students had made their way into the space based on demographics and discipline, indicating that our space was privy to some of the barriers to participation that were commonly discussed in the literature. If we were to continue to let the space operate in an open-ended free-for-all where we open the doors and let anyone do whatever they would like, these trends would be unlikely to change.

Our space structured a number of endeavors to encourage engagement and to help people realize the possibilities. For example, we ran workshops where participants could learn skills such as 3D modeling or sewable electronics, complete small projects such as an embroidered bag, or get an introduction to a machine such as the CNC router. Our space was approached by schools, camps, and other events, so we developed an educational component to bring making to others and we invited makerspace participants to help lead those activities. The student staff working in the space were encouraged to express excitement in projects and facilitate connections or collaborations as appropriate. One-on-one equipment training sessions afforded the opportunity for staff to tailor their introductions to new makerspace participants based on their interests.

A number of community-led endeavors did emerge that the space supported and I tried to use as guideposts in our own framing of the space and how I communicated it to others. The most notable was a student-led organization centered around 3D printing prosthetic devices for children with limb differences. This organization was highly active, brought a new population into the space, and grounded a way for me to frame the makerspace in terms of "enabling student groups that are helping the broader community". However, I was unsure of how to further operationalize that idea or develop the space towards fulfilling that kind of promise.

In a different approach, I turned to the HCI literature on making, where it is common to frame making as a mechanism of democratizing technology production and

empowering individuals and communities [16]. One of the examples of this promise cited in the HCI literature is how makerspaces enable anyone to create IoT devices for themselves, which is typically a task that is reserved for researchers or designers [125]. Makerspaces enable individuals to create these customized devices for themselves rather than needing HCI researchers or designers to design for them. This example from the literature provided one possible answer to my questions about what is supposed to be happening in the makerspace and what broader promise we should align our efforts with. Specifically, this suggests that the promise of making is the democratization of the ability to create personalized devices. An example of this promise in practice is makers creating customized IoT devices for themselves. For me as a makerspace leader, this meant our immediate actions should encourage and support this particular use case. This was a satisfying answer to the question about the practice and promise of making at the time, but as I describe next, left me with new questions about how I should move forward with guiding the makerspace to better fulfill that promise.

I had not yet observed anyone making IoT devices in our space, but students I talked to seemed excited about it. Our makerspace had an abundance of the required tools and materials, but I thought we might need some workshops, tutorials, or examples to help people realize what is possible, in line with one of Schneider et al.'s definitions of empowerment [169]. As I was conceptualizing what these workshops might look like, I turned to HCI literature to understand what the possibilities were and to see if there were some big ideas I could leverage to inspire the students. Also, since HCI literature emphasizes the shift in who creates IoT devices from HCI researchers and designers to makers [125], then understanding the scope of conversations in HCI literature around the topic seemed like a reasonable place to start. Unsurprisingly, the HCI literature on IoT contained a mixture of technological innovations, novel interactions, and critical research pointing out some of the concerns or nuances to be aware of when creating

always-on devices for the home. For example, a 2016 DIS workshop proposal pointed out that despite the promise of IoT to promote holistic benefits to humans, there are many dangers and pitfalls and aimed to explore how we can "challenge, preserve or promote human values" in IoT [186]. Privacy and security are known concerns with IoT and are difficult for researchers to tackle [188]. Lingel argues that the way IoT technologies are typically conceived is unconfigurable and rigid - and suggests drawing on insights from how craftspeople configure their homes to think of IoT in a more configurable, flexible, and responsive way [127]. Other important considerations for IoT include specific requirements of devices for survivors of domestic abuse and concerns regarding privacy breaches surrounding intimate devices [120, 191]. As a makerspace leader who shares these values and concerns of HCI researchers, I was left wondering how I should introduce IoT to the makerspace.

This realization led me to the following conclusion: If our makerspace was going to work towards making's promise of democratization in part by encouraging makerspace participants to explore the possibilities of IoT devices or other such technological innovations, we also had a responsibility to ensure they fully consider the human experiences that these devices knowingly or unknowingly engender. In other words, if our makerspace was going to align with the narrative of how the making phenomenon democratizes technological production, there should also be HCI mindsets and practices embedded in the fabric of our makerspace and related activities. If "democratizing technological production" is the answer to the question "Where are we going?" or "What broader promise should we align our efforts with?", then one of the answers to the question "How do we get there?" is that we encourage makers to create IoT and other such devices, and the implications of that answer is that we also need to bring consideration for the human experience in with those activities.

Figure 3.1 and Figure 3.2 illustrate what happens if we continue to focus on the narrative often discussed in HCI literature that makers are already participating in

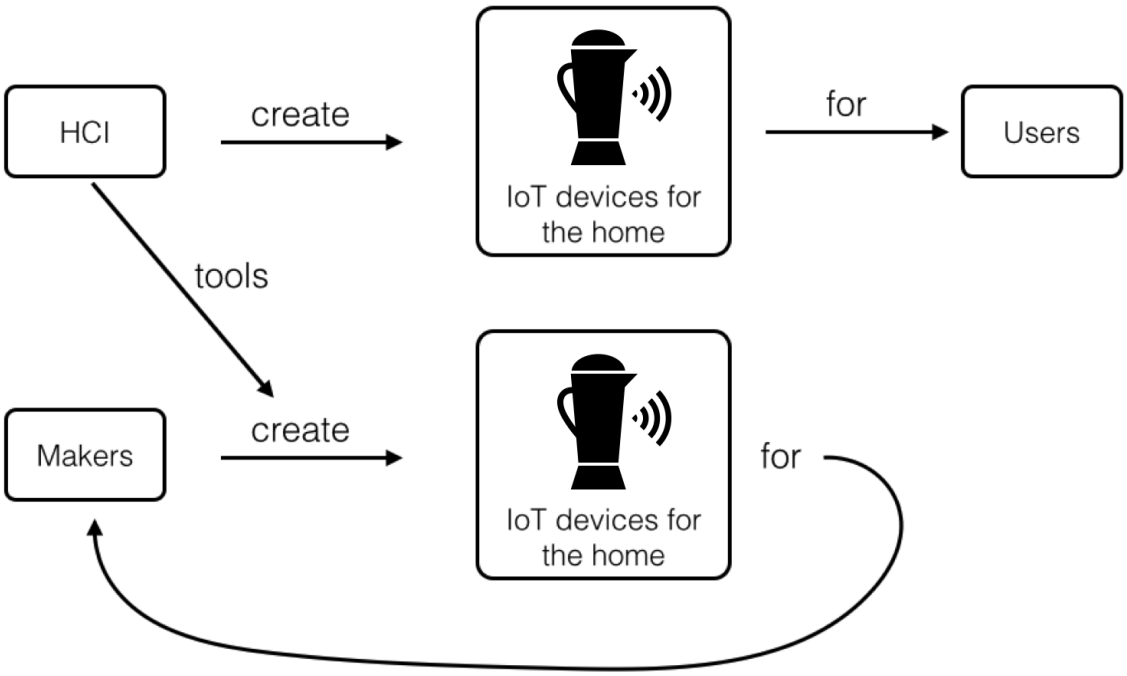


Figure 3.1: HCI researchers suggest that makers are creating similar devices for themselves that HCI researchers and designers used to create for users, which means a new endeavor for HCI research is to shift to designing tools that enable makers to create these artifacts [163].

democratized technological practice only from the perspective of the artifacts they are creating. If we instead think about the difference in process, mindset, and practice between the makers and the HCI actors who might have focused on those same devices before, we realize the devices from HCI systematically embody and embed consideration for the human experience, while analogous endeavors in the making phenomenon might embody some of these considerations, but not systematically (Figure 3.2). This idea resonates with Carroll and Kellogg's argument that artifacts in HCI embody psychological claims and theories [43].

However, it was unclear how we might incorporate this HCI-like perspective in our makerspace– Would our guided workshops follow a human-centered design process? It was also unclear what that meant for our role as makerspace leaders– To what extent would I be overstepping my bounds by attempting to influence makers' mindsets and practices? To bring HCI mindsets and practices into the maker world, I would have

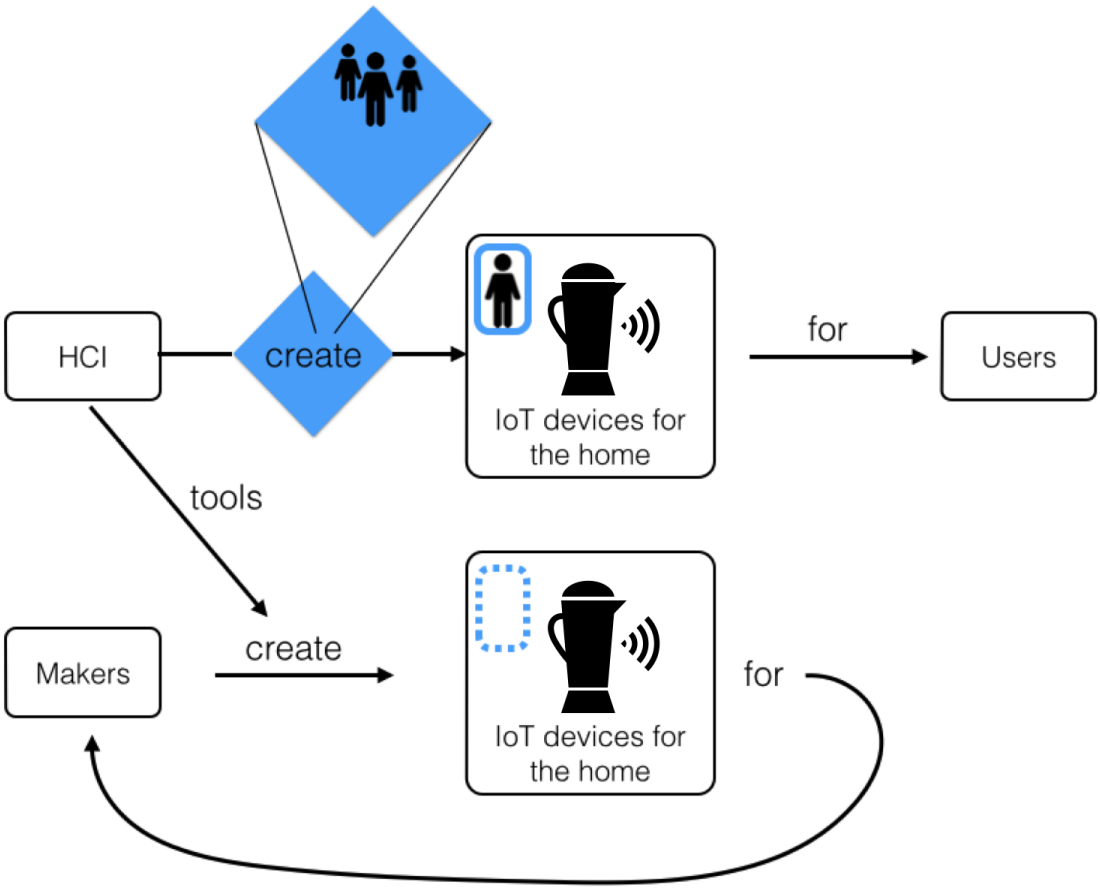


Figure 3.2: I suggest that noticing differences in processes in HCI practice and the making phenomenon sheds light on differences in the considerations embodied in the artifacts.

to change from being a peripheral facilitator of a free-for-all space to something more deliberate and involved. While taking on this new role would be in line with Bardzell et al.'s call to the HCI maker research community to "prototype alternate maker ecologies" and make a more serious commitment to social progress [16], I encountered a number of tensions and power dynamics that I was not sure how to reconcile. For example, if our makerspace were to commit to any one definition of social progress (such as taking the human experience into account when creating IoT devices for the home), that would inevitably de-value certain endeavors in the space. However, with no commitment to social progress, the makerspace is already de-valuing endeavors that are invisible within the current value system and running the risk of endeavors in the space leading to negative consequences. In Chapter 1, I noted how some of this work was influenced by an underlying feminist sensibility, and this is one of those places where that perspective manifests. A feminist stance paradoxically not only calls for an intervention to advocate for those who could be participants in making phenomenon and for those impacted by the things makers make, but also suggests that those in power should not impose a singular viewpoint on others. I was conscious of my position of power as a leader of the makerspace, but I did want to move the space towards the goal of democratization. This shed light on the need for guidance for makers and makerspace leaders on how to align their efforts with the promise of democratization. In other words, if our makerspace was to accept "democratization" as the answer to "Where are we going?", then we would need something to guide our immediate actions towards that promise.

3.1.1 Deciding to Develop a Normative Theory

I decided to develop a mechanism for guidance for makers and makerspace leaders in the form of a normative theory. A normative theory states how things should be or states considerations to keep in mind when moving forward, while a descriptive theory describes how things are or how they were. An example that shows the difference

comes from decision-making, where a normative theory guides the ideal decision to make in a given context based on the preferable outcome and a descriptive theory captures the decisions that people typically make [25]. A normative theory of design points designers to an ideal process, principle, or method they should employ to result in a better design. An example of a normative theory of design from the domain of architecture is a set of tenets of good design for houses from Frank Lloyd Wright, such as not subdividing a house into too many rooms [116]. Normative theories might be in the form of design patterns or design objectives [116] or something else. Implicit or explicit in any normative theory is a set of criteria that the normative theory fulfills better than another theory or the absence of the theory.

While research outcomes in the field of HCI are not typically in the form of normative theory, the premise of a normative theory is not far from typical HCI research contributions. HCI contributions are often in the form of design principles or implications for design, which are intended to guide future designers in particular design endeavors and design principles in general are common in HCI [66, 164]. Naturally, these design principles are normative in nature since they tell what should be done. A normative theory is more formalized and generalized.

Makers are not necessarily participating in formal design endeavors. However, they are participating in endeavors that in some ways resemble design, as discussed by Desjardin et al.'s notion of the "everyday designer" [58]. While makers are unlikely to be interested in a formal normative theory, there is evidence of makers explicitly discussing claimed values and navigating tensions relative to their endeavors [180], so it is possible that suggesting different values to align with could be impactful. Makerspace leaders are also not participating in design endeavors. However, there are many ways the process of setting up a makerspace resembles a design endeavor and could be informed by types of guidance that designers adopt such as a normative theory. While there is guidance for makerspace leaders such as the makerspace

playbook [98, 4], most of these resources focus on the equipment profile, policies, and safety guidance.

I decided the normative theory would take a value-based approach by focusing on different values that could be embedded in practices and mindsets rather than on processes of making themselves, since making involves so many different kinds of processes. Makers tend not to be guided by theories, though they are perhaps guided by values, as Toombs et al. points out many ways makers explicitly and implicitly negotiate values [180]. Making-related processes tend to result in artifacts, while values are broader and application of values can result in artifacts, initiatives, experiences, or other types of outcomes such as care [181]. The focus on values was also inspired in part by Value-Sensitive Design, a design method that ensures values are explicitly discussed and taken into account at all steps of the design process [83]. Value-Sensitive Design involves conceptual and empirical investigations of values to consider the implications of aligning a design with a particular value on both direct and indirect stakeholders. Since some of my concerns with democratization in making had both to do with direct stakeholders such as potential makerspace participants who face barriers to entry and indirect stakeholders such as the communities who are impacted by the artifacts that makers create, this also made Value-Sensitive Design appropriate to align with.

Another factor in my decision that the normative theory would take value-based approach was how imagined HCI would engage with the theory. Since many HCI endeavors support makers by designing tools or experiences, HCI researchers could use the theory to design for and promote certain values in the making phenomenon.

The majority of the supporting evidence for the theory is theoretical rather than empirical. When providing support for a normative theory, one approach is to explicitly establish and justify criteria that will be used to compare the proposed theory against a different theory [141]. In the case of making, there are no existing normative

theories about how makers or spaces for making should operate or the values they should align with. While there are many studies that look at what is happening in the making phenomenon, the contexts studied (and perhaps the maker phenomenon as we consider it) are far too heterogeneous and none of this work has converged on any descriptive or normative theories as of yet. I will thus use the normative criteria in a theoretical argument that discusses manifestations of the different values in real or hypothetical HCI practice and making contexts. Given the NTHCM calls for a shift in values rather than a specific design process, the locus of the outcomes of the application of the theory range from an individual's act of making to a new type of maker ecosystem.

My goal was thus to construct a guiding normative theory that would help me as a maker leader, other maker leaders, HCI researchers, and makers themselves adjust and calibrate their individual endeavors based on different values to ensure the collective output of the making phenomenon has a positive impact on humanity. Constructing the initial definition of the theory involved 1) defining democratization in the form of specific criteria 2) identifying prominent values in the making phenomenon that are in the way of those criteria for democratization and 3) identifying complementary values from HCI research and practice and discussing what they offer towards better fulfillment of the criteria for democratization. I describe these steps in the rest of the chapter.

3.2 Defining Democratization

Since HCI literature on making and making enthusiasts themselves often cite democratization as a hallmark of the making phenomenon, I decided to take that concept as a starting point and would figure out how to determine whether local actions align with these goals or not. I began with a literature review on democratization as well as empowerment with the goal of finding a more concrete way of discussing the concepts. While the topic of the dissertation primarily focuses on democratization,

empowerment is a closely related concept that is often discussed in conjunction with democratization. The definitions of democratization that I consider in many ways subsume the concept of empowerment and pursuing democratization involves pursuing empowerment as well. While democratization and empowerment are discussed often, I found they are not well-defined in HCI and making communities, so I would have to construct my own definition.

In order to construct a set of criteria for democratization, I conducted a literature review, which I summarize below. The goal of the literature review was to draw from existing definitions or frameworks for democratization and empowerment in literature on the making phenomenon or in HCI. In the absence of a complete definition or framework, I was looking for a piecemeal way of addressing my two main concerns about democratization in the making phenomenon as I had experienced them while working to set up a university makerspace: 1) how to systemically address barriers to access such that everyone is included in the democratization and 2) how to take responsibility for the implications of the democratization of technology production on society, for example, the extent to which consideration for the human experience was taken when makers were working with indirect stakeholders. This literature review intended to generate an initial set of criteria to lay the basis of the theory project that I would refine later on after exploring how these ideas relate to the practice of making and maker leadership. In Chapter 7, I return to the theoretical construct of democratization and turn to literature on democracy in other fields to refine the criteria.

3.2.1 Democratization in Making

I looked to articles and other points of view from the making phenomenon to better understand how they used the concept of democratization, looking for a definition or a concrete understanding of what it means. While many making enthusiasts use the term, I was unable to find any specific definition or any critical look at the extent to

which the promise is being fulfilled. My main takeaway was that "democratization" in the making phenomenon is synonymous with the term "access", and is primarily used as a way to frame making rather than a concept that is engaged with deeply. I discuss a few examples that illustrate that point below.

Dale Dougherty, an early enthusiast of the branded maker movement and the founder of Make Magazine, uses democratization as a central concept in his view of the making phenomenon. In response to an interview question about how making relates to citizenship, he says, "I view making as a form of participation, and what we're seeing broadly is the democratization of technology. In other words, it's cheaper. It's accessible to more people. The difference between the tools that amateurs and professionals use are diminishing in cost and in difficulty. And so to me, in particular working with students and other people, I think we're trying to invite them to participate in a culture that is strongly dominated by technology and science, and that those tools allow them not only to participate, but to effect change" [135]. He goes on to talk about how making is about providing the opportunity to shift from "passive spectators" of the world around them to active agents of change. While he does not define democratization any more specifically, nor does he discuss what it takes to truly pursue this goal, my interpretation is that his idea of "democratization" is about the general public having access to tools and materials that they did not have access to before. He does admit that there are barriers to access, but sees these as naturally lowering over time due in part to technological innovations that make fabrication even easier.

Gershenfeld is an enthusiast of a slightly different part of the making phenomenon, citing the potential of digital fabrication labs, which have a more specific equipment profile than makerspaces. Gershenfeld focuses on the hallmark of such technology to give individuals the ability to make almost anything rather than purchasing a mass produced product from the store [87]. While Gershenfeld does not use the concept

of democratization explicitly, he does draw a parallel between widespread adoption of such devices and democracy, stating, "Just as accumulated experience has found democracy to work better than monarchy, this [revolution in the means of production enabled by digital fabrication] would be a future based on widespread access to the means for invention rather than one based on technocracy" [87], p.42. Gershenfeld's notion similarly is about the opportunity for more people to have access to certain capabilities than they did before.

I also looked at research papers on makerspaces that were outside of the domain of HCI. Many of these belong to fields related to education, peer production, or STS (Science and Technology Studies). Specifically, I searched for mentions of democratization and looked further when there was evidence of a specific definition or critical engagement with the concept. There was one example of a paper on making that has a more political and specific consideration of democratization. Stornaiuolo and Nichols discuss a making initiative in a high school centered around "making publics", which means leveraging various tools to turn a particular audience into a public centered around a matter of concern [173]. The leader crafted a number of open-ended making and technology related assigned projects that all involved various audiences. The authors claim that giving students repeated opportunities to consider different audiences gives them opportunity to develop a literacy for making publics. Several of the students were able to turn their projects into ongoing endeavors of civic action, though there were many instances where simply having an audience was not enough to help the students see the potential and the entire experience took a significant amount of work on behalf of their teacher and organizer. Nevertheless, this paper is a helpful account of evidence of the potential and challenges for maker-related contexts to mediate leveraging technologies for civic action.

Overall, this investigation supported my intuition that there was a need for more critical engagement with the idea of democratization in the making phenomenon and

there was an opportunity to develop guidance for makers and makerspace leaders on how to ensure their efforts align with such goals.

3.2.2 Empowerment in HCI Literature

I discussed the concept of democratization in HCI research in the related work section (Chapter 2). I also conducted a review of the literature in HCI on empowerment, a related concept that is often mentioned in conjunction with democratization, hoping that might shed light on a concrete definition. For example, a framework that highlights some of the barriers to empowerment might shed light on some of the things that are in the way of democratization.

Early HCI research had an additional challenge of establishing itself as a field of importance and deserving of attention from the rest of the computing community [51]. In 1995, Cooper and Bowers performed a Foucaldian Discourse Analysis on HCI texts to uncover the hidden rules that governed the rhetorical choices the authors made [51]. Many of these choices had to do with helping HCI establish itself as a field. For example, HCI authors would portray users as frustrated, angry, helpless, and idiotic. Cooper and Bowers describe the "crisis rhetoric" that HCI authors use and how a chapter from Schneiderman titled "Fighting for the User" adopts a "political-war discourse", where HCI is the only one left to advocate for the user and save them [51, 171]. This helped HCI portray itself as necessary and portray the work it was doing as part of a narrative of progress. Additionally, Cooper and Bowers discuss empowerment as a key part of the legitimating function of HCI. While some HCI researchers were shifting focus to empowering designers by creating tools or principles they could use to create better systems, Cooper and Bowers saw this as part of the same rhetorical strategy: "HCI still has a duty to empower and hence a reason to be."

I discuss the three waves of HCI [93] in a later section, but Cooper and Bowers point out how second wave HCI depends on first wave HCI rhetorically to justify

what it is doing [51]. This means that rhetorical choices, including the emphasis on empowerment, made in the first wave have certainly influenced future HCI. It can be difficult to distinguish between decisions made based on rhetorical strategies and discursive rules versus other types of goals. Nevertheless, empowerment has continued to be a common term in HCI. Schneider et al. point out how there are many "passionate calls" from HCI researchers to other HCI researchers to leverage technology to empower people in various ways, but they all use the term in different ways [169].

Schneider et al. present a framework of different ways empowerment is discussed in HCI literature [169] (Figure 3.3). They claim empowerment as more of a 3rd wave HCI endeavor as HCI becomes more concerned with culture and society. They also point to mission statements of several tech companies that use the word empower or empowerment as part of how they frame what they are doing. This shows that this rhetoric or this goal is pervasive not just in HCI research, but also in technology in the world. Schneider et al.'s framework is a helpful overview of different definitions empowerment takes in HCI research. I draw on categories from this framework directly when establishing the criteria for democratization.

3.2.3 Criteria for Democratization

Based on the general HCI literature, the HCI literature about making, and other literature about making, I distilled the following set of criteria that aims to capture and make concrete various aspects of democratization as well as address some of my primary concerns relative to democratization.

3.2.3.1 NC1: Democratizing Access to Tools and Material Empowerment

Democratization of access to tools for making and individuals being empowered to view artifacts and materials as things you can manipulate are related since they lead to the same thing: the ability to produce things. This criteria has two dimensions,

Categories	Manifestation	Definition	Examples
CONCEPT OF POWER	power-to	Power is understood as "something - anything - which makes or renders somebody able to do, capable of doing something" (as in [8]).	Multi-sensory, interactive maps for visually impaired children[17].
	power-over	Power is understood as a relation between two actors where "A has power over B to the extent that he can get B to do something that B would not otherwise do" [23].	A system that helps people to confront policy makers [41].
PSYCHOLOGICAL COMPONENT	feeling	Empowerment as perceived control, self-efficacy, competence and motivation to exert power.	A system that increases users' self-esteem by balancing scores according to physical ability [33].
	knowing	Empowerment results in understanding and learning the awareness of action opportunities and the development of skills related to problem-solving and exerting power.	Educational games [45, 46, 90] or a system that allows women to gain self-knowledge by looking at their vaginas [3].
	doing	Empowerment results in the exertion of power and taking action.	Systems that enable people to achieve their goals in the first place, or in quicker or more efficient ways [7, 64].
PERSISTENCE OF EMPOWERMENT	transient	Empowerment happens immediately, and only, during system use.	Mobile phones [61] or systems assisting or supporting handicapped persons [7, 18, 72].
	persistent	Empowerment happens beyond and persists after system use.	A public voting system [88] or an educational videogame [45].
DESIGN MINDSET	participatory	Technology can only be empowering when designed from the empoweree's perspective.	Multimodal games for fall rehabilitation co-designed with seniors [93].
	expert	Researchers analyze the need for empowerment from a third person perspective.	Researchers analyzing crowdsourcing platforms, which encourage the exploitation of crowdworkers [1].

Table 1. The categories and their manifestations of our framework, illustrated by examples from the literature we reviewed.

Figure 3.3: Schneider et al.'s framework of empowerment in HCI [169]

drawing from different places.

NC1-a is derived from Tanenbaum et al.'s discussion of how democratized technological practice through making intertwines pleasure, utility, and expression. Tannenbaum et al. discuss what it means for making to be democratized and how it must involve the combination of pleasure, utility, and expressiveness, pointing out that even in instances of making that start with one of these values, all 3 are actually intermingled [174]. For example, the value of pleasure or playfulness might be expected to be a hallmark of making only in the developed world, while the value of utility is the focus for making in developing countries. However, the privileged maker playing and the maker creating solutions in the developing world incorporate pleasure, utility, and expression in their practice [174]. This means that these seemingly separate values actually are more often intertwined than separate. This definition of democratization belongs in this category of access because to truly democratize access to the tools, the access needs to not be biased towards any certain use case over another.

> NC1-a (access): There is the possibility of, appreciation for, or representation of all three of the following: pleasure, utility, and expression.

NC1-b draws from Shneider et al.'s framework of empowerment in HCI literature and from Roedl et al.'s definition of material empowerment. Satisfying this criteria requires overcoming some of the psychological barriers that feminist scholars have pointed out have prevented some women from participating in makerspaces [35, 182]. Since power is at the basis of empowerment, to feel empowered to do something and take action using tools and materials requires the power to come from somewhere or for some other entity to catalyze the empowerment [169]. Being materially empowered thus requires not only having access to the tools and materials, but also requires a psychological component of feeling in control as well as having various literacies that go beyond just how to operate the machine. Combining this idea with some of Schneider et al.'s categories of empowerment, I arrive at the next criteria for democratization:

> NC1-b (access): There are mechanisms in place to help people *feel* empowered, *know* the possibilities afforded to them, or take action to *do* something with the tools and materials.

3.2.3.2 NC2: Socially Progressive Empowerment and Democratization Through Discourse

Socially progressive empowerment is related to publics, a more political aspect of democratization, because they both involve taking action and purpose-driven social aspects. Fulfilling this criteria requires extending or pushing forward the ways both research in HCI and practitioners in the making phenomenon typically consider these aspects.

This criteria relates to Roedl et al.'s notion of makers as socially progressive, though it takes it further. Roedl et al. discuss aspects of socially progressive making as recog-

nizing the universality of making as a pathway to spreading technological literacy, the prevalence of open-source resource and knowledge sharing, and the active resistance to consumer culture [163]. These are all certainly significant and socially progressive. However, when HCI research focuses only on these things, this reinforces a historical blind spot to structural, systemic, or socioeconomic aspects of social progress. HCI research can continue to highlight a narrative of technological progress and still claim to be contributing, though there is some HCI research that has started to engage more directly with politics [163].

This criteria also relates to some of the promises that making, in particular digital fabrication, will bring, including working towards a sustainable circular economy [6, 88]. It also relates to some of the critiques of that vision, namely that the technology itself will not instigate that sort of change [88]. Publics are not discussed often in making research and are even a contested topic in political theory, though in some form they are critical to democratically engaged society [76, 173]. This criteria relates to the work by Stornaiuolo and Nichols that investigates a context for making that deliberately focuses on fostering opportunities for creating publics and for students to develop necessary skills [173]. As Stornaiuolo and Nichols conclude from a discussion of various political theorists' notion of publics and youth media, "Seeing oneself in relationship to others is fundamentally democratic work, necessary for developing a common world and public culture. Engaging in public action in the presence of others is a way of living that resists homogenization and contests mass production by highlighting democratic plurality" [173]. This insight sheds light on what it is reasonable to expect from contexts for making in terms of forming publics and providing opportunity for civic action and social change through making.

> NC2 (social progress): There is evidence of or space for and support for dialogue and groups to form around matters of concern. There are opportunities for discourse and opportunities to cultivate relevant skills

(including, for example, literacy regarding social implications and possibilities).

3.2.3.3 NC3: Risk Mitigation

This criteria comes from technology literature outside of HCI and making, though is relevant to technology. Garvey considered the democratization of artificial intelligence technology, in particular as discussed by major tech companies who claim this as a goal and drive initiatives to create free libraries and resources for the general population [85, 84]. They draw upon Woodhouse's framework for the democratic governance of technology through intelligent trial and error and list a series of considerations that should be taken when pursuing the goal of democratizing access to AI [85, 122]. One category of considerations has to do with prudence and asks whether there are mechanisms in place that will help in the eventual occurrence of problems and to mitigate risk [85].

Gershenfeld et al. draw parallels between past technological revolutions such as the Internet, citing its promise to democratize communication and future technological revolutions such as digital fabrication, which democratizes the means of production [88]. They suggest that we should learn from the Internet that technology needs infrastructure and societal support to help it achieve that promise and that many unexpected negative outcomes emerge where the technology becomes adopted [88]. We should ensure that digital fabrication has such additional support and that there are mechanisms in place to help guide and shape the maker phenomenon in the future when unintended consequences inevitably emerge.

Based on these perspectives and in particular drawing specifically on some of Garvey's criteria in the risk framework, I derive the next normative criteria:

> NC3 (risk): There are precautions in place to help mitigate forseeable or future unforseeable risk. There is flexibility built in to be able to respond

and adapt to these risks in the future.

3.3 Identifying Values in the Making Phenomenon

In the following sections, I discuss a number of places where an entanglement of individualistic, artifact-based, and internal-facing mindsets and practices manifest in the making phenomenon and in research on making, as well as some of the ways these values might prevent the criteria for democratization from being fulfilled. I do not claim that this set of values is universal, all-encompassing, or even the most prominent in the making phenomenon. Rather, as illustrated by the following examples, they are prominent to some extent, and when they do manifest, they are arguably impactful on the outcomes of the making phenomenon. I chose these values based on my own perceptions of the making phenomenon through running a makerspace and through literature I had read.

I used the following definitions in this initial investigation. Later, I will discuss how I fleshed out the definitions of the values beyond these initial definitions based on how they manifest in practice in the interview study presented in Chapter 4.

Artifact-based: Focusing on the artifacts that are created in a makerspace or the tools, machines, or materials.

Internal-facing: Focusing on oneself rather than on others. This could mean a maker focusing on their self or a makerspace focusing on what is happening internally. An internal-facing makerspace thinks only of serving the people within it and an internal-facing maker or making endeavor exists only for the enjoyment or fulfillment of the initiator.

Individualistic: Focusing on hallmarks of making relative to individuals and on the experience of individuals in the making phenomenon.

3.3.1 Empowering Makers

An *individualistic* and *internal-facing* value system manifests in much of the common rhetoric surrounding makerspaces and the making phenomenon. Dale Dougherty, the founder of Make media and quite likely the person who coined the term "Make" as the word that would characterize the making phenomenon, used the phrase "We are all makers" to motivate the phenomenon [65]. Dougherty focused on what a maker can accomplish, driven by their own sense of purpose, when given the right tools and community [64]. While this might seem like empowering and inclusive language, an individualistic and internal-facing value system can cause problems in terms of the criteria for democratization in several ways. The most obvious way is in terms of empowering people to know what is possible to do there and showing them they are capable of doing those things (NC1 (access)). While there are many actions one can leverage making to take, these are not immediately obvious. Framing the maker phenomenon only in terms of what an individual can do, such as with the "we are all makers" rhetoric, makes it harder for the individual to know what significant things they can do (NC1 (access)). Additionally, when the rhetoric of making focuses on how "you" the maker can do whatever you would like, but doesn't tell you what that might be, empowerment is limited to what the individual can already imagine, which is a barrier to some individuals.

Toombs et al. similarly found that makers they interviewed "clearly hope that they can individually woo women and other non-traditional participants," but this resulted in blindness to the "structural problems" that prevent participation [181]. This *individualistic* approach to access is thus limiting since it prevents the space from taking a more socially progressive approach to inclusion (NC2 social progress). Toombs et al. also characterize this approach as "colonizing" in the sense that making sure individuals feel cared for is "good for business" since it benefits the space as a whole when there are more participants. This *internal-facing* consideration is not

a problem for any of the criteria for democratization in and of itself. However, if obtaining more individual participants were the only focus and the only end goal of a particular space, it seems likely that there would not be emphasis on endeavors for social progress (NC2) or focusing on some of the nuance of the participation such as the range of types of participation or the psychological component (NC1 access), especially if it makes participants less aware of the structural problems as Toombs et al. claim.

3.3.2 Empowering Others

In this section, I use the specific use case of DIY assistive technology (DIY-AT) to illustrate additional implications of individualistic and artifact-centered values relative to the normative criteria. A common use of spaces for making and digital fabrication tools is assistive technology for one's self or for others. DIY-AT potentially opens the door for the maker phenomenon to be less internal-facing and less artifact-based by affording opportunities for different participants and different conversations. However, I show in this section that there is much evidence of these values and as a result many of the normative criteria are not met.

Hurst et al. recognized that assistive technologies in general can empower people, but many people do not have access to these devices, and many more abandon their devices [41, 106]. Researchers saw the emerging DIY community as holding potential for people to create their own assistive devices and predicted that online platforms such as Instructables and Thingiverse would enable such practices [106]. Indeed, communities and distributed networks have formed around fabrication of assistive devices, helped by websites such as Thingiverse [40].

There are ways in which these communities could even better achieve their goals of helping people if equipped with a different mindset. e-NABLE, for example, is a distributed network of volunteers and is one of the fastest growing of these communities dedicated to printing and distributing 3D prosthetics [154]. Meissner et al.

point out how not considering the possibility of the people with disabilities as makers is "contradicting the discourse of democratisation and empowerment surrounding making" [136]. In some contexts, a more effective strategy than creating devices for others would be to run workshops for people with disabilities such as the DIY-Abilities workshops Meissner et al. present [136].

It is not clear where this tendency amongst makers and researchers to focus on people with disabilities as recipients as opposed to makers and designers themselves stems from. This could be seen as evidence of the *individualistic* and *internal-facing* values that seem to pervade the maker phenomenon. While makers who make devices for others are drawn by the desire to help people [154] and are looking externally to put their skills to use, they are keeping themselves in the equation by making devices rather than teaching skills to others. This focus on *artifacts* and the makers themselves (*internal-facing*) limits the extent to which these makers are participating in the making phenomenon's claimed goal of social good.

These places where individualistic, internal-facing, and artifact-based values manifest cause problems relative to all of the criteria for democratization. The focus on the devices themselves means that volunteers never realize the importance of the social aspects of their endeavors (NC2 (social progress)) and means that the communities that participate in these endeavors probably mostly attract people with tech-centric fabrication skills and encourage community members to learn only those skills (NC1 (access)). They do not realize that they could, and perhaps even should, be helping the device recipients learn how to print and operate the digital fabrication tools for themselves (NC1 (access)). This also resonates with Constanza-Chock's observation that some makerspaces "do partially challenge ableism through a common emphasis on assistive technology, such as 3-D printed prosthetics, but typically do so through the individual/medical model of disability, rather than the social/relational model, let alone a disability justice analysis" [52], limiting the opportunity for social progress

(NC2). Lastly, the volunteers do not understand the risks of the devices and what sort of physical harm they might be causing the recipients as well as the sort of psychological harm caused by raising their hopes about a device that might not actually work (NC3 (risk)).

3.3.3 HCI Research on Making

HCI research on the making phenomenon often looks at *artifacts* made by *individual* makers. There is a large body of HCI literature that focuses on the design of digital fabrication tools for novices to lower the barrier to the types of *artifacts* that an *individual* can create by embedding knowledge about the physical world and operation of the devices into the design tools themselves [22]. For example, these tools might help users fluidly shift between physical and digital representations [80], convert 3D models into interlocking pieces [133], convert 3D models into wireframes for faster prototyping to speed up iteration cycles and decrease frustration [139], allow for incremental printing while modeling [156], design functional chairs by sketching [167], or easily add interactivity to 3D printing objects [168]. These are all designed for personal fabrication, considering the experience between one user and the tools that will help them create the objects they want to make.

Roedl et al. describe two types of maker empowerment in HCI discourse: 1) material empowerment, where makers have the ability to shape materials and use tools to accomplish various goals and 2) socially progressive empowerment, where makers embody democratic attributes by using and contributing to open source repositories and resisting consumer culture [163]. While not all of the papers that present fabrication tools directly cite democratization or empowerment as goals, they are in line with Roedl et al.'s notion of material empowerment since they paint a picture of progress in the form of enabling makers to create different types of artifacts more easily. However, Roedl et al. point out how this notion of progress within HCI regarding making is rather apolitical, which allows HCI research to "continue to portray

itself as contributing to social progress through technological development in support of makers while sidestepping the need to consider structural socioeconomic issues or engage in controversial public debates" [163]. In other words, by focusing on material empowerment by building *tools* for makers and limiting the definition of socially progressive empowerment to aspects that mostly concern *individuals*, such HCI research has a blind spot to many larger problems (NC2 social progress).

3.3.4 Observations of CCI Makerspace

Upon reflecting on my experience with managing and spending time in the CCI Makerspace, I found evidence of individualistic, artifact-based, and internal-facing values enacted in various practices. While these practices might seem neutral enough, I also discuss some foreseeable problems in these instances in relation to the criteria for democratization.

- My default question for people in the makerspace is "What are you making?" While I often wanted the question to lead to a discussion about something else, we would often get stuck talking about the details of the fabrication and implementation of the artifact. This reflects artifact-based values since although we do talk about the process by which the artifact was created, we never talk about anything beyond the artifact such as what purpose it serves or what it means.

  This is problematic in relation to NC2 (social progress), in particular the part about facilitating dialogue, since it seems this question is not enough in itself to spark the kind of dialogue necessary to instigate social change through making.

- When I give an introductory tour of the makerspace to people, I find myself discussing the machines we have and the types of artifacts one can create with them: "With the laser cutter, you can cut or engrave flat sheets of material and create 3D objects by stacking, slotting, or bending". Not only is this an artifact-

based introduction, it is also individualistic since it frames the possibilities in terms of "you", in this case the potential makerspace user.

This is particularly problematic for NC1 (access) since it assumes that the person has the skills required to come up with an idea for how to apply that technology. Conversations that are individualistic and artifact-based might spark ideas or connections for people with certain pre-existing technological identities [9, 75], but not for others. Being creative and coming up with an idea can be a barrier for some who might not be comfortable with tinkering with machines or exploring in front of others.

- My definition of a makerspace is "a community-centric space with tools where people come to make things that are interesting and important to them". This definition frames the makerspace as something that serves its inhabitants (individualistic) and focuses on how the space enables people to make things (artifact-based). While the community piece is in there, it is a self-serving community: a community that benefits and supports members of the community and that goes away when the members go away. Additionally, one of our main metrics of evaluation was the number of people who were active in the space each day. We knew this wouldn't be the only measure of success, but in the absence of developing anything better, this is what we relied on to demonstrate that the space was valuable for the CCI community. Equating high traffic with success of a makerspace is individualistic since it measures the benefit by how many individuals it serves by being in there. It is also internal-facing since it doesn't measure anything beyond the walls of the space.

  This is problematic for both the social progress (NC2) and risk (NC3) aspects of democratization in that understanding social progress and mitigating risk require consideration of aspects beyond the space.

3.4 Identifying Values in HCI Research and Practice

In the previous section, I discussed examples of individualistic, artifact-based, and internal-facing mindsets and practices in the making phenomenon and how they might hinder making's promise of democratization because they prevent the criteria for democratization from being fulfilled. Naturally, my next question was: What are some alternate values that could manifest in the making phenomenon that might have more desirable outcomes in line with the movement's broad promises? While there are multiple sets of alternate values to consider, I decided to focus on values in the field of HCI as opposed to a different community for a number of reasons. Firstly, the making phenomenon and field of HCI both share the goals of democratization and empowerment [16]. As discussed in the related work section, this means that HCI researchers can fulfill these broad goals in part by supporting and spreading maker empowerment. Additionally, several HCI researchers have suggested that HCI designers draw upon the "maker ethos" by adopting aspects of the maker mindset as an upgrade to HCI design. There are deep synergies between HCI and making and it is reasonable to turn to the field of HCI to consider ways to improve the overall outcomes of the making phenomenon since HCI researchers turns to making for ways to improve HCI practice.

Secondly, in the beginning of this chapter, I presented a reflection on questions I faced as a makerspace leader about what broad promise we should align our space with and how we should align our efforts with that promise. The answer that I am exploring in this dissertation is that the promise of the making phenomenon is democratized technology production and that if we were going to align with this goal, we have a responsibility to prompt an HCI-like consideration for the human experience along with any technological developments we introduce to the space. Adopting values from HCI that are complementary to the identified values from making would be in line with that agenda.

Thirdly and more broadly, making is a site of technological production. Throughout its entire history, HCI researchers and practitioners have been working within various sites of technological production to argue the imperative to consider the human aspect of technology on behalf of the user. Before UX departments existed in industry or as a field of academic study, HCI advocates argued their importance [51]. HCI educators also face a challenge in incorporating HCI in degree programs where students do not see the value in it [7, 112, 117]. Since HCI advocates are accustomed to working HCI into these different sites of technological production, it is reasonable that the making phenomenon would be yet another place where there is potential for human-centered mindsets and practices.

In the rest of this section, I consider each of the three values from making introduced above (individualistic, artifact-based, internal-facing) and look for ways that HCI research and practice embody contrasting values or how HCI researchers consider other values in relation to these. These values were selected to provide a frame for further investigation; I do not claim that they fully encompass the field of HCI as a whole or that they are the only alternatives to consider in the making phenomenon.

3.4.1 Interaction-based

While making artifacts is a crucial part of HCI research and design, endeavors in HCI are less about the artifacts themselves, and more about the *interactions* with and around the artifacts. For example, artifacts or prototypes are often not thought of as solutions or representations of the future, but rather as probes or pivot points that help the designer decide which future is preferable [70, 166]. HCI researchers have also developed several more formal ways to discuss and understand interaction such as the Gulf of Evaluation and Execution, which considers the steps a user goes through as they perceive an interface, act on it, and perceive the result [146], as well as Activity Theory, which considers artifacts as mediating a complex set of activities between individuals, communities, and rules [13]. In general in HCI, to fully understand and

produce meaningful artifacts, we need to consider the complex contexts they are situated in.

Some of the more socially progressive (NC2) HCI research on the making phenomenon has been interaction-based. For example, Toombs et al.'s investigation of care ethics in a hackerspace required understanding the interactions in and around the space [181]. Similarly, Lindtner et al.'s work with makerspaces in Taiwan and China shows that looking at the relationships between communities and making, rather than the devices that were being produced, sheds light on different ways the making phenomenon could bring about social progress (NC2) [123]. Fox et al. discuss how feminist hackerspaces shift the focus from "hacking devices" to "hacking culture," which could be seen as an embrace of a particular type of interaction instead of the artifacts themselves [81].

Bringing interaction-based mindsets and practices into the making phenomenon itself would involve similarly promoting an emphasis and appreciation for the less visible hallmarks of making endeavors and a consideration for the interactions prompted by the artifacts that were created within the makerspace.

I considered other terms before deciding on interaction-based. I first considered human-impact-considering, but changed it to interaction when I noticed there were relevant interactions between humans and artifacts other than just impact. Interaction-based includes human-impact-considering, but is broader to include other aspects. I also considered experience-based instead of interaction-based. However, experience-based was harder to define and there are far fewer formal constructs or frameworks through which to understand experience. This may be due to the fact that focus on user experience is a more recent focus in HCI [93].

3.4.2 Collective

While Human-Centered Design processes in HCI tend to focus on individual users-their needs, personalities, and the unique contexts they inhabit, HCI research has

shifted over the years to recognize the need for also taking a more *collective* look at the impact of technology. This shift is evident in the three emerging waves of HCI [93]. First-wave HCI, focused on achieving measurable performance goals such as the likelihood for human error in an interface [93]. Second-wave HCI begins to recognize context as important and considers the information processing that happens in both humans and interfaces as well as the dialogue between. Third-wave HCI considers emotion, values, culture, and experiential goals [93]. Although these waves emerged chronologically, they are all still of importance in the HCI community currently [93]. When considered broadly, these waves not only represent a shift in focus away from an individualistic single user approach to design towards considering design more collectively and at scale, but they also shift away from the artifact itself, in favor of consideration of various interactions around the artifact.

Additionally, Dourish suggests a shift away from an individual-centric model of behavior change when it comes to broad problems such as environmentally friendly behavior [67]. Rather than focusing first on the individuals and multiplying to scale, HCI research can rather focus first-hand on the collective and use the collective to drive or frame the individuals' behaviors [67]. For example, many apps attempt to prompt small changes in behavior among individuals, with the idea that little actions add up to large scale change. Dourish's alternate collective-first approach would be to first look at the collective movement and then figure out how individuals fit in. For example, an app could help users understand how actions they perform fit into the larger movement [67].

In the making phenomenon, a shift from individualistic to collective would be in line with calls that other researchers have made. For example, both Lindtner et al. and Costanza-Chock suggest the need to shift away from narratives that focus on individual countercultural heroes in the making phenomenon who resist the tyranny of capitalizing by hacking and making [52, 124]. Lindtner et al. says that focusing

only on these narratives leaves us blind to some of the actual forms of resistance that may be happening. Costanza-Chock calls for makerspaces to "develop their own shared analysis of unjust power (the matrix of domination), how to dismantle it, and the specific role of design, hacking, making, and fabrication in that much larger process", which in part involves the "development of shared identities beyond the neoliberal entrepreneur." Bringing collective mindsets and practices into the making phenomenon would similarly involve awareness and interrogation of the collective making phenomenon and emphasis on the hallmarks of the making phenomenon that live at the community or collective level.

It was not immediately clear which value from HCI research and practice was complementary to individualistic mindsets and practices in the making phenomenon. In Hofstede's cultural dimensions, the opposite of individualist is collectivist, where groups are prioritized over individuals and certain groups might even be prioritized over others [100]. While HCI research often does focus on groups [93], it does not prioritize certain groups over individuals or others in this way, so collectivist was not an appropriate value for HCM. I searched for a word that captured the meaning of humanity-centric. I considered humanistic, humanism-based, which refer to other specific scholarly practices or periods in history [15, 50]. Humanity-centric is better than societal in the sense that it is vague enough to relate to many different levels including individuals, communities, and global. However, humanity-centric was proving to be too vague and undefinable to be useful. I had settled with societal for a while during my initial thinking, but this was too narrow. I found that I was using "societal" to refer to any group, including a community or all the makers involved in a particular project, so it seemed like collective was a more appropriate term to capture that concept.

3.4.3 External-facing

Since HCI as a field started with the goals of helping people, there has always been an external-facing aspect at its core. However, there has been a complex relationship with internal and external goals throughout HCI history. Early HCI research had an additional challenge of establishing itself as a field of importance and deserving of attention from the rest of the computing community [51], thus needing to pursue some internal-facing goals in order to pursue its external-facing goals. Some of the ways in which HCI demonstrated its importance was to draw upon "crisis rhetoric" or portraying users as frustrated, angry, helpless, and idiotic and how HCI is the only one left to advocate for the user and save them [51]. Part of seeming legitimate involved constructing a narrative of progress that painted HCI as a crucial part of that progress [51, 163]. Cooper and Bowers saw this as a rhetorical strategy: showing how "HCI still has a duty to empower and hence a reason to be." So even in pursuing external-facing goals, there is still always an internal-facing benefit to HCI in those pursuits. HCI researchers recognize that and are continually unpacking the discursive rules that drive our current research and aiming to shed the negative implications of those self-serving endeavors. For example, Pal plays on the CHI 2016 tagline "CHI4Good" with a provocative question of "CHI4Good or Good4CHI?", suggesting that HCI has an opportunity to grow to more generously pursue external endeavors such as serving marginalized populations or HCI4D initiatives [152].

3.5 Human-Centered Making and the Normative Theory of Human-Centered Making

In the previous sections I discussed two sets of values: individualistic, artifact-based, and internal-facing mindsets and practices in the making phenomenon and collective, interaction-based, and external-facing mindsets and practices in HCI research and practice. I have pointed out ways the individualistic, artifact-based, and

internal-facing values in the making phenomenon get in the way of the goals of democratization and empowerment. To investigate whether the presence of collective, interaction-based, and external-facing mindsets and practices in the making phenomenon better meets the goals of democratization and empowerment, I use these values as the basis of the definition of Human-Centered Making (HCM).

> Definition: *Human-centered Making* (HCM) is making-related practices and mindsets that enact or are guided by a value system that is interaction-based, collective, and externally-facing and is not primarily artifact-based, individualistic, and internally-facing.

These are some examples of these values evident in maker practices and mindsets of individuals or contexts for making:

- A club that 3D prints prosthetics for kids is *artifact-based* if it only talks about the devices they create, but is *interaction-based* if they emphasize the social community aspect and realize that interaction with the community is more impactful for some individuals than the devices themselves.

- An individual who is participating in a club that 3D prints prosthetics for kids has an *interaction-based* emphasis if they recognize that the recipient might not like the device or if they establish a genuine relationship with the recipient. An individual in this club that exhibits *artifact-based* values might assume the recipient has a certain relationship to their limb difference and the recipient will automatically be excited about receiving a life changing device.

- An *artifact-based* and *individualistic* makerspace draws attention to the fact that automatic cat feeders are a common artifact participants are making, drawing attention to how whimsical and personal an endeavor this is. An *artifact-based* and *external-facing* makerspace draws attention to participants who are creating furniture for local families who need it.

- An *interaction-based* and *collective* makerspace might draw attention to participants who are evaluating whether a public installation about climate change is actually inspiring anyone to change their behavior.

- An *internal-facing* makerspace cites the benefits it brings to the people who are active within it. An *external-facing* makerspace cites the benefits the people within it bring to the people outside.

- An *internal-facing* maker cites the benefits a makerspace brings to their self such as what they learn and what they are able to make. An *external-facing* maker cites the benefits making affords them to bring to others such as leveraging the laser cutter to create novel learning materials for their students.

- An *interaction-based* makerspace helps people who enter understand the impact of different artifacts on people and think critically about whether something is a good making endeavor based on thinking through what problems it might create even if it solves the original problem it set out to solve. An *artifact-based* makerspace helps people learn how to use the machines and provides technical workshops on how to perform various techniques.

As evident from these examples, sometimes the values of HCM lie at the level of the context, and sometimes they lie at the level of the individual. In Chapter 4, I will use an interview study to develop a more specific and grounded understanding of where HCM lives and how it manifests.

3.6 Normative Theory of Human-Centered Making

This dissertation also centers around the *Normative Theory of HCM* (NTHCM), which aims to guide makers, leaders of contexts for making, and researchers studying and designing tools and experiences for making in how they should think about making. The difference between the NTHCM and HCM is that HCM is a set of

values and the NTHCM is a guide that directs makers and maker leaders to embody that particular set of values. The NTHCM says that the particular set of values is something to strive for, while HCM just gives a name to the set of values without putting a value judgement on it.

> Definition: The *Normative Theory of Human-Centered Making (NTHCM)* states that the value system that surrounds making practices, mindsets, and contexts should embrace interaction-based, collective, and externally-facing values and balance or de-emphasize artifact-based, individualistic, and internally-facing values.

The Normative Theory of HCM is meant to be applied by three main categories of people: 1) leaders of maker communities or contexts 2) individuals making within these contexts or on their own and 3) researchers, especially HCI researchers, studying and designing experiences and tools for makers.

1) The NTHCM is applicable and relevant in guiding leaders of maker contexts (such as makerspaces, maker activities or modules in education, and other physical or virtual spaces that could be considered part of the making phenomenon) to shape and guide what happens within them. These leaders have the role of framing what making is, why it is important, and what the purpose of the particular context is. Implicitly and explicitly defining these things can have a direct impact on what types of endeavors are welcomed to the space and what sorts of ideas are born in the space. For example, a makerspace that aligns with the NTHCM not only offers training on the machines, but also provides conceptual support for project conception and impact-evaluation.

2) Individuals who are making might be impacted by the theory in a few ways. They might be part of a context that embodies HCM or they might choose to consider the value shift on their own. Either way, decisions where these values might manifest lie at a few different levels. Firstly, as an individual is choosing what to make,

there are certain making endeavors that are more aligned with HCM than others. For example, if assigned an open-ended fabrication project, choosing to iterate on a design of a prosthetic device or experimenting with new techniques for sustainable clothing is more external-facing and collective than making an automatic cat feeder or a light up responsive shelf. Secondly, as an individual conducting the process of making something, there are ways of going about doing that which are more aligned with HCM than others. For example, if they were creating a device for a community member, consulting that person throughout the process is more interaction-based than if they were to guess what that person wants.

My intent is not to specifically discourage individuals who create automatic cat feeders. There is nothing wrong with this as an endeavor- it is fun, creative, and expressive. It would be undesirable to adopt utilitarian values around making such that automatic cat feeders are discouraged since they do not fulfill an obvious need. However, if automatic cat feeders are all anyone ever creates, that is perhaps evidence of a problem that lies at the level of the context or space within which these items were created since it shows that people are not leveraging making to have the fullest range of its possibilities.

3) The theory aims to help researchers choose phenomena to study and, in fields such as HCI, choose types of interventions to pursue. As Roedl et al. point out, HCI research on making claims social progress as a framing and motivating factor, but HCI researchers' pursuits often lack the engagement with controversial topics or confrontation of power dynamics that might be in the way of truly pursuing those goals [163]. This is due, in part, to a common focus in HCI research on the material empowerment aspect by designing tools for makers [163], which is an artifact-based and individualistic perspective on making. Using the NTHCM as a guide, HCI researchers might choose to focus more on interactions in the making phenomenon (such as Toombs et al.'s look at care ethics in makerspaces [181]), or collective values and

trends at a broad scale (such as Kuznetsov and Paulos' large scale survey of people who use platforms for online maker communities [115]).

3.7 Summary and Next Steps

In summary, I have introduced the NTHCM based on how I derived it from literature and my experience in the making phenomenon. The general idea of the NTHCM is to bring values from HCI into the making phenomenon in order to better satisfy the promise of democratization. The NTHCM seemed to satisfy my need for guidance in the making phenomenon relative to the makerspace. What was needed at this point was an understanding of how the values manifest in practice, how to look for the values, and what it is like to operationalize the NTHCM. In the next 3 chapters, I present a series of empirical studies that aim to refine and test the theory by focusing on how it relates to maker practices, mindsets, and contexts for making.

CHAPTER 4: STATEMENT MAKING INTERVIEW STUDY: DEVELOPING THE DEFINITION OF HCM

This chapter uses a particular maker context to develop our understanding of HCM. Specifically, I use this analysis to answer the following research questions:

- What does HCM look like in practice? Where does HCM live?
- How do the values of HCM interact or relate? Can they co-exist? Are they ever in conflict? Are there times that the making values can support or strengthen the HCI values (or vice versa)?

To answer these questions, I performed a qualitative analysis using the 6 values of HCM as codes on interviews conducted with participants in Statement Making, a 3-time annual digital fabrication fashion show that I co-directed and ran. In the following sections, I describe the initial goals of Statement Making, details of how the event was conducted, why Statement Making was an appropriate context to develop the definition of HCM from, and the results from an interview study.

4.1 Statement Making Digital Fabrication Fashion Show

Statement Making was a digital fabrication fashion show co-directed for three consecutive years (Spring 2017, 2018, 2019) at UNC Charlotte by myself and a recent graduate who managed the Fab Lab in the Arts department.[1] Statement Making aimed to address some of the critiques we observed of the local maker culture in and around the spaces we were creating: while there were makerspaces in different departments, they felt siloed off from each other; participation in each space did not seem

[1]Some passages in this section have been quoted verbatim from my published work [151].

to be as varied as it could have been; there were not many students collaborating; and overall it felt like there was unfulfilled potential for the role that these spaces could play in the fabric of the university or the broader community. Together, we decided to host a makerspace-related event to encourage participation and collaboration, and decided a fashion show would make sense because it affords the opportunity to combine a range of technological, artistic, and personal interests.

Each year, the prompt for participation in Statement Making was to "Make a Statement" in the form of a wearable garment and showcase it at a public runway event. For several months leading up to each annual event, there were workshops on different fabrication techniques for textiles to encourage exploration and provide opportunities for participants to meet each other. Participants could apply for small grants to cover the cost of supplies. The directors encouraged digital fabrication, but accepted anything that was made with purpose and intention.

The focus and goals of the directors evolved over time as we reflected on what the event meant and what it could mean. Initially, the public language around the event consisted of "Statement Making: A Digital Fabrication Fashion Show" and the prompt to "Make a Statement". The show was a platform for individuals and groups to make a statement, but if the directors had a statement themselves, it was not explicitly expressed. In the third iteration of the show, a pamphlet laid out what the directors were hoping to achieve by creating this open-ended platform. Overall, Statement Making was about prompting individuals and groups to take control at a variety of levels: over the tools and machines around them, over something meaningful in the world, over the confines of mass-produced technology and consumables, etc. Sustainability was a theme emphasized by the directors, since even though there was potentially waste as part of the making process, overall the practice of making has the potential to be part of a more sustainable circular economy [88].

During the second year of the event, the directors received a grant to build a 64 foot

stage that would not only be the platform for the event, but would be a semester-long project for a Sculpture Installation class in the Arts department. A digital fabrication student organization led the construction of the stage and the sculpture class created panels covered in e-waste from the university in the shape of mountains of landfill.

4.1.1 Justification for Using this Context for the NTHCM

Statement Making was chosen for this study because it was a maker experience that is non-traditional in some ways and a typical maker experience in others. On one hand, it was a showcase event with an emphasis on digital fabrication that highlights things people made with very open-ended criteria for participation, much like a Maker Faire or other maker sharing events. On the other hand, it had the format of a fashion show, which is not typical in maker contexts, and prior work about Statement Making has argued that incorporating a performative aspect naturally brings feminist HCI design principles into play [19, 148]. Specifically, in prior work, I investigated Statement Making relative to feminist HCI design principles, and point out ways they relate [19, 148]. Bardzell's feminist HCI design principles are one way of drawing attention to how design can resonate with principles of feminist theory and feminist activism. The principles include pluralism, participation, advocacy, and embodiment. The argument I made in prior work was that since Statement Making was a maker event that centered around a performative aspect, it naturally resonated with these feminist HCI principles because it foregrounded bodies, voices, and meaning.

Statement Making was not designed to bring HCI values into the maker experience, was not designed with the specific values of HCM in mind, and was not designed with the goals of democratization and empowerment in mind. However, it did align with these goals since it facilitated interactions between many different groups of people, emphasized ideas rather than artifacts, and aimed to reach a wide community. From reflecting on the event at a high level, Statement Making seemed to align with the criteria for democratization presented in Chapter 3. There was evidence of participants

making things that were useful, expressive, and fun (NC1-a access); the workshops leading up to the event afforded the possibility to help potential participants understand the possibilities and develop a sense of agency (NC1-b access); there were a number of participants who participated by creating garments that made a political or activist statement, showing there were opportunities for dialogue and for groups to form around matters of concern (NC2 social progress); as an event with a start and an end, there were few concerns for risk that would have emerged in that short time frame (NC3 risk). While a more careful analysis would be needed to determine the full extent to which Statement Making did and did not meet these criteria, this initial speculation serves the purpose of justifying the use of Statement Making as a context through which to deepen our understanding of the values of HCM.

4.2 Interview Study Methodology

I performed an interview study, recruiting from participants, supporters, volunteers, and mentors who were involved in any of the past instances of Statement Making. Interviews were conducted via video call or in person based on each participant's availability. The interviews were semi-structured, aiming to understand motivations for participating, how they described their participation, and how they perceived the event as a whole. Question prompts included, "What did you make?", "What was your motivation for participating?", "What is Statement Making?", and "What were some memorable aspects of the experience?". The interviews were audio recorded and transcribed manually by the researchers, omitting names mentioned by participants.

I performed thematic coding on the transcribed interviews. The first pass of analysis used the six values introduced above as codes (individualistic, artifact-based, internal-facing, collective, interaction-based, external-facing). The fidelity of analysis was by topic, so several sentences could belong to the same unit of analysis or a given response to a question could be broken into several units of analysis based on how many topics were expressed. A quote could have one or several codes assigned to it.

Table 4.1: Contrasting sets of values from making and HCI

Making Value	Definition	HCI Value	Definition
Individualistic	One person, identity, personal	Collective	Many people or things, society
Artifact-based	Things created, tools for making	Interaction-based	Interactions with things or people
Internal-facing	Serving or considering self, looking inwards	External-facing	Serving or considering others, impact

Table 4.1 summarizes the definition of each value used when coding.

The second level of analysis looked separately at each value and co-coding between pairs of values (for example, all the quotes that were coded as both individualistic and artifact-based). I used an iterative open-coding technique to find emerging themes to characterize the ways each value or set of values manifested. During the secondary level of coding, I also coded whether participants expressed the values as values of their own or if they were simply noticing that those aspects were there. Additionally, I coded whether the participant was discussing their own participation within Statement Making, their perceptions of Statement Making as a whole, or general thoughts they had that are independent from Statement Making.

4.3 Results

4.3.1 Participants

Interviews were conducted in August and September 2019. There were a total of 16 participants (12 designers, 2 faculty mentors, and 2 students who volunteered or helped in other ways). Due to the low number of non-designers who participated in the study, I only include the 12 designers in this analysis. 6 designers were women, 1 was non-binary, 5 were men. Regarding race / ethnicity, participants reported that they were African American (1), Indian (1), mixed (1, black and German), Latino (1), Asian (2), and white (6). Table 4.2 summarizes the backgrounds and participation details of the study participants and table 4.3 summarizes the years of participation.

Table 4.2: Study participants who designed pieces for the show. * participated through a digital fabrication Art class. ** participated in a class focused on exploring computation in clothing taught by Dr. Latulipe *** participated in a class I taught focused on designing to prompt reflection about interaction with technology

	Major	# Times Participated	Part of a Team?	Design(s)
P1	Art	2	Yes	Fictional science fiction character; costume with functioning prosthetic arm
P2	None, identifies as Designer	1	No	Light-up jacket that responds to music
P4 ***	Computing	1	Yes	Government-controlled headpiece from alternate future that lights up based on wearer's creative contribution
P5	Computing	1	Yes	Costume based on model's identity and cultural heritage
P6 **	Computing	1	Yes	Pair of shirts for remote communicate through touch and haptic feedback
P7	Architecture	2	Yes	Cosplay characters from Star Wars and Zelda
P8 *	Art	1	Yes	Poncho with message about water waste in textile industry
P12 ***	Computing	1	Yes	Hat and glasses from alternate future based on social media over-use
P13	Computing	1	No	Jacket with painted message about immigration-related injustices
P14	Computing	3	Yes	Dress that lights up when lightning strikes the state; color changing light-up shirt; shirt that changes color based on emotion of someone standing in front of the wearer
P15 ***	Computing	1	Yes	Glove and shirt that display an incriminating message when phone is over-used
P16	Architecture	1	No	Parametric design-generated pattern on dress

Table 4.3: Years of participation. "X" indicates the interviewee participated as a designer. "(x)" indicates the interviewee was present at the event.

	2017	2018	2019
P1	X	X	
P2			X
P4			X
P5		(x)	X
P6			X
P7	(x)	X	X
P8	(x)	(x)	X
P12			X
P13			X
P14	X	X	X
P15			X
P16	(x)	X	

4.3.2 Timing and Influences on Participants

Since Statement Making changed over the years and each participant engaged with it in a slightly different way, I reflect here on some of the possible influences. All of the participants except for P1 and P16 participated in the most recent iteration of the event, which means most of the participants were commenting, at least in part, on the most developed and evolved version of Statement Making. Some of the participants, such as P14, participated multiple years. In many cases, these participants discussed how their participation or perception changed, and I discuss these details in the relevant sections below.

It is possible that some of the participants were influenced by interactions or conversations they had with me or that I unknowingly promoted the values of HCM in the makerspace or the Statement Making event. P8, for example, said they heard about the show when I came to one of their art classes to introduce it. When I introduce Statement Making to classes, I typically emphasize the range of different directions participants take, mentioning how some make a political statement, some

experiment with a novel fabrication technique, or some explore techniques for more sustainable clothing. P8's project centered around the topic of sustainability, which may have been influenced by that initial introduction.

As indicated in Table 4.2, some of the participants (P4, P12, P15) participated in Statement Making through a class that I taught and were likely influenced by the ideas discussed in that class such as using design to reflect on different possible versions of the future. Some of their responses to the interview questions reflect this influence, which I draw attention to in the sections below.

4.3.3 Overview of Coding and Co-Coding Occurrences

As discussed in the methodology section, I began by coding for instances of the 6 values. Figure 4.1 shows the number of times each value was coded and the connecting lines show how many times each pair of values were coded together. I present this not to draw any quantified conclusions about the the extent to which Statement Making promotes each value; rather I present this breakdown to contextualize the following analysis of the values themselves.

4.3.4 Artifact-based and Interaction-based

There was evidence of artifact-based and interaction-based mindsets and practices that manifested separately as well as together.

4.3.4.1 Artifact-based

Many of the times artifact-based mindsets and practices manifested, participants were discussing or noticing artifacts in a significant way, but were not emphasizing them as a value. For example, when asked what they would make if they participated again, some participants answered in terms of what technology they would use (P1, P6, P8). For example, P8 said "I know I want to involve lights. I'm not sure how yet" and P1 "would get more into the technical side of it." When asked what was memorable about previous years, some participants answered in terms of the artifacts

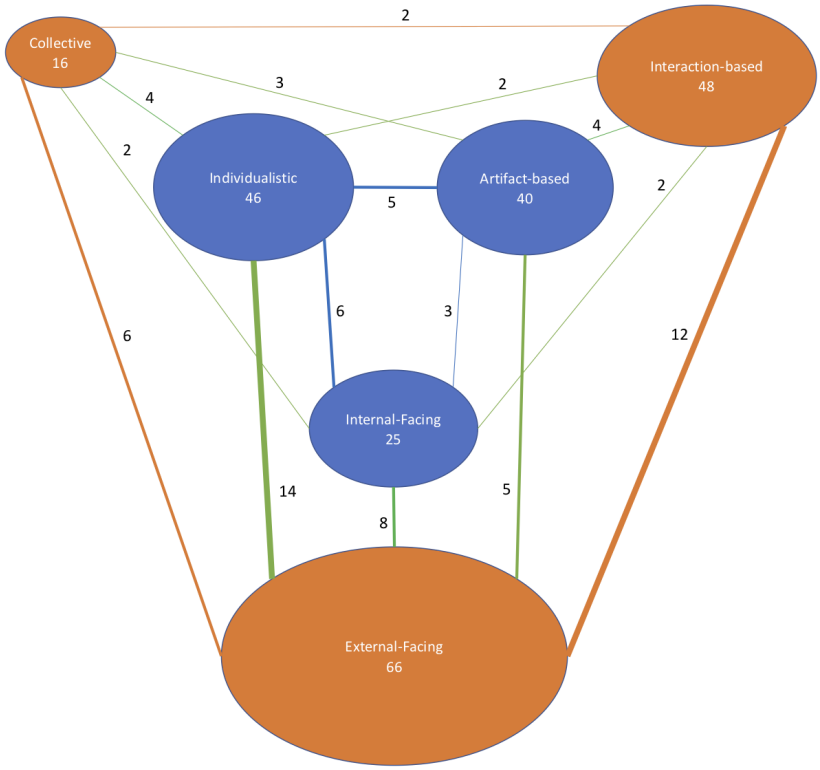


Figure 4.1: Nodes in this diagram represent the values (orange for HCI values, blue for maker values) and the size of the nodes roughly maps to code frequency. The connecting lines are weighted to roughly map to the frequency of co-coding between pairs of values.

they saw on stage (P1, P8, P12). This is in contrast to participants who answered these questions in terms of the ideas behind the pieces or the purpose they would want to achieve.

There were several instances where artifacts were an important part of participants' general practice. P8, an art student, was discussing the challenge of communicating an idea to others through art and said the best way to get better is to learn more about "technical practices for placement of objects, color, tone, gestalt principles", in other words, study more about artifacts. P16, an architecture student, thought the "politicalness of it distracted from the technology aspect", preferring more of an emphasis on the artifacts.

Artifacts also invited participation. P5 reported that it was a particular fibre optics piece from the former year that prompted them to participate. P8 and P16 decided to participate because they wanted to learn more about specific technologies. P1 saw the artifacts they were creating as a way to inspire others regarding what is possible with digital fabrication or prosthetics. Artifacts were also sources of exclusion, as P4 said that before participating in Statement Making during a class, they were not interested in it because it seemed very "hardware-based" and thus outside of the realm of a "normal comp sci student who's just involved in software".

Artifact-based mindsets and practices were co-coded with individualistic several times among P2 and P5, who both expressed positive sentiment around the combination of values. They talked about how they put aspects of themselves or their personalities into the artifacts they were creating, such as "an entire hat out of balsa wood and then those panels actually have like hand drawn pictures of things that were important to all of us" (P5).

4.3.4.2 Interaction-based

Participants discussed several types of interactions, described below.

Several participants commented on how the event prompted conversations between

participants, particularly across disciplines (P2, P14, P15, P16). Some participants described the goal of their artifact to be prompting conversations, or how the pieces at the event prompt conversations; most also indicated this was a positive aspect of participation (P5, P12, P15). P5, for example, noted how the event "opened up a lot of conversations that I think in a lot of spaces wouldn't have been as cordial and as civil" and P12 thought their piece could have prompted conversation beyond the event attendees in how "it definitely made people think in that room. And there were a few hundred people in there maybe. So it made them think. And it opens up conversations with their friends and then their friends."

Some participants made artifacts that had other interaction-based goals, for example to mediate remote human connections and communicate the value of connection (P6). P16, an architecture student, treated their participation similar to the way they treat architectural models, as a externalization of a concept to interact with and reflect on: "...you play with different forms and physical aspects." (P16).

All the participants made something that was worn by a human, so there was some level of interaction. However, participants treated this aspect with differing levels of depth. P7 wore their own piece to avoid working with a model entirely, which was one of the few instances of explicitly not valuing interaction. Several participants took care to incorporate their model's comfort and basic usability into the piece (P12, P5). The next level of consideration for the model had to do with more complex motion and human behavior (P15, P2). P2 considered the fluidity of the body while dancing and did not want their jacket to hinder that. P15 noted the nuance of creating something aimed to change someone's behavior, specifically how you can not just create "a robot that would tell you" what to do directly, but a better approach is what they made, where "you put on the clothes and you're now enveloped in the technology".

At an even deeper level, P5 worked closely with their model to create something based on the model's identity and culture. P5 reported getting to be part of a

"bigger thing", which was "having the opportunity and the honor to be part of [model] honoring herself and the women of her heritage and her culture". P13's piece was about US immigration, which drove P13 to have conversations with neighbors and friends to understand the stories of people who had been unfairly affected by laws and policies. The names of those people were incorporated into P13's piece.

Several participants commented on how having their piece on a model in front of an audience brought different life or meaning (P2, P13, P15). For example, P15 said "I think it's hard to look at a mannequin and say oh that's me." P13 realized that the physical features of the person wearing the piece, such as hair and skin color, would also change the audience's perception. P8 and P15 commented on the challenges of creating something to communicate a particular message since you can not control how it is perceived.

Lastly, several participants mentioned broader and more general interactions between humans and technology (P1, P12, P16). For example, P1 saw a relationship between Statement Making as a whole and "Black Mirror stuff and all that cool like conceptual things. All that has to start with someone having an idea, like what if we wore contact lenses that recorded everything. How does that technology work. And so I think part of Statement Making was exploring these ideas.. and especially wearables. How do people interact with clothing, how do they interact with the world?... Do computers have a role to play in wearables?"

4.3.4.3 Artifact-based and Interaction-based

There were some instances where participants discussed a shift from artifact-focused to interaction-focused or something else. Both P1 and P14 participated multiple years, starting off with technology or technique-related interests and adopting a more idea-based participation in later years due to collaborations. For example, P1 worked with a model who had a limb difference the second year to create a costume based on her identity. When asked what "make a statement" means, P1 responded "I kind

of took a dump on that whole thing. Because I definitely put the statement last I thought. Which was kind of my bad. I wish I would have had something stronger to say. But I was more focused on making a cool thing you know, which you know wasn't really my proudest moment. You make a robot helmet, it's like OK but why." Interacting with the model and seeing her on stage were the most rewarding parts of the P1's participation in the second year. P14 participated 3 years in a row, making a dress that lights up when lightning strikes in the state, a color changing LED shirt, and then a shirt that changes color based on the emotions of the person standing in front of the wearer as a commentary on emotion and toxic masculinity. P14 was driven by an interest in the technology throughout, and describes how the last idea with the toxic masculinity came about as the result of an initial interest in emotion detection technology and some conversations with the model about men and emotion. P14 describes how the idea came about: "[My co-designer] and I initially met and we knew we wanted to do something with computer vision. And recently I had been learning about machine learning and I had found some really cool libraries to work with for detecting emotions and I showed them to [co-designer] and he got on board, but we still didn't really know what we were going to do with it until [our model] talking about how this could be applied to toxic masculinity and that's what we can make the piece about... and we were like ok, I think we can put something together here. And then we can form the piece around that, which I was super excited to get behind."

Similarly, P4 describes how within one project, the focus shifted from the artifact to the ideas. They knew they wanted to make a dress that lights up, has a stunning visual component, and somehow transforms over time. From there, they asked themselves what it would be like if everyone dressed like this, what it would mean, and eventually constructed a conceptual alternate reality that their piece was part of.

4.3.5 Individualistic and Collective

4.3.5.1 Individualistic

Individualistic mindsets and practices manifested in several different ways, all relating to the designers: emphasizing designers' uniqueness, designers being driven by personal interests or identity, designers' expression or voice, designers being proud of their accomplishments, or designers' learning experiences. Details of each category are below.

Some participants made several statements about how Statement Making encouraged uniqueness or identity in some way (P4, P5, P7). P5 valued how Statement Making was "a space that allows people to not only be themselves, but to be the loudest and brightest version of themselves" and P4 noted how "Statement Making allows you to represent who you are as a person."

P5, P8, P13, and P16 perceived Statement Making as supporting or emphasizing voice or expression. P5 was the only participant who talked about marginalized voices, noting "I think in every set of models, there was a person of color, there was a woman. There was someone who is somehow marginalized in American culture, who don't get their voices heard." P5 also expressed a perspective on the role of voice in activist spaces and the value in being supported for doing something personal: "I think on some level we discounted ourselves because other statements felt so important. And it wasn't until the end that we were talking to people who were like that's brave to put yourself out there like that and we were like wow, someone actually thinks the statement we were making has value. I think in activist spaces and in art spaces it's very easy to feel like you are not doing enough."

P1, P2, P5, P6, P7 all expressed interest in participating due to personal interest or identity. For P1, "it was more about expressing or chasing some kind of dream of mine more than it was about telling the world what I thought about something." P6 was working with a group of students from foreign countries who wanted to make

something that would help them connect with people back home. P5 wanted to participate again, making something centered around their "queer identity and being a disabled person".

P12 and P15 mentioned they were proud of themselves for participating, which was co-coded with internal-facing. P13 speculated that in general, Statement Making gave designers something to be proud of.

Additionally, some participants (P1, P5, P14) talked about individualistic mindsets and practices in relation to the model. P5's and P1's groups both worked closely with their models to create something built off of their identity and personality. P5 and P14 mentioned how empowering it must be for their models or models in general to wear such meaningful pieces.

A significant number of instances of individualistic practices and mindsets were co-coded with other values. Two were co-coded with artifact-based, as discussed in the artifact-based section, where individuals described putting part of themselves into their artifacts. P1, P2, P5, P7, P8, P12, and P14 all said something that combined individualistic with external-facing mindsets and practices. P5, P7, P8, and P14 discussed how Statement Making simultaneously afforded an experience that was personally and externally meaningful. For example, P7 commented on how "the message people are trying to give out is very powerful. Just to themselves and also to what they are trying to make a statement about." P5 commented on the dual emphasis on "things that are impactful and personal". P1 and P7 talked about showing off their skills to others, both for their own benefit, and for the sake of exposing others to their personal interests. P7 talked about pieces that had a message (such as sustainability) and discussed how Statement Making did not only focus on the message, nor did it only focus on making nice things, but rather it allowed both, as participants could "be creative and find their edge on what is going on" with the big issues.

4.3.5.2 Collective

When collective mindsets and practices manifest, most of the time they were in conjunction with other codes. There were very few instances where they showed up in isolation. A few people (P12 in particular) had several quotes that expressed this value. One of the ways collective mindsets and practices were evident was when participants referred to a collective "we", implying that they perceived themselves to be part of something larger (P4, P8).

P2 was excited about the elevated culture of light up clothing, saw himself as a trendsetter in that culture, and spoke about how some people spark or ignite others. They talked often about wanting to spark a culture where people embody his mission statement to "Stand up, step out, and get elevated." They refer to culture in a collective way.

P4 participated in Statement Making as part of a class and used their piece to explore an alternate future where everyone wears the same thing and the government uses it to control their behavior. They were thinking at a societal level in terms of what it would look like for everyone to wear their piece and how systemic hierarchies of power would influence the experience.

P16, who, as discussed in the artifact-based section, felt the "politicalness" distracted from the technology, said that the collection of perspectives at the show was actually helpful in that it freed them from feeling tied to any one type of approach. P16 also wanted to participate again, but wanted to make a collection of artifacts, since it is a common practice in architecture to use a series of artifacts to reflect on variations of a technique.

The rest of the instances of collective mindsets had to do with how actions can compound to create change, collective trends in technology or digital fabrication, and what their role in relation to those things were. For example, P14 said that "computer science has some real diversity problems and some really siloed problems

into our way of thinking and how we take on certain problems, and any opportunity to break the silo and communicate with other people and talk to other people who have very different ways of thinking than us is very valuable. Not just for us but for people in general for creating software. For our careers and for our lives. Just not getting into the group think mentality". P12 said that participating in the show put questions into their head such as what happens when their city gets 5G and self-driving cars: "most of the time it is people who are making money from this who aren't considering all the possible negative effects it's going to happen on normal people, which is very troubling to think about. But you also can't really stop it." Several expressed the viewpoint that technology is a strong force that is difficult to control (P12, P13, P14), but through small actions, one person can initiate change. P12 and P14 saw Statement Making in general and the things they were doing as participants as helping to drive that change.

P2 and P16 were the only two participants who explicitly communicated collective as a value. P16 valued looking at a collection of artifacts instead of just one to better understand a technique and show"iterations of one idea that kind of continues." P2 valued the idea of an "elevated" culture of light up clothing.

There were several values that repeatedly co-occurred with collective practices and mindsets. External-facing mindsets and practices co-occurred with collective 6 times among P2, P12, and P14, which is not surprising because considering something at a collective or societal level often inherently involves considering aspects external to one's immediate context. The quotes that were external-facing and collective fit emphasized computing, technology, digital fabrication, or Computer Science as a whole. P2, for example, who wanted to create a culture around light up clothing, said they were "very interested in finding more people like me".

4.3.5.3 Individualistic and Collective

Individualistic and collective mindsets and practices only co-occurred among two participants, both of whom pointed out how individual actions can spread or compound. P2 described how they see themselves as a front-runner, exploring their own interest in light up clothing, but with the broader goal of sparking a larger elevated culture: "sometimes we don't realize just how powerful our actions can become for others... I consider myself a forerunner or just a person who is there before I'm even there. My ideas kind of shift into the future and I'm like hey - this. This is important, this matters. This means something and you need to get it, get a move on it. roll the ball in that way. Light the rocket. Blast off into that space."

I asked P12 whether they felt they had control over the future of technology, and P12 shared some personal views: "I wouldn't say that I personally have control over it because it's going to evolve whether we want it to or not just because the cats already out of the bag kind of thing. So people over the world are going to be creating whatever they want to. But I think that one person could start a movement to change the way that certain aspects of technology are going." This view is not directly related to Statement Making, but P12 also reported that they felt they were contributing to that movement through their project in how it "...definitely made people think in that room. And there were a few hundred people in there maybe. So it made them think. And it opens up conversations with their friends and then their friends."

4.3.6 Internal-facing and External-facing

4.3.6.1 Internal-facing

The largest category within the instances of internal-facing mindsets and practices had to do with participants who participated because they wanted to learn something or perceived the value of Statement Making in terms of their personal learning (P2,

P7, P8, P13, P14, P16). For example, P16 wanted to learn a particular 3D modeling software. P8 and P16 viewed other pieces as windows into opportunities and resources they could adopt, such as "technological processes that were available to me as a student" (P8). P2 had been hoping to find more connections to people who were doing similar things so as to improve what they made.

When asked what sort of impact they hoped their piece would have, P5 and P6 answered in terms of the benefits it brought to the group that created it: P5 said "I think for people who were involved it was really obvious. I think for people in [model's] life it was really obvious. I think for people in the crowd, they were like that's a cool little green witch ... [model] was like its the prettiest I've ever felt. I felt so in my element. I felt great. And that's all we really cared about at the end of the day."

P4, P12, and P14 commented on how their piece or the experience prompted them to think about other aspects in their own life. For P4 and P12, this was technology usage: "I actually looked at my phone, which can track your screen time. And I looked at mine and it was ridiculous how much time I spend on social media. ... It's crazy how much time you spend. And it really made me think that I need to take my own advice and listen to my own statement and cut back on some." P14, one of whose pieces dealt with the topic of toxic masculinity, said "it got me thinking about my life and my relationships with other men that I know and things like that".

4.3.6.2 External-facing

External-facing mindsets and practices was the most frequent value, but most were co-coded with other codes, many of which have already been discussed. Most of the instances of external-facing were neutral observations, it was rarely expressed as an explicit value.

Several participants suggested that an area for improvement would be for Statement Making to improve its reach to more participants or audience members, or they

commented on how wide its reach already was (P1, P2, P4, P5, P6, P8, P14, P16). P4 also commented on how before getting involved with Statement Making during a class, they perceived it as being rather "niche".

Many of the pieces participants made were external-facing by touching on themes or topics that were political or matters of concern for the general public or intended to touch on such themes in future years. Specific topics included immigration reform in the US (P13), Hong Kong protests or surveillance (P14), poverty (P15), water waste in the textile industry (P8), over usage of social media (P12), toxic masculinity (P14), and exposing prosthetics in a positive light (P1).

Several others showed evidence that they associated Statement Making with some sort of external goal (P7, P12, P13, P15). For example, P12 defines Statement Making as "something that is pertinent to what people are dealing with right now in their lives". P1 and P5 considered the broader context within which Statement Making exists, such as how the political context of 2017 put people in a certain mindset (P1) or how the conversations happening as part of Statement Making relate to computing culture.

P4, P8, P14, and P15 mentioned the exposure to different disciplines that Statement Making affords. P14 found this particularly valuable, stating that "there is a lot to be said about cross disciplinary communication. So much of the college experience is siloed into majors and different departments and people sticking with what they know. A lot can be said about getting people to talk to each other and getting students to talk to each other. So there is a lot of value in that".

4.3.6.3 Internal-facing and External-facing

Earlier, we discussed the intersection of individualistic and external-facing, where participants expressed perceptions of Statement Making as being both about personal expression and external goals. Similarly, there were instances of internal-facing and external-facing co-occurring in a similar way. P1, P7, and P8 discussed how partic-

Table 4.4: A selection of quotes that illustrates examples of each value and how they overlapped

Individualistic	**Both**	**Collective**
"A space that allows people to not only be themselves, but to be the loudest and brightest version of themselves" (P5)	"Impactful and personal" (P5)	"I think that it definitely made people think in that room. And there were a few hundred people in there maybe. So it made them think. And it opens up conversations with their friends and then their friends" (P12)
Internal-facing	**Both**	**External-facing**
"It was more personal learning. I know a lot of the pieces were very politically driven and such but I wasn't really interested in that. I wanted it to be more of the digital technology side of the statement. so mine was more of a personal learning experience." (P16)	"The idea of showing off your work but doing it in a way that's very meant to bring yourself up and other people around you" (P8)	[Statement Making is] "something that is pertinent to what people are dealing with right now in their lives" (P12)
Artifact-based	**Both**	**Interaction-based**
"My goal is to do it to the quality of like a production designer on like a movie or a commercial where its like wow that thing looks like real" (P1)	"Recently I had been learning about machine learning and had found some really cool libraries to work with for detecting emotions and I showed them to [group member] and he got on board, but we still didn't really know what we were going to do with it until [model] started talking about how this could be applied to toxic masculinity and that's what we can make the piece about." (P14)	"I think that bigger thing was having the opportunity and the honor to be part of [model] honoring herself and the women of her heritage and her culture ... and to be allowed the space to be a part of that. Because I never would have had that experience, I never would have heard those stories, I never would have had the opportunity to sit in her mom's living room and meet her family." (P5)

ipating can be both beneficial for the participant and for others. For example, P8 discussed "..showing off your work but doing it in a way that's very meant to bring yourself up and other people around you. Like the one ... piece that was like cellophane and it had a bunch of words on it and it was definitely a feminist statement and I feel like she was empowered when she made that."

4.4 Discussion

I return to the research questions and discuss where HCM lives and how our results shed light on the relationship between the values. Table 4.4 provides a selection of quotes that highlights the values and places where they overlap. While manifestation of the values may be influenced in part by participants' personalities, I also reflect on aspects of the event that may have prompted or afforded the results.

4.4.1 Relationship Between Values

Balance Between Artifact-based and Interaction-based Mindsets and Practices

I found evidence for strongly artifact-driven participation as well as interaction-driven participation. Some of the participants were motivated by the technology, by the opportunity for learning, and making cool stuff (P1, P2, P7, P16). Others were driven by interactions with the model or by interactions with technology (P5, P6, P12). For example, P7 and P16 had perhaps the strongest focus on the artifact – P7 avoided working with a model altogether and P16 found the 'politicalness' to be distracting from the technology. However, other participants viewed their work in terms of various interactions: P1 viewed P7's piece as an invitation to a particular making community, or an indicator that "ok, they let the nerds in here".

I found evidence within the participants that there are many opportunities for a focus on artifacts and a focus on interactions to co-exist. In fact, there was evidence where one value even influenced or led to the other: Artifact-based is sometimes the starting point for interaction-based (such as where P1 and P14 started with a primary artifact focus and later expanded to incorporate interactions), and sometimes interaction-based is the starting point for artifact-based (such as with P12, where general interactions between humans and technology inspired the artifact).

In reflecting on the aspects of Statement Making that may have fostered this balance between artifact-based and interaction-based mindsets and practices, a contributing factor may have been the focus on wearables and clothing. By taking the format of a fashion show, all participants made something that was worn by a human, meaning there was an interaction with the artifact to consider. Participants considered this interaction to varying degrees: some ignored it, some thought about the comfort or ergonomics of their piece, and some focused on the identity and personality of the model. By focusing on making things that directly interface with humans, the event provided opportunities for varying degrees of focus on the artifact, the interactions, or both.

While there was evidence of deep interaction-based experiences (P1, P5, P13),

many of these interactions were not evident to the researchers until the interviews happened. For example, the researchers and event directors did not know that P5 had formed connections with their model's family or that P13 had interviewed immigrants who were unfairly treated. Interactions are generally less visible than artifacts. To be fully promoted or supported, there need to be explicit pathways and emphasis in place. Statement Making explicitly fosters conversations before and at the event, but there were some interactions that arose organically through working with a model.

Balance Between Individualistic, Internal-facing, Collective, and External-facing Mindsets and Practices

I consider these two sets of values together because external-facing mindsets and practices were found to frequently co-exist with both individualistic and internal-facing mindsets and practices. There was evidence of a simultaneous acceptance of both sides of these value sets, where participants acknowledged the presence of both internal and external-facing as well as individualistic and collective mindsets and practices without conflict or hierarchy. For example, when P5 mentions "impactful and personal", this shows the casual acknowledgement for both aspects. There was also evidence that individualistic or internal-facing values were actually important for collective or external goals. For example, P5 appreciated feeling valued for doing something personally meaningful in an activist space that they otherwise did not feel important enough for, P7 commented on finding a personal take on a big issue, and P8 commented on "bring[ing] yourself up and other people around you". These points indicate how in endeavors for social good or civic action, while the external purpose is the driving factor, it is still important for individuals to feel like they have a place.

The prompt of "make a statement" may have contributed to the balance between all of these. Participants could focus on the "making" part of the invitation with artifact-based approach. Or they could focus on the statement part either as a verbal statement or as a "statement piece", as artifacts in fashion are sometimes called. The

statement aspect could be interpreted in a personal way such as personal expression (internal-facing). Or it could be interpreted in terms of the impact of the statement, such as making a political statement or promoting an agenda for civic action (external-facing). The prompt also implies that everything has meaning; even if the maker did not intend to make a statement, they know the audience will be watching through that lens and interpreting for themselves. Participants recognized this duality and this ambiguity in their comments about how the event invites both personal expression and externally meaningful actions.

4.4.2 Where HCM Lives

Reflecting on the relationship between internal-facing and external-facing goals within Statement Making helps us understand one of the key places where HCM lives that we might not have realized otherwise. The internal-facing goals were to provide a platform and support for the participants' endeavors and personal growth. It also provided the opportunity for (and even inspired or prompted) individuals to adopt agendas towards political change or civic action, while not telling them which agendas to pursue or dictating that they participate in this way. It was seen as having broad participation (though it could certainly improve in this area) and welcomed multiple disciplines.

While the civic agendas and broad participation could be seen as external-facing, I believe the event also has meaning beyond the sum of the individual pieces, though it is hard to articulate what that is. Part of that meaning might be captured in the description the directors put in the pamphlet the third year: "With Statement Making, we call the community to action to help us ignite a shift in the relationship between digital technology and humanity. This is a shift from being passive responders to active creators. This is a shift from letting technology reinforce oppressive norms to using technology to disrupt them." This framing explains what Statement Making as a whole is working to do and why it is important to have a platform that highlights the

contributions of individuals. Interestingly, this external-facing message of Statement Making is strengthened if the participants within Statement Making have internal-facing and individualistic pursuits of their own. The external meaning may also come in part from how all the pieces were positioned on a stage that had a statement about sustainability itself, thus not only directly communicating that as a possible value for voluntary adoption, but also positioning all the individual making endeavors against a backdrop of waste, consumerism, and mass production.

This suggests that a key aspect of HCM is the dynamic between how the goals of the context relate to the goals of the individuals and how external goals may in fact be strengthened by internal-facing and individualistic ones.

4.4.3 Outcomes and Future Work

The purpose of this study was to understand how Human-Centered Making manifests in making contexts as well as how and where to look for it. Specifically, we learned the following points.

- Human-Centered Making is something that lives not just in an individual or a context for making, but rather in the ways they interact with each other. If maker leaders or HCI researchers are to study this phenomenon, they need to understand these dynamics. I do not expect that this study alone provides enough insight about HCM to inform how maker leaders could go about implementing or promoting it, but if they do, they would need to take a holistic approach that not only provides opportunities for individuals to adopt these values, but also reframe the context within which the individuals operate to allow for these dynamics to emerge.

- If there are values on the making side and HCI side in a context or individual, it can still be Human-Centered Making, and there are times that the values on the making side actually strengthen or support the values on the HCI side.

> This means that there is no evidence that maker leaders and HCI researchers who are supporting artifact-based, individualistic, or internal-facing endeavors should completely abandon or discourage those efforts. It also means that if maker leaders would like to implement or promote HCM, they would need to balance the incorporation of the HCI values with any making values that are already there.

While this study was primarily conducted towards the goals of developing the NTHCM, the implications of which will be discussed in Chapter 8, these results may also have merit as a contribution to HCI research independent of that broader discussion. For example, this understanding of the relationship between values that were chosen to represent an alignment with making and values that were chosen to represent an alignment with HCI research and practice may be of interest to HCI researchers who have claimed interest understanding how HCI research can draw on making or DIY culture as a way to upgrade formal HCI design practice [11, 16, 115]. Understanding relationships between the making and HCI values sheds light on concrete aspects of making that could become part of HCI design or ideation processes. For example, HCI researchers could participate in individualistic internal-facing activities where they prototype devices of some sort that express their identity as part of a design process, later reflecting on the interactions or the collective meaning of what they created, mirroring the way artifact-based and individualistic practices in Statement Making laid the foundation for meaningful interactions and a meaningful collective.

Overall, this analysis has shed light on ways the 6 values of HCM manifest individually and how they might interact with each other. I have only studied one context in this way, so future work is needed to see how the values interact in other contexts. There may be a more extensive taxonomy of ways the values can relate. However, I can use this knowledge gathered so far to inform the studies in the next chapters

to see the extent to which HCM is a helpful construct to reflect on existing maker contexts (Chapter 5) and to guide future maker efforts (Chapter 6).

CHAPTER 5: HCI CAPSTONE COURSE STUDY: USING THE NTHCM AS AN ANALYTIC LENS

This chapter presents an analysis of a particular maker context using the NTHCM as a lens. The purpose of this analysis was to answer the following research question:

> Is the NTHCM helpful for researchers or makerspace leaders to draw insights regarding a particular maker context or to shed light on how to improve it?

To answer this question, I used the NTHCM as a lens during qualitative analysis on data collected from a capstone course for HCI students. The capstone course was conceived of and run by Dr. Wilson and myself, and focused on applying advanced HCI techniques such as Participatory Design in a project related to 3D printed prosthetic devices for children with limb differences. In the following sections, I describe the initial research and learning goals of the course, details of how the course was conducted, why this context was appropriate to study in the development of the NTHCM, the results from the study about the course, and what the results mean for the NTHCM.

5.1 HCI Capstone Course for Prosthetics

During the Fall 2019 semester, Dr. Wilson and I ran a capstone course that centered around assistive devices for a group of five computing students who were concentrating in or had an interest in HCI. The primary goal of the course was to serve as an educational experience for the students, though I also planned to use gathered data from the course for research.

5.1.1 Motivation

Non-profit organizations such as e-NABLE and the Helping Hand Project [1, 3] use open source 3D designs to create low cost recreational prosthetic devices for children with limb differences. These groups have been of interest in prior HCI research, some of which I discussed in Chapter 3 when discussing examples of the making values. In summary, some of the main findings from this research are that the volunteers who create these prosthetics are focused on the devices themselves without necessarily considering many of the risks or safety concerns; many device recipients abandon their devices quickly since the functionality they bring is not significant, though they still appreciate the social aspect of being part of the community [154, 99]. There is also literature that highlights the experiences of people who through fabricating and iterating on their own devices have a meaningful experience that relates to identity [95, 27].

This related work led us to our own investigation of the relationship between the volunteers who make devices and the device recipients. There was a group of students on campus who participate in these sorts of activities, a local chapter of the regionally based Helping Hand Project [3], which is associated with the larger e-NABLE organization [1]. I interviewed a few of these students and found that some of the ways they described the relationship with the participants were not as empathetic or nuanced as might be possible [150]. As an HCI researcher, I saw ways that HCI methods might be relevant in these practices. For example, understanding interview techniques from user-centered design processes, participatory design, and ethnography might help volunteers recognize the nuance of creating prosthetic devices for children with limb differences and approach the task from a people-centered perspective rather than a device-centric perspective. This realization lead us to create the capstone course. We had several goals in mind as we created the course, some of which have changed since:

- Original Research Goals: We wanted to see if students with an HCI background approach the task of working with someone with a limb difference differently than other maker volunteers we interviewed and read about. The capstone course would shed light on what aspects of HCI the students drew on throughout the project and would inform HCI-related learning modules for makers. While we created and ran the course at the same time that I was developing the NTHCM, we did not directly consider the 6 values of the NTHCM to inform the course.

- Outreach Goals: We wanted to support the goals and desires of the project participant, who had received multiple 3D printed prosthetic devices in the past. We wanted to create space for a project to serve the participant, whether that was in the form of customizing a device, exploring different applications of 3D printing, or something else entirely.

- Learning Goals: We wanted the students to learn advanced HCI techniques such as Participatory Design and to get experience with reading and writing HCI research papers.

5.1.2 Justification for Using this Context for the NTHCM

While my research questions, detailed below, have changed since running the capstone course, it remains an appropriate context to study by using the NTHCM as an analytic lens. One reason is that the original research goals and the learning goals of the capstone were in line with the goals of the NTHCM. Specifically, the capstone aimed to explore the possibilities of bringing HCI mindsets and practices into the common maker endeavor of creating 3D printed prosthetic devices for children with limb differences. Our research and community goals were to understand what HCI-related mindsets and practices students who have a background in HCI drew upon as they approached the task. We planned to use these findings to inform the design of

possible activities or other types of interventions for makers to provide opportunities for the work they were doing with children with limb differences to be even more meaningful and impactful. Since the goals of the capstone were closely related to the goals of the NTHCM, it made it a reasonable context to use for testing the usefulness of the NTHCM as an analytic lens.

Reflecting on the structure of the capstone at a high level also sheds light on ways it may not have fully met the criteria for democratization introduced in Chapter 3, indicating there are ways to improve, and the NTHCM may help determine the specifics of those improvements. The students in the course may have had some opportunity for exploring the pleasurable and expressive aspects of digital fabrication themselves, but because of the structured nature of a course, the main focus was on utility (NC1-a access). The project for the semester was to work with a high school student with a limb difference, and while there may have been room to explore pleasure, utility, and expression, the group was mainly focused on the utility aspect of device functionality (NC1-a access). The narrow focus on device functionality may have been an indicator that there were not enough mechanisms in place to help the students or the participant they were working with know the possibilities and feel empowered (NC1-b access). The course did center around accessibility, so the focus invited the topic of social progress, however there was not much room for the group's own concerns or dialogue to emerge due to the structured nature of the course (NC2 social progress). As a structured course, there was not much risk involved seeing as the instructors guided the process along the way (NC3 risk). Because there seems to be room for the capstone course to improve in terms of the criteria for democratization, it was an appropriate context to look at through the lens of the NTHCM.

5.1.3 Course Overview

As a capstone, the course was heavily project-based and left significant room for the students to shape and lead the experience. We met with all the students weekly

for one hour to review what they had been doing and discuss what they should do in the following week. The project revolved around working with others to design assistive devices and the topic of participatory design. The students worked with a local high school student who had been a device recipient of the Helping Hand Project for many years. We introduced the task for the semester to the students in as open-ended a way as possible. We told them they would be working with the previous device recipient, but we were careful not to say that their main project would be building a device for her. We were similarly open-ended about what to expect when coordinating with the participant. We did this to leave room for the students to shape the goals and the nature of the process and for the participant to form her own expectations. We planned for the semester to be roughly divided into three phases. As the semester went on, we adapted and guided the students within this framework towards what they should focus on so that they could have a meaningful learning experience regardless of what path the design process took. Details of the weekly expectations can be found in Table 5.1 and an overview of each phase of the course is detailed below.

The first phase involved learning about the Helping Hand Project, 3D printing, and the existing open-source devices. The students were assigned HCI readings on assistive devices, were told to browse around the online e-NABLE community, and 3D print a Raptor Hand prosthetic device to practice the process.

The second phase involved beginning to work with the participant and continuing to learn digital fabrication techniques. Their goal of the second phase was to create a practice device with the participant using a process similar to what the Helping Hand Project does as quickly as possible. The reason for this was for the students to understand the limits and possibilities of the technology before using them in a design task. This idea is supported by Fitton et al.'s finding that the complexity of design ideas increased when children participate in a making task before the design task [78].

In the third phase, after that practice device, they would be able take the project in any direction they wanted and didn't have to base it around the specific devices. In the second phase, we told the students that the purpose of doing the practice device was for their own learning benefit and so that they could relate any of their findings to the existing practice and process of the Helping Hand Project. We thus guided the students in this second phase towards coming up with a plan for the first meeting with the participant which would primarily focus on taking measurements and gathering general input. We encouraged the students to fabricate this first device as quickly as possible, which meant it would mostly be a straightforward download and print process, with perhaps some minor incremental improvements over the open-source design.

The third phase was intended to take the bulk of the semester. We assigned some readings on participatory design and some autoethnographic accounts of individuals who regularly build, iterate on, and wear prosthetic devices themselves. The students were tasked with conducting an additional session or set of sessions with the participant that enacted some form of participatory design.

Table 5.1: Summary of weekly activities and blog post topics.

Week #	Blog Topic	Additional Details
2	Introduction post	
2	Learning about the community	Reading the Helping Handbook and online resources
3	Learning about the devices	Read about devices and explore 3D printing / modeling
3	Read Sharing is Caring paper [40]	Comment on how the paper relates to HCI
4	Print a device	Each student practice prints the Phoenix hand
4	Plan for 1st meeting with participant	Goals are to measure and start getting to know participant
4	Pick and read 3 ASSETS papers	
5	Answer specific questions	Questions asked about the steps and goals of creating an assistive device for someone, the steps and goals of the human-centered design process, and challenges of these processes
7	Learn about PD	Students were given some links to get started and searched for research papers
7	After 1st meeting with participant	
8	Printing device	Printing basic device for participant to practice
9	Planning PD activity	Planning for 2nd meeting with participant
10	More learning about PD	Reading chosen papers
11	Planning PD activity	Continuing to plan for 2nd meeting with participant
12	After 2nd meeting	Reflecting on how the second meeting with the participant went
15	Final blog post questions	Questions included reflecting on what they learned and how it applies to other areas, what they would do if they did the project again, what they would think about if they were to create an organization like the Helping Hand Project, and what a successful interaction with a device recipient looks like.

5.2 Research Study

I used the capstone course as a context for study in order to develop the NTHCM. Specifically, I asked if using the NTHCM as a lens can help shed light on what aspects of the course worked well and where there might be room for improvement. This analysis aimed to answer the following research question:

> Is the NTHCM helpful for researchers or makerspace leaders to draw insights regarding a particular maker context or to shed light on how to improve it?

To answer this main question, I used the NTHCM to ask the following:

- Capstone-RQ1 (Participant differences): Are some participants more aligned with HCM than others?
- Capstone-RQ2 (Change over time): Did any of the participants become more aligned with HCM over the course of the semester?
- Capstone-RQ3 (Identify factors): Can the NTHCM shed light on what aspects of the course influenced which values were most evident in the mindsets and practices of the students?

For each of these questions, I also reflected on what the insights mean for us as leaders of the capstone context and what they could mean for leaders of other makerspace contexts in general. For example, if the NTHCM shows us differences in participants of a particular context, how might that information be helpful to the leaders of that context? If the NTHCM leads us to insights that can help us improve the capstone course, it may be helpful for other makerspace leaders or HCI researchers as an analytic tool as well.

5.2.1 Methodology

To answer the research questions above, I used the NTHCM as a lens during a qualitative study of the capstone course. The data used in this study was collected over the course of the semester in the form of blog posts, plans, and papers written by the students, as well as observational notes I took throughout the semester. Informed consent was obtained at the end of the semester for the written material, and the need for consent was waived for the observational notes.

Of all the data collected, the primary source of data used in the analysis was the weekly blog posts because they allowed for longitudinal consideration as well as comparison between students. I performed a thematic analysis on the blog posts using the 6 values of HCM, coding instances of each value. I conducted this coding process on the entire data set twice to ensure I recorded all instances of the values. I then performed quantitative and qualitative analysis on the coded data, detailed in the following sections. For quantitative analysis, I compared the number of instances of each value across students and over time. I also performed additional qualitative analysis to understand the way each value manifested over time. This involved identifying additional themes for each value within each blog post.

The fidelity of analysis was by topic, so several sentences could belong to the same unit of analysis or a given response to a question could be broken into several units of analysis based on how many topics were expressed. A quote could have one or several codes assigned to it. The second level of analysis looked separately at each criteria and used an iterative open-coding technique to find emerging themes to characterize the ways each criteria manifested.

5.2.2 Results

I describe the results of the qualitative analysis of the capstone course using the NTHCM as a lens. The blog post materials from 4 of the 5 students (P1, P2, P3,

Table 5.2: Number of instances of each value coded

Total making values			Total HCI values		
82			91		
Artifact-based	Internal-facing	Individualistic	Interaction-based	External-facing	Collective
54	23	5	56	33	2

P4) from the course were included in this analysis. Table 5.2 summarizes the number of instances of each value coded. Throughout the analysis, I often group artifact-based, internally-facing, and individualistic mindsets and practices, referring to them as the "making values" of HCM. I similarly use the term "HCI values" to refer to interaction-based, externally-facing, and collective mindsets and practices.

5.2.2.1 Participant Differences

I first investigated if any students were more aligned with HCM than others (Figure 5.1). P2 was the only student who exhibited more making values than HCI values. P1 and P3 were approximately even, with slightly more instances of HCI values. P4 has the most drastic difference between numbers of values, with more on the HCI side.

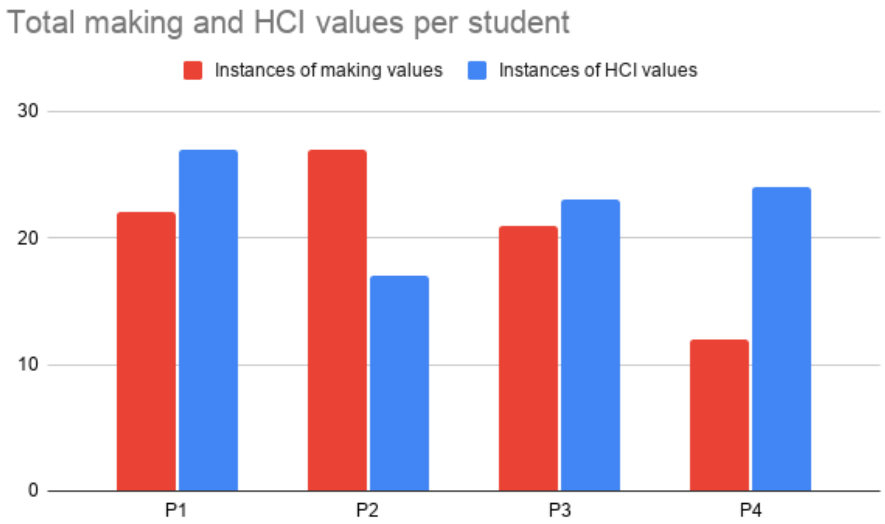


Figure 5.1: Total making and HCI values per student

The fact that there were differences in the extent to which the students were aligned with HCM means that while the course may have had some impact on their mindsets and practices, it may have affected each student differently, or that students focused on different aspects from each other in their writing or in general. To understand why this difference occurs, I investigated some additional aspects of the data in the next sections.

5.2.2.2 Change Over Time

To understand whether students' mindsets and practices changed over the course of the semester, I looked at the overall breakdown of values for each blog post as well as the breakdown for each student. I use a centered 3-point moving average to understand how the breakdown of making versus HCI values changes over time. I tried several different types of trend lines such as linear and polynomial, but none yielded an appropriate fit. The moving average is helpful for understanding general trends with data that jumps along the y-axis. Most importantly, I use the moving average to visually compare trends amongst the students and see where individuals differ from the aggregate.

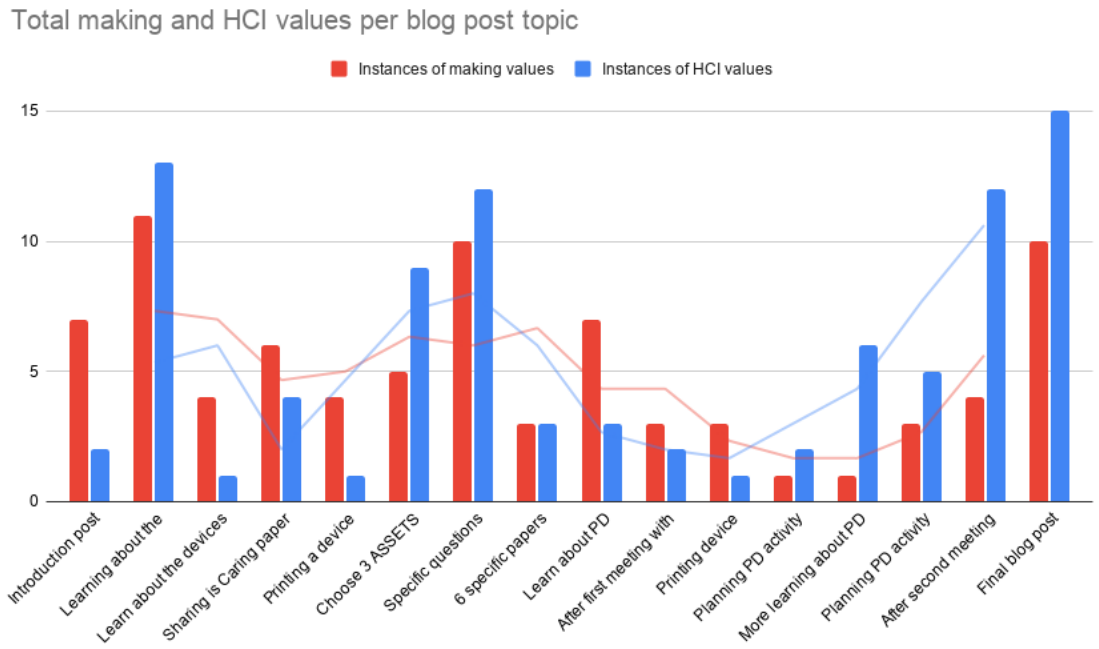
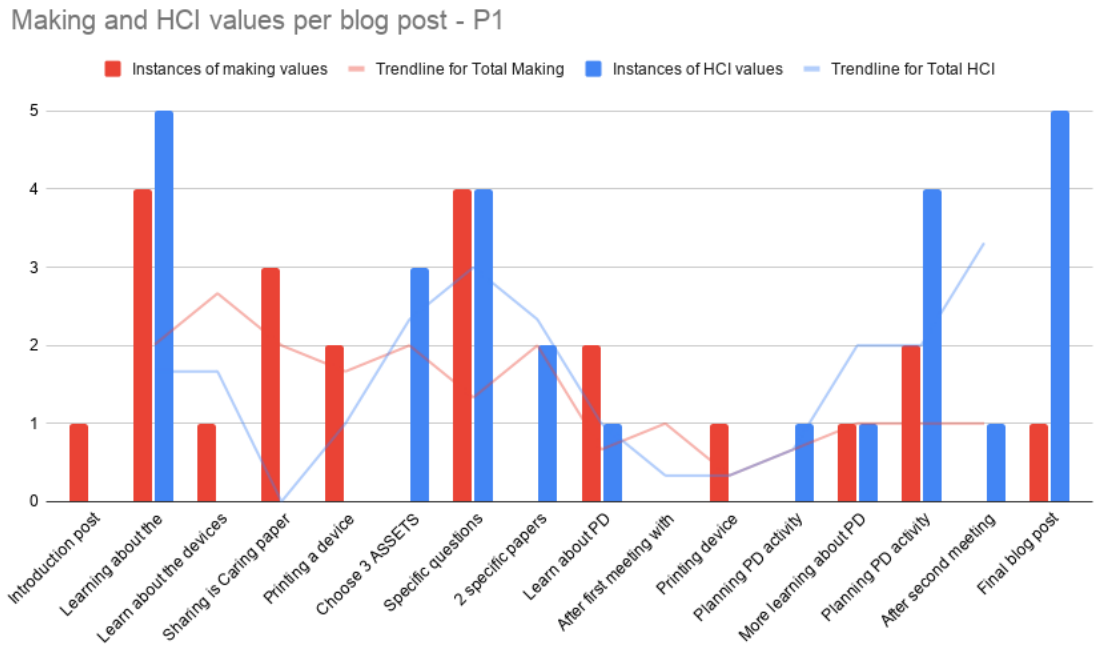


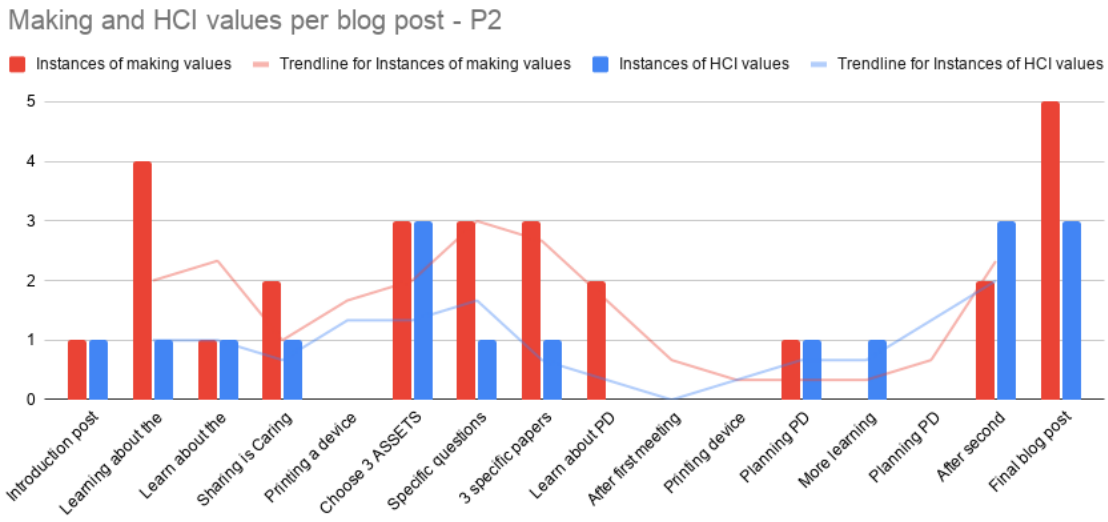
Figure 5.2: Total making and HCI values per blog post topic. The blog posts listed along the x-axis are in order of when they occurred during the semester. Most blog posts correspond to 1 week, though there are some weeks with multiple blog posts. Red and blue lines indicate moving average for making and HCI values, respectively (centered over 3-blog period)

In the aggregate breakdown of values per blog post, we can see variance in instances of making and HCI values (Figure 5.2). The moving average smooths some of that variation out, and we see the most significant differences in moving average at the beginning and at the end of the semester, with the beginning of the semester being slightly more aligned with the making values and the end of the semester being more aligned with the HCI values. It may be the case that the topics of the blog posts at the beginning and end of the course prompted one type of values more than the other. The qualitative analysis in the following section will help understand why the particular values manifested the way that they did.

I also compared the moving average of the aggregate breakdown of values to the moving average of each student to see how students progressed compared to each other and compared to the aggregate (Figure 5.2).

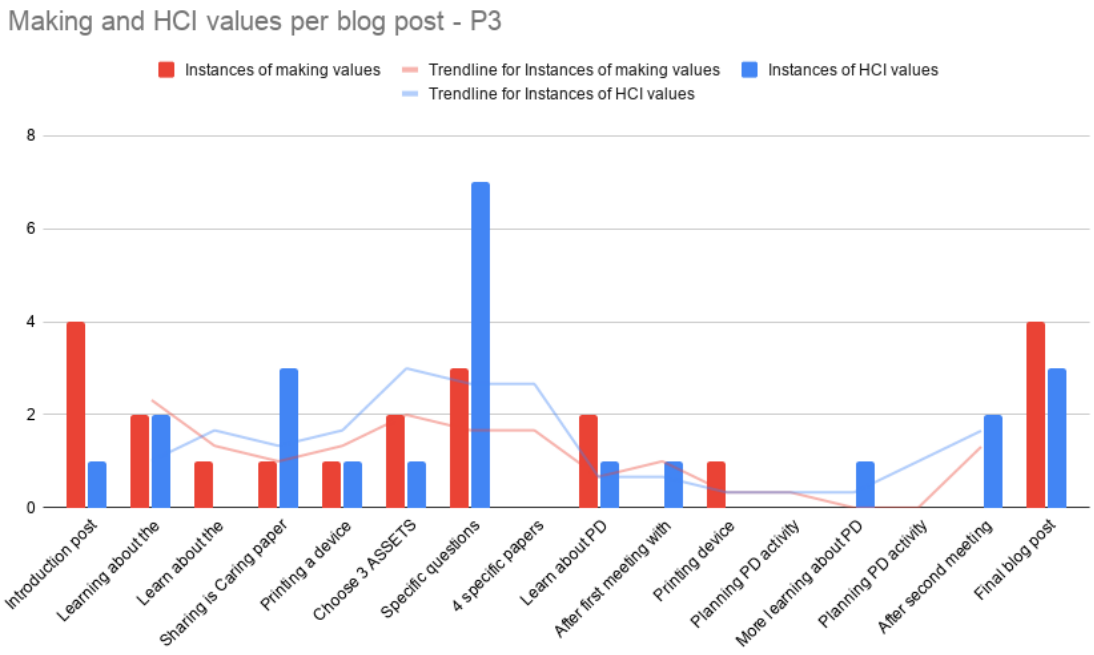


(a) P1

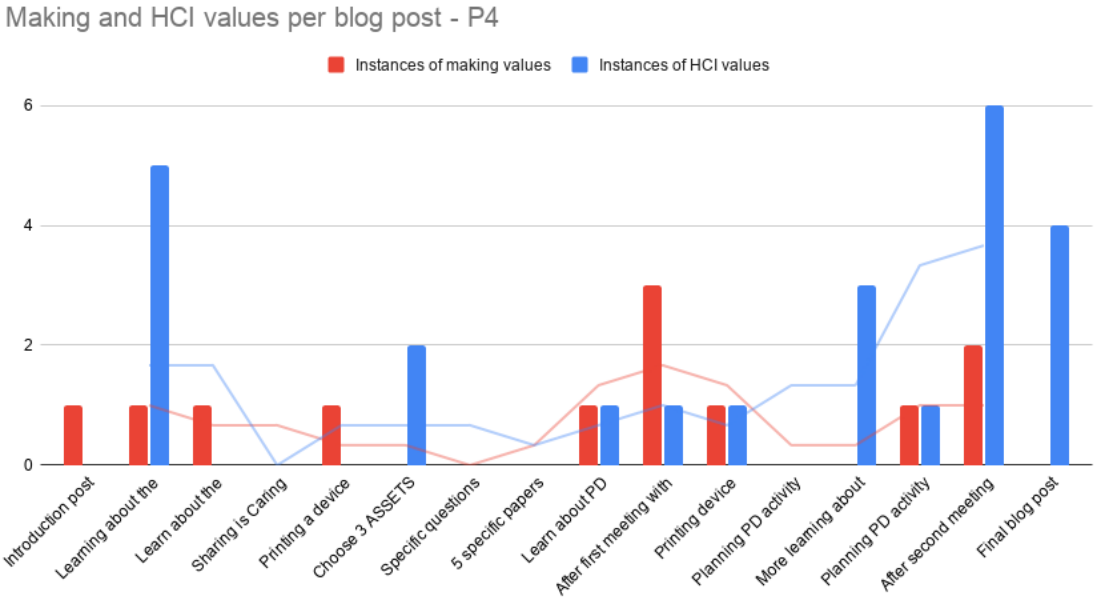


(b) P2

When comparing students' charts to each other, it seems that P1 had the most apparent difference between the beginning and end of the semester. Other than when learning about the community, P1's first few blog posts were heavy with making values. The middle of the semester was a mix of both making and HCI values,



(c) P3



(d) P4

Figure 5.2: Making and HCI values per blog post per student.

and the last few posts were heavily HCI focused. P2 and P3 showed little change throughout the semester. They both had a relatively similar number of making values and HCI values from week to week. P2 may have become slightly less making-focused as the semester went on, but ended the semester with a roughly equal focus on the HCI and making values. P4 also ended the semester with a noticeably higher number of HCI values than making values, though some missing blog posts throughout the semester makes it difficult to see long term trends.

Overall, this analysis shows that not only did each student have a different breakdown of values in total, but they also progressed through the semester differently. We can see that while some blog posts may have prompted a more making-heavy or a more HCI-heavy response, the students still responded differently from each other. This means that while the students may have been learning, they were learning differently or were focusing on different aspects throughout the course. To understand what these differences are, in the next section I discuss the results of additional qualitative analysis that looks at how the values manifested each week.

5.2.2.3 Identifying Factors

In this section, I present the results of a week-by-week analysis to understand the ways the values manifested. For each week, I performed an additional level of thematic analysis to group the ways the values manifested, reflecting on what aspects of the course might have influenced the values to manifest in this way and reflecting on what the impact of each week might have had on other parts of the course. I discuss here the weeks that had notable findings in the form of evidence that a particular aspect of the course influenced the values that were evident or evidence that the students' values were changing.

In Week 2, the students introduced themselves and discussed what they were expecting to learn or do during the semester. Of the 6 quotes from week 2, all of them had making values, two of which were also coded with HCI values. Of the making

values, P1, P3, and P4 expressed internal-facing and artifact-based expectations: P1 was looking to build their HCI portfolio and both P3 and P4 were excited about learning about prosthetic devices. The quotes coded with HCI values were both external-facing and expressed interest in helping others (P2, P3). This shows that the students approached the course with more making-aligned expectations, looking to make devices and learn more than looking to help others. These initial expectations may have influenced their outlook in later weeks and contributed to the fact that the beginning of the semester was more making-aligned (Figure 5.2).

In Week 2, students also familiarized themselves with E-Nable, the Helping Hand Project, and other communities around the world doing something related to 3D printed prosthetic devices. They explored online resources, as well as the Helping Handbook, which is a written manual for volunteer makers. There was a high number both of making and HCI values, with slightly more HCI values than making values. Of the 10 instances of making values, 8 of them were artifact-based, which is unsurprising since the focus of the communities is creating devices. Of the HCI values, about half were interaction-based and half were externally-facing, commenting on the value of the support community, the interactions between different people who are involved, and the different ways one might interact with a prosthetic device. The only 2 instances of collective from the entire semester were in Week 2, both from P4, and both thinking about the diversity of the overall composition of the community creating these devices. Overall, this seems like a good balance of values. Artifact-based was the most frequent value (8 instances), followed by externally-facing (6 instances). This may have caused students to perceive a primary focus on artifacts, but recognize that there are other aspects as well.

In Week 3, students read and wrote reflections about a paper by Buehler et al. titled Sharing is Caring: Assistive Technology Devices on Thingiverse [40]. The paper begins with an analysis of different types of assistive devices in Thingiverse, an

online platform for sharing files for 3D printed objects. The paper also presents the results from a questionnaire that was sent to the designers who created these designs to understand their process and motivation. The main findings highlighted that most of the designers did not have a disability themselves, though a good portion of them were designing for people they knew, and very few had any sort of formal training in assistive technology. The authors suggest that this sheds light on opportunities for increased communication between designers and people with disabilities and opportunities for people with disabilities to self-design tools. My own reading of the paper was initially artifact-based, particularly the first half which includes a chart and several pictures of different artifacts the authors noticed. A more careful reading of the paper and consideration of the contributions, however, reveals the true contributions are more interaction-based, in the form of suggestions for various interactions between groups of people.

The students' responses were more making-aligned (6 instances, 5 of which were artifact-based), though there was some evidence of HCI-aligned perceptions (3 instances). P3, P1, and P2 commented on how the article related to HCI, and some responses aligned with the making side of HCM, and some aligned with the HCI side. P3 mentioned the external-facing aspect of HCI, emphasizing the importance of needfinding. P1 and P2 mentioned the artifact-based focus of HCI, commenting on how HCI involves analyzing artifacts and the benefits of technology. P1 and P3 commented on the artifacts of the community, noting how many different options there were. P2 also mentioned the artifacts of the community, but noted that the interactions between designers and the recipients would make the artifacts even better. Overall, this reading may have reinforced the artifact-based focus of the broader Helping Hand community and of HCI. While there were a few mentions of the interactions or the benefits of looking externally, they were mainly mentioned as secondary to the artifacts.

During week 4, the students were focused on printing a Phoenix hand for practice. Unsurprisingly, their blog posts were almost exclusively artifact-based since their focus was on creating an artifact. The only HCI value evident in this blog post was P3, who commented on the value of getting to know some experienced members of the student organization to help (interaction-based). I discuss more about the potential impact of the seemingly inevitable artifact-based focus of building a practice device in the discussion section of this chapter.

Also during week 4, the students read and commented on 3 chosen papers from the ASSETS conference. All of the students happened to choose Hawthorn's "Cyborg Pride Self-Design in e-NABLE" [95] as one of their papers. There were a few instances (4 total) of making values among P3 and P2, focusing their comments on the devices themselves. All students also exhibited HCI values (7 instances total). For example, P3, P2, and P4 all recognized the value of designers opening up their processes to having more in depth interactions with the recipients, or the value of having the recipients act as designers themselves (interaction-based, external-facing). P1 mentioned some other interactions, particularly the lack of information on the long-term experience of using the devices, and how people with disabilities or assistive devices are perceived by others. Overall, it seems that the students were not too focused on the devices, nor were they too focused on the interactions. Compared to the previous week when students were reading papers, this is a much more balanced set of values. This indicates that reading multiple sets of papers to understand a topic was worthwhile.

In week 5, students answered a series of specific questions in their blog posts, such as listing the steps of creating an assistive device for someone, the steps of participating in a Human-Centered Design process, and listing the challenges, similarities, and differences of these processes. One notable finding is that the students generally found the process of creating a device for someone to be similar to the process of

Human-Centered Design, and P1, P2, and P3 all discussed how interacting with the recipient or user is an important part of the process. The students had an internal-facing view when discussing the role of the designer compared to the role of the user. For example, P2 said that the role of the device recipient is to "try to think like a volunteer and share information that you would like to know as a volunteer" and P1 said that the recipient is there to provide the designer with ideas to improve the design. These are internal-facing because they see the collaboration with a device recipient or end user as serving the designer and bettering the design process rather than as serving the recipient. P3, however, goes beyond to discuss how this is one of the challenges of doing Human-Centered Design, and mentioned a few times about how breaking down the barrier between the designer and user is worthwhile. This centering of the designer might be the result of prior expectations and understanding of HCI, as well as the fact that this experience was taking place in a college course, which naturally centers student learning.

In week 7, the students met with the participant for the first time. Only P4 and P3 blogged about this event, with 3 instances of values on the making side and 2 on the HCI side. All of the values on the making side were artifact-based, which was expected because the purpose of this first meeting was for the purpose of taking measurements to create a practice device. P4 also commented on some of the device recipient's comments about having received many devices in the past, but none of them worked very well, due in part to the fact that "nobody had asked them for their input". P4 hoped their team would be able to take a more interaction-based approach and gather helpful feedback. P3 commented on the interactions that took place during the meeting, noting that it could have been smoother and more comfortable. Overall, there were not enough blog post comments to know entirely what values the students were most aligned with at this point. However, reflecting on the instances of artifact-based and how the instructions for the week were to focus on taking measurements

for a practice device and gathering some ideas for possible minor modifications or customizations, it is likely that the focus of the students was primarily artifact-based and possibly secondarily interaction-based.

In week 7, the students also started learning about participatory design, reading some papers and online resources. Their initial perceptions of participatory design were more artifact-based and internally-facing (7 instances total), with 3 instances of externally-facing values from the HCI side. The internally-facing perspective considers the participatory design process from the perspective of the designer, using the process to gather more information to better suit the designers' goals (P1, P2, P3, P4). They also talked about opening up the process, involving all stakeholders, and letting the user drive the design process (P1, P3, P4). However, it seemed that the purpose of opening up the process in such a way was towards the designer's goal of achieving a better outcome. The abundance of artifact-based and internally-facing perceptions of participatory design expressed during their first interactions with the concept may have an impact on how fully they internalized and eventually implemented the idea later in the semester. The students continued to learn about participatory design in later weeks, but these initial perceptions are telling about the challenges of understanding the topic.

In week 9, the students were working on printing a practice device for the participant and thinking about how they could incorporate participatory design in their next meeting with the participant. Their blog posts were brief and there were not many values coded overall. When the students discussed printing the hand, their focus was primarily artifact-based (P1, P3, P4). P4 also pointed out that they felt more strongly motivated to create a device for another person (externally-facing) than they did when they were creating a practice hand earlier in the semester. As the students were thinking about how to incorporate participatory design in their own project, both P1 and P2 were thinking about how they would interact with the participant,

which is a shift in values from their initial perception of participatory design. However, P2 was still thinking from an internal-facing perspective, thinking about how the design group could get more insights from the participant, rather than how they could work together to uncover and work towards a goal.

In weeks 10 and 11, the students were reading more about participatory design in the form of research papers and specific activities, as well as planning the specifics of a participatory design-oriented meeting with the participant. In these weeks, the students saw the value of opening up the design process. Most of their perceptions of the readings were interaction-based or external-facing, with 10 instances of these HCI-aligned values and 4 of making-aligned values. For example, P1 commented on how a particular paper "shows that limited participation by the design leader leads to a better result. They took on the role of supervisor and had limited involvement in guiding the design" (external-facing) and P4 commented on how "the researchers were really in the trenches with the participants" (interaction-based). P1 also expressed the value of an individualistic approach, where the design sessions should be centered around the unique personality of the participant. Overall, as the students learned more about participatory design, the way they talked about it became more aligned with the HCI values.

After the second meeting with the participant, the students primarily commented on the interaction-based and external facing aspects of the session. P2, P3, and P4 all commented on the environment they had set up for interacting with the participant, starting with the casual conversations on the way to the meeting room from the parking lot. P2 mentioned some of what the team wanted to communicate to the participant: "to inform her that we were designing together and not just taking her feedback and making a design." P1 and P4 reported on one of the activities the group facilitated during the meeting, which was more about communicating what it means to design than about ideating specific design ideas. P4 said the activity helped the

participant "get more familiar with me and put her into a designer role." P4 and P2 also reported on a card sorting activity that aimed to understand the values and goals of the participant. Their comments were both artifact-based and interaction-based, touching both on the types of interactions the participant wanted to have with the device, what that means for the device itself. Overall, P4 summarizes how "... when approaching this design we were heavily focused on functionality and usability, which were our goals. When in reality her goals were how visually appealing it is and in how many ways she can use the device. This led us to a discussion about color schemes, fabric choices, and adding printable fingernails to the device. These were not questions we were asking before, and because these activities put us all in a design position, we finally got to hear about what [the participant] valued in design."

While the students' reflections on the second meeting with the participant were not only more aligned with the HCI side of the definition of HCM, they were also in line with the ideas behind participatory design such as designing with participants rather than for them. However, the students' second device iteration was closely related to the first one and continued to focus on some of the ideas uncovered in the first meeting with the participant. In the blog post, P2 reported that the main outcome of the second meeting in terms of design direction was that the new device should be black. The students also incorporated a sunflower design motif through fabric, added pencil holder, and made some additional adjustments for comfort. It is possible that with longer term sustained interaction with the participant, more options could have been explored, but in the short semester time frame, the students were just starting to understand the value of participatory design as the semester was wrapping up.

In reflecting on the semester, students answered a number of specific questions in a final blog post such as what kind of challenges organizations like the Helping Hand Project face, what they would do differently if they did the semester over, and how they would determine whether a project such as theirs was successful. Reflecting on

their answers through the lens of the NTHCM sheds light on some realizations that all students had, as well as some concepts that students have different perceptions of. All students articulated the value of interacting with the recipient. P2 said they would have "tried to have more meetings and longer ones so that we could incorporate a higher level of participatory design into our project." P4 recognized that having enough volunteers to facilitate the needed personal attention with the device recipients is a challenge that organizations face. P2, however, also saw an opportunity to automate part of the process and require less interaction: "Since I am from a computer science background, I would have a strong technical program where we would develop an app so that patients can measure themselves from the comfort of their home." This idea is in contrast to the ideas of participatory design and reflects artifact-based and internal-facing goals by centering the skills of the designer and focusing on a single technological solution rather than fostering relationships. When asked what a "successful interaction or relationship with a device recipient looks like", the students were split. P3 and P2 discussed success in terms of the device itself- if the recipient is still using the device later on, the project was successful. P4 and P1 answered in a more interaction-based way, in terms of whether the recipient feels like their ideas are being taken into account and whether they feel comfortable.

5.2.3 The Capstone Context as a Whole

So far, I have discussed how the individual students aligned with individual values. The Statement Making study in Chapter 4 shed light on how HCM not only lives in individuals' mindsets and practices, but also in the way the individuals and the context interact, and that it is important to see if the values are in conflict or synergy with each other. I use those findings to reflect here on additional ways HCM did or did not manifest in the capstone course.

One possible configuration or relationship between artifact-based and interaction-based values, as indicated by the results of the study in Chapter 4, involves partici-

pants being drawn to a particular event or context due to their artifact-based focus, while others were drawn with an interaction-based focus. Some embraced both and there were times when an artifact-based foundation lead the way for an interaction-based perspective. In the capstone course, I was not able to find a similar apparent synergy between interaction-based and artifact-based perspectives. In fact, these ideas may have been in conflict with each other. There were times when an artifact-based focus got in the way of the possibilities for meaningful interactions with the participant to form.

One possible configuration of the relationship between internal-facing and external-facing aspects of a context for HCM, as indicated by the results of the study in Chapter 4, is where the external-facing purpose of the context is strengthened by the internal-facing and individualistic endeavors of the participants, such as designers expressing their personality or learning a new skill, strengthened the event's message about taking control. In the capstone course, if the students were thinking more internally about their own learning or portfolio, that got in the way of the external-facing goals of working with the participant. To truly have an external-facing mindset in the capstone, the students would have had to let go of the desire to have something for their portfolio in order to be open to the idea that the outcome of supporting the participant might be intangible.

Similarly, one of the places to look for HCM, as indicated by the results of the study in Chapter 4, is in the interactions between the context and the participants. Human-Centered is not only carried out by the individuals, nor is it carried out only by the context for making, but rather an important aspect of Human-Centered Making is how the context and the participants view, frame, and contribute to the goals of the other. As a formal course for credit, the capstone was limited in this way. As instructors, we had specific goals for student learning and while we were able to adjust slightly based on how the project was developing, our goals for the participants

did not change in the way they did for the context of Statement Making.

Looking at the distribution of values overall, there was not much evidence of collective or individualistic mindsets and practices. Many Statement Making participants exhibited an individualistic focus in the way they centered their garment design around the unique personality or desires of the model. A similar individualistic focus could have been present in the capstone experience in the form of tailoring the device to the recipient's personality. The artifact-based focus of starting with an existing open-source design may have gotten in the way of realizing that this was even a possibility. If this individualistic mindset had been present in conjunction with an external-facing or interaction-based relationship with the participant, the capstone would have been much more aligned with HCM. While there was little evidence of collective mindsets and practices, this does not seem to indicate a problem. There may have been an opportunity to reflect broadly on HCI endeavors and topics such as universal accessibility, where there is a trade-off between designing products that meet everyone's needs and products that are highly customized and individualized.

5.3 Discussion

5.3.1 Insights for the Capstone and Other Maker Leaders

I reflect here on how the results discussed above shed light on how we could improve the capstone if we were to run it again. I also generalize these insights in terms of how they could be applied by maker leaders in other contexts.

Prior Experiences and Expectations– The fact that there were significant differences in the distribution of values throughout the semester amongst the students shows that pre-existing mindsets, expectations, and personal differences were influential throughout. We could have been more intentional about providing definitions for concepts students may have had some prior understanding of. For example, we asked students about their perceptions of HCI and found they had different definitions, some more artifact-based and some more interaction-based. This would have been

a good opportunity to define what we consider HCI to be and what definition will be most relevant to the activities of the class. Instead of only asking what HCI is in the blog posts, we could have asked students to come up with a definition together, which we could have prompted feedback on to ensure students were thinking about the same thing when we talked about HCI. While other maker-related contexts may not have a direct focus on a formal concept such as HCI, they may consider doing the same thing by asking participants what they think it means to do social good, or what they think the goals of the project are or the nature of the process they think they will utilize to accomplish it.

Building Devices– Students in the course built several practice devices early in the semester so they could understand the process and the possibilities before having to participate in a design project using those same tools and materials. They first built a device on their own to learn how 3D printing works and they built a practice device using measurements from the participant to understand the additional challenges of ensuring fit and comfort. However, the focus on devices at the beginning may have reinforced any initial artifact-based assumptions, or may have introduced an artifact-based leaning to begin with. Even though we tried to communicate the purpose of building the devices as being for practice and learning before starting the design project, that message may have gotten lost. As an improvement, we could have given the artifact-based learning assignments more of an interaction-based focus. For example, when building the initial practice device, the students could have been asked to do small modifications to the device to express aspects of their own personality or someone in the class for the purpose of understanding how the processes we were focusing on in the class were not about just the devices themselves, but rather about identity and personality. Similarly, maker leaders of other semi-structured contexts centered around a project with a social aspect would want to be mindful of how the necessary fabrication skills are introduced. While the fabrication skills are important,

they can distract from the nuances of the social considerations of the project.

Readings and HCI topics– While the students' responses to the first HCI reading assignment were more making-aligned than HCI-aligned, later reading assignments were more balanced. Similarly, when the students started learning about Participatory Design through readings and articles, their understanding was more making-aligned, but grew to be more HCI-aligned throughout the semester. This shows that shifting a perspective takes time and it is worthwhile to have multiple assignments or discussions to give students time to digest the topic. We might have started those readings earlier in the semester and added more variations on them so there would be even more opportunities for increased understanding. However, this analysis shows that the HCI and Participatory Design readings were successful at facilitating students' shifting interpretation over time. Maker leaders of other contexts should be mindful that even when discussing interaction-based topics directly, it takes time for students to understand those topics from an interaction-based perspective.

5.3.2 Using the NTHCM as an Analytic Lens

In this study, I used the NTHCM as a lens for analysis by coding a longitudinal data set for instances of the 6 values and comparing total instances of values per individual, seeing how the number of values changed over time, and performing additional qualitative analysis to see different ways the values manifested. Since the NTHCM suggests collective, interaction-based, and externally-facing values should be present, this analysis shed light on ways the course could have been improved based on places those values could have been present but were not, particularly in terms of making sure to define key terms, bringing interaction-based aspects into making assignments, and recognizing that one reading on the topic would not be enough. If maker leaders or HCI researchers are interested in using the NTHCM as an analytic lens, these are some suggestions and insights about how the NTHCM could be used.

I showed that the NTHCM is appropriate to use for a semi-structured making

context that had the general goal of prompting mindfulness of the human aspect during a common making endeavor. The NTHCM would be likely be helpful for maker leaders or HCI researchers to understand other such endeavors, such as projects or classes that involve making for "social good." Each of the pairs of values of the NTHCM sheds light on different aspects. The internal-external distinction could help leaders of these contexts distinguish between different types of goals the participants have, such as their level of commitment to helping others versus their focus on personal growth and learning. The artifact-interaction dimension can shed light on how much the participants are fixated on the technology or device, compared to whoever is impacted by the "social good" aspect of the project. The individualistic-collective dimension was less relevant in our context, but may help other maker leaders or HCI researchers understand how participants perceive the broad impact of their project as opposed to just the immediate impact. Understanding these dimensions could be useful for maker leaders who would like to find opportunities to shift technical endeavors to be more sociotechnical.

Understanding these dimensions could also be of interest to HCI research on understanding the making phenomenon by shedding light on new ways to understand existing maker practices and new types of experiences to support through design. In particular, this lens could help forward HCI research agendas related to understanding makers as "everyday designers" or understanding what design-like practices makers engage in [58, 115]. HCM is another way makers engage in design-like activities and performing an analysis through the lens of HCM can shed light on different ways these practices manifest. The study in this chapter contributed to these agendas by showing how difficult it is to center a making endeavor around the goals and values of another person, even when the makers have a background in HCI and are being guided on how to incorporate advanced HCI techniques into the process. Additionally, if future work that evaluates the extent to which application of the NTHCM

brings about the promise of democratized technological practice shows promise, then performing this type of analysis would be of even greater interest for HCI researchers to guide their research and design efforts in the making phenomenon towards that promise. However, as I will discuss in Chapter 7, results indicate that the NTHCM is limited in its capacity to bring about democratization.

I used the NTHCM to compare differences between students overall and to see if all students progressed throughout an experience in the same way. Using the NTHCM on blog posts is a reasonable way to get longitudinal data and understand how the activities of each week influenced the students' mindset and practices. However, if future makerspace leaders are interested in understanding more concretely whether there was a shift in values over a semester, it would be better to ask the same questions of the students periodically and compare their answers. My study was limited in this way since some of the variation in values over the semester was due to different question prompts.

This study also shed light on additional questions about the nature of the NTHCM. These questions will need to be answered as part of future efforts to develop the theory. I counted the number of instances of each value, where an instance was considered at the level of an utterance, which could be a few words or a few sentences. Another analysis could have calculated the percent of each blog post that aligned with each set of values, rather than the number of instances. This raises the question of how the values should be counted. If a student writes a very long sentence with an artifact-based focus, should that be quantified as more artifact-based than if the students express an artifact-based idea in a phrase of a few words? Similarly, if a quote expresses multiple values from the HCI side, is that quote more aligned with HCM than if it only expresses one value?

In summary, this chapter explored the potential of using the NTHCM as an analytic lens to shed light on how a particular maker context with a sociotechnical focus could

be improved. The analysis shed light on the fact that each student aligned with different values throughout the semester, helped identify some factors that may have caused a more making-aligned focus, and supported the conclusions that leaders of this or similar maker contexts should be aware of prior expectations, should take time to break down definitions, and should be aware that shifting from a making-aligned perspective to an HCI-aligned one takes time. Future maker leaders or HCI researchers could use these insights directly or could use the NTHCM in a similar analysis to generate new insights. In the next section, I shift to questions about how the NTHCM could be useful not only in reflection, but to generate new directions for maker leaders.

CHAPTER 6: USING THE NTHCM AS A GUIDE

The previous chapter investigated the extent to which the NTHCM was useful as a reflective lens during a formal analysis to see how a particular maker context could have been improved. In this chapter, I discuss some empirical investigations that aim to understand the opportunities and challenges of using the NTHCM as a guide for maker leaders to generate or direct future maker endeavors. The research questions this section aims to answer are:

> How do maker leaders react when asked to consider the 6 values of the NTHCM? Where do they see the values playing out? Does considering the values help the makerspace leaders generate new ideas or directions? How do the values relate to things they think they are important or relevant?

I focus on the experiences of maker leaders rather than makers because the NTHCM requires not only consideration of individual maker practices and mindsets, but also consideration of the context as a whole, and it is more likely that maker leaders are thinking about or considering their influence in that way. The NTHCM also aimed to fill a gap in guidance that I experienced as a maker leader, not necessarily as a maker, so investigating how other maker leaders react to the values was an appropriate place to start.

I first present the results of an interview study with maker leaders to see how they react to the values. I then attempt to use the NTHCM myself in the context of the CCI makerspace, reflecting on how it could inform my own future actions or changes.

6.1 Interview Study

I conducted a semi-structured interview study with makerspace leaders to understand their goals and practice as leaders, their interpretation of and reaction to the values of HCM, and their ideas about how to implement or promote collective, interaction-based, and externally-facing mindsets and practices specifically. Interviews were conducted remotely via video chat in January 2021, audio recorded, and then transcribed for qualitative analysis.

Participants were informed that the study was about perceptions of making and that I was interested in their reactions to certain ideas as they relate to making. They were told to be as honest as possible about any positive or negative connotations that came to mind and that if the ideas did not seem relevant to them, they should feel free to say so.

The first questions in the interview were centered around the participants' practices, goals, and characteristics they associate with a good makerspace. To understand their initial reactions to and associations with Human-Centered Making, I pasted a list of the 6 values in the chat window of the video in alphabetical order (artifact-based, collective, externally-facing, individualistic, interaction-based, internally-facing). I told participants that this was a list of concepts and I was interested in their interpretation of the concepts as they relate to makerspaces. They were instructed to read each concept down the list and express what comes to mind about that concept in relation to makerspaces. If nothing came to mind relative to makerspaces, they were instructed they could give a general definition or association. After discussing each of the values, I then pasted the three HCI-related values as a list in the chat (collective, externally-facing, and interaction-based) and asked participants to imagine they were trying to align their makerspace or their own making endeavors with that set of concepts. I asked what their initial thoughts would be and what kinds of things they would do or think about. As needed, I asked follow up questions for more specifics or

elaboration. After discussing the values, I returned to asking about the participants' own practices and asked what their own set of guiding principles or values would be if they had to distill those into a few concepts.

6.1.1 Participants

A total of three makerspace leaders participated in the study. All participate in making endeavors themselves and either manage one or more academic makerspaces or mentor students in academic makerspaces. P1 facilitates structured and unstructured programming of academic makerspaces and makes art as well as objects for their home or personal use. P2 is a self-identified life-long maker and manages several making-related spaces at a university. P3 makes things for teaching purposes and personal reasons, mentors students who 3D print prosthetic devices, and would very much like to start or run a makerspace if they had the time and resources. Two of the participants were women, one was male. Two were white, one was Asian, though all were born in the USA. One participant was in their late twenties, one was in their early thirties, and one was in their early forties.

6.1.2 Results

To analyze the results, I transcribed the interviews and grouped the responses by question. I performed thematic analysis to find emergent commonalities in the responses, which I summarize here.

6.1.2.1 Interpretation of the Values

I first discuss how participants interpreted each value, pointing out places their interpretations were similar or different from each other. The purpose of this analysis was not to determine whether or not participants could "guess" the meaning behind the words I intended, but rather to understand the breadth of ways each concept could be interpreted. I also discuss places where participants' interpretations differed from my original definition of the values, either where participants thought of aspects

I had not, or vice versa.

Participants had different responses for artifact-based. Artifact-based reminded P1 of Statement Making, the digital fabrication fashion show introduced in Chapter 4 because "people made artifacts, they wore artifacts. It felt like an artifact too because it was documented". P1 then generalized artifact-based to being about "tangible objects". P1's initial association of artifact-based with Statement Making was surprising when considered in light of the findings of the study in Chapter 4, which suggested Statement Making was more about the interactions around the artifacts than about the artifacts themselves. However, P1's explanation and generalization of the concept was consistent with the definition and the results of the prior study. P2 focused on how artifacts could be used, defining artifact-based as "something physical or even digital that you are using as a reference... [or] something that is able to be studied". P3's association was more specific, thinking first about an artifact as an interruption during a scientific experiment and then thinking about someone in the makerspace recreating an artifact from anthropology.

All participants thought that collective had to do with makers working together in some way. P2 and P3 thought about groups of makers working on the same project together. This interpretation could also be seen as synonymous to "collaboration." P1 interpreted it as being about how decisions in a particular makerspace are made- not by one person, but rather by a group with vested interest. P2 also mentioned it could have to do with not only a group working together on a making project, but also if a makerspace has a particular mission.

Participants had different interpretations of externally facing. P1 and P2 both thought of making sure the makerspace promotes itself and reaches out to people who are not yet participants. P1 was the only one who thought about helping people in the community beyond, saying "we are going to make something better if we are externally facing". P1 and P2 also thought about money-related considerations, with

P2 commenting on making sure the makerspace is producing things that potential donors will appreciate and P1 thinking about revenue generation. P3 mainly commented on the external interactions between individuals in a makerspace in the form of emotions they show externally to each other.

For individualistic, participants' responses were similar. P3 thought about "customizing projects with your own flair and flavor", P2 thought about "individual goals, like what do you want to do in the space", and P1 thought about the more selfish aspects such as "making decisions for you masked on your needs with little regard for what's best for a larger group of people". All these responses have to do with focusing on the needs and desires of individual makers, though P1's answer may have overlapped with the concept of internal-facing.

For interaction-based, P1 and P2 focused on the interactions between the makerspace participants and the tools, machines, or learning materials in the form of workshops, activities, and hands-on training sessions. P2 also mentioned interactions between people in the space and the importance of developing relationships and having conversations that go beyond surface level introductions. P3 was the only participant who thought about the interactions that happen with the objects the person in the makerspace is making, including how "other people are going to see it and interact with it". P3's interpretation was in line an aspect of HCM that was deemed important in Chapter 3 in light of the criteria for democratization, which involves thinking about the impact of the endeavors in the space on people beyond the space, though the interactions mentioned by P1 and P2 are also important.

P1 and P2 both saw internally-facing as related to what happens when a makerspace serves only a single audience. P2 also commented on the necessary interactions between the makerspace leader and staff members such as figuring out policies, which were internal-facing since they were about the logistics of ensuring the makerspace is functional. P3 responded differently, thinking about the internal emotion

of those who interact with things that are made: "whatever you are making in the space, how is it going to make the other person feel." It should be noted that internal-facing came immediately after interaction-based in the list of values, which made P3 think about interactions between the made artifacts and other people who see or interact with it. P3's answer for internal-facing may have been influenced by the adjacency to this other prompt. I later asked P3 about the extent to which makers align with internally-facing versus externally-facing, and P3 talked about how some makers want to know what others are doing (externally-facing) while others keep to themselves (internally-facing), which sheds further light on P3's interpretation of the values.

6.1.2.2 Ideas for Aligning with Collective, Interaction-Based, Externally-facing Mindsets and Practices

When asked how they might go about adopting or aligning with collective, interaction-based, and externally-facing mindsets and practices, all participants thought having the right team of staff would be crucial. P1 thought adopting the values would be more a culture shift that happens over time and said "it doesn't sound like a tool thing, that sounds like a people thing. And it seems like you would need to have a really fantastic team who know how to wield their human skills to get this to happen." P2 talked about "initiatives" and "figuring out some concrete things we could do, concrete projects we could engage in to get at these things". P2 thought there would somehow have to be a shift in how people thought about the makerspace- "thinking about it as a collective instead of 'hey, there's this space you should come to."' All the participants also mentioned curating or communicating certain aspects of the space to foster these values. P3 said, "you need to have a good catalog of things people have done in the space", P2 thought it would be necessary to "show evidence of a collective" and P1 said, "you are trying to pose to the public and to the community. You are trying to say- let's do these experiences together."

When asked about concrete activities or endeavors that represent these ideas, participants mostly offered additional high level thoughts. For example, some of P2's thoughts on collective were, "the collective part of it could be that we want to develop a collective, whatever that would mean. Or that the collective would be even the team that would figure out how to do all of this stuff," and then later said that workshops and events would be the concrete way of moving forward on that. P3 said that all the workshops and activities he has looked over "do a pretty good job of doing these things" and didn't think he could select just one. P1 provided additional thoughts about customer service to make sure people coming into the space feel comfortable and how "your main leader needs to be really good at managing people and then use those people to be your hands in the community... have the team be your stars." While these thoughts are all in line with HCM and may be part of the endeavor, they do not necessarily propagate the values in and of themselves.

6.1.2.3 General Reactions

When asked what they would say or do if they decided they wanted their makerspace or their own maker endeavors to be more collective, interaction-based, and external-facing, none of the participants responded negatively. P2 thought it would not "be a terrible idea" and P3 said, "I think that's important." P1 and P2 both brought up concerns about resources. P1 thought it would require a marketing budget and P2 thought if there were not adequate resources, pursuing these values "would cut down on the main goals of the spaces". P3 expressed surprise at several points during the interview. When first asked about what externally-facing makes him think of, he said, "Oh my gosh, where do you guys come up with this stuff," which could have been a reaction to the concept itself, or could have been reflective of the unfamiliarity of considering values in relation to technological or educational spaces. At the end of the interview when asked if anything else came to mind that he wanted to say, P3 admitted that "the activity was kind of weird", referring to the part of the

interview where I asked about types of activities that related to each of the values. When asked for initial reactions to each of the six concepts, P1 was the only one who offered a positive or negative value judgement for any of them, responding that individualistic and internally-facing were not things to strive for.

6.1.2.4 Values and Guiding Principles for Makerspaces

When asked what makes a makerspace better than others, all participants agreed that the people and staff in the space were important. P2 and P3 thought machines were important, but without the right people, the makerspace would not be good. After thinking about the values of HCM, participants were asked what their own guiding values for their makerspace or an ideal makerspace were. All participants' responses centered around making sure participants in the space feel a certain way. All commented explicitly on making sure everyone feels welcome. P1 and P3 both thought awareness of processes such as how to get trained are important. P2, who commented on how her background as a teacher influences her role as a maker leader, thought her two guiding principles were to encourage possibilities while helping participants understand what is realistic and "encouragement of thinking about things in new and unusual ways". P1 and P2 both mentioned helping participants realize that their idea might be hard work, but to work through it anyway. P1 also had some thoughts about how the community should operate, such as "candor," where community members should feel comfortable speaking up to each other if someone is doing something offensive or unfair, rather than always looking to the leader of the space to resolve conflicts and where members of the community "should be able to influence in the same way that the head of the lab is".

6.1.3 Discussion

Overall, most of the participants' interpretations of the values were in line with my own definitions in some way. Their definitions and examples did not represent

the entirety of the concepts as I had thought of them, which is not surprising. I was prepared to suggest my own definitions, but decided not to, in order to see how the participants saw their own definitions playing out. P3 was the only one who thought about interactions with the artifacts beyond the person who made them, so this would likely need clarification in the future since that is one of the reasons why the NTHCM was created. All participants also thought about collective mostly in terms of endeavors that could happen within the makerspace in the form of groups of people working together on a project or the space itself feeling like it has a collective mission, rather than the collective making phenomenon or the collective impact of the endeavors of makers, even when they are not explicitly associated with each other. Another important aspect of collective is thinking about the collective making phenomenon or the collective impact of technology or fabrication as a whole on society, so this would also likely need clarification if the hope is for makers and maker leaders to think about these aspects directly.

Overall, there was not much evidence that thinking about the values gave the participants new ideas about how to guide their making endeavors. When asked to consider collective, interaction-based, and externally-facing values explicitly, participants' responses were in line with HCM and showed evidence of understanding the nuance of fostering these ideas in the making phenomenon. They knew it would have to be a people-driven effort and would require a shift in culture that would need to happen over time. While all participants expressed ways of thinking about making endeavors that were in line with HCM, they did not suggest new ideas that were sparked by thinking about how to adopt the values of HCM explicitly. Some of the participants' responses stressed the importance of figuring certain things out, but did not offer suggestions, such as when P2 said "the collective part of it could be that we want to develop a collective, whatever that would mean" and when P3 said "to make the makerspace more externally facing, I would say you need to have a good

catalog of things people have done in the space that they know that they can do." It is almost like saying the way to be more collective is to be more collective and the way to be more external is to be more external. This was a short brainstorming session, so perhaps with more time the values would be more successful at sparking ideas for future endeavors, but there was little evidence of that in these interviews.

One of the reasons the NTHCM exists is because of concerns I had about the lack of human awareness in many making endeavors, as discussed in Chapter 3. Not only did the values themselves seem distant from the immediate thoughts and concerns of the maker leaders, the ultimate purpose of the NTHCM also seemed distant. None of the leaders raised concerns about typical maker endeavors or discussed ways they thought makers themselves needed intervention. In fact, P1 thought the community should feel like they have the ability to lead as much as the leader and hoped makerspace participants would speak up for themselves to navigate conflicts with others in the space. P3 thought that most of the guidance he gives makers is in the form of "recommendations based off my experience in the makerspace" such as which machine or material might be most appropriate. P1 and P2 both felt the guidance they usually give is in the form of helping students realize the possibilities and helping them realize that making can be hard work, but they should work through it. Most of their thoughts and efforts going forward were about bringing more people in. It seems unlikely that these maker leaders would intervene in or guide existing maker practices to become more collective, interaction-based, and externally-facing. If any of them were to use the values, my guess would be they would use them to start new endeavors rather than prompting re-consideration of existing ones. There may be a shift through an additive approach, rather than a shift by changing what is already happening.

6.2 Autoethnographic Reflections

I reflect here on how, as a makerspace leader, I might act on and use the NTHCM as a guide myself. I asked myself similar questions that I had asked the participants in the last study, thinking about concrete activities and endeavors I could promote going forward. I documented these reflections over the course of several weeks, taking notes when something crossed my mind. Most of this ideation took place before the interviews in the previous section, though I presented the results of the interviews before these reflections in order to center the experiences and thoughts of others. These reflections also took place several months into the COVID-19 pandemic, throughout which the CCI Makerspace had been closed for open-ended participation, and at which point I was quite distant from the everyday practice of making and of makerspace leadership. Nevertheless, these reflections represent how I would engage with the NTHCM as a maker leader and help shed light on its merits and shortcomings as a guide.

6.2.1 Language and Rhetoric

When I introduced the values of HCM in Chapter 3, I reflected on a few ways the making values manifested in my own maker experience. For example, I discussed how my question to people working in the makerspace is usually "what are you making?" and how when I give tours around the space, I focus on talking about the different machines and the types of artifacts they can create, which both reflect artifact-based values. I had also reflected on my individualistic and internal-facing definition of a makerspace as a place that primarily serves the people who come there to make things. I reflect again on these aspects here and how I might promote more collective, interaction-based, or externally-facing values in these instances.

Instead of asking makerspace participants what they are making, I might instead ask them what they are thinking about. While they are often thinking about whatever

it is they are making, phrasing the question in this way at least leaves room for them to answer in other ways. When I give tours of the Makerspace, I might comment first on the types of activities we have seen in the space, such as clubs or initiatives that have formed and reasons people come to the space, such as for making gifts for others, learning new skills, or meeting new people. We could also shift our definition from being about a place that serves individuals in their needs to "a place for discovery" or "a place to explore alternate relationships with production", which are more interaction-based, however these are still individualistic.

6.2.2 Workshops

One of the ways to introduce ideas into the makerspace is through workshops: short semi-structured guided sessions with a small group of students that focus on a particular idea, skill, or project. Workshops are a good way to introduce ideas not only to the students who attend, but also to those who interact with the facilitator while they are preparing the workshop, as well as those who see the advertisements. Workshops not only provide an opportunity to bring new values into the makerspace, but also run the risk of reinforcing the values that the NTHCM suggests should not be the primary values, so I reflected on some of the workshops we had run in the past and tried to shift artifact-based, individualistic, and internal-facing aspects to be more interaction-based, collective, and externally-facing.

Many of our earlier workshops focused on a particular machine or technique, such as 3D printing, laser cutting, or CNC routing, and followed a similar format. For 3D printing, for example, we would show examples of what can be made (some were physical examples, some were pictures of examples), we would show the process or work flow of what types of software would be needed to translate an idea into an artifact, we would demonstrate a sample cut or print, and we would let everyone customize their own small version of something and watch the workshop facilitator fabricate it.

One way to make these workshops more collective could be to have participants work on small pieces that become something larger when put together. This would give participants an understanding of the benefits of working together and an intuitive sense of what it feels like to create or be part of something that is bigger than oneself. Upon reflection, I found that we had conducted a few workshops that culminated in the creation of a collective artifact. One was an e-textiles workshop that focused on sewable electronics and sewing techniques where participants made squares to practice applying the skills creatively (Figure 6.1). These were then connected to each other to form a quilt-like artifact. In a workshop session with elementary school students, participants visited different stations to create pieces that were compiled together to mimic an artwork (Figure 6.2). The challenge is what kind of collective endeavor artifact should be created such that the act of being part of it is meaningful. As documented in some of our previous work, the students who participated in the collage project were not very interested in looking at the final product when they were done [149]. Perhaps a series of workshops or a public event centered around creating a public art installation would be a meaningful form of collective participation. Another question is whether a symbol of collective participation is sufficiently collective as opposed to actual collective action.

Figure 6.1: Sample workshop project where participants made e-textile squares for a quilt

Figure 6.2: Sample workshop project where participants collaboratively made a collage to resemble a work of art

I also reflected on whether there were workshops we had run that were already aligned with interaction-based, collective, and external-facing values. One workshop in particular came to mind: Sustainable Modular Textiles. I created this workshop after hearing about a branch of work as part of the Fab Foundation network [2] with

circular open source sustainable fashion [5]. They point out the enormous amount of waste created by the fast fashion industry. Since trends go in and out of style so quickly, clothing companies quickly and cheaply produce clothing that does not last very long and ends up in landfills shortly after consumers purchase the items. The circular open source sustainable fashion idea explores how digital fabrication technology can be used to create modular interlocking pieces that can be assembled and disassembled into different items of clothing. Rather than throwing something away when it goes out of style, it could be disassembled and turned into something else. This idea is also related to the Fab City initiative, a growing network of 28 cities around the world that have taken the pledge to become completely self-sustaining by the year 2054 [6].

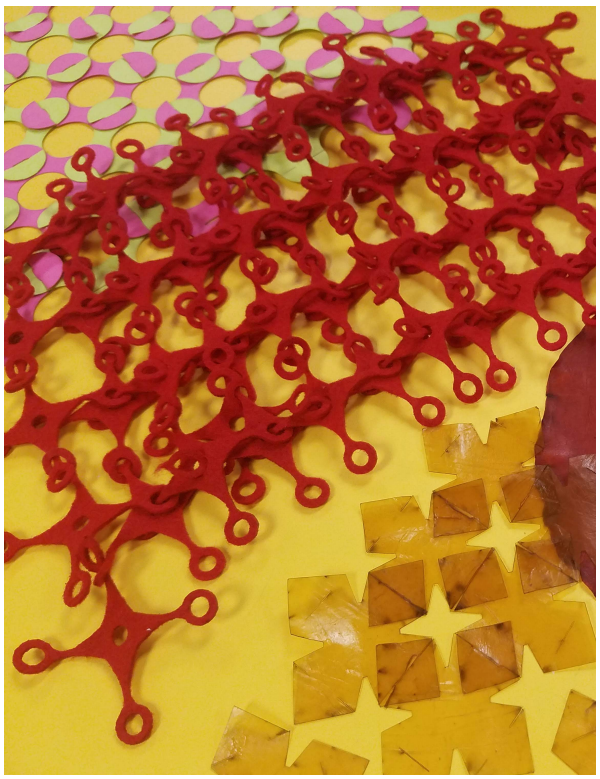


Figure 6.3: Workshop project that centered around circular open source textiles

In the workshop, I discussed the problems with fast fashion, the idea of open source circular fashion, how a circular economy could be enabled by digital fabrication, and

examples of modular textiles created by others. I then lead a step-by-step tutorial in a 2D design software of how to create modular interlocking textile pieces and the participants created some of their own designs which we then cut out using the laser cutter (Figure 6.3). This modular textiles workshop was collective and external-facing because it was framed in terms of a societal problem that exists because of a particular set of actions that becomes problematic at a collective scale. It was also framed in terms of a particular possible collective outcome of the making phenomenon, as claimed by the Fab City initiative: a more sustainable circular economy. These initiatives are also all happening in the real world, giving the workshop an external-facing aspect. While the workshop did focus on the skills required for creating artifacts, the value of the artifacts and the conversations about the artifacts were more about the interactions the artifacts afforded. Specifically, the project was about creating interlocking modular pieces that could be assembled and reassembled in different ways, which is an interaction. This interaction also enables a broader shift in the interactions with or relationship between humans and clothing, where instead of throwing things away when they go out of style, we might disassemble and reconfigure them in a different way.

This particular workshop aligns well with the NTHCM even though I was not thinking about the values when I created the workshop. I do not think that reflecting on the values themselves would have lead me to such a workshop- it was my interactions with the Fab network and my interest in the modular textiles that lead me to run the workshop. However, reflecting on the workshop through the lens of the NTHCM may shed light on how other workshops could be designed to bring these values into the making phenomenon.

6.2.3 Miscellaneous Changes

To become more collective, we might host events where makerspace participants share what they are working on to provide an opportunity for reflection on the collec-

tive output or endeavors of the makerspace. Ideally, such an event would have more of an interaction-based focus than an artifact-based focus. While Maker Faires come to mind as an example of such an event, they are primarily artifact-based.

To become more interaction-based, we might highlight the narratives of different makerspace participants in a newsletter or other format, emphasizing not only what they make, but also their relationship to the tools or the interactions afforded by the endeavors.

Training sessions on various machines are often part of participants' entry into the makerspace. These sessions focus on how to safely operate the machine, teach participants the workflow of preparing files, and the protocols of the space. They are naturally artifact-based since they focus on tools and processes, individualistic since they are typically one-on-one sessions, and internal-facing since they focus on participants' learning. They are interaction-based in the sense that participants interact with the tools throughout the experience to get a sense of the process, and staff running the training sessions are instructed to use the time to get to know the participant and foster interest in the offerings of the space. It is not immediately clear what a more Human-Centered Making approach to these sessions would be. Should part of the safety training be to discuss safety more broadly in the form of potential unintended consequences of the collective impact the tool or the artifacts it can produce might have on society? Should the training make sure to highlight use cases of the machine that serve an externally-facing purpose?

6.2.4 Makers Creating PPE for COVID-19

In March and April 2020, in the first few months of the COVID-19 global health crisis, it became apparent that there was an immense shortage of personal protective equipment (PPE) including face shields, masks, and other medical supplies. All around the world, makers began fabricating devices such as face shields and prototyping solutions to shortages of other equipment. One of the first devices was a 3D

printed face shield with a laser cut visor, originally created by the Prusa 3D printer company in Prague, Czech Republic and open source files shared online [158]. Local groups of makers assembled themselves, took these files as a starting point, worked with local medical professionals, and fabricated numbers of them that were then put to use. One of these groups, which eventually came to be known as Charlotte MEDI, formed in our area and our makerspace participated in supporting the Charlotte MEDI effort of producing 100,000+ face shields for local medical professionals and front-line workers. I reflect here on this local group participating in this project, asking "Is this Human-Centered Making?", "What caused this to happen?", and "Would application of the NTHCM have caused such an endeavor to happen?"

The MEDI group was operated by a small team of maker leaders who were in contact with doctors, and through a team of volunteer makers throughout the city of Charlotte, fabricated face shield designs in large quantities. The central team was working to transition from 3D printing to injection molding, which would allow for faster production. The central team instructed the volunteer makers to 3D print different prototypes, which were given to doctors for feedback so the team could hone in on the ideal design for the injection molding. When I first heard about the design the Prusa company had posted, I wondered how much input they had from medical professionals and whether anyone would use such a device due to safety concerns, so initially I perceived the possibility that this could be a naïvely artifact-based ambition. However, when it became clear that there were no other options and local hospitals were asking for as many of these devices as possible, those initial worries dissolved. The local group was very interaction-based, working closely with doctors to get feedback and understand their concerns. This was clearly an external-facing effort, though participating as a maker seemed to satisfy an internal-facing need to feel useful at a time when there was a lot of uncertainty. The success of the group depended on a network of makers adopting a collective mindset rather than

an individualistic one. The MEDI group needed makers to print specific devices in mass quantity to get feedback; they did not need every maker modifying the device or trying to optimize. Any individualistic instinct to try to be the one who figures out the optimal design needed to be set aside for the makers to each become a small part of a collective that was creating a large number of devices. What made the group successful was not only the artifacts themselves, but rather the successful network of makers, interactions with the doctors, distribution channels, and communication amongst all constituents. In other words, it was the interactions, or the infrastructure, that was the hallmark of this particular group.

One of the things that caused the MEDI group to form and others like it was the urgent need for PPE locally and all over the world. I also believe it was in part the enthusiasm for artifacts and the desire to feel helpful amongst makers that helped get the initiative get off the ground. If we had been following the guidance of the NTHCM before the Prusa design came out and before any of these groups had formed, the NTHCM might have cautioned against the optimistic idea that we would be able to create anything medical professionals would actually want to use and may have prompted us to start by asking doctors what they wanted, which may not have garnered a positive response if they did not know what was possible. Having the Prusa artifact as a proof-of-concept may have been the spark that made all the other endeavors possible.

6.2.5 Discussion

Overall, using the NTHCM to inform possible makerspace improvements proved to be challenging. While it was relatively easy to find examples of heavily artifact-based, individualistic, and internal-facing endeavors, it was difficult to think of ways those particular endeavors could be shifted to be more collective, interaction-based, or external-facing. None of the shifts mentioned above seem like they would be enough to make any perceptible difference. For example, using different language to describe

the makerspace may not go far enough. Rhetoric that reinforces artifact-based, individualistic, and interaction-based mindsets and practices may be a symptom of the problem, but changing the rhetoric may not fix the problem itself. Implementing the NTHCM would need to be holistic makerspace-wide endeavor, propagated in as many places as possible and by as many people as possible. However, even the sum of all the ideas discussed above might still be too subtle.

The NTHCM was helpful as a reflective lens, however. As I was trying to use it to generate suggestions, I found it easier to use NTHCM to shed light on existing mindsets, practices, or contexts to emulate or to continue to promote. The NTHCM helped highlight some of the features that differentiate various workshops and making endeavors. At the very least, it could shed light on whether a particular set of making endeavors represents plurality of making across a particular set of dimensions.

6.3 Takeaways

As evidenced by both the interview study and the autoethnographic reflections, the NTHCM does not easily fit into the practice of making or makerspace leadership. While the values themselves were not out of line with the makerspace leaders' own values, the ways the NTHCM intends to guide or steer the making phenomenon is different from how they saw their role in guiding or steering others. Using the values to reflect on past endeavors shed light on endeavors to continue or things that could be improved, but using the values to guide how to move forward did not garner many concrete new ideas.

The implications of these findings for the NTHCM are that additional work would need to be done to determine whether it has any role guiding makers or maker leaders in practice. For example, perhaps the maker leaders would need to reflect on the values over the course of time, or perhaps it would be easier to use them as a guide during the actual practice of makerspace leadership, rather than talking about hypothetical situations. In the meantime, we can conclude that the NTHCM is more appropriate

for researchers or perhaps maker leaders as a reflective lens than as a guide for the practice of making.

This study shed light on some interesting avenues for additional HCI research on the making phenomenon. While there is a lot of research in HCI on making as a grassroots effort, there is less research on makerspaces that started with some degree of top-down support or control, as university makerspaces typically are. There was evidence of the makerspace leaders aligning their goals with democratization, such as how P1 spoke of trying to foster an environment where makers feel like they can speak up amongst each other for what they feel is right and where makers can steer the space as a whole. HCI research could work to understand how leaders in these positions navigate their own positionality and how they lead in such a way that the participants have such a sense of agency.

These findings about the NTHCM also shed light on additional questions for HCI relative to makerspaces and the promise of democratization. The NTHCM had made some assumptions, such as assuming that if someone could figure out what needed to happen in the making phenomenon, HCI researchers could influence makers and makerspace leaders to make it happen through design. I reflect more on these particular assumptions in the discussion chapter.

CHAPTER 7: THEORY EVALUATION

In Chapter 3, I introduced Human-Centered Making (HCM) and the Normative Theory of Human-Centered Making (NTHCM) using literature to justify the choice of values that formed the definition. In Chapters 4-6, I presented a series of empirical studies that develop our understanding of HCM by shedding light on how the values relate to real maker practices and contexts as well as identifying opportunities and challenges when operationalizing the theory as an analytic lens or as a guiding construct in the making phenomenon. So far, I have shown how the theory and the values of HCM were grounded in a preliminary definition of democratization, consisting of 3 aspects (access, social progress, and consideration of risk) that were demonstrably lacking in the making phenomenon, I have shown examples of what the values look like in maker contexts and practices, and I have shown how HCM can be used as an analytic lens by maker leaders or HCI researchers to shed light on ways a semi-structured maker context could improve. While there was more work to be done to translate the theory into concrete formats such as sets of guidelines or suggested activities that would be of more direct interest to makers and maker leaders, my next step was to more formally justify the theory using literature and empirical studies by working towards answering this question:

> Do maker contexts that implement or embody the NTHCM contribute to the promise of democratization?

To answer this question, I would have to test this hypothesis:

> Making practices and mindsets that implement or embody the NTHCM result in democratization in ways that making practices and mindsets

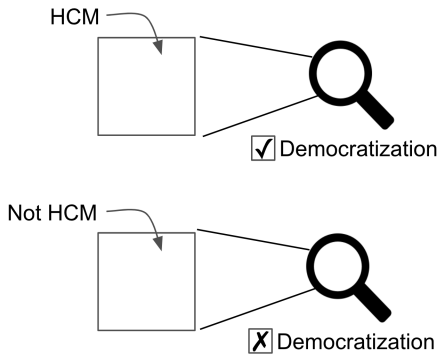


Figure 7.1: Illustration of the hypothesis about the evaluation of the NTHCM

within the current making phenomenon do not.

Figure 7.1 illustrates this hypothesis, showing that the NTHCM aims to lead to outcomes related to the promise of democratization that might not otherwise be achieved. While answering this question in full was out of scope, I worked towards it by exploring the relationship between HCM and a particular representation of democratization, feminist utopianism, in the context of Statement Making. I did not aim to determine whether the values of HCM in the context of Statement Making caused democratization to happen, but rather how the relationship between the values of HCM and the concept of democratization manifested and related to each other, generating hypotheses about the outcomes of the application of the NTHCM relative to the promise of democratization for future study.

In this chapter, I present a theoretical and empirical investigation aimed at understanding the relationship between the NTHCM and democratization. I first turned back to the literature to develop an updated and more complete definition of democratization and decided to use the concept of feminist utopianism. I then conducted a case study analysis with Statement Making, the digital fabrication fashion show I introduced in Chapter 4. In Chapter 4, I presented the results of an interview study with Statement Making participants that shed light on ways the 6 values of HCM manifested in this particular maker context and how the values relate to each

other. In this chapter, I perform additional analysis on the same set of interviews, this time looking for evidence of whether the context aligns with principles of feminist utopianism. Specifically, the analysis asks these questions:

- How did feminist utopianism manifest in Statement Making?
- Does the way feminist utopianism manifested in Statement Making relate to the way the values of HCM manifest in Statement Making?
- Does looking at Statement Making through the lens of feminist utopianism uncover different aspects of the HCM values or of Statement Making itself?

I answer the first question with a qualitative study that was very similar in nature to the study in Chapter 4: I conducted a thematic analysis of the interview data using a set of criteria for feminist utopianism as codes. I answer the second question by considering Statement Making as a design artifact through which I explore the relationship between two abstract concepts (HCM and feminist utopianism). While there is not necessarily a specific methodology in HCI for using a design or an artifact to investigate the way two different theoretical constructs might relate to each other, designed artifacts are often considered by HCI researchers as embodying theories and are used as probes through which to reflect on abstract ideas [43, 192]. The way I use Statement Making to investigate possible relations between HCM and the principles of feminist utopianism is in line with these ideas (Figure 7.2). This study sheds light on places where feminist utopianism overlaps with the values of HCM and places where these two ideas shed light on different aspects of the data.

Ultimately, this analysis sheds light on some of the shortcomings of the NTHCM and caused some of the intended outcomes of the normative theory project to shift. The analysis shows aspects of democratization that the NTHCM misses and the merits of feminist utopianism in and of itself as a guiding theory towards democratization. This realization forms the basis of Chapter 8, where one of the primary contributions

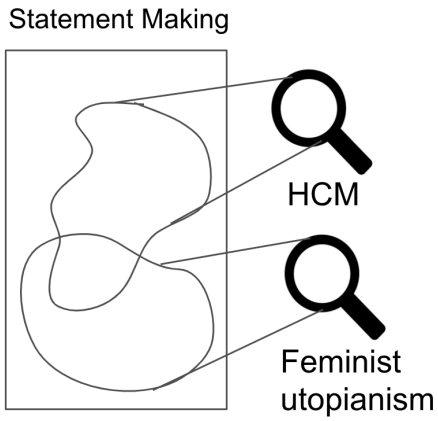


Figure 7.2: Approach for using Statement Making to understand the relationship between HCM and feminist utopianism

of the dissertation is a discussion of the NTHCM and feminist utopianism as fellow travelers and a comparison of the underlying assumptions of each.

The rest of this current chapter outlines the process of how I came across the idea of feminist utopianism while searching for an updated definition of democratization, what it means, and how it is an appropriate construct to use for democratization in the making phenomenon. I then present an empirical study using feminist utopianism as a lens to understand the context of Statement Making and to understand HCM.

7.1 Theories of Democratization and Democracy

In this section I summarize some of the theories and definitions of democratization and democracy from academic communities outside of HCI that I encountered as I was searching for an updated definition to use to evaluate the NTHCM. Some of these are mentioned in HCI literature as well. My goal during this literature review was to find a theory or framework of democratization. The criteria derived in Chapter 3 were sufficient as an initial definition upon which to construct the theory since they address some of the known shortcomings of the making phenomenon. They represent an attempt to bring sociotechnical considerations into the pursuit of democratization in the making phenomenon as opposed to the primarily material aspects HCI research

has focused on in the past [163]. However, they do not represent a complete view of democratization, nor are they heavily informed by theory outside of HCI research.

My next step was to more fully understand the social aspect of democratization of technology production and use this new framework of democratization to more holistically evaluate the hallmarks and shortcomings of the NTHCM through a round of deeper theoretical and empirical investigations. The definition or framework for democracy or democratization would need to relate to making in a clear way, so I primarily focused on literature that was already discussing technology in some way. For example, Nelimarkka performed a literature review in HCI research on how participation is configured in democratic decision-making processes [142]. The primary dimension that guides their summary distinguishes between representative, referendum, and assembly democracy, which represent different ways decisions are made based on the will of the people. This, however, is an example of a framework that is not directly helpful in an obvious way in the making phenomenon since democratization in making is not necessarily about conscious decision making, but rather about access to certain capabilities. In this section, I thus discuss a few different accounts of democracy and democratization, along with a discussion about why it is difficult to draw on these theories directly in relation to the NTHCM or in design and making more generally, and how I ultimately settled on feminist utopianism. I did not intend to conduct a comprehensive literature review, I only intended to review the literature until I found a satisfactory construct. The account described below justifies the frameworks I considered and the decisions made as I considered them.

I encountered some ideas that were not necessarily complete theories of democracy, but that captured some of the challenges of democratization and resonated with aspects of the making phenomenon. In general, these fragments support the idea that more political accounts of democracy would be relevant to the making phenomenon since some of the issues are similar. For example, the self-interest assumption wonders

if individuals are actually capable of acting not only in their self interest [47, 130]. Similarly, some wonder what the role of citizens in a democratic society should be and point out how some citizens will likely always be slightly unaware of their place [47, 46]. They point out the danger of uninformed participants, proposing that citizens should be the ones who choose the end and experts or elected officials should be the ones to implement it. Interestingly, this is almost the opposite of how I had been conceiving of democratization in the making phenomenon- makerspaces give the power of implementation to the individuals and I had felt it was my role as a leader to figure out how to "choose the aims" of enabling such endeavors. It would be worth looking into these ideas further to see how they manifest and how they are addressed in practice. I, however, was searching for a breadth of ideas before adopting one to understand deeper, so I moved on to other literature.

Libertarianism is a view on democracy that has recently resurged in US culture. Libertarianism focuses on the rights and free will of individuals, resisting any sort of control that infringes directly on individuals [29]. Libertarianism accurately captures many makerspaces in the current maker phenomenon that focus on the individual with few rules or impositions. Toombs et al. report how members of a hackerspace exhibit libertarian values, but they need to negotiate those values with other values such as taking care of each other, which makes the manifestation of libertarianism in making complex [181]. While libertarianism is generally embraced by some, it also raises concerns. Anderson discusses how libertarianism equates freedom with the ability to do whatever one would like, but has a naïeve understanding of the social conditions that are necessary for such freedom to happen in the first place [12]. Overall, libertarianism is neither an ideal to strive for, nor is it sufficient for capturing the social aspects that are needed for the making phenomenon to even function, let alone take into account the impact of their endeavors or of the making phenomenon as a whole.

Ideas related to deliberation and the public sphere are sometimes used in HCI literature as frameworks to analyze discourse [18, 143], so I decided to look more into the theories behind these endeavors as they relate to computer technology.

Ess summarizes a framework of three definitions of democratization by Abramson et al. [8]. The first is *plebiscite*, where "individual autonomy" is emphasized and democratic participation primarily happens in the form of individuals voting directly in matters of public affair. One problem with plebiscite democracy is that it runs the risk of becoming majoritarian, run only by the majority opinion, where there is potential for the majority to "trample the rights of minorities" [63]. Abramson et al.'s second definition is *communitarian*, where the common good is emphasized over individuals. The danger with communitarian democracies is that one community might be able to put their needs above another community's. The third type is *pluralist*, which emphasizes groups' equal ability to compete and oppose other groups in a "market game" of power. Abramson et al. claim that pluralist combined with communitarian can mitigate many of the problems with both [8, 76]. This idea resonates with the individualistic and collective values that are part of the definition of HCM, where plebiscite embodies individualistic values and communitarian embodies collective values. The findings of the interview study with Statement Making participants (Chapter 4) suggested that a balance between the alternate sets of values is best, which is perhaps supported by Abramson's notion of pluralist democracy.

While there have been critiques as early as 1996 that computers were not going to fulfill their promise of democracy, Ess goes on to discuss how Habermas' ideas rescue the promise [76, 92]. Habermas combines communitarian and pluralist democracy and focuses on discourse, arguing that during discourse and dialogue within and between groups is where consensus arises. As long as certain "rules of reason" hold such as requiring that everyone gets a chance to speak, a chance to voice responses to others, and there is a general openness to argument, then through these dialogues, consensus

can be pursued and democracy can be achieved. This also allows a better meeting between theory and praxis since theoretical and utopic ideas can be negotiated with local concerns through the praxis of dialogue. Even Habermas' theoretical ideas themselves can iterate through the praxis of dialogue, making them less susceptible to the theory-praxis critique. Habermas also talks about the public sphere, which is a place where this discourse happens. Public officials are part of the sphere as well as individuals, so it is an important mechanism through which opinions can turn into action [76, 32]. The public sphere is a contested topic in studies of democracy, with questions such as whether there is one public sphere or multiple public spheres for different matters of concern and how exactly the sphere influences society [49]. Publics can also mean "shared culture, knowledge, or discourse that brings people together, often in collective action" [23, 173].

If I were to move forward with these ideas, my research question would become: "Do maker contexts that implement or embody the NTHCM contribute to the formation of publics or discourse and deliberation in the public sphere?" I would need to eventually (either through empirical methods or by theorizing) understand what the deliberation is about- what are the decisions makers make or would make? In the ideal scenario, do we expect makers to deliberate about the impact they would like the making phenomenon to have on the world? Deliberate about the things they make individually or collectively? Deliberate about the desired essence of maker culture? If making is about democratization of technology production, then what are the decisions that go along with that democratization? These seemed like strange questions to ask and even stranger for me to try to answer. There was no obvious way to fit such formal notions of democracy into the power relations, decisions, or conversations that are prominent in the making phenomenon without additional theorizing.

This new question about whether maker contexts lead to the formation of publics or deliberation is also very similar to one of the criteria for democratization I derived

in Chapter 3, NC2 (social progress), which asks about whether there is room for groups to form around matters of concern. Focusing on this new question as the primary indicator of how well the NTHCM measures against the a holistic definition of democratization would capture this aspect well, but would not necessarily capture the other criteria for democratization such as risk mitigation or access.

Publics are also mentioned often in HCI research or relative to design [62, 110, 119]. While Habermas was focused on the public sphere as more of a singular entity, publics are pluralistic. Many form for different reasons, and they do not exist beforehand. Dewey has many writings on democracy, one of which emphasizes the importance of education, not as a way to communicate specific ideas to students, but rather as a model of how a democratic society operates and allows students to practice participating in a similar environment [59]. Democracy is not only about governance, but rather a way of life. Dewey discusses how past theories of education are either completely individualistic, serving the uniqueness of the individual, while others were completely in favor of the common good, where educating students is done in the interest of the military or other aspects of society [59]. Dewey's view of education falls in the middle, where an individualistic approach to education strengthens the collective since "the emancipated individual was to become the organ and agent of a comprehensive and progressive society." [59]. These ideas relate to making and are in line with many of the foundational principles of the NTHCM. Dewey's views move away from governance and decision making directly, which makes them easier to apply to the making phenomenon. Like educational environments, perhaps makerspaces could be places where individuals practice how to behave in a democratic society. The relationship between the individualistic and collective also resonates with the findings from the interviews I conducted with the Statement Making participants. Specifically, I noticed how HCM lives in the relationship between the context and the participants and Statement Making is an example of how a certain individualistic

focus can strengthen the collective impact of the context. These resonances suggest Dewey's notions of democracy as reasonable to understand more deeply and use as an evaluative measure for the NTHCM.

Dewey also offers a criteria for such an environment: "How numerous and varied are the interests which are consciously shared? How full and free is the interplay with other forms of association?" [59] Striving for the fulfillment of this criteria involves a multitude of groups with different interests engaging with and appreciating each other's points of view. This would certainly be a reasonable concept to measure the NTHCM against by asking "Do contexts that align with the NTHCM have more varied interests and more interplay with other forms of association than contexts that do not align with the NTHCM?" However, this question is very abstract and I would need to study many different contexts to understand the forms of association that are possible and identify all the implicit and explicit interests that should be considered. Future work might consider this as a starting point, but determining the concrete measures and indicators was out of scope of my project. Additionally, I soon encountered feminist utopianism, which is built on some of Dewey's ideas and subsumes these questions.

7.2 Feminist Utopianism

I came across the topic of feminist utopianism as I was investigating HCI literature on concepts that are adjacent to democratization and empowerment such as participatory design [20] and found that it would be a suitable concept to use for the evaluation of the NTHCM.

7.2.1 Definition

Typical utopian thinking has been criticized as being a "fantasy" that lacks any connection to the present, as valuing "totalizing" and inflexible ideas that could very easily go horribly wrong, and as not allowing the public to participate in ideating

the vision [20].[1] Feminist utopianism is an alternative discussed by philosophers including Johnson, Benhabib, McKenna, and Levitas that addresses some of these critiques [20, 26, 111, 121, 134]. The defining feature of feminist utopianism is a process model of utopia where multiple possible futures are emerging as the result of lived experiences, rather than an end state model that involves an individual thinking about an abstract representation of a single static possible future [134]. In the process model, the utopia is not the end result, but rather the way in which the futures emerge, or the path along which multiple possible futures are in progress. Better futures are possible, but they are "un-representable", meaning it is not possible to describe them ahead of time [20].

Bardzell introduces feminist utopianism to the HCI community, presenting a strong argument for its merits, particularly as a fellow traveler to Participatory Design (PD) [20]. Some of the shortcomings of Participatory Design are the difficulties in scaling beyond local experiments and the fact that PD endeavors still involve a designer configuring the participation. Feminist utopianism addresses both of these by offering a perspective on how similar ideas might manifest at a community-wide or society-wide level [20]. Hope et al. discuss how their iterative process of creating spaces to re-imagine breastfeeding-related products, services, and policies relates to both the ideas of feminist utopianism and Participatory Design [102].

I use the following six criteria throughout this chapter to capture the main aspects of feminist utopianism. The first five criteria were taken directly from McKenna, who presents them as a way to understand a context in terms of the process model of feminist utopianism [134]. Contexts that embody these criteria are in line with the feminist utopian ideas that value a participatory emergent pursuit of a better undefined future rather than abstract totalizing narratives that are removed from the current reality. I added the sixth criteria ourselves to capture the utopian aspect of

[1]Some passages in this section have been quoted verbatim from my published work [151].

feminist utopianism, rather than just the process-model aspect.

All Participate Freely: Promote free and open participation by all people in the society

Making Informed Choices: Lead people to recognize the limits and possibilities of any particular situation and propose realistic choices for action.

Flexible Ideas: Encourage people to avoid making dogmatic claims and to remain open to change.

Flexible Futures: Encourage people not to focus on achieving some end, but on developing abilities for multiple ends to be realistically possible

Interconnectedness: Open up possibilities and promote an awareness of our interconnectedness and diversity.

Pursue Better: Actively pursue radically better versions of the future.

7.2.2 Justification

This concept of feminist utopianism and these criteria in particular satisfied some of the questions I faced as I was reading about different definitions of democratization and democracy. It was much clearer how feminist utopianism could apply to the making phenomenon- I did not feel required to answer questions such as what should the topics of deliberation be about since the idea behind the process model of feminist utopianism is that a range of possibilities emerge and unfold over time, only as a result of participation and lived experience, not as the result of abstract thinking. This meant that aspects of democracy such as deliberation could still be a goal, but I did not need a concrete idea of what the deliberation would be about or where it was headed. The feminist utopia criteria also resonated with our early ideas that we would define the purpose of the makerspace based on what we saw emerging,

but helped us think more specifically about the conditions under which this would happen. If these criteria were evident in our makerspace, perhaps the context would be primed for a better-defined and fulfillable promise to emerge. McKenna's criteria are built on Dewey's ideas of community and democracy, which are also in line with the process-model [59, 60, 134].

Feminist utopianism also relates to, and perhaps subsumes, the initial criteria for democratization I presented in Chapter 3 and used to derive the definition of the NTHCM. The first criteria for democratization, NC1-a (access), based on Tanenbaum et al.'s definition of democratized technological practice [174], states that there must be room for pleasure, utility, and expression, not just one of these aspects, which is in line with the "all participate freely" criteria. NC2-b (access), which emphasizes the psychological component of knowing what options are available, is in line with the feminist utopia criteria of "making informed choices", which involves knowing the limits and possibilities of a given situation. NC3 (social progress), states that there must be opportunities for groups to form around matters of concern and for there to be opportunities for social progress. Feminist utopianism by definition commits to social progress, but does not define what kind of social progress or what that looks like. The path-based model, the flexible consideration of multiple better possible futures, and the general commitment to something better, mean feminist utopianism has a primary commitment to social progress even without a definition of what that is. Lastly, feminist utopianism has mechanisms in place for risk management (NC3 risk mitigation) since it assumes that a perfect static society is not possible. The "making informed choices", and "flexible ideas" criteria embed a self-healing mechanism of sorts for any problems that might arise since the presence of these aspects mean members of the community are reflecting on the limit to which endeavors actually have the desired impact on others or on any environment they are situated within.

For these reasons, feminist utopianism is an appropriate construct to use to evaluate

the NTHCM. The research question becomes "Do maker contexts that implement or embody the NTHCM contribute to the presence of indicators of feminist utopianism?"

7.3 Feminist Utopia and Statement Making

As a step towards understanding the relationship between feminist utopianism and the values of HCM, I first conducted an empirical study to see how a maker context could align with principles of feminist utopianism.[2]

7.3.1 Methodology

For this study, I conducted an additional analysis of the interview data I collected and reported on for the study in Chapter 4. As a reminder, that was a semi-structured interview study where I recruited participants who were involved in any of the past instances of Statement Making. The interviews were semi-structured, aiming to understand motivations for participating, how participants described their participation, and how they perceived the event as a whole. Question prompts included, "What did you make?", "What was your motivation for participating?", "What is Statement Making?", and "What were some memorable aspects of the experience?". The interviews were audio recorded and transcribed manually by the researchers, omitting names mentioned by participants.

I performed thematic coding on the transcribed interviews. The first pass of analysis used the six feminist utopia criteria introduced above as codes. The fidelity of analysis was by topic, so several sentences could belong to the same unit of analysis or a given response to a question could be broken into several units of analysis based on how many topics were expressed. A quote could have one or several codes assigned to it. The second level of analysis looked separately at each feminist utopia criteria and used an iterative open-coding technique to find emerging themes to characterize the ways each criteria manifested.

[2]Some passages in this section have been quoted verbatim from my published work [151].

7.3.2 Results

7.3.2.1 All Participate Freely

Many participants (P2, P4, P5, P7, P13, P14, P16) perceived Statement Making as open and accepting of all sorts of disciplines, types of garments, perspectives, and people. P5 found that Statement Making was "a space that allows people to not only be themselves, but to be the loudest and brightest version of themselves". Even P14, who "was able to ignore" the prompt to "make a statement" for two out of three years of participation and P16, who felt the show was more "political" than anything they were interested in pursuing, did not feel like they were being constrained or forced to approach or think about their participation in a certain way. P16, who was originally invited to view the show by some architecture friends, was expecting a more architectural perspective throughout. When realizing there were many other aspects, they reported, "Initially I thought it was kind of odd. But then after being in it, I kind of liked that idea because it didn't limit me to what I could create. It was just whatever I wanted, I could. So I wasn't limited to having just one type of idea which I really liked." P1 and P16 mentioned how Statement Making provided an opportunity for them to pursue certain making endeavors that they had been thinking about for some time.

There is certainly room for Statement Making to be even more free and open for participation. P4 reported that before they were involved, they perceived the community to be rather "niche". Several participants also suggested that Statement Making could reach an even broader audience (P1, P4, P7, P8, P16).

Other than the designers participating in the event, other forms of participation included collaborations with the model and garments that prompted or sparked conversations with the audience. P13's primary goal was to get people to come talk to them after the show: "I was definitely going for as big of an impact as possible so people would come and ask us and get more insight on that current situation." P1

and P5 talked about how their models participated as collaborators. P1 said that their model "was kind of just there to learn about the process. We were all figuring it out too as we went ... I think we were all just kind of brainstorming together equally". P1 exhibited a sense of camaraderie with their model, figuring the process out together. However, they also describe their model as being "just kind of there", which perhaps indicates that the model's participation was not as full as possible.

There were also several examples of participation beyond Statement Making that were prompted or discussed. P5 commented on how their model now seems generally more confident and willing to "talk about things that are important to her". P4 recognized an internal shift that made them feel more aligned with the identity of creator, rather than consumer of technology. P13's garment centered around the topic of immigration. Rather than simply aiming to educate the audience, P13 interviewed acquaintances who had been impacted to understand their stories and perspective. P12 reported that Statement Making allowed them to participate more deeply with computing than they typically had in their classes.

The main takeaways regarding participation are that designers felt unconstrained in what they were able to contribute and the event prompted some of them to do things they had been thinking about. The designers were not the only ones who benefited from free and open participation; there was meaningful participation amongst the models, the audience, and other people in the designers' lives, all of which was initiated by the designers themselves. While there is room for Statement Making to grow in terms of broadening participation, there is evidence that it is ripe with opportunity for the depth and breadth of participation that feminist utopianism calls for.

7.3.2.2 Making Informed Choices

Several participants discussed factors that they considered as they made choices relative to the specific garment they were creating for the show. P1 discussed how aspects of the model's personality and preferences were the basis of the design: "when

we were initially designing or coming up with the general look of what it was going to be, she was involved in that. Cause you know I didn't want to like go crazy and do something she had no interest in or didn't identify with at all because we wanted it to be something she could feel cool or confident wearing". P2 and P12 took into account what it would be like to wear the piece. P2, in particular, took an experimental approach in fitting the technology to the body: "... I love getting through that process, finding out what works, what doesn't. For instance, the waistline ... it's very non local, it doesn't move as much. But when you sit down, when you lean on something, you hug somebody or you do any kind of extreme dancing, that line isn't straight anymore, it's very wavy, it's very all over the place. So it's a learning process." P8 and P14 mentioned taking the audience's perception into account as they were ideating their piece, noting how difficult it is to know whether they will perceive the intended meaning. P8, for example said, "If you are making it and you have the idea in your head you think oh this is readily apparent. This is how I'm thinking about it so this is how its coming out. And then people will be like I didn't get that at all. So it's like a challenge of being something that's not just consumable but easily understood, not just hidden behind seventeen layers of thought and weird connections. If you relate something to something else but that's just you, an audience isn't going to get that." All these choices participants were making were informed by other people.

Several participants discussed their garments (P7, P8, P12, P15) or Statement Making itself (P5, P8, P12) as a way of informing others about specific topics such as the waste associated with the clothing industry or to prompt them to think about their own usage of social media. Interestingly, none of the participants described their garments as "solving" problems, even if they were related to real-world problems. Some specifically realized the limitations of what they made. P8, whose garment was about water waste in the clothing industry, said, "we are sustainable in our ideas but

not our execution". P5 and P15 realized that the ideas behind their project may become clear during conversations, but the garment likely did not speak for itself to carry the message to the audience. P15 also realized the complexity of designing technology that influences human behavior: "we had to make sure that we involved the glove which was human centered. And it's not like we created a robot that would tell you - you've been on blah blah blah. [Rather], you put on the clothes and you're now enveloped in the technology." In other words, P15 created a glove that naturally "envelopes" the user to guide toward new behavior instead of a brute force approach that tells them to change their behavior explicitly. There seems to be a good balance between having a forward-thinking and optimistic perception of their projects and realizing the limits of the outcomes they are able to achieve, which is a healthy alternative to the technosolutionism that is one of the central critiques of the making phenomenon.

Statement Making was also seen as a way to help participants realize what resources they have access to or realize their own agency for doing something meaningful (P5, P7, P8). P7 said, "making a statement, just like on the front of the line, not the back. You become a leader. You be like 'oh yeah, maybe that person who I've always known that wasn't really much and can do something that big, maybe I can do the same thing."' This is important because some of the barriers associated with makerspaces are that potential participants do not know what is possible. One of Schneider's definitions of empowerment includes the psychological component of knowing what is possible and having a sense of agency to develop the skills to accomplish it [169].

P4 and P12 discussed limitations and possibilities of technology more broadly. Both P4 and P12 participated in a design studio course that explored the broad impact of technology on society explicitly, but they both also associated these ideas with Statement Making itself. P12 reported now thinking about "a lot of questions as in like what are we going to do about certain things... we depend so much on technology

for so many things and its troubling to think about the what ifs. And now that's really in my head after doing all this. And I think that's good. Because I think I'm becoming more thoughtful about what I'm doing and what's happening but it is interesting because I never really thought about it too much before." P4 also pointed out how the prompt was much more vague than anything they had responded to before, which required a different type of thinking, saying "It kind of teaches you to think outside the box when it comes to designing with technology. Because when I started the class, I just thought like designing - designing the computer. But there are so many things that you can do differently to kind of like solve a problem that you've never thought of." P12 and P13 also expressed some general thoughts on the limits and possibilities of the future of technology, which may have been prompted by Statement Making or may have been thoughts they had anyway. Both discussed the fine line between technology that has a positive impact and a negative impact: "if you take a kitchen knife and start swinging it around, it looks very scary. But if you see someone cooking with it, you're going to be hopeful that it's going to taste good, so I think it's kind of in the same vein. I think there's a lot of things once you start getting technology into it, it's really cool. Like I mentioned before, my grandmother has Alzheimer's. It would be really cool to have some sort of chip on her so every time she ran away, I know exactly where she is. But then think about me being twenty one and having that exact same chip on me, is now a more terrifying concept" (P13). P13 also thought that one of the best ways for people to navigate this technology-heavy world is to be equipped with knowledge about how the technology operates in order to make the best decisions. P4 commented on how these realizations such as "are we really that like blinded by social media, by the technology that we have" prompt "reflections on yourself as a designer".

These are all important concepts to be in the consciousness of the making phenomenon since makers may be the ones creating the types of technologies that the

participants were discussing the positive and negative implications of. Statement Making may have prompted these conversations, or was at least a context around which these conversations could happen. The next steps related to this aspect of feminist utopianism would be to extend these conversations to think about how these insights about the future should inform current choices.

7.3.2.3 Flexible Ideas

There was evidence of participants changing their minds about something as well as evidence of how they associated Statement Making with the possibility for multiple interpretations. When asked what Statement Making was about or what it meant, there was no single answer and some participants pointed out how it left room for interpretation. For example, P5 said "there is no specific guidance. It's not make a political statement or make an environmental statement. We interpreted that as this is who I am this is the cross section of my reality. Other people interpret that as we are going to make a statement about the environment. Or a statement about resources or abortion rights or what have you."

Some participants expressed flexibility in their making process (P1, P2) or in the ideas they associated with their project (P1, P2, P14, P15). P1 and P14 both participated multiple years, and both changed from a more technology-based focus to a more meaning-based focus throughout their participation. P14 reported being "really happy" they took a different approach "because it gave me a whole other perception on something that I thought I understood previously." P15 looked back at the piece they created and pointed out ways they "kind of disagree with the statement" they made. If this was a hackathon or a competition-based format, participants would have to stand by their products or sell them to the judges whether or not they really believed in them. Statement Making provided room for this more balanced perspective.

Statement Making prompted some participants to consider changing their own behavior or prompted them to consider alternate perceptions of technology. P12 said

that they "actually looked at my phone, which can track your screen time. And I looked at mine and it was ridiculous how much time I spend on social media. And I don't actually think I spend that much time, but when you look at the hours that you are spending a day, even if you're just opening it for five minutes ten minutes and closing it, it's crazy how much time you spend. And it really made me think that I need to take my own advice and listen to my own statement and cut back on some." P14, whose garment made a statement about toxic masculinity, reflected on their relationships with men and emotions, saying how one of their pieces "made me think about my involvement with toxic masculinity and the people I know and just being able to share emotions and how people I know that don't do that and how it's affected me. I don't know what question pops in my head, but it certainly got things spinning." P4 and P12 commented on technology in the world, questioning the pervasiveness of social media and other technologies, and wondering if there are other ways things could be. Specifically, P12 wondered, "what are we going to do about certain things like that are - we depend so much on technology for so many things and its troubling to think about the what ifs" and P4 said that they "had some kind of existential crisis. I was like, are we really that like blinded by social media, by the technology that we have. So it does bring you back ... reflections on yourself as a designer."

7.3.2.4 Flexible Futures

P5, P7, P8, P14, and P16 explicitly discussed Statement Making as an opportunity for learning. P16 wanted to learn parametric design to later apply to processes in architecture. P5 reported that Statement Making "gave me a lot of the communication skills necessary to be a better user-based designer". P14 participated for the purpose of general broadening of skills: "when I make things, I like to make things a little out of my element. If no one stopped me, I would be writing software until the end of time. Opportunities that allow me to branch out and work with fabric, which is

something I've never worked with before, work with fashion, get at least an experience to talk to a lot of artists and what their experience with the makerspace movement was. And just being able to branch out and not constantly write software for every single creative thing I do." These types of learning endeavors are in line with the feminist utopian criteria for flexible futures because they show a desire to hone a broad set of skills for various purposes.

There were other ways participants showed flexibility during their Statement Making endeavor and were not set on achieving one particular thing. Several participants did not know what they were going to make when they started, but let various factors influence their ideas (P1, P5, P12, P4, P14). P1 and P5 both let the model's ideas and preferences drive the process. P5 said how their process"was mostly centered around - you're our model, we want you to be comfortable, we don't want you to have to think about the way you use it" and P1 similarly focused on making something "more tailored to [the model's] identity". P14 had an idea for the technology they would use (computer vision), but was open to applying it in various ways and ultimately made a statement about toxic masculinity. All these participants were also working in collaborative groups while they were designing, which may have influenced the flexible outcomes they were open to.

P2, P12, and P16 all reported other types of flexibility in their making process, particularly in response to learning about constraints embedded within the tools and materials. For example, P2 went through a "trial and error experimentation process" to fit the LEDs to a jacket. When asked what strategy they would use if they participated again, P12 said "probably just tinkering with it like we did in our class". While this sort of material experimentation is not unique to Statement Making, the fact that it was there alongside the more refined idea-driven endeavors shows that Statement Making is still a maker event. It is important relative to feminist utopianism because it shows an appreciation for the explorability of materials and

discovery based on emergent properties.

There was also evidence of participants thinking about the different possibilities for the future of technology (P1, P4, P12, P13, P15, P16). Some of them were asking themselves "what if" questions about the possibilities and others saw Statement Making as exploring some of those "what ifs". P15 said "I think all the statements are like ok - here we are now. This is where we will end up in the future, whether that's good or bad. Or this is how we can end up, this might be better for the future". P1 thought of Statement Making as similar to Black Mirror, a show that tells technology-centric stories in various dystopian near-future worlds. Similar to Black Mirror, they saw Statement Making as exploring "how do people interact with clothing, how do they interact with the world? How do the things we wear have to say about that? ... Do computers have a role to play in wearables?" This flexible mindset towards the future of technology is in line with feminist utopianism because it involves simultaneously considering multiple possible futures and thinking carefully about what they each mean.

Some participants also discussed their own relationship to the emerging future of technology or what an individual's relationship to that future could be (P2, P8, P12). Their ideas were in line with feminist utopianism in that they saw themselves as situated amongst many other people and were aware of the ambiguities or uncertainty of trying to steer things a certain way. For example, P12 and P8 both tackled complex problems (addiction to social media and waste created by the clothing industry) not in terms of a technological solution, but rather in terms of aiming to inform or educate people about the topic. P12 did not think that one person could alter the course of trends in technology, but could "start a movement" by getting people to think and then they start conversations with others and the ideas spread. P2 discussed their project in terms of being the starting point for an "elevated" culture of light-up clothing. P2 talked about how everyone adds their own energies to the jacket they

made and how some of the terminology associated with Statement Making "gets me thinking before I even know what it is". Overall, this shows a way of thinking about and working towards a different future, but without a clear definition of what it will look like.

7.3.2.5 Interconnectedness

Many of the ways participants commented on interconnectedness and diversity had to do with ways in which Statement Making showcased different viewpoints or perspectives next to each other, or how Statement Making drew attention to interconnections that would otherwise be unnoticed. Several participants pointed out how there were many different approaches or interpretations on the same stage (P1, P7, P12, P13, P14, P16). They all valued this diversity for reasons such as expanding their own viewpoints or seeing what else is possible. P16 initially "thought it was kind of odd" and "wasn't sure what direction it was supposed to be in" but later appreciated it for the purpose of understanding perspectives beyond the ones you might typically encounter. P12, P13, and P14 also commented on how there were similarities across the differences, such as how this was a "group of people that are all doing the same thing but in such different ways" (P14) or how despite there being a split between pieces "that were making a statement and ones that were technical", they also "feel like there were some pieces that kind of meshed together and kept it coherent" (P13).

Some of the specific connections participants noticed were between different disciplines (P8, P13, P14, P15). P15 "learned there is a group of computer science - I wouldn't call it a subset of CS, but there's a mix between UX, UI, computer science, and humanitarianism. Didn't know that was ever a thing. I feel kind of dumb now, not thinking that way. But I didn't think that you could mix computer science and art." P14 appreciated how Statement Making provided an "opportunity to break the silo and communicate with other people and talk to other people who have

very different ways of thinking... just not getting into the group think mentality." Other than disciplinary differences, participants observed that differing viewpoints were supported (P4, P5, P13). P5 said that Statement Making "opened up a lot of conversations that I think in a lot of spaces wouldn't have been as cordial and as civil" and P13 noticed how "there wasn't any arguing despite some of the more loaded pieces, I suppose. It was all supported whether or not that person agreed with any of it." Some of the pieces aimed to shed light on marginalized experiences (P5), such as the cultural heritage of the model or what it is like to wear a prosthetic (P1), and some participants shared ways they learned about experiences related to topics such as immigration, autism, or culture (P13, P6, P5). Similarly, there was evidence of participants trying to understand what others were saying or doing, and generally associated Statement Making as a context based on working towards mutual understanding (P15, P16). P2, P4, and P8 all expressed appreciation for the teams they had worked with and for teamwork in general. P13 felt a general connection to the other participants in the form of an "energy" they felt at all the events leading up to the show.

Another type of interconnectedness has to do with situatedness, considering the larger context in which a particular artifact, making endeavor, or event exists. P5 said, "I felt like I was part of something bigger than myself". P4 looked at the show like "taking one piece of the puzzle or a string and then you keep pulling. As I was watching the show being presented, it was just like pull one after another and Statement Making as a whole, there is so much to it", showing they were trying to figure out what the larger context means. P4 considered their own piece as situated in that context as well: "as a designer, from building our prototype, seeing all the little work that goes into it, but then putting it onto the stage, it's really insightful. It's like being able to see that my prototype ties into something". P1 thought that the current events of the time influenced the participants: "you know it's a political time.

People want to make statements. People have strong opinions about things that are going on... Maybe if it was twenty years ago, we'd just say 'make a cool thing"'.

7.3.2.6 Active Pursuit of Radically Better Future

While many of the participants were pursuing an agenda of some sort throughout their participation, there were a few comments in particular that expressed a desire for a radically better future or a broader sense of possible change. Some of these mentioned specific ways that the general or local computing culture could change for the better (P4, P5, P14). P4 discussed feeling "pigeonholed" as a software developer and appreciated how Statement Making challenges this way of thinking: "with Statement Making, it is really grand, but I feel like it will push our department to motivate our students to kind of think as innovators. And not just people who code day in and day out." P5 pointed out how in the local computing scene, "we all like to pretend that we are super diverse and very progressive, but in reality that's not really true," and how Statement Making drives actual change in that direction. P2 spoke in more abstract terms about the future: "I consider myself a forerunner or just a person who is there before I'm even there. My ideas kind of shift into the future and I'm like hey - this. This is important, this matters." They also spoke of how one person's actions can spark others to join in and add their own ideas. When asked whether these ideas relate to Statement Making, they said that this is "everything about Statement Making". All these desires for a better future are in line with feminist utopianism in that they are forward thinking, but not in a specific or pre-determined way.

7.3.3 Takeaways

I reflect here on the extent to which Statement Making aligned with the principles of feminist utopianism and the ways in which feminist utopianism manifested in the context of Statement Making.[3] Overall, there was evidence of free and open

[3]Some passages in this section have been quoted verbatim from my published work [151].

participation in the form of makers feeling like they could pursue any type of making endeavor they wanted, feeling like they could be their complete self, and feeling like they could express whatever they wanted. There was also free and open participation in the form of makers including others in their making process, such as collaborating with their model or incorporating stories from their friends and neighbors. There were several aspects makers drew upon to make informed choices and several aspects that helped them realize the limits and possibilities of the situation. Many of them drew upon input from their models, either as inspiration or as a constraint. There were also many conversations happening in and around Statement Making that served a similar purpose: some garments aimed to inform about specific topics such as water waste and some aimed to prompt reflection about where technology in general is headed. There was general flexibility in terms of how participants approached their projects, how they interpreted the prompt over time, how they viewed others' pieces, and how they perceived the event as a whole. This was related to the appreciation for interconnectedness and diversity that the show fostered. Participants noticed the wide range of differing view points present on a common stage and were able to find threads of coherence and commonalities. There was also evidence that Statement Making was perceived as forward-thinking, but was not aiming towards any particular future. Several participants expressed desires or instincts towards radically better versions of the future without having a concrete definition of what that looks like. Overall, these are all aspects that are in line with the feminist utopia criteria and help us understand what a feminist utopia-aligned context for making might look like.

There are certainly ways Statement Making could be more aligned with feminist utopianism. The directors of the event set criteria for inclusion and exclusion, which may have barred some from participation. Aspects of the event such as the emphasis on digital fabrication rather than all types of making and how potential participants needed to first see value in making a wearable garment for a show represent typical

maker norms that Statement Making does not fully depart from and that may have had an impact on who the event represents. As white women in Art and Computer Science, the directors embody a some characteristics that are underrepresented in typical maker culture as well as some characteristics that are over-represented. While there was a larger group of students helping and we tried to lead in a participatory way, this may still have had an impact on decisions that were made as well as how the event was perceived by students.

Based on this analysis, there was evidence that Statement Making aligned with principles of feminist utopianism to an extent that was non-trivial. Based on the analysis in Chapter 4, there was evidence that the values of HCM manifested in the mindsets and practices of Statement Making participants. My next question, discussed in the next section, was whether there was evidence of how these different concepts relate to each other in the context of Statement Making.

7.4 Feminist Utopia and HCM in Statement Making

At this point, I have discussed two separate analyses of one set of interviews with Statement Making participants: one that investigates how the values of HCM manifest in that context (described in Chapter 4), and the other that investigates how Statement Making aligns with feminist utopianism (described above). My next step was to understand the relationship between the values of Human-Centered Making and the principles of feminist utopianism to see if feminist utopianism could be used as an evaluative measure for the NTHCM or if making practices and mindsets that align with the NTHCM result in democratization, as defined by feminist utopianism.

To explore the relationship between the principles of feminist utopianism and the values of HCM as they manifested in Statement Making, I conducted an empirical investigation to further understand the quotes that I had coded with both feminist utopia principles and with HCM values.

7.4.1 Methodology

Because there is no specific methodology in HCI to using a design artifact to understand the relationship between two abstract ideas, I took an exploratory approach to this analysis that involved looking through the data and previous results multiple times to see where evidence of a relationship between HCM and feminist utopia might emerge. I discuss the insights I gathered from looking at the level of individual quotes.

7.4.2 Results

Since I had coded the interviews with Statement Making participants with both the values of HCM and with the principles of feminist utopianism, I looked at instances that were coded both with values of HCM and with feminist utopia criteria, similar to the way I had looked at instances of places where the values were co-coded in the first Statement Making study (Chapter 4).

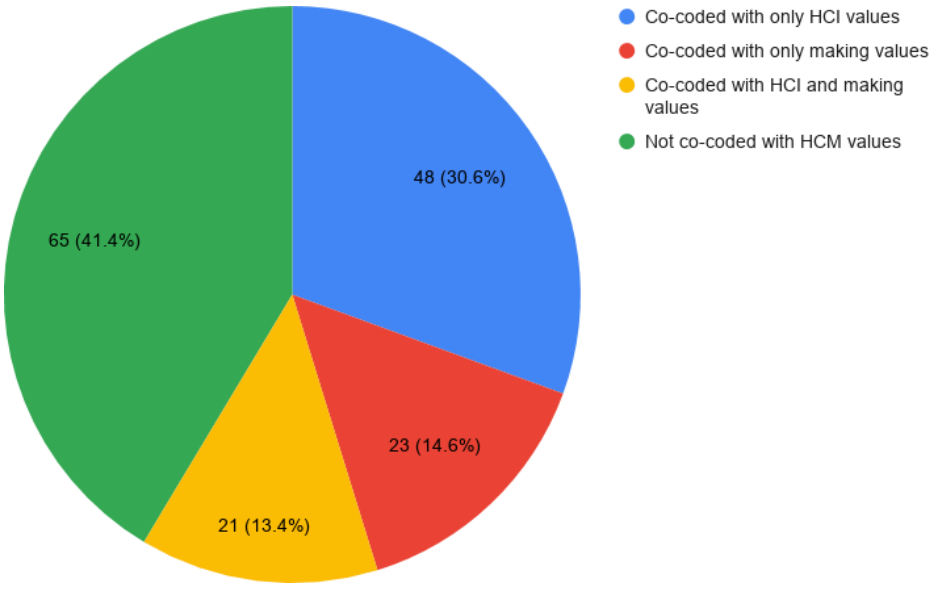


Figure 7.3: Quotes coded with feminist utopianism

A total of 157 quotes were coded with the principles of feminist utopianism (Figure 7.3). Of these, 48 were co-coded with values from the HCI side of the definition of

HCM, 23 were co-coded with values from the making side of the definition of HCM, 21 were co-coded with values from both sides of the definition of HCM, and 65 were not co-coded with any of the values of HCM. While this analysis is not intended to be quantitative, this provides context for the qualitative analysis.

Within each of the categories mentioned above, there were very few emergent patterns. For example, there were 18 quotes that were co-coded as representing interaction-based values and at least one of the feminist utopian criteria. Of these, 5 indicated the feminist utopian criteria of making informed choices, 1 indicated flexible ideas, 4 indicated flexible futures, and 8 indicated interconnectedness. Each of these categories has further distinctions based on the specifics of how the feminist utopian criteria and values manifested. As an example, I discuss the different ways instances of interconnectedness and interaction-based values manifested. Three of these quotes (P13, P13, P15) expressed how the participant's focus on the *interactions* between the garment and the model wearing it lead to reflections on the situatedness of the artifact, or how the context of the artifacts being worn on a body influences the *interconnections* they draw attention to. Three other quotes (P5, P16, P16) commented on the *interactions* and conversations the participant had with other participants as well as their appreciation for the *differing viewpoints*. One participant (P6) commented on how the *interactions* that one of the designs affords draw attention to *diversity*. One participant (P6) reflected on how their garment, which allows for communication between remote individuals through touch and haptic feedback, may have prompted onlookers to reflect on the abstract relationship between "interaction and connection".

I also grouped the 18 quotes that were coded with interaction-based values and at least one of the feminist utopian criteria based on what type of interaction was discussed. Within this set, there were 4 instances of participants discussing the interactions they had with their models (P1, P2, P5, P12). Two of these were co-coded with making informed choices (P1, P12), 1 was co-coded with flexible ideas (P2), and

1 was co-coded with flexible futures (P5). Specifically, P1 said "I drew a bunch of different sketches and paintings and we showed them to the whole team and to [the model] too and got everyone's feedback and that was our design process, just kind of like hey what do we think about this. Do we like this, I don't know. And then we picked it and modified it. It was more like a critique session, but it was cool." This shows the *interactions* the participant was having with their model *informed the choices* made while making the garment. P2 said "... but yeah I would love this for more people and put it on people because everybody has their own energies to it.. adds their own energy to it and like I said it goes back to that mission statement, step up stand out, if you feel confident in wearing something that's going to have everyone looking at you then you definitely have the mindset that you are ready to do that and be seen, dance, move elegantly or efluescently. Just really you know showcase it in your own way." This shows that the participant sees different people *interacting* with the garment as giving it different meaning, which is a way of having *flexible ideas*.

While these categories shed light on ways the values of HCM relate to the feminist utopia criteria in different circumstances, there are few instances of each type of relationship and few obvious higher level groupings or emergent patterns. Many of the quotes represent a completely unique relationship between HCM and the feminist utopia criteria or could only be grouped with 1 or 2 others. It is not surprising that there were not more emergent groupings due to the sheer number of codes used (6 values for HCM and 6 criteria for feminist utopianism) which means there are 36 different possible ways a value of HCM could be co-coded with a feminist utopia criteria, not even counting pairs of values or feminist utopia criteria. It could have been the case that each of the HCM values related primarily to one of the aspects of feminist utopianism, but this analysis shows that was not the case. This does not mean there is no relationship between HCM and feminist utopia in the context of Statement Making, it just means such a relationship is not evident at the level of

individual quotes. It is possible that the presence of HCM values influenced the extent to which feminist utopianism was present, but that participants did not express this relationship within a single quote.

I also investigated the 65 quotes that were coded with the feminist utopia criteria but none of the HCM values. I first reflected on each quote in relation to the definition of HCM to see if there were any relations to the previously discussed insights about how HCM manifested in Statement Making. 40 of the 65 quotes could have related to the values in some way, even though the values were not coded in the quotes directly. For example, P4 discussed the value of having a team that was composed of participants with different backgrounds, embodying the interconnectedness criteria. P4 did not mention the interactions between the team members, but appreciation for teamwork is related to an interaction-based mindset and P4 discussed interactions with the team in other quotes. For the other 25 of the 65 quotes, however, there was no apparent relation to any of the values based on my past understanding of how the values had manifested in other places. These instances of feminist utopianism became interesting to me because they seemed to capture aspects of democratization that the NTHCM would be unlikely to generate. I discuss some of the most common aspects here.

One of the aspects of Statement Making that feminist utopianism shed light on that HCM did not is consideration of the future itself. While the collective value in HCM sometimes manifested in thoughts about the future impact of technology, collective does not necessarily invite or prompt thoughts about the future and there was evidence of participants thinking about the future of technology in ways that was not necessarily collective (or aligned with the other values). For example, P12 listed some of the applications of digital fabrication they had not thought of before, such as agriculture, and how different that would be, as well as wondering what social media will be like. P15 said how "the statements are like ok– here we are now. This

is where we will end up in the future, whether that's good or bad. Or this is how we can end up, this might be better for the future," which does not relate directly to any of the values since P15 is talking about statements rather than garments. Explicit consideration of the future is certainly important for NC3 (risk), one of my original criteria for democratization, since accessing risk requires thinking about the future.

HCM does not draw attention to ideas, thinking, or reflection into focus, unless they are tied to an artifact, interaction, or one of the other values. The analysis with the feminist utopia criteria shed light on some important instances of ideas (P4, P5, P8, P12). P5 reflected on the different topics of conversation in the makerspace compared to those that were part of Statement Making. P12 appreciated the opportunity to reflect on the ideas of all the different participants. P4 said that Statement Making as a whole "makes you ask a lot of questions". P5 focused on the idea of sustainability in their project, and distinguished how "we were sustainable in our ideas but not our execution". P12 commented on the depth of thought that Statement Making afforded: "I got to really in depth think of an idea which I haven't really done much in CS". These quotes showed evidence of all the feminist utopia criteria, but particularly making informed choices and interconectedness. Ideas themselves are important for the NC2 (social progress) criteria. Morozov warns of the danger of assuming that technologies themselves will cause social progress [138]. While the artifact-based – interaction-based dimension brings the focus away from artifacts and towards how they are used, this does not fully invite or prompt consideration of the social aspects or the ideas themselves. The fact that feminist utopianism shed light on some of the ideas and reflections that the HCM did not raises concerns about whether the NTHCM would go far enough to promote social progress.

Similarly, some of the instances where the feminist utopian criteria did not relate to the values of HCM in an obvious way discussed aspects of the open-ended prompt and some of the subtleties or nuances of designing with such open expectations (P4, P5,

P12, P13, P14, P16). For example, P5 said that participating "... also taught me that design is much more open ended than I ever thought it would be. I thought it was more structured and it's just not, because human beings aren't." P12 and P13 talked about some of the trade-offs of pursuing emerging technologies, where "any time you have something that is super positive, you are always going to have some sort of backlash and people who are using it for the wrong reasons" (P12). These instances related to the feminist utopia criteria of making informed choices and flexible futures, since there was flexibility in what participation could look like and participants reflected on what their decisions to participate in a certain way looked like. P16, who was initially trying to figure out what direction the show was encouraging participants to take, "realized that it could literally be anything" and viewed that as a positive thing, which embodied the all participate freely criteria. All these instances are important for NC2 (social progress) as they allow participants to define what progress means without dictating a specific definition, similar to the previous point. They are also important for NC1-b (access), which is about making sure participants feel like there are possibilities and options. Statement Making achieved this without explicitly enumerating those options and did so in a way that could not be explained by the values of HCM.

7.4.3 Takeaways

My goal for this analysis was to understand the relationship between HCM and feminist utopianism, which I used as a definition of democratization, as they manifested in the context of Statement Making. It aimed to generate hypotheses that would guide future studies that use feminist utopianism more formally as an evaluative measure for the NTHCM. I found ample evidence of ways Statement Making embodied the principles of feminist utopianism. However, the analysis that aimed to understand the relationship between feminist utopianism and HCM shed light on some of the shortcomings of HCM. Rather than hypotheses about how the presence

of HCM might lead to the presence of feminist utopianism, this study suggests that the NTHCM and feminist utopianism are better suited as fellow travelers. Feminist utopianism and the NTHCM are two different approaches to the questions I faced as a makerspace leader discussed in Chapter 3: Where is the making phenomenon going and how do we get there? Both feminist utopianism and the NTHCM consider that participation, democratization, access, and empowerment are principles of where we are going, but the NTHCM and feminist utopianism suggest different ways of getting there. The NTHCM calls for a particular shift in values, while feminist utopianism is about what can emerge as the result of participation along paths with certain qualities. I discuss these differences in the next chapter, along with what my findings regarding these different approaches mean for HCI's pursuit of democratization.

CHAPTER 8: DISCUSSION AND CONCLUSIONS

Throughout this dissertation, I have reflected on the experience of being a makerspace leader attempting to answer the question of where the making phenomenon is headed and how I should make sure our makerspace is aligned with that direction. I took the commonly cited promise of democratization as the starting point, identified some values within the making phenomenon that were demonstrably in the way of this promise, drew upon HCI research and practice to suggest a set of alternate values, and used a series of empirical studies to explore what those values looked like in practice. I defined HCM to be a particular balance between the sets of values and defined the NTHCM to be a theory that suggests these values as a guide. I then turned to the literature for a more robust definition of democratization to use for evaluating the NTHCM and adopted feminist utopianism, which ended up being less appropriate for evaluating the NTHCM and more appropriate as a guiding construct in and of itself for the making phenomenon.

In this chapter, I first summarize what we learned about HCM and feminist utopianism, including the extent to which these concepts can be used by maker leaders or HCI researchers to guide their actions and reflect on emergent activities towards the goal of democratization. I then reflect broadly on this project in terms of the overarching research question regarding HCI's pursuit of democratization.

8.1 The Normative Theory of Human-Centered Making

The driving hypothesis for this dissertation was:

> The NTHCM, which calls for a shift in the values of the making phenomenon to more closely resemble the values of HCI research and practice,

> is theoretically grounded, relates to existing maker practices and contexts, and there is reason to believe that adopting the theory will bring the making phenomenon closer to the promise of democratization.

I reflect on each of the components of this hypothesis here based on the results from the investigations throughout the dissertation.

8.1.1 Groundedness

In Chapter 3, I derived the definition of HCM and the NTHCM using a set of criteria for democratization that were derived from the literature, and I used literature from HCI and making to justify a set of values to guide making practices and mindsets. Reflecting back on how this theoretical development evolved and how my understanding of HCM and the NTHCM evolved as the result of the empirical studies in Chapters 4, 5, and 6, there are some aspects of the process that stand out as indicators that the grounding of the theory is not as theoretically sound as it might have been. In particular, one problem was that the more literature I gathered that implicitly or explicitly mentioned any of the values, the broader my understanding of the values became. Rather than helping hone in on a more concrete understanding of what it meant to adopt interaction-based mindsets and practices, each additional instance of interaction-based mindsets and practices, for example, added on to a seemingly endless taxonomy of ways interaction-based values could manifest relative to the making phenomenon.

Similarly, my understanding of how the values should be balanced is also not fully grounded. While the interview study presented in Chapter 4 sheds light on possible relationships between the sets of values such as how interaction-based mindsets and practices sometimes build on an initially artifact-based focus, there are likely additional ways they could be configured. While additional studies could shed light on additional relationships, it is not clear if we would ever reach the end of a seemingly endless taxonomy of possible configurations. This weakens HCM and the NTHCM

as a theoretical construct because there are so many different ways it could manifest, some of which are likely much more in line with its primary goals of democratization than others.

Also, it is possible there are counter examples of making that are in not in line with HCM, but that are desirable or that are demonstrative of democratization. For example, the Charlotte MEDI group discussed in Chapter 6 challenges the NTHCM by suggesting the possibility of successful social impact due to a primarily artifact-based endeavor.

Lastly, some of the assumptions that the NTHCM was built on are not fully grounded. Particularly, the NTHCM assumes that HCI is the place from which to model ideal values. While there are logical reasons to draw from HCI, as discussed in Chapter 3, there are other options as well. For example, an empirical or theoretical investigation of a self-identified feminist hackerspace or of an endeavor that more explicitly implements democratization and participation such as Malmö Living Labs [28] could have revealed an alternate set of values.

8.1.2 Relates to Existing Practices and Contexts

The interview study with the Statement Making participants (Chapter 4) showed evidence of the values of HCM in practice and Chapter 5 showed evidence that HCM could be used as a reflective lens to improve a semi-structured making event, which both support the statement that the NTHCM relates to maker practices and contexts. However, there was also evidence of ways HCM and the NTHCM do not. The most significant indication of the limit to which the NTHCM relates to maker practices and contexts was the study presented in Chapter 6 with the makerspace leaders and my own reflections on how to use the NTHCM as a generative guide for future maker endeavors. While the maker leaders did not think the values were unimportant, it was difficult to use the values to generate new ideas and the types of goals the maker leaders did express were different from the goals of the NTHCM. My own usage of

the NTHCM also proved it was challenging to see ways it could drive actions, but supported the idea it could be used as a reflective lens. The breadth of the ways the values could manifest poses challenges. A maker or makerspace leader who was using the NTHCM as a guide could, for example, understand the value of interaction-based as primarily relevant to how people in the space interact with each other, which would be worthwhile. However, this may prevent them from realizing there are other types of interaction-based mindsets and practices, such as considering the interactions with artifacts after they leave the makerspace. Unless these makers or makerspaces also adopt a pluralistic approach to the values, they may not continue thinking about other ways a particular endeavor could align with the values.

Additionally, the studies showed that HCM was difficult to pinpoint and using the NTHCM as a reflective lens was not straightforward. While some of the analysis in Chapter 5 used the values themselves to understand students' tendency towards the HCI side or the making side over time, this did not exhaust the insights the NTHCM would be able to garner. Additional analysis was needed to reflect on the capstone course as a whole in terms of how the values related to each other and how the participants and the context interacted. This makes the NTHCM difficult to use as a reflective lens or to guide new actions.

8.1.3 The Promise of Democratization

This dissertation did not aim to formally evaluate the NTHCM in terms of its capacity to bring about democratization. This would be a large project in and of itself that would be out of scope. However, the purpose of the empirical study in Chapter 7 was to begin to understand, or to generate hypotheses, about the relationship between the NTHCM and a more formal notion of democratization. While the NTHCM addressed some of the concerns about democratization that are represented in the criteria for democratization in Chapter 3, looking at the NTHCM through the lens of a more formal and complete definition of democratization sheds light on ways it falls short

(Chapter 7). While artifact-based, internal-facing, and individualistic mindsets and practices are demonstrably in the way of specific democratization-related concerns, adopting interaction-based, external-facing, and collective mindsets and practices are not necessarily sufficient to address those concerns or sufficient when considered in relation to other definitions of democratization.

8.1.4 Implications for HCI Research on the Making Phenomenon

I reflect here on what HCI researchers should do with these findings about the NTHCM and what they mean for HCI's pursuit of democratization. If there was stronger evidence in support of the NTHCM, then HCI researchers could be called upon to figure out how to design such that HCM would be promoted in the making phenomenon. For example, HCI researchers could explore how to promote the values through visual cues or ambient information, could design experiences for makers that surround these values, and could even see if there were ways the tools themselves could be designed such that the experience of using them prompted makers to think about these values.

However, since findings showed that the NTHCM is neither related closely enough to existing maker practices, nor does it capture a broad enough definition of democratization, I would not recommend HCI endeavors to figure out how to promote the values of HCM in the making phenomenon so explicitly. There is, however, still merit in the NTHCM for HCI research. Chapter 3 showed support for the argument that being exclusively artifact-based, individualistic, and internal-facing in the making phenomenon would cause problems for even a very narrow definition of democratization. Similarly, if HCI endeavors only support or promote these values (i.e. if HCI research only focuses on designing tools for individual makers to use in unique ways), then these HCI endeavors would similarly not achieve the promise of democratization. I do not recommend that all HCI endeavors related to the making phenomenon shift away from these values or towards collective, interaction-based, and external-facing

values explicitly, but rather, I suggest that there is benefit to at least some HCI endeavors promoting or looking at the making phenomenon in a way this is collective, interaction-based, or external-facing. This finding is consistent with Roedl et al.'s observation that HCI research on the making phenomenon primarily focuses on material empowerment of individual makers while not paying close attention to some of the more social or political aspects of making [163].

8.2 Feminist Utopianism

While I intended for feminist utopianism to be an evaluative measure for the NTHCM, I actually found it to be a helpful construct for maker leaders and HCI researchers in and of itself. I discuss its merits and the nature of its applicability here. Overall, feminist utopianism is grounded in feminist theory, democracy, and critiques of utopianism, it relates to the practice of making and maker leadership as evidenced by the study in Chapter 7 and the discussion below, and it shows promise for democratization because it *is* a way of conceptualizing democratization. While the dissertation was driven by a hypothesis about the groundedness, relation to practice, and promise for democratization of the NTHCM, feminist utopianism does a better job of meeting these needs. I expand on these ideas below and in the following section, I reflect more broadly on what these findings about the NTHCM and feminist utopianism mean for HCI's pursuit of democratization in the making phenomenon.

8.2.1 Groundedness

Not only is feminist utopianism an already established philosophical concept, but I will also show here how it embodies the values of HCM, showing that many of the theoretically grounded merits of the NTHCM apply even more to feminist utopianism. In many ways, feminist utopianism is a more collective, interaction-based, and external-facing approach to working towards the promise of democratization in the making phenomenon than the NTHCM itself, even though these values were part

of the definition of the NTHCM. Specifically, feminist utopianism is more collective than the NTHCM since a feminist utopia is something that happens at a collective community-wide or societal level. The NTHCM considered the collective impact of the making phenomenon primarily in terms of the aggregate of all the endeavors happening within it and suggests that individuals should shift to be more collective, which is actually a rather individualistic view of collective action. Feminist utopianism is more interaction-based than the NTHCM because it is dependent on particular types of interactions within a community, whereas the NTHCM is more narrowly centered around activities related to the creation of artifacts. Feminist utopianism is also more external-facing than the NTHCM when considered from the position of an HCI researcher or makerspace leader. Specifically, the study presented in Chapter 5 showed evidence of how an internal-facing mindset can manifest in a maker who, in the process of working with a stakeholder to create something, explicitly or implicitly seeks to maintain their own positionality as the center of the endeavor even when the opportunity is presented for them to center the goals and experiences of others. Similarly, the NTHCM can be seen as a more internal-facing approach since it originated from a single HCI research endeavor and single point of makerspace leadership, and represents an implicit desire for that HCI research endeavor to maintain positionality and for that point of makerspace leadership to maintain control, whereas feminist utopianism is not something that exists in the world and cannot be harnessed, controlled, or articulated before it exists by a single researcher and requires thinking externally to that positionality. I reflect more on the specifics and implications of this last point in later sections as part of a broader discussion about HCI's engagement with democratization.

These points about the values show that feminist utopianism is grounded in some of the same ideas as the NTHCM. It should also be noted that the fact that considering feminist utopianism through the lens of the NTHCM shed light on ways it aligns with

the values further supports the point that HCM is useful as a reflective lens.

8.2.2 Relation to Maker Practice

The reason I decided to engage with the topic of democratization was because of questions I had as a makerspace leader about the promise our makerspace should align with and how we should move towards it, or "Where are we going and how do we get there?" as outlined in Chapter 3.[1] Feminist utopianism tells us that the promise of makerspaces is not to bring about a particular version of the future but rather to be a component in the unfolding of processes where multiple possible better futures are considered and pursued. Makerspaces do not represent a utopian glimmer of the future, but rather a utopian glimmer of a type of path along which better unrepresentable but possible versions of the future unfold. The promise of makerspaces is not a particular end result, but rather the type of path, type of processes, and types of interactions they have the potential to enable.

The practice of makerspaces (and the practice of maker leadership) is thus to pay attention to the path the makerspace is on and implement mechanisms that prompt the feminist utopia criteria such as flexibility, interconnectedness, and making informed choices. The practice of making happens through lived experience and involves developing an understanding of the possibilities, the pursuits and goals of others, the situated context, and flexibly moving forward. The practice of making is not necessarily about making artifacts, but about developing meaning and understanding. It is about realizing what is possible, thinking critically about the limits, and understanding others' perspectives, as well as the situated context. In Chapter 7, I showed that McKenna's principles are helpful as a reflective lens to understand a past maker context and we suggest they may be helpful as a guide for maker leaders going forward. There are certainly academic and non-academic accounts of making that already align with this way of thinking, such as critical making [31, 96], Bowler

[1] Some passages in this section have been quoted verbatim from my published work [151].

et al.'s prompts for mindful making [34], or Hope et al.'s feminist hackathons [102] among others, and a feminist utopian approach to making would be a fellow traveler to these endeavors. Insights about their efforts along with this shift in framing from end-state to process that we've presented can both inform our future efforts going forward.

Looking at past making endeavors through the lens of feminist utopianism also helps distill concrete principles for future maker endeavors. Specifically, based on the study presented in Chapter 7, these are some of the aspects of Statement Making that seem to have contributed to the ways Statement Making aligned with principles of feminist utopianism and that may be reasonable for maker leaders more generally to adopt.

Shift focus away from artifacts Part of what helped Statement Making align with the feminist utopia criteria was the way participants viewed each other's work and viewpoints: with curiosity, understanding, and awe. While the makerspace does not prohibit participants from these same perspectives, it perhaps does not do enough to prompt them. While any project conducted in the makerspace has meaning to the person who made it and perhaps others, it is up to the person who made it to advocate for it and for themselves. The makerspace context could play a larger role in drawing attention to the fact that things have meaning and the people who made them have viewpoints. Statement Making achieved this by providing a stage to showcase participants' efforts and by framing the participants' contributions as "statements", which emphasized the ideas and meaning *behind* the artifacts. Similarly, the stories we tell about making contexts could be less about the artifacts people created and more about what relationships were fostered or what endeavors were initiated.

Opportunity for social progress without being solutionist As soon as we frame a makerpsace or a context for making in terms of a challenge or prompt such

as 'helping the community', we make it much harder for many of the feminist utopian criteria to emerge because we have set a particular type of agenda. Several of the participants had a social agenda to push, but none of them saw themselves as trying to 'solve' it, rather they viewed their efforts as raising awareness, starting conversations, bringing certain narratives to the forefront, or exploring the nuances of the issue. This means that they are more likely to be on a flexible path where such better futures unfold.

Prompt awareness of situatedness Situatedness is an important part of understanding interconnectedness. It is not enough to just understand the different artifacts in relation to each other, one must also understand the context in which they were created, and the general technological landscape that all these artifacts are part of and are commenting on. Makerspace leaders can be sure to prompt similar reflections on the broader context within which actions are situated. Oftentimes makerspaces have a rather individualistic emphasis, which is perhaps a remnant of the "rugged individualism" culture in computing [75]. This is reinforced by rhetoric of personalization and customization the makerspace provides [87]. To get away from this, makerspace leaders could shift from only talking about what "you the maker" can do to talking about what "we the makerspace" can do together or what "we the makerspace" are trying to figure out together. The specifics of this framing would shift over time since the first thing that "we the makerspace" might be trying to figure out is "what are we the makerspace trying to figure out". While there is evidence of HCI researchers working to figure out the broader trends makerspaces are situated within [123, 20], we have not found evidence of those conversations happening in makerspaces or evidence of HCI researchers trying to prompt makers to think in that way.

Actively Pursue a Radically Better Future The above suggestions attempt to provide actual concrete guidance and as a result are rather incremental. We encourage makerspace leaders to meditate on the concepts of feminist utopianism and realize that the mechanisms by which they could be realized might require a departure from other aspects of the current reality. When we came up with Statement Making, we momentarily left behind the idea of thinking of a makerspace context as a physical space to thinking about it as an event or as culminating in a performance. Similarly, makerspace leaders could work with the makerspace participants to come up with different models, plans, formats, and endeavors. Also, Statement Making was started in response to critiques of the local campus maker culture and aimed to be different. Some students even joined because it offered something different. Makerspaces could try different endeavors that communicate "we are doing something different here" through different aesthetics, values, purposes, or prompts. If participants perceive the context they are operating within as standing in opposition to the norm in some way, that may prompt conversations, reflections, and other forms of considering versions of a radically better future.

Pluralism In line with the *flexible ideas* criteria of feminist utopianism, Statement Making was not concretely defined. Participants interpreted the prompt in different ways and assigned their own meaning to their pieces and to others'. We similarly need a flexible way of allowing different meanings to be assigned to endeavors in the makerspace. While makerspaces are technically open-ended and claim to allow any form of association the participants would like, a challenge is that there are a lot of pre-conceptions about what they are for. Statement Making allowed for a range of technological, political, artistic, expressive, problem-solving, future-imagining pieces without enumerating those categories beforehand, which would have inevitably left someone out. This also left room

for different maker-related identities to participate. Makerspace leaders should similarly think about how to provide opportunities for these different types of endeavors to emerge. This suggestion is closely related to Bardzell's feminist HCI principle of pluralism [19], and is still an important component of feminist utopianism.

Overall, because of the fact that feminist utopianism satisfactorily answers the questions that arose from my experience as a makerspace leader about what promise to align the makerspace with and how to work towards that promise, and because reflecting on the study that used feminist utopianism as a lens during analysis in Chapter 7 yielded the distilled concrete set of actions for makerspace leaders presented above, we can conclude that feminist utopianism relates well to existing maker practices and contexts. Future work will need to be done to investigate how well feminist utopianism can drive actions and how those endeavors would be initiated and perpetrated. However, even the principles above show promise that feminist utopianism has merit beyond its use as a reflective lens in driving new making efforts forward.

8.2.3 Promise of Democratization

Feminist utopianism was chosen for study as a definition of democratization, the justification of which was discussed in Chapter 7 so naturally it shows promise in its ability to guide towards democratization. The study in Chapter 7 also shows its relevance to the question of democratization specifically as it applies to the making phenomenon.

8.2.4 Implications for HCI Research on the Making Phenomenon

Designing to encourage makers or makerspaces to become more aligned with feminist utopianism is a much less straightforward task that it would have been to design

to encourage makers or makerspaces to become more aligned with particular values.[2] Perhaps HCI researchers could adopt McKenna's principles [134] as goals of design endeavors: design to promote flexibility or design to make makers appreciate their interconnectedness. However, feminist utopianism suggests that there are new ways to think about even the nature of the relationship between researchers in HCI and the making phenomenon. Much of the HCI literature on making paints an optimistic narrative of progress, where the making phenomenon represents a glimmer of a future abundant in participation, democracy, and empowerment. By supporting making in any way, researchers can claim that HCI is inching towards this promise [163]. Despite known critiques, this narrative prevails [16]. Part of the reason might be that it is not clear what an HCI intervention in framing the practice and promise of making looks like. HCI researchers face similar questions relative to the making phenomenon that we as makerspace leaders faced relative to our own makerspace: How do HCI researchers contribute to any futuring projects in the domain of making without overstepping their bounds? How do HCI researchers balance their own agendas for the making phenomenon with the agendas of the community (or the agenda-less, open-ended spirit of the community)? Just like we as makerspace leaders have an imperative to not leave the space in a completely open-ended free-for-all format, HCI researchers have a similar imperative: In the absence of aligning with an improved perspective on the promises of the making phenomenon, HCI researchers risk continuing to reinforce a status quo that does not have broad participation and has not yet considered the unintended consequences. Perhaps the relationship between HCI and the making phenomenon might also be informed by feminist utopianism. Rather than thinking up an abstract end-goal (or ignoring the need to think beyond our immediate actions), maybe HCI researchers should develop a relationship and pathway for HCI and the making phenomenon to participate in the process of such a future emerging.

[2]Some passages in this section have been quoted verbatim from my published work [151].

8.3 HCI's Pursuit of Democratization through the Making Phenomenon

While feminist utopianism was originally meant to help determine the extent to which the NTHCM could guide the making phenomenon towards the promise of democratization, it ended up having merits as a guide for democratization in and of itself. I thus considered the NTHCM and feminist utopianism to be fellow travelers with different approaches towards similar goals of democratization and participation. The way each expresses and engages with democratization is different, however. I reflect here on some of those differences and unpack assumptions I had made when I was constructing the NTHCM about how the broad concept of democratization relates to design endeavors. Many of these assumptions may have contributed to the reasons why the NTHCM did not fulfill its own promises as well as feminist utopianism. I reflect on what this means for HCI's pursuit of democratization and the assumptions that underlie familiar frames of legitimacy in HCI. It is in this section that I provide support for the thesis statement of this dissertation:

> HCI endeavors that pursue the promise of democratization through research and design efforts related to the making phenomenon require moving beyond several underlying assumptions of typical HCI practice: assumptions about how the endeavor will scale, assumptions about HCI's role in driving the effort, and assumptions about how theory and praxis relate.

8.3.1 Assumptions About Scale

Some of the differences between the NTHCM and feminist utopianism have to do with assumptions about how design endeavors will scale and how the small experiments or prototypes are assumed to relate to the future.[3] When I started constructing the NTHCM, I was thinking mostly in the context of our own makerspace or specific

[3]Some passages in this section have been quoted verbatim from my published work [151].

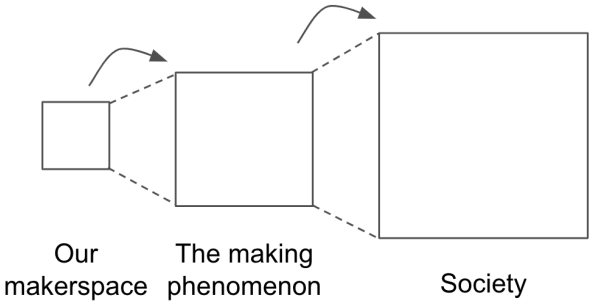


Figure 8.1: Assumption about scale in the NTHCM

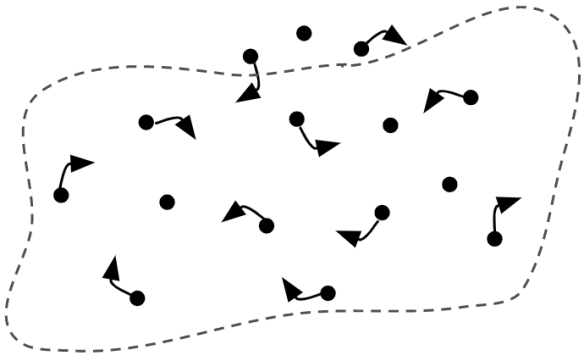


Figure 8.2: Feminist utopianism

maker endeavors such as 3D printing prosthetic devices for children with limb differences. I saw our makerspace as being a collection of individuals, and the making phenomenon as a collection of makerspaces, and that the making phenomenon represented or modeled how all of society would interact with technological production. Our makerspace was thus a scaled down versions of what the making phenomenon could be, which was a scaled down version of what society could be (Figure 8.1).

This assumption about scale meant I also assumed that if the theory I was developing worked within the context of a particular maker endeavor or in our makerspace, it would work in the making phenomenon as a whole. When I was deriving the definition of the NTHCM, I was thinking in terms of mindsets, practices, and outcomes that would be evident and measurable in our local maker context and assumed that was sufficient. I was not considering phenomena and factors that emerge or are ev-

ident only at a broader or societal level. Some of the ways in which the NTHCM is complex have to do with explaining how individual makers and the context they operate within interact. The study in Chapter 4 shed light on how this was difficult to represent formally, even for a simple event.

Much of HCI focuses on smaller endeavors as well, particularly in the way HCI design endeavors consider prototypes and artifacts [43, 192]. The idea is that the future is complicated and uncertain, but a prototype is a more immediate and understandable probe into the future [69, 72]. For the prototype to have an actual place in the future, some sort of scaling needs to happen, though Brown et al. wonder whether and how HCI endeavors can actually scale [36]. As Lindtner et al. suggest, HCI endeavors that focus on democratization often do so at such a small scale that the politics are barely visible [124]. Even Participatory Design faces challenges when trying to scale up since PD endeavors typically focus on local challenges and a designer is required to be part of the endeavor to configure the participation [20]. This is also related to a point Dourish and Mainwaring make when discussing the colonial impulse of the Ubicomp research agenda [68]. They claim there is often a problematic underlying assumption that whatever is happening within the research lab needs to be happening elsewhere: "research laboratories are the world in microcosm, and what they have, the rest of the world will want". Similarly, the NTHCM assumed that shifting individual maker mindsets and practices would yield a shift in the making phenomenon as a whole and that a small endeavor illustrating the merits of the NTHCM would serve as a proof of concept that the NTHCM could fix the societal question of democratization.

In contrast, a feminist utopia is a society-wide phenomenon that is happening everywhere all at once (Figure 8.2). While feminist approaches have been used in HCI, design, and even the making phenomenon before for the purpose of emancipation [19, 45, 148], looking at the interview study with Statement Making participants

through the lens of feminist utopianism (Chapter 7) helps us realize the possibility for a broader form of emancipation in the making phenomenon. Bardzell discusses how the feminist HCI design principles are more focused on design in-the-small, while there are other concepts that can help with "democratic design experiments (writ large)" [20]. One of the reasons to take a larger-scale look at a context such as Statement Making or a makerspace is, as Bardzell points out, due to some of the shortcomings of only looking at individual experiences. Specifically, petit récits, which focus on local narratives, typically from marginalized voices, are one approach to interrogating problematic totalizing visions [20]. Some of the shortcomings of this approach are how there is no room for theory or moral universals and how there are "no mechanisms for us to reject marginal perspectives that should be marginal" [20]. This is a particularly salient concern in the making phenomenon since there are very few mechanisms of control in spaces that have a completely open-door policy. The feminist HCI design principles and research that uses these principles to reflect on whether a particular design or experience was emancipatory or empowering for individuals [19, 148] fall into this category of design in-the-small: while the emphasis is on understanding the conditions that foster positive experiences for individuals, this understanding does not shed light on how the broader context could be arranged or how to avoid situations where the conditions are exploited by individuals with other values. These points culminate in Bardzell's question: "The intellectual challenge therefore is to find a way to preserve the moral universals, the utopian impulse, and the drive to design toward replacing the current situation with preferred ones, without relying on a now discredited modernist epistemology. How can we throw out the bathwater without throwing out the baby, too?" [20]. In other words, how to keep the pursuit of broad systemic change while reducing the assumption that "a skilled expert produces futures on behalf of everyone" [20]. Bardzell suggests feminist utopianism as an answer since it allows for broad re-imagining of society, but does not depend on one person to

figure out what it means. Before encountering feminist utopianism, these questions were similar to the ones I presented in Chapter 3 about what the broader promise of the making phenomenon was and what the extent of my right or responsibility to intervene was. My approach to answering these questions was to align with the promise of democratization and to develop the NTHCM as a guide for how to get there. However, the NTHCM falls into this category of design in-the-small and was conceived of by a single individual, both of which are critiqued in this perspective that argues the merits of feminst utopianism for consideration in design approaches [20].

Statement Making was not a large scale example of a feminist utopia, but it was certainly larger than what we would have initiated if we were trying to maintain complete control over how participation was configured. There were times when running Statement Making, especially the first one, that I felt it was too big too fast and that we should perhaps scale back. Luckily, we did not, because part of what made Statement Making successful is the fact that it was big and different. This also opened my eyes to what it could mean to start something that was at a scale beyond what I could possibly understand before starting it. It is difficult, but interesting, to imagine what a similar shift in scale or a feminist utopian approach would look like for other HCI endeavors. One challenge of thinking at a broader scale that happens all at once is how it starts and who instigates it. We would need to move away from our instinct to start with an individual artifact or the interactions immediately surrounding a single artifact. We would need to figure out how a path can unfold everywhere within a given scope simultaneously at once without relying on someone initiating something that starts small and grows or propagates. We would need to figure out ways of doing this where we simultaneously let go of control so conversations can emerge everywhere, but where we still have a sense of responsibility over the consequences. With Statement Making, we got started by setting the bounds of the

event: a digital fabrication fashion show. Unfortunately, this meant we inevitably left out some people such as those who were not interested in digital fabrication or those who did not see value in expressing an idea through a wearable garment in a fashion show format. Perhaps the feminist utopian principles embedded in Statement Making would help it grow and expand in a dynamic way that includes more people, but Statement Making certainly does not represent what a society-wide relationship with technological production could look like.

Ultimately, the takeaway for HCI researchers is the insight that HCI endeavors working towards the promise of democratization that assume smaller scale versions will automatically scale to larger versions is limiting. While there is value in pursuing small scale endeavors, it cannot be assumed that the insights will automatically apply to larger scale endeavors. While it is not clear how exactly HCI researchers should go about pursuing larger scale endeavors, feminist utopianism is a construct that can help HCI researchers think about such a scale. If HCI researchers were only thinking of small endeavors that scale up, that would limit the likelihood of realizing or appreciating ideas such as feminist utopianism.

8.3.2 Assumptions About Stance and Positionality

In Chapter 1, I introduced two figures (Figures 1.2 and 1.3) to illustrate how the different levels of research questions related to each other. For convenience in the discussion, they are reproduced here as Figures 8.3 and 8.4. In order to make progress towards HCI's promise of democratization in the making phenomenon, I let go of my stance as an HCI researcher and asked the question from the position of a makerspace leader. In some ways, this was necessary. From the stance of an HCI researcher, the question would have been "Towards the goal of democratization, how can HCI prompt the making phenomenon to be more mindful of the impact of their endeavors on the human experience?", and HCI researchers do not necessarily have standing to intervene in external communities in this way without adopting

undesirable qualities such as being paternalistic or colonial. I thus asked a similar question from the stance of a makerspace leader, which was much more reasonable: "Towards the goal of democratization, how can I, as a makerspace leader, ensure the makerspace that is in the domain of my responsibility or control is mindful of the impact it has on the human experience within the space and external to it?"

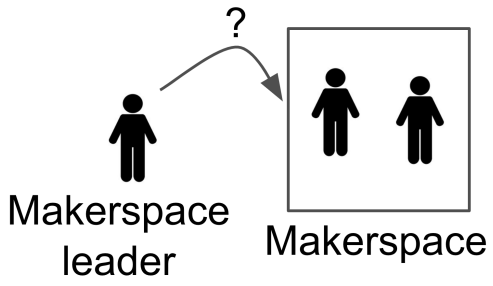


Figure 8.3: Focusing on what makerspace leaders should do towards the promise of democratization in the making phenomenon

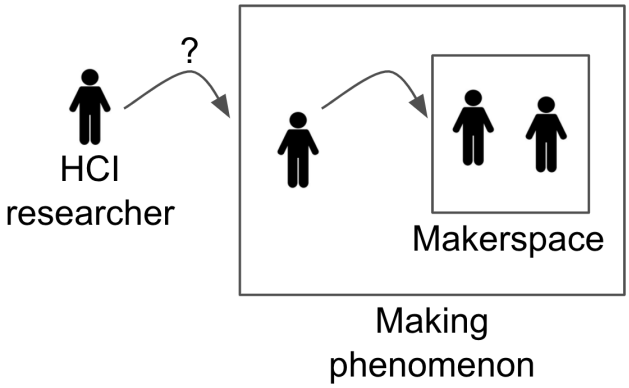


Figure 8.4: Using insight about what makerspace leaders should do towards the promise of democratization in the making phenomenon to shed light on implications for HCI.

My pursuit of democratization as a makerspace leader by way of developing the NTHCM was thus done with HCI in mind; the NTHCM was structured in a way that the outcomes would be easily transferable back to my role as an HCI researcher or for other HCI researchers. My investigations from the standpoint of a makerspace leader involved figuring out *what* needed to be implemented with the goal of turning that information over to other HCI researchers to figure out *how* to implement it.

The choice to pursue values was in part because if I could distill a set of values, I had confidence HCI researchers would be able to figure out how to design tools or experiences for the making phenomenon to propagate or manifest those values.

In this way, the endeavor of creating the NTHCM was *stance-preserving* for HCI, a term that I introduce here to mean that the NTHCM maintained the fact that HCI researchers would have a place in figuring out how to make it happen and HCI would have a place in initiating those endeavors. In contrast, feminist utopianism is less stance-preserving for HCI: there is not an obvious place for HCI in initiating or driving a feminist utopia since the primary driver of progress in a feminist utopia is all the participants in the society. Before expanding on this idea or unpacking the implications, let us first illustrate a similar idea in a slightly different context in order to draw a parallel with a point discussed earlier. The results of Chapter 5 shed light on how an internal-facing mindset can manifest in a maker who, in the process of working with someone who has a limb difference to create a prosthetic device, explicitly or implicitly seeks to maintain their own positionality as the primary driver of the endeavor. Figures 8.5, 8.6, and 8.7 illustrate a generalization of this idea, where a maker with an increasingly external-facing mindset is working with a stakeholder who will benefit from a particular artifact being created (such as a prosthetic device). In these figures, the dotted lines represent who the maker perceives as the primary driver, initiator, or designer during the endeavor, where internal-facing, similar to the idea of stance-preserving introduced earlier, means they are preserving their role as the driver of the making endeavor and external-facing means the maker is opening up their notion of who the driver is. Figure 8.5 represents a maker who perceives the other stakeholder (such as the person with a limb difference they are working with) as being there to help the maker fulfill their own goal of making an optimal product. On the other hand, Figure 8.7 depicts a maker who sees the other stakeholder as the primary driver of the making endeavor, while the maker is a spectator, facilitator,

or a resource that can be called on by the stakeholder when needed. The making endeavor is framed and centered entirely external to the maker.

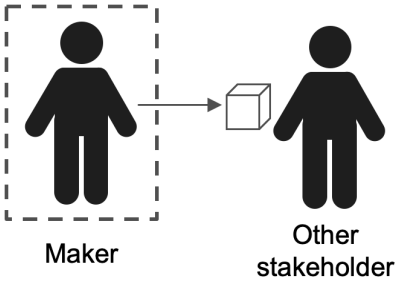


Figure 8.5: An internal-facing approach to creating something for someone else, where the maker focuses on how their role as a maker can help others or how they can make things *for* others

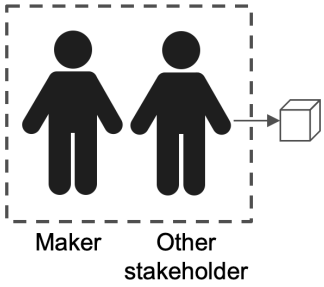


Figure 8.6: A partially internal-facing, partially external-facing approach to creating something for someone else, where the maker focuses on the process of creating something *with* an external stakeholder

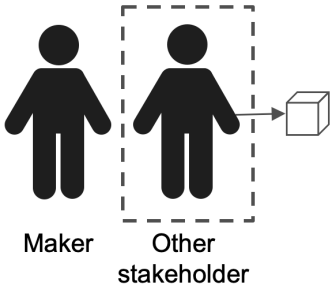


Figure 8.7: An external-facing approach to creating something for someone else, where the maker focuses their endeavors on the other stakeholder, seeing their own role as facilitating, enabling, or standing by as a resource for the stakeholder who is driving the endeavor

Similarly, if we return to the broader point about HCI's stance relative to democratization, we see how feminist utopianism more closely resembles the external-facing

approach in Figure 8.7. A revised version of Figure 8.4, which depicts how I originally imagined the development of the NTHCM would inform HCI about what kind of endeavors to pursue, is depicted in Figure 8.8, where the dotted lines show how the HCI researcher is focusing on HCI as the driver of the goal of democratization through HCI endeavors related to the making phenomenon. Again, this is the approach I took with the NTHCM, focusing on types of outcomes that would be useful to guide future HCI design endeavors such as values. Alternatively, Figure 8.9 illustrates how HCI thinks about democratization in the making phenomenon when considering a topic such as feminist utopianism. Since feminist utopianism exists at a society-wide scale and is driven not by a single design endeavor, but rather by everyone in the society, in order to even consider this idea, HCI has to de-center itself because it is not immediately obvious what HCI's role in a feminist utopia would be; a feminist utopia is not something HCI can design in the same way it designs for other types of experiences.

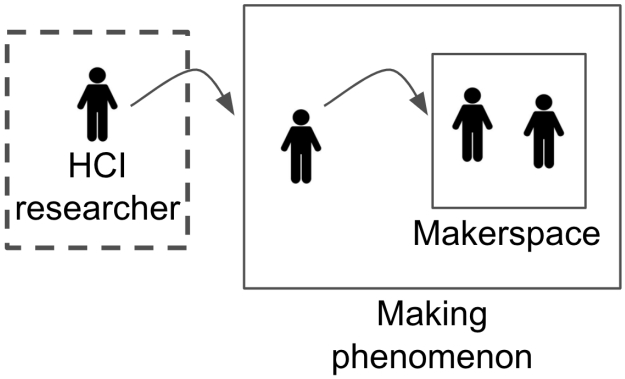


Figure 8.8: An HCI researcher focusing on their role when thinking about how to pursue the goal of democratization in the making phenomenon

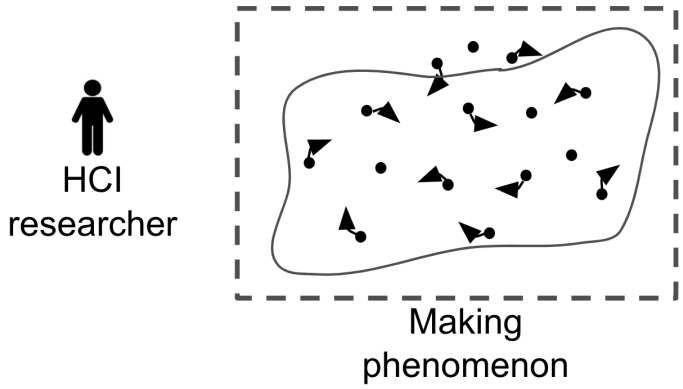


Figure 8.9: An HCI researcher focusing on democratization in the making phenomenon independent of their role in perpetrating it

Ultimately, the takeaway for HCI researchers is the insight that HCI endeavors that seek to preserve HCI's role as the driver, initiator, or designer in projects that seek the promise of democratization may be limiting the extent to which that promise is fulfilled due to the fact that some approaches to democratization require looking beyond types of outcomes and endeavors that HCI is accustomed to. Thinking about the question, "How should HCI researchers pursue democratization?" through the development of the NTHCM limited the extent to which this question could be answered. Asking first, "What could democratization look like here?" would be a better approach. HCI endeavors that seek the goal of democratization should reflect on whether the endeavor is attempting to preserve HCI's stance, which could be limiting, and should make sure they are open to other types of endeavors.

8.3.3 Assumptions about the Separation of Theory and Praxis

One of the motivations of developing the NTHCM was to bridge the theory of democratization with the practice of making. It was not immediately obvious how to do this, however. In Chapter 3, I expressed some concerns about the impact of the making phenomenon if makers were not taking into consideration the human experience of their making endeavors. While the collective actions of all makers and makerspaces influence the extent to which democratization manifests and the

implications of the making phenomenon as a whole, each individual maker does not necessarily think about that and their actions may or may not directly contribute to the collective output. For example, if we were to decide that a broad awareness of the impact of technology on society should be part of the making phenomenon, then it would not be clear where that conversation should take place or whose responsibility it would be to enact it. If someone wanted to laser cut a keychain, would they need to think about the possible societal consequences of the making phenomenon as a whole?

The NTHCM attempted to bridge theory and praxis by identifying values that were chosen with the goal of relating to both makerspace mindsets and practices as well as democratization more broadly. The values were generative rather than prescriptive; they would not dictate what activities should or should not take place, but rather would invite certain considerations relative to those activities, theoretically bridging theory and practice at just about any locus of making. The challenge with the NTHCM was that the values were difficult to relate directly or concretely to maker practices and they did not fully embody or implement democratization. The NTHCM also treated democratization as a design goal, which is a common technique in HCI for guiding design endeavors [164], and attempted to figure out the conditions, in the form of values, that would cause this goal to emerge.

Feminist utopianism relates theory and praxis in a different way. Rather than the theory and practice being separate, the theory is embodied, embedded in lived experience, and emerges over time as the result of participation. Rather than the theoretical promise of making, which could be about the democratization of technology production or something else, being an abstract representation of a possible far off future, the promise of making is dynamically negotiated and pursued by the participants. The promise is possible, but it is unrepresentable in the form of a theory or vision because the promise *is* the way the practice and actions of the participants unfold.

When I was developing the NTHCM, I had assumed that I would have to figure out how to relate the theory with the practice, but it turned out that there was already an established construct that was helpful here.

Ultimately, the takeaway for HCI researchers is that there are ways of thinking about democratization not as a theory or outcome that is separate from practice, but rather where it is a particular condition, attribute, or configuration of participation. Instead of thinking of the theory of democratization and the practice of participation separately, HCI researchers who are pursuing the promise of democratization should consider theory and praxis in a way that is more closely intertwined. This is neither a new idea in the realm of democracy, as discussed in Chapter 7, nor is it new in the field of HCI as HCI is accustomed to artifacts as embodying and representing theories [43]. The suggestion here is for HCI to also consider the different ways sociotechnical systems can embody or represent theories and figure out how to design with that information in mind.

8.4 Conclusion

In summary, this dissertation aimed to construct, develop, and evaluate a theory that would guide makerspace leaders and HCI researchers towards the promise of democratization of technology production in the context of the making phenomenon. The theory, the NTHCM, is built on a definition of democratization that focuses on broadening access and consideration for the impact of the endeavors in makerspaces. It consists of values from making (individualistic, internal-facing, artifact-based) that seem to be in the way of those goals and values from HCI research and practice (collective, external-facing, interaction-based) that show promise for achieving those goals. Empirical and theoretical investigations showed that while entirely individualistic, internal-facing, and artifact-based mindsets and practices in the making phenomenon may be problematic in progressing towards the goal of democratization, shifting to be more collective, external-facing, and interaction-based is not necessarily the answer

to the problem, nor are any of these values directly relatable to the practice of makers or maker leaders. These findings suggest that HCI researchers should be mindful of which values their own endeavors relative to the making phenomenon are reinforcing. While there is no evidence to suggest all HCI research on the making phenomenon should be guided by this shift, there is evidence of the merits of collective, interaction-based, and external-facing mindsets and practices in the making phenomenon. Ideally, there are at least some HCI endeavors that embody and propagate these values.

On the other hand, feminist utopianism, which was originally meant as an evaluative measure to help determine the extent to which the NTHCM aligns with a more holistic definition of democratization, shows potential for being a guide to help maker leaders to understand how democratization happens and to recognize and realize some of the characteristics of the path along which it may emerge are. Feminist utopianism is grounded in democratic ideals and relates to maker practice in the way that it answers questions about how the making phenomenon can progress forward without imposing one particular definition of progress on everyone. Findings showed how feminist utopianism is a useful lens to understand an existing maker event and using such analysis to generate additional concrete guidance for maker leaders. These findings suggest that HCI researchers might find ways to promote principles of feminist utopianism in the making phenomenon and to consider different relationships between the field of HCI and the making phenomenon as a whole.

This dissertation also shed light on some of the underlying assumptions that limited the NTHCM in the extent to which it was able to pursue the goal of democratization: assumptions about how endeavors will scale, assumptions about HCI's role in driving the effort, and assumptions about how theory and praxis relate. HCI researchers who align their efforts with democratization should make sure they are not limiting what they are able to envision by assuming that smaller endeavors represent scaled down versions of larger endeavors that operate the same way, should make sure to

consider what democratization looks like without primarily centering the question around HCI's role in driving the endeavor, and should consider different ways that sociotechnical systems can embody or represent theories and figure out how to design with that information in mind.

REFERENCES

[1] "Enabling the future," *http://enablingthefuture.org*. [Online]. Available: http://enablingthefuture.org/

[2] "The fab foundation," https://fabfoundation.org. [Online]. Available: https://fabfoundation.org/

[3] "The helping hand project," *https://www.helpinghandproject.org*. [Online]. Available: https://www.helpinghandproject.org/

[4] "Make a space kit," *Retrieved from https://nationofmakers.files.wordpress.com/2017/11/make-a-space-kit.pdf*. [Online]. Available: https://nationofmakers.files.wordpress.com/2017/11/make-a-space-kit.pdf

[5] "Open source circular fashion," https://oscircularfashion.com/. [Online]. Available: https://oscircularfashion.com/

[6] "Fab city global initiative," https://fab.city/, Accessed 10 Feb 2020. [Online]. Available: https://fab.city/

[7] J. Aberg, "Challenges with teaching hci early to computer students," in *Proceedings of the fifteenth annual conference on Innovation and technology in computer science education*, 2010, pp. 3–7.

[8] J. B. Abramson, G. R. Orren, and F. C. Arterton, *Electronic Commonwealth: The Impact of New Media Technologies on Democratic Politics*. Basic Books, Inc., 1988.

[9] A. Adam, "Hacking into hacking: Gender and the hacker phenomenon," in *Gender, Ethics and Information Technology*. Springer, 2005, pp. 128–146.

[10] M. G. Ames, "Charismatic technology," in *Proceedings of The Fifth Decennial Aarhus Conference on Critical Alternatives*, 2015, pp. 109–120.

[11] M. G. Ames, J. Bardzell, S. Bardzell, S. Lindtner, D. A. Mellis, and D. K. Rosner, "Making cultures: empowerment, participation, and democracy-or not?" in *CHI'14 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2014, pp. 1087–1092.

[12] E. S. Anderson, "What is the point of equality?" *Ethics*, vol. 109, no. 2, pp. 287–337, 1999.

[13] L. J. Bannon and S. Bødker, "Beyond the interface: Encountering artifacts in use," *DAIMI Report Series*, no. 288, 1989.

[14] L. J. Bannon and P. Ehn, "Design matters in participatory design," *Routledge handbook of participatory design*, pp. 37–63, 2012.

[15] J. Bardzell and S. Bardzell, *Humanistic HCI*, ser. Synthesis Lectures on Human-Centered Informatics. Morgan & Claypool Publishers, 2015. [Online]. Available: https://books.google.com/books?id=beCOCgAAQBAJ

[16] J. Bardzell, S. Bardzell, C. Lin, S. Lindtner, A. Toombs *et al.*, "HCI's making agendas," *Foundations and Trends® in Human–Computer Interaction*, vol. 11, no. 3, pp. 126–200, 2017.

[17] J. Bardzell, S. Bardzell, and A. Toombs, "Now that's definitely a proper hack: self-made tools in hackerspaces," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2014, pp. 473–476.

[18] J. Bardzell, G. Freeman, S. Bardzell, and P.-Y. Chen, "Join.love: A sociotechnical genealogy of the legalization of same-sex marriage," in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, ser. CHI '20. New York, NY, USA: Association for Computing Machinery, 2020, p. 1â13.

[19] S. Bardzell, "Feminist HCI: taking stock and outlining an agenda for design," in *Proceedings of the SIGCHI conference on human factors in computing systems*. ACM, 2010, pp. 1301–1310.

[20] ——, "Utopias of participation: Feminism, design, and the futures," *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 25, no. 1, p. 6, 2018.

[21] S. Bardzell, J. Bardzell, and S. Ng, "Supporting cultures of making: Technology, policy, visions, and myths," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 2017, pp. 6523–6535.

[22] P. Baudisch and S. Mueller, "Personal fabrication," *Foundations and Trends® in Human–Computer Interaction*, vol. 10, no. 3–4, pp. 165–293, 2017.

[23] N. K. Baym and D. Boyd, "Socially mediated publicness: An introduction," *Journal of broadcasting & electronic media*, vol. 56, no. 3, pp. 320–329, 2012.

[24] J. Bean and D. Rosner, "Making: movement or brand?" *Interactions*, vol. 21, no. 1, pp. 26–27, 2014.

[25] D. E. Bell, H. Raiffa, and A. Tversky, *Decision making: Descriptive, normative, and prescriptive interactions*. Cambridge university Press, 1988.

[26] S. Benhabib, *Situating the self: Gender, community, and postmodernism in contemporary ethics*. Psychology Press, 1992.

[27] C. L. Bennett, K. Cen, K. M. Steele, and D. K. Rosner, "An intimate laboratory?: Prostheses as a tool for experimenting with identity and normalcy," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 1745–1756.

[28] E. Björgvinsson, P. Ehn, and P.-A. Hillgren, "Participatory design and democratizing innovation," in *Proceedings of the 11th Biennial participatory design conference*. ACM, 2010, pp. 41–50.

[29] D. Boaz, *Libertarianism*. Simon and Schuster, 2010.

[30] S. Bødker and M. Kyng, "Participatory design that matters–facing the big issues," *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 25, no. 1, pp. 1–31, 2018.

[31] L. Bogers and L. Chiappini, "The critical makers reader:(un) learning technology," *INC Reader*, no. 12, 2019.

[32] J. Bohman and W. Rehg, "Jürgen Habermas," in *The Stanford Encyclopedia of Philosophy*, fall 2017 ed., E. N. Zalta, Ed. Metaphysics Research Lab, Stanford University, 2017.

[33] A. Bousseau, T. Tsandilas, L. Oehlberg, and W. E. Mackay, "How novices sketch and prototype hand-fabricated objects," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 397–408.

[34] L. Bowler and R. Champagne, "Mindful makers: Question prompts to help guide young peoples' critical technical practices in maker spaces in libraries, museums, and community-based youth organizations," *Library & Information Science Research*, vol. 38, no. 2, pp. 117–124, 2016.

[35] L. Britton, "Power, access, status: The discourse of race, gender, and class in the maker movement," *University of Washington Technology and Social Change Group*, 2015.

[36] B. Brown, S. Bødker, and K. Höök, "Does HCI scale? scale hacking and the relevance of HCI," *Interactions*, vol. 24, no. 5, pp. 28–33, 2017.

[37] S. Browne, *Dark matters: On the surveillance of blackness*. Duke University Press, 2015.

[38] L. Buechley and B. M. Hill, "Lilypad in the wild: how hardware's long tail is supporting new engineering and design communities," in *Proceedings of the 8th ACM conference on designing interactive systems*. ACM, 2010, pp. 199–207.

[39] L. Buechley and H. Perner-Wilson, "Crafting technology: Reimagining the processes, materials, and cultures of electronics," *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 19, no. 3, p. 21, 2012.

[40] E. Buehler, S. Branham, A. Ali, J. J. Chang, M. K. Hofmann, A. Hurst, and S. K. Kane, "Sharing is caring: Assistive technology designs on thingiverse," in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. ACM, 2015, pp. 525–534.

[41] E. Buehler, A. Hurst, and M. Hofmann, "Coming to grips: 3D printing for accessibility," in *Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility*. ACM, 2014, pp. 291–292.

[42] R. Calderon, S. Fels, J. Anacleto, N. Memarovic, and W. T. Thompson, "Hacking HCI3p: second workshop on human computer interaction in third places," in *Proceedings of the 2014 companion publication on Designing interactive systems*. ACM, 2014, pp. 195–198.

[43] J. M. Carroll and W. A. Kellogg, "Artifact as theory-nexus: Hermeneutics meets theory-based design," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1989, pp. 7–14.

[44] D. Chachra, "Why I am not a maker," *The Atlantic*, vol. 23, 2015.

[45] S. S. Chivukula and C. M. Gray, "Bardzell's" feminist hci" legacy: Analyzing citational patterns," in *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 2020, pp. 1–8.

[46] T. Christiano, *The rule of the many: Fundamental issues in democratic theory*. Routledge, 2018.

[47] ——, "Democracy," in *The Stanford Encyclopedia of Philosophy*, fall 2018 ed., E. N. Zalta, Ed. Metaphysics Research Lab, Stanford University, 2018.

[48] D. L. Cogburn, "Hci in the so-called developing world: What's in it for everyone," *Interactions*, vol. 10, no. 2, p. 80â87, Mar. 2003. [Online]. Available: https://doi.org/10.1145/637848.637866

[49] W. contributors, "Public sphere Wikipedia the free encyclopedia," 2019, online; accessed 27-December-2019. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Public_sphere\&oldid=931300224

[50] ——, "Humanism — Wikipedia, the free encyclopedia," 2020, [Online; accessed 13-February-2020]. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Humanism\&oldid=937420608

[51] G. Cooper and J. Bowers, "Representing the user: Notes on the disciplinary rhetoric of human-computer interaction," *Cambridge Series on Human Computer Interaction*, pp. 48–66, 1995.

[52] S. Costanza-Chock, "Design justice: Towards an intersectional feminist framework for design theory and practice," *Proceedings of the Design Research Society*, 2018.

[53] A. Crabtree and T. Rodden, "Domestic routines and design for the home," *Computer Supported Cooperative Work (CSCW)*, vol. 13, no. 2, pp. 191–220, 2004.

[54] C. Crivellaro, R. Comber, M. Dade-Robertson, S. J. Bowen, P. C. Wright, and P. Olivier, "Contesting the city: Enacting the political through digitally supported urban walks," in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. ACM, 2015, pp. 2853–2862.

[55] L. Dahlberg, "The internet, deliberative democracy, and power: Radicalizing the public sphere," *International Journal of Media & Cultural Politics*, vol. 3, no. 1, pp. 47–64, 2007.

[56] A. Dementyev, J. Hernandez, S. Follmer, I. Choi, and J. Paradiso, "Skinbot: A wearable skin climbing robot," in *Adjunct Publication of the 30th Annual ACM Symposium on User Interface Software and Technology*, ser. UIST '17. New York, NY, USA: ACM, 2017, pp. 5–6.

[57] A. Desjardins and A. Ball, "Revealing tensions in autobiographical design in HCI," in *proceedings of the 2018 designing interactive systems conference*. ACM, 2018, pp. 753–764.

[58] A. Desjardins and R. Wakkary, "Manifestations of everyday design: guiding goals and motivations," in *Proceedings of the 9th ACM Conference on Creativity & Cognition*. ACM, 2013, pp. 253–262.

[59] J. Dewey, *Democracy and education: An introduction to the philosophy of education*. Macmillan, 1923.

[60] ——, *Public & its problems*. Ohio University Press, 1954.

[61] C. Dierk, S. Sterman, M. J. P. Nicholas, and E. Paulos, "Häiriö: Human hair as interactive material," in *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction*. ACM, 2018, pp. 148–157.

[62] C. DiSalvo, J. Maki, and N. Martin, "Mapmover: A case study of design-oriented research into collective expression and constructed publics," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI '07. New York, NY, USA: Association for Computing Machinery, 2007, p. 1249â1252. [Online]. Available: https://doi.org/10.1145/1240624.1240813

[63] T. Donovan, D. Smith, and C. Mooney, *State and local politics: Institutions and reform*. Nelson Education, 2012.

[64] D. Dougherty, "The maker movement," *Innovations: Technology, Governance, Globalization*, vol. 7, no. 3, pp. 11–14, 2012.

[65] ——, "We are makers," *TED*, February 2011. [Online]. Available: https://www.youtube.com/watch?v=mlrB6npbwVQ

[66] P. Dourish, "Implications for design," in *Proceedings of the SIGCHI conference on Human Factors in computing systems*, 2006, pp. 541–550.

[67] ——, "HCI and environmental sustainability: the politics of design and the design of politics," in *Proceedings of the 8th ACM conference on designing interactive systems*, 2010, pp. 1–10.

[68] P. Dourish and S. D. Mainwaring, "Ubicomp's colonial impulse," in *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, 2012, pp. 133–142.

[69] A. Dunne and F. Raby, *Speculative everything: design, fiction, and social dreaming*. MIT press, 2013.

[70] P. Ehn, "Playing the language-games of design and use-on skill and participation," in *Acm Sigois Bulletin*, vol. 9, no. 2-3. ACM, 1988, pp. 142–157.

[71] P. Ehn and M. Kyng, "The collective resource approach to systems design," *Computers and democracy*, pp. 17–57, 1987.

[72] P. Ehn, E. M. Nilsson, and R. Topgaard, *Making Futures: Marginal Notes on Innovation, Design, and Democracy*. The MIT Press, 2014.

[73] H. Ekbia and B. Nardi, "Social inequality and hci: The view from political economy," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 2016, pp. 4997–5002.

[74] C. Ellis, T. E. Adams, and A. P. Bochner, "Autoethnography: an overview," *Historical Social Research/Historische Sozialforschung*, pp. 273–290, 2011.

[75] N. Ensmenger, ""Beards, sandals, and other signs of rugged individualism": Masculine culture within the computing professions," *Osiris*, vol. 30, no. 1, pp. 38–65, 2015.

[76] C. Ess, "The political computer: Democracy, CMC, and Habermas," *Philosophical perspectives on computer-mediated communication*, pp. 197–230, 1996.

[77] A. W. Fisher, *The Play in the System: The Art of Parasitical Resistance*. Duke University Press, 2020.

[78] D. Fitton, J. C. Read, and J. Dempsey, "Exploring children's designs for maker technologies," in *Proceedings of the 14th International Conference on Interaction Design and Children*. ACM, 2015, pp. 379–382.

[79] M. Flintham, C. Karner, K. Bachour, H. Creswick, N. Gupta, and S. Moran, "Falling for fake news: investigating the consumption of news via social media," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 2018, p. 376.

[80] S. Follmer, D. Carr, E. Lovell, and H. Ishii, "CopyCAD: Remixing physical objects with copy and paste from the real world," in *Adjunct Proceedings of the 23Nd Annual ACM Symposium on User Interface Software and Technology*, ser. UIST '10. New York, NY, USA: ACM, 2010, pp. 381–382. [Online]. Available: http://doi.acm.org/10.1145/1866218.1866230

[81] S. Fox, R. R. Ulgado, and D. Rosner, "Hacking culture, not devices: Access and recognition in feminist hackerspaces," in *Proceedings of the 18th ACM conference on Computer supported cooperative work & social computing*. ACM, 2015, pp. 56–68.

[82] G. Freeman, N. McNeese, J. Bardzell, and S. Bardzell, ""pro-amateur"-driven technological innovation: Participation and challenges in indie game development," *Proc. ACM Hum.-Comput. Interact.*, vol. 4, no. GROUP, Jan. 2020. [Online]. Available: https://doi.org/10.1145/3375184

[83] B. Friedman, P. Kahn, and A. Borning, "Value sensitive design: Theory and methods," *University of Washington technical report*, no. 02–12, 2002.

[84] C. Garvey, "AI risk mitigation through democratic governance: Introducing the 7-dimensional ai risk horizon," in *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society*. ACM, 2018, pp. 366–367.

[85] ——, "A framework for evaluating barriers to the democratization of artificial intelligence," in *Thirty-Second AAAI Conference on Artificial Intelligence*, 2018.

[86] D. Gauntlett, *Making is connecting*. John Wiley & Sons, 2013.

[87] N. Gershenfeld, *Fab: the coming revolution on your desktop–from personal computers to personal fabrication*. Basic Books, 2008.

[88] N. Gershenfeld, A. Gershenfeld, and J. Cutcher-Gershenfeld, "Designing reality," 2017.

[89] C. Gleason, P. Carrington, L. B. Chilton, B. M. Gorman, H. Kacorri, A. Monroy-Hernández, M. R. Morris, G. W. Tigwell, and S. Wu, "Addressing the accessibility of social media," in *Conference Companion Publication of the 2019 on Computer Supported Cooperative Work and Social Computing*, 2019, pp. 474–479.

[90] K. N. Gollihue, "Re-making the makerspace: Body, power, and identity in critical making practices," *Computers and Composition*, 2019.

[91] D. Green and D. Kirk, "Open design, inclusivity and the intersections of making," in *Proceedings of the 2018 Designing Interactive Systems Conference*. ACM, 2018, pp. 173–186.

[92] J. Habermas, T. McCarthy, and T. McCarthy, *The theory of communicative action*. SciELO Brasil, 1984, vol. 1.

[93] S. Harrison, D. Tatar, and P. Sengers, "The three paradigms of HCI," in *alt.chi '07*, 2007.

[94] B. Hartmann, S. Doorley, and S. R. Klemmer, "Hacking, mashing, gluing: Understanding opportunistic design," *IEEE Pervasive Computing*, vol. 7, no. 3, 2008.

[95] P. Hawthorn and D. Ashbrook, "Cyborg pride: Self-design in e-nable," in *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, 2017, pp. 422–426.

[96] G. Hertz, *Critical making*. Telharmonium Press, 2012.

[97] P.-A. Hillgren, A. Seravalli, and A. Emilson, "Prototyping and infrastructuring in design for social innovation," *CoDesign*, vol. 7, no. 3-4, pp. 169–183, 2011.

[98] M. Hlubinka, D. Dougherty, P. Thomas, S. Chang, S. Hoefer, I. Alexander, and D. McGuire, "Makerspace Playbook: School Edition," *Retrieved from Maker Media website: http://makerspace.com/wpcontent/uploads/2013/02/MakerspacePlaybook-Feb2013. pdf*, 2013.

[99] M. Hofmann, J. Burke, J. Pearlman, G. Fiedler, A. Hess, J. Schull, S. E. Hudson, and J. Mankoff, "Clinical and maker perspectives on the design of assistive technology with rapid prototyping technologies," in *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, 2016, pp. 251–256.

[100] G. H. Hofstede and G. Hofstede, *Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations*. SAGE, 2001.

[101] N. Holbert, "Bots for tots: Building inclusive makerspaces by leveraging ways of knowing," in *Proceedings of the The 15th International Conference on Interaction Design and Children*. ACM, 2016, pp. 79–88.

[102] A. Hope, C. D'Ignazio, J. Hoy, R. Michelson, J. Roberts, K. Krontiris, and E. Zuckerman, "Hackathons as participatory design: Iterating feminist utopias," in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, ser. CHI '19. New York, NY, USA: Association for Computing Machinery, 2019, p. 1â14. [Online]. Available: https://doi.org/10.1145/3290605.3300291

[103] L. Houston, S. J. Jackson, D. K. Rosner, S. I. Ahmed, M. Young, and L. Kang, "Values in repair," in *Proceedings of the 2016 CHI conference on human factors in computing systems*. ACM, 2016, pp. 1403–1414.

[104] N. Hudson, C. Alcock, and P. K. Chilana, "Understanding newcomers to 3D printing: Motivations, workflows, and barriers of casual makers," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 384–396.

[105] J. S. Hui and E. M. Gerber, "Developing makerspaces as sites of entrepreneurship," in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, ser. CSCW '17. New York, NY, USA: Association for Computing Machinery, 2017, pp. 2023–2038.

[106] A. Hurst and J. Tobias, "Empowering individuals with do-it-yourself assistive technology," in *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility*. ACM, 2011, pp. 11–18.

[107] M. Jack and S. J. Jackson, "Logistics as care and control: An investigation into the UNICEF supply division," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 2209–2219.

[108] S. J. Jackson and L. Kang, "Breakdown, obsolescence and reuse: HCI and the art of repair," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2014, pp. 449–458.

[109] H. Jenkins and D. Thorburn, "Introduction: The digital revolution, the informed citizen, and the culture of democracy," *Democracy and new media*, vol. 1, p. 17, 2003.

[110] T. Jenkins, C. A. Le Dantec, C. Disalvo, T. Lodato, and M. Asad, "Object-oriented publics," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 827–839.

[111] G. Johnson, "The situated self and utopian thinking," *Hypatia*, vol. 17, no. 3, pp. 20–44, 2002.

[112] Z. Jordan, J. A. Nocera, A. Peters, S. Dray, and S. Kimani, "A living hci curriculum," in *Proceedings of the First African Conference on Human Computer Interaction*, 2016, pp. 229–232.

[113] Y. Kafai, D. Fields, and K. Searle, "Electronic textiles as disruptive designs: Supporting and challenging maker activities in schools," *Harvard Educational Review*, vol. 84, no. 4, pp. 532–556, 2014.

[114] Y. B. Kafai and K. A. Peppler, "Transparency reconsidered: Creative, critical, and connected making with e-textiles," *DIY citizenship: Critical making and social media*, p. 179, 2014.

[115] S. Kuznetsov and E. Paulos, "Rise of the expert amateur: DIY projects, communities, and cultures," in *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries*. ACM, 2010, pp. 295–304.

[116] J. Lang, "Understanding normative theories of architecture: The potential role of the behavioral sciences," *Environment and behavior*, vol. 20, no. 5, pp. 601–632, 1988.

[117] I. Larsen-Ledet, N. A. Bressa, and J. Vermeulen, "Reflections on teaching a mandatory hci course to computer science undergraduates," in *The 2019 EduCHI Symposium on HCI Teaching and Learning*, 2019.

[118] H. T. Le, G. Boynton, Y. Mejova, Z. Shafiq, and P. Srinivasan, "Revisiting the American voter on Twitter," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 2017, pp. 4507–4519.

[119] C. A. Le Dantec, J. E. Christensen, M. Bailey, R. G. Farrell, J. B. Ellis, C. M. Danis, W. A. Kellogg, and W. K. Edwards, "A tale of two publics: Democratizing design at the margins," in *Proceedings of the 8th ACM Conference on Designing Interactive Systems*, ser. DIS '10. New York, NY, USA: Association for Computing Machinery, 2010, pp. 11–20.

[120] R. Leitão, "Anticipating smart home security and privacy threats with survivors of intimate partner abuse," in *Proceedings of the 2019 on Designing Interactive Systems Conference*. ACM, 2019, pp. 527–539.

[121] R. Levitas, *Utopia as method: The imaginary reconstitution of society*. Springer, 2013.

[122] C. E. Lindblom, *The policy-making process*. Prentice-Hall, 1968.

[123] S. Lindtner, S. Bardzell, and J. Bardzell, "Reconstituting the utopian vision of making: HCI after technosolutionism," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 1390–1402.

[124] ——, "Design and intervention in the age of "no alternative"," *Proc. ACM Hum.-Comput. Interact.*, vol. 2, no. CSCW, Nov. 2018.

[125] S. Lindtner, G. D. Hertz, and P. Dourish, "Emerging sites of HCI innovation: hackerspaces, hardware startups & incubators," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2014, pp. 439–448.

[126] S. Lindtner and C. Lin, "Making and its promises," *CoDesign*, vol. 13, no. 2, pp. 70–82, 2017.

[127] J. Lingel, "The poetics of socio-technical space: Evaluating the internet of things through craft," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 815–826.

[128] T. J. Lodato and C. DiSalvo, "Issue-oriented hackathons as material participation," *New Media & Society*, vol. 18, no. 4, pp. 539–557, 2016.

[129] A. Lucero, "Living without a mobile phone: an autoethnography," in *Proceedings of the 2018 Designing Interactive Systems Conference*. ACM, 2018, pp. 765–776.

[130] J. J. Mansbridge, *Beyond self-interest*. University of Chicago Press, 1990.

[131] A. Marshall and J. Rode, "Deconstructing sociotechnical identity in maker cultures," in *Proceedings of the 4th Conference on Gender & IT*. ACM, 2018, pp. 91–100.

[132] J. N. Matias and M. Mou, "CivilServant: Community-led experiments in platform governance," in *Proceedings of the 2018 CHI conference on human factors in computing systems*. ACM, 2018, p. 9.

[133] J. McCrae, N. Umetani, and K. Singh, "FlatFitFab: Interactive modeling with planar sections," in *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology*, ser. UIST '14. New York, NY, USA: ACM, 2014, pp. 13–22.

[134] E. McKenna, *The task of utopia: A pragmatist and feminist perspective*. Rowman & Littlefield Publishers, 2001.

[135] C. McLaren, "Making makers: An interview with Dale Dougherty," Mar 2017. [Online]. Available: https://www.guggenheim.org/blogs/lablog/making-makers-an-interview-with-dale-dougherty

[136] J. L. Meissner, J. Vines, J. McLaughlin, T. Nappey, J. Maksimova, and P. Wright, "Do-it-yourself empowerment as experienced by novice makers with disabilities," in *Proceedings of the 2017 Conference on Designing Interactive Systems*. ACM, 2017, pp. 1053–1065.

[137] S. Milkes Espinosa, S. McDonald, and B. S. Olgado, "Tweetheads: An exploratory analysis of twitter use by heads of state across the democracy index," in *Conference Companion Publication of the 2019 on Computer Supported Cooperative Work and Social Computing*. ACM, 2019, pp. 304–308.

[138] E. Morozov, *To save everything, click here: The folly of technological solutionism*. Public Affairs, 2013.

[139] S. Mueller, S. Im, S. Gurevich, A. Teibrich, L. Pfisterer, F. Guimbretière, and P. Baudisch, "Wireprint: 3D printed previews for fast prototyping," in *Proceedings of the 27th annual ACM symposium on User interface software and technology*. ACM, 2014, pp. 273–280.

[140] M. J. Muller, "Participatory design: the third space in HCI," in *The human-computer interaction handbook*. CRC press, 2007, pp. 1087–1108.

[141] G. Nathan, "Social freedom in a multicultural state: A normative theory of the politics of multicultural integration," Ph.D. dissertation, 2009-01-01. [Online]. Available: http://search.proquest.com/docview/1373249932/

[142] M. Nelimarkka, "A review of research on participation in democratic decision-making presented at sigchi conferences. toward an improved trading zone between political science and hci," *Proc. ACM Hum.-Comput. Interact.*, vol. 3, no. CSCW, Nov. 2019.

[143] M. Nelimarkka, J. P. Rancy, J. Grygiel, and B. Semaan, "(re)design to mitigate political polarization: Reflecting habermas' ideal communication

space in the united states of america and finland," *Proc. ACM Hum.-Comput. Interact.*, vol. 3, no. CSCW, Nov. 2019. [Online]. Available: https://doi.org/10.1145/3359243

[144] C. Neustaedter and P. Sengers, "Autobiographical design in HCI research: Designing and learning through use-it-yourself," in *Proceedings of the Designing Interactive Systems Conference*, ser. DIS '12. New York, NY, USA: ACM, 2012, pp. 514–523.

[145] E. M. Noam, "Why the internet is bad for democracy," *Communications of the ACM*, vol. 48, no. 10, pp. 57–58, 2005.

[146] D. Norman, *The design of everyday things: Revised and expanded edition*. Basic books, 2013.

[147] I. F. Ogbonnaya-Ogburu, A. D. Smith, A. To, and K. Toyama, "Critical race theory for hci," in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 2020, pp. 1–16.

[148] J. Okerlund, M. Dunaway, C. Latulipe, D. Wilson, and E. Paulos, "Statement making: A maker fashion show foregrounding feminism, gender, and transdisciplinarity," in *Proceedings of the 2018 Designing Interactive Systems Conference*. ACM, 2018, pp. 187–199.

[149] J. Okerlund, M. Dunaway, C. Roenigk, and D. Wilson, "Towards a design space of short-session making workshops for middle school-aged students," in *International Symposium on Academic Makerspaces*, 2018.

[150] J. Okerlund and D. Wilson, "DIY assistive technology for others: Considering social impacts and opportunities to leverage HCI techniques," in *Proceedings of FabLearn 2019*. ACM, 2019, pp. 152–155.

[151] J. Okerlund, D. Wilson, and C. Latulipe, "A feminist utopian perspective on the practice and promise of making," in *CHI Conference on Human Factors in Computing Systems (CHI '21), May 8–13, 2021, Yokohama, Japan*, ser. CHI '21. New York, NY, USA: ACM, 2021. [Online]. Available: http://doi.acm.org/10.1145/3411764.3445126

[152] J. Pal, "CHI4Good or Good4CHI," in *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, 2017, pp. 709–721.

[153] ——, "The fallacy of good: marginalized populations as design motivation," *interactions*, vol. 24, no. 5, pp. 65–67, 2017.

[154] J. Parry-Hill, P. C. Shih, J. Mankoff, and D. Ashbrook, "Understanding volunteer at fabricators: opportunities and challenges in DIY-AT for others in e-NABLE," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 2017, pp. 6184–6194.

[155] E. Paulos, T. Jenkins, A. Joki, and P. Vora, "Objects of wonderment," in *Proceedings of the 7th ACM conference on Designing interactive systems*. ACM, 2008, pp. 350–359.

[156] H. Peng, R. Wu, S. Marschner, and F. Guimbretière, "On-the-fly print: Incremental printing while modelling," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, ser. CHI '16. New York, NY, USA: ACM, 2016, pp. 887–896.

[157] K. Philip, L. Irani, and P. Dourish, "Postcolonial computing: A tactical survey," *Science, Technology, & Human Values*, vol. 37, no. 1, pp. 3–29, 2012.

[158] J. Prusa, "From design to mass 3d printing of medical shields in three days," Mar 2020. [Online]. Available: https://blog.prusaprinters.org/from-design-to-mass-3d-printing-of-medical-shields-in-three-days_32578/

[159] M. Resnick, M. Flanagan, C. Kelleher, M. MacLaurin, Y. Ohshima, K. Perlin, and R. Torres, "Growing up programming: democratizing the creation of dynamic, interactive media," in *CHI'09 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2009, pp. 3293–3296.

[160] H. W. Rittel and M. M. Webber, "Dilemmas in a general theory of planning," *Policy sciences*, vol. 4, no. 2, pp. 155–169, 1973.

[161] J. A. Rode, "Reflexivity in digital anthropology," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2011, pp. 123–132.

[162] J. A. Rode and E. S. Poole, "Putting the gender back in digital housekeeping," in *Proceedings of the 4th Conference on Gender & IT*. ACM, 2018, pp. 79–90.

[163] D. Roedl, S. Bardzell, and J. Bardzell, "Sustainable making? balancing optimism and criticism in HCI discourse," *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 22, no. 3, p. 15, 2015.

[164] Y. Rogers, H. Sharp, and J. Preece, *Interaction design: beyond human-computer interaction*. John Wiley & Sons, 2011.

[165] D. Rosner and J. Bean, "Learning from ikea hacking: i'm not one to decoupage a tabletop and call it a day." in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2009, pp. 419–422.

[166] A. Salovaara, A. Oulasvirta, and G. Jacucci, "Evaluation of prototypes and the problem of possible futures," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 2017, pp. 2064–2077.

[167] G. Saul, M. Lau, J. Mitani, and T. Igarashi, "Sketchchair: An all-in-one chair design system for end users," in *Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction*, ser. TEI '11. New York, NY, USA: ACM, 2011, pp. 73–80.

[168] V. Savage, R. Schmidt, T. Grossman, G. Fitzmaurice, and B. Hartmann, "A series of tubes: adding interactivity to 3D prints using internal pipes," in *Proceedings of the 27th annual ACM symposium on User interface software and technology*. ACM, 2014, pp. 3–12.

[169] H. Schneider, M. Eiband, D. Ullrich, and A. Butz, "Empowerment in HCI - a survey and framework," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ser. CHI '18. New York, NY, USA: ACM, 2018, pp. 244:1–244:14.

[170] D. Schuler, "Can technology support democracy?" *Digital Government: Research and Practice*, vol. 1, no. 1, pp. 1–14, 2020.

[171] B. Shneiderman, *Designing the User Interface*, 1st ed. New York: Addison Wesley, 1987.

[172] J. Stark, F. Anderson, G. Fitzmaurice, and S. Somanath, *MakeAware: Designing to Support Situation Awareness in Makerspaces*. New York, NY, USA: Association for Computing Machinery, 2020, pp. 1005–1016.

[173] A. Stornaiuolo and T. P. Nichols, "Making publics: mobilizing audiences in high school makerspaces," *Teachers College Record*, vol. 120, no. 8, 2018.

[174] T. J. Tanenbaum, A. M. Williams, A. Desjardins, and K. Tanenbaum, "Democratizing technology: pleasure, utility and expressiveness in DIY and maker practice," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2013, pp. 2603–2612.

[175] Y. Tao, J. Gu, B. An, T. Cheng, X. Chen, X. Zhang, W. Zhao, Y. Do, T. Zhang, and L. Yao, "Demonstrating thermorph: Democratizing 4d printing of self-folding materials and interfaces," in *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 2018, p. D405.

[176] A. S. Taylor, "Out there," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI '11. New York, NY, USA: Association for Computing Machinery, 2011, pp. 685–694.

[177] A. S. Taylor and L. Swan, "Artful systems in the home," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM, 2005, pp. 641–650.

[178] S. Thanapornsangsuth, "Using human-centered design and social inventions to find the purposes in making," in *Proceedings of the 6th Annual Conference on Creativity and Fabrication in Education*. ACM, 2016, pp. 17–25.

[179] P. Tolmie, J. Pycock, T. Diggins, A. MacLean, and A. Karsenty, "Unremarkable computing," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM, 2002, pp. 399–406.

[180] A. L. Toombs, "Hackerspace tropes, identities, and community values," in *Proceedings of the 2017 Conference on Designing Interactive Systems*. ACM, 2017, pp. 1079–1091.

[181] A. L. Toombs, S. Bardzell, and J. Bardzell, "The proper care and feeding of hackerspaces: Care ethics and cultures of making," in *Proceedings of the 33rd annual ACM conference on human factors in computing systems*. ACM, 2015, pp. 629–638.

[182] S. Toupin, "Feminist hackerspaces: The synthesis of feminist and hacker cultures," *Journal of Peer Production*, vol. 4, 2014.

[183] M. Tucker, *Out there: Marginalization and contemporary cultures*. MIT Press, 1990, vol. 4.

[184] J. Van Dijk, "Digital democracy: Vision and reality," *Public administration in the information age: Revisited*, vol. 19, p. 49, 2012.

[185] J. A. Van Dijk, "Digital divide research, achievements and shortcomings," *Poetics*, vol. 34, no. 4-5, pp. 221–235, 2006.

[186] S. Viller, P. Worthy, M. Bodén, J. Weigel, G. Fitzpatrick, T. Rodden, and B. Matthews, "IoT: Designing for human values," in *Proceedings of the 2016 ACM Conference Companion Publication on Designing Interactive Systems*. ACM, 2016, pp. 61–64.

[187] E. von Hippel, "Democratizing innovation: Users take center stage," 2005.

[188] R. H. Weber, "Internet of things–new security and privacy challenges," *Computer law & security review*, vol. 26, no. 1, pp. 23–30, 2010.

[189] T. Whelan, "We are not all makers: The paradox of plurality in the maker movement," in *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, 2018, pp. 75–80.

[190] L. Winner, "Do artifacts have politics?" *Daedalus*, pp. 121–136, 1980.

[191] M. Wynn, K. Tillotson, R. Kao, A. Calderon, A. Murillo, J. Camargo, R. Mantilla, B. Rangel, A. A. Cardenas, and S. Rueda, "Sexual intimacy in the age of smart devices: Are we practicing safe ioT?" in *Proceedings of the 2017 Workshop on Internet of Things Security and Privacy*. ACM, 2017, pp. 25–30.

[192] J. Zimmerman, J. Forlizzi, and S. Evenson, "Research through design as a method for interaction design research in HCI," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM, 2007, pp. 493–502.

[193] S. Zuboff, "Big other: surveillance capitalism and the prospects of an information civilization," *Journal of Information Technology*, vol. 30, no. 1, pp. 75–89, 2015.

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