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Noticing and Enacting Equity Across Design Sites of Knowledge

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Abstract

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Our commitments influence the narratives we center, the technologies we design, and the knowledge we create. Yet, little scholarship exists that documents the lived experience of enacting our commitments in practice. I propose that there is a unique opportunity to explore how individuals notice how they enact equity in their everyday. In doing so, I build on the theory that social change can be achieved by individual people making contributions toward larger equity movements. In this dissertation, I ask: *How might we conduct research projects across sites of knowledge that both generate localized knowledge and center equity? And What does the process of documenting the development of an equity praxis across sites of knowledge uncover?* To answer my first research question, I weave together three projects where I produced scholarly contributions to HCI education (Site 1), learning sciences (Site 2), and computing education (Site 3). Collectively, these three sites make visible the critical implications of what it means for people to notice their actions and how those actions contribute to the collective movement of creating equitable spaces. To answer my second research question, I document my process to reflexively develop my equity praxis that was informed by theory, iteratively developed, and grounded by my research sites. My dissertation offers an expansive view of noticing and enacting equity that deepens our understanding of the multiplicity in approaches and the propagation of our actions to enact social change across sites. I argue that naming an equity praxis transforms the researcher as well as their relations with others; a process of action and reflection of agentic people upon their world to transform it toward creating equitable futures.

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1 Chapter 1. Introduction

Equity efforts are participatory efforts. Equity efforts are important because different people need different things to succeed in different contexts. Recently, issues of equity have been brought to the forefront of conversations and scholarly efforts due to grassroots and social justice movements led by Black women. This evidenced by movements such as Black Lives Matter, by activists addressing the digital divide during COVID-19, and students leading DEI initiatives in higher education. In turn, heightened attention to issues of equity have led to many engaging in conversations about racial injustice, police brutality, and the inequities brown and black youth face every day. Black women scholars have long conducted intersectional research and led social justice moments to rectify social injustices around the globe (Rankin & Thomas, 2019). While these efforts may not result in endless scholarly publications, their work has made immeasurable positive impacts to people's lives, much more than an academic paper could make.

Equity is also a wicked problem to disentangle (Buchanan, 1992). That is, there is no right answer to doing equity and there is more than one way to approach creating equitable futures. There exist numerous researchers who explore issues of equity in design, education, and HCI through their scholarship and who each take different approaches to tackling equity. For example, Dr. Harrington and colleagues highlight key areas of tensions and considerations toward more equitable participatory design engagements that center local community needs (C. N. Harrington et al., 2019). Dr. Vossoughi et al. argue that the ways we conceptualize making and equity can restrict or expand who is involved in the growing maker movement and who will benefit from it (Vossoughi et al., 2016). Drs. Katz and Gonzalez explore digital and social equity to understand how increased technology access can mitigate social disparities (Katz & Gonzalez, 2016). Within the space of scholars focused on equity, some propose design and curriculum recommendations (Fields et al., 2017; C. N. Harrington et al., 2019), others focus on theorizing equity for education (Bang et al., 2016; Vossoughi et al., 2016), while others invest into proposing policy implications toward systems-level equity changes (Bishop & Noguera, 2019; Kim & Sunderman, 2005).

While existing approaches to tackling issues of equity are valid and help move the needle on addressing issues of equity within STEM, I focus on how individuals enact their commitment to

equity. Little scholarship exists which foregrounds the lived experience of doing equity, that names the challenges and tensions of upholding equity commitments in practice, and that illustrates what doing equity looks like while leading research projects. I chose to study equity in terms of the individual commitments we make about equity and how we enact those commitments through our everyday actions. Through this dissertation, I propose that there is a unique opportunity to explore closely how we as individuals notice the ways in which we promote equity while going about our everyday professional work. In doing so, I build on the theory that social change can be achieved by individual people making contributions toward larger equity movements. I argue that doing equity means individuals taking actions every day while situated in communities to provide others with the resources necessary to thrive.

Given the explosion of knowledge contributions around issues of equity in multiple research communities, it is important to look for themes across projects and extract common threads to collectively move forward equity-oriented projects. As equity conversations permeate our everyday lives, we might ask: *How do we notice equity in moment-to-moment interactions? How do we enact an equity commitment through our actions? How might we share our equity-oriented approaches to inform others' practice?* We know that researcher philosophies influence the commitments made in scholarly efforts which in turn influence the underlying tenets in projects. Yet often these commitments or core tenets are not articulated in our research efforts or publications. The intersection of equity-oriented goals and localized knowledge generation across projects makes it challenging to notice, trace, and name tenets of equity-oriented projects.

One way to address this challenge is for individuals committed to equity to systematically look across their past projects that are situated in different contexts and describe the tenets that undergird these projects. By articulating the tenets in advance, new knowledge can be generated through engagements in the field and the tenets can be iterated on. Looking across my past research projects and connecting to future projects, in this dissertation I ask: **RQ1:** *How might we conduct research projects across sites of knowledge that both generate localized knowledge and center equity?* And **RQ2:** *What does the process of documenting the development of an equity praxis across sites of knowledge uncover?*

To notice equity across sites of knowledge, I organize this dissertation into two parts. The first part makes scholarly contributions across three sites where I led research investigations on:

- Site 1: Scaffolding design students to notice during their engagements with end-users in a master's level human computer interaction course.
- Site 2: Elevating the funds of knowledge that bilingual adults and children leverage in the home when collaboratively searching for information online.
- Site: 3: Supporting a teen-led computing education program through a design partnership model that actively centers youth of color in the creation of learning experiences within their own communities.

I simultaneously led these investigations on topics of HCI education (Site 1), information search (Site 2), and computing education (Site 3) while advancing the development of my equity praxis.

The second part of this dissertation details the process through which I named my equity commitments and how I noticed my enactments on those commitments in action. In documenting the twelve-month process to develop my equity praxis I make contributions toward:

- Naming an equity praxis as transformation of the researcher as well as their relations with others; action and reflection of agentic people upon their world to transform it.
- Pushing the boundaries of how we legitimize scholarship in academia that documents a researcher's commitments and their process of taking up those commitments in action.
- Supporting individuals to engage in critical reflexivity to intentionally notice how they are enacting equity or furthering perpetuating inequities through their everyday actions.

1.1 Research Questions

The goals of this dissertation are two-fold, to contribute empirical scholarship to the communities of HCI education, learning sciences, and computing education while also distilling the process of developing my equity-oriented approach in design. Specifically, this dissertation asks two key research questions:

RQ1. How might we conduct research projects across sites of knowledge that both generate localized knowledge *and* center equity?

RQ2. What does the process of documenting the development of an equity praxis across sites of knowledge uncover?

I explore these two central questions by taking the reader on a journey of how I positioned myself to lead multiple projects where I centered equity, how I learned to notice equity for myself, and how I shared my process with others to notice equity in their own lives. To answer my first research question, I weave together three projects that I engaged in as a researcher with an equity lens while producing scholarly contributions to the research communities of HCI education (Site 1), learning sciences (Site 2), and computing education (Site 3). For each site, I share local knowledge contributions and I detail how those projects simultaneously informed the development of my equity praxis by drawing connections between my positionality, my tenets, and my sites of knowledge approach. To answer my second research question, I document how I developed my equity praxis over twelve months by naming my commitments, enacting them in the field, noticing the work of acting on the commitments, and iteratively developing them. I close the dissertation by reflecting on what my process to develop my equity praxis can mean for other designers, researchers, and educators who care deeply about making the world a better place through their individual actions and commitments.

Together, the three sites show my process of noticing people's invisible knowledge and elevating the ways in which people figure things out in the face of inequities. The combinations of the three studies I present also propose a novel approach to interdisciplinarity – tying together theories from multiple disciplines each with their own epistemological stance through the lens of equity. All three sites have a design component where I aimed to transform the world around me and to be transformed by the ideas that were intergenerationally and collaboratively generated.

Collectively, these studies make visible the critical implications of what it means for people to notice their actions, the consequences of their actions, and how those actions contribute to the collective movement of creating equitable spaces in engineering, computing, and design. This is

important because scholars, policy makers, and educators are constantly proposing ways to bring in more diverse perspectives while activists and students raise concerns about how unwelcoming and uncomfortable STEM spaces can be. The process to document my equity praxis opens new pathways for researchers and designers to intentionally reflect on how they are enacting their commitments in the kinds of scholarship they publish and technologies they create. This dissertation aims to move beyond saying words about equity to demonstrating action on equity. Through my equity praxis process, I demonstrate the value of taking a critical, self-reflective stance on how equity shows up in our everyday. I suggest: *What if we all took on the responsibility of being a more intentional about paying attention to the micro-moments we have with one another, about reflecting on how we are acting in accordance with our commitments that we name, and about putting forth an effort to take actions every day that move forward equity movements?* I propose the insights from this dissertation can provide a path for people wanting to bring equity into their everyday work through a self-reflective, ongoing approach.

My dissertation aims to contribute toward designing equitable experiences for people such that they can contribute to theory building through their stories that are “*just big enough to gather up the complexities and keep the edges open*” (Haraway, 2016). In this dissertation, I evidence the power of participatory design and technology design to support the inclusion of voices from students with non-dominant backgrounds (Pinkard et al., 2017). hooks contends that theory that is developed from concrete, lived experiences is what makes “*feminist transformations possible*” (Hooks, 2014). Unpacking the significance of developing theory from lived experience reveals the centrality of noticing and amplifying invisible knowledge. Through this dissertation, I generate research findings about localized knowledge across sites and advanced human centered design approaches toward noticing equity.

1.2 Dissertation Contributions

My dissertation offers three types of contributions to a range of scholarly communities: empirical, theoretical, and methodological.

- Theoretically, through Site 1 in Chapter 4, I extend the concept of noticing for HCI as encompassing the ways in which designers observe important details of users' feedback and body language, interpret user input, and dynamically adapt during user sessions.
- Empirically, through Site 2 in Chapter 5, I demonstrate how adults and children draw on their funds of knowledge when searching collaboratively, with and for their family members to build their collective knowledge of technology and problem solving.
- Methodologically, through Site 3 in Chapter 6, I contribute a novel approach for the computing education community in which youth are positioned as design partners toward reimagining computing education experiences that center community members.
- Theoretically, in Chapter 7, by looking across my sites, I distill tenets of an equity praxis to notice how they enact equity commitments through our actions.
- Methodologically, in Chapter 7, by sharing my equity praxis, I demonstrate a process through which others can document, trace, and reflect on their own commitments.

1.3 Key Terms

In this section, I elaborate on what I mean by the key terms used throughout the dissertation: noticing, equity, sites of knowledge, tenets, and praxis.

1.3.1 Noticing

I leverage the concept of noticing from teacher education (Sherin et al., 2011) to think about the ways in which we attend to micro-moments in our busy, everyday environments. In teacher education, the iterative process of noticing can be described in three steps. In situ teachers are bombarded with sensory details in the classroom; next, they attend to elements of the sensory overload, take a noticed thing, interpret it, make sense of it, and finally take action based on the noticed thing (Sherin et al., 2011). The notion of noticing can also be extended to the ways in which athletes take in multiple sensory inputs during a game or a match and make split second decision about how to respond in the moment. Noticing occurs in the moment and is something that takes practice over time to recognize, react, and act on complex stimuli automatically.

To me, noticing has to do with recognizing the value of a word, a gesture, or any micro-moment to enact a commitment to equity. I see my own journey of learning to notice equity in complex

situations as iterative and ongoing. Noticing equity requires scaffolds to know what to look for, to trust your intuition of what feels like an equity situation, and to act in the situation.

1.3.2 Equity

I draw on my extensive research experience and lived experience to argue that equity is not about offering the same thing to everyone. Equity starts by foregrounding the historical injustices that exist in the lives of youth that have been marginalized. Ultimately, equity is about people having control of their own resources and assets to design their own futures.

(Nasir et al., 2006) write that equity is “*about enabling youth to appropriate the repertoires they need in order to live the richest life possible and reach their full academic potential.*” Similarly, (Vossoughi et al., 2016) proposed that equity-oriented design and research, “*must begin with a clear analysis of educational injustices and how they shape the lived experiences ... of young people and their communities*” (pg. 215). I build on this body of work to argue that equity is not just about supporting an individual's needs but elevating peoples’ assets through a design approach that foregrounds the invisible knowledge they hold culturally and historically.

Equity has to do with promoting justice through the procedures, processes, and distribution of resources by institutions. My research recognizes that tackling equity issues requires an understanding of the root causes of outcome disparities within our society. Everyone requires unique support to thrive in schools, informal learning settings, and workplaces. Equity recognizes that everyone comes from a different place, holds different identities, has different needs and assets, and as such requires actions that support individual needs. A drive to develop, notice, and enact a praxis of equity across sites of knowledge guides my dissertation.

1.3.3 Sites of Knowledge

“Multi-sitedness is more an imaginary than a specific strategy for designing ethnographic methodology. Multi-sited research involves innovative ways of bounding the potentially unbounded, but also of refusing the more usual non-ethnographic bounding of the intensively probed and usually site specific ethnographic study.” - (Marcus, 1999)

Inspired by (Vossoughi & Gutiérrez, 2014), in this dissertation I study the phenomenon of equity across “sites” to generate an expansive understanding of equity that encompasses how it shows up in everyday actions across contexts that are vastly different from one another.

Choosing multiple sites to study equity. In studying learning across contexts and borders, (Vossoughi & Gutiérrez, 2014) write that a phenomenon must be studied across activity systems to attend to the genesis of a practice. They argue, “*multi-sited sensibility aligns with and necessitates more expansive understandings of human learning, including the ways every day and scientific or school-based knowledge can be productively reorganized to deepen participation and understanding.*” Vossoughi & Gutiérrez write that through multi-sited sensibility we can understand the phenomenon by asking “*How did we get here? And where might we go?*” I translate their approach of taking an expansive view of human learning to taking an expansive view of noticing and enacting equity that deepens our understanding of the multiplicity in equity approaches and the propagation of our actions to enact social change.

Building on this line of existing research, I use the term “site” in my dissertation to describe the places where I explore my research questions and the term “sites of knowledge” to describe a place where I have the opportunity and privilege to observe how people in those places acquire facts, skills, and information through lived experience. Additionally, I see parallels between the theoretical term “funds of knowledge” (Moll et al., 1992) and my use of the term “sites of knowledge” in the shared commitment to challenge dominant discourses of people who have been pushed to the margins by elevating their skills, strengths, and resources.

Reflexively constructing sites. I see strong connections between my work and how multi-sited ethnography scholars conceptualize the idea of sites. I also see parallels to how researchers come to study multiple sites by engaging with people and artifacts. In describing multi-sited ethnography for the computer supported collaborative work community (CSCW), (Bjørn & Boulus-Rødje, 2015) write that, “*The site is not simply out there, waiting to be discovered, but instead is constructed reflexively by every choice the CSCW researcher makes.*” Additionally, in the book *Multi-Sited Ethnography: Theory, Praxis and Locality in Contemporary Research*, the

authors argue that researchers know where to move to and where to stay as their object of study and theory guides them (Falzon, 2009, p. 253).

In my dissertation, I see myself studying equity in the sites that I reflexively constructed with educators, master's students, and children in a formal academic setting (Site 1), with families, adults, and children in the home (Site 2), and with teenagers, librarians, and adults in an informal after school space (Site 3). I also gave myself flexibility to recognize the sites I wanted to move to and the sites where I chose to spend time in given the influence of my theoretical groundings (*e.g.*, funds of knowledge, critical pedagogy, feminist human computer interaction) and my intuition to notice invisible knowledge. Center to multi-sited ethnography processes is intense methodological reflection within the research process (Falzon, 2009). I evidence the rigorous methodological reflections I have done within and across each of my sites via memos, peer debriefs, and constant reflections throughout my project engagements.

Partial perspectives as insufficient. (J. Cook et al., 2009) write that “*The original idea behind multi-sited research was that the partial perspective afforded by a single research site was insufficient for understanding local phenomena such as trade and ethnic identity, because these things are part of systems that operate on a much larger – specifically, on a global – scale.*”

Likewise, I believe that studying equity in a single local site is insufficient to capture the nuanced details of how equity exists within a larger, complex system of oppression in the United States. Therefore, I refer to each of the three projects I highlight in this dissertation as “sites” where I have explored the phenomenon of equity as embedded within larger systems of inequities while individuals and communities leverage their knowledge as resilience.

1.3.4 Tenet

A tenet is a principle generally held to be true in common by members of a movement. I chose the word tenet to describe the principles that people within larger equity movements might be interested in. My tenets are elements of my praxis, of my philosophy, and my approach to equity.

In *Teaching to Transgress*, bell hooks writes that professors who embrace tenets of critical pedagogy still conduct their classrooms in a manner that only reinforces bourgeois models of

decorum (Hooks, 2014). hooks writes about the irony in which professors who teach subject matter conversations on politics of difference, race, class and gender and engage in intellectual conversations that critique domination, still maintain classroom dynamics that remain conventional. I believe bell hooks is saying that embracing and accepting the tenets of critical pedagogy is not enough, our actions must reflect the instantiation of those tenets. The tenets of my equity praxis that I describe in this work do not exist in isolation. As such, I call the naming and tracing of the tenets a praxis - a theory that I live in action.

1.3.5 Praxis

Praxis is simply about the relationship between action and reflection. A praxis is about theory and practice. In *Pedagogy of the Oppressed*, Freire writes that education is constantly remade in praxis. In order to be, it must become (Freire, 2018). Education is the process of becoming, men and women as unfinished beings in a world that is also an unfinished reality.

(Freire, 2018) writes that without reflection, we only have activism. Without action, we only have words. Unity, harmony, and organization is necessary for the oppressed to engage in the struggle for liberation. In *Teaching to Transgress*, hooks (Hooks, 2014) references Freire to argue that it is not enough for individuals to change how they think, conscientization is not the end, it must always be joined by meaningful praxis (pg. 47). Freire, as quoted by hooks (pg. 48), writes “... *praxis is not blind action, deprived of intentionality or of finality. It is action and reflection. Men and women are human beings because they are historically constituted as beings of praxis, and in the process, they have become capable of transforming the world - of giving it meaning.*” I see my dissertation as a form of documenting the ways in which I have become capable of transforming the world and of giving meaning to my lived experiences.

The equity praxis I discuss throughout this dissertation is one that I have followed, as an individual who constantly reflects on my work and my approach. In *Teaching to Transgress*, hooks writes about collective efforts when she cites Freire to argue how the liberation of one is the liberation of all. hooks writes, “*Authentic help means that all who are involved help each other mutually, growing together in the common effort to understand the reality which they seek to transform. Only through such praxis - in which those who help and those who are being*

helped help each other simultaneously- can the act of helping become free from the distortion in which the helper dominates the helped” (Freire quoted by hooks) (pg. 54).

1.4 Dissertation Overview

My dissertation is organized into eight chapters.

1.4.1 Chapter 2 – Related Work

In Chapter 2, Related Work, I described the three research foundations that I draw on to inform my research approach. I situate my work by describing how I conceptualize equity, the sociocultural lens I take on learning, and the critical pedagogy perspective that drives my work.

1.4.2 Chapter 3 – Approach

In Chapter 3, Approach, I offer details about how my participatory design approach informs how I design with others and the case study perspective I take to develop my equity tenets. I also describe the epistemology lens that informs how I see knowledge in my research, how I came to the research plan, and how my positionality shows up in my approach.

1.4.3 Chapters 4-6 – Leading Projects and Centering Equity

In Chapters 4, 5, and 6 I show three of my research sites where I both generated knowledge about a specific topic while advancing my equity praxis. For each site, I introduce the context, present a previously published research paper, and draw connections to my equity tenets.

1.4.4 Chapter 7 – Developing an Equity Praxis

In Chapter 7, I take a deep dive into my equity praxis. I describe my process over three phases to document my praxis and how I traced my tenets in action. Chapter 7 includes a visual that summarizes the key components of my praxis as tool for others to think with.

1.4.5 Chapter 8 – Closing Thoughts

In Chapter 8, I close my dissertation by reflecting on my equity praxis and my research journey.

2 Chapter 2. Related Work

I situate my work by explaining how I conceptualize equity, the sociocultural perspectives of learning that inform my thinking and framing, and the theory from critical pedagogy that drives the development of my equity praxis. I provide an overview of the related work I build on to inform how I think about equity-oriented design and research, equitable learning experiences, and envisioning equitable futures. Next, I detail the ways in which prominent scholars who identify with sociocultural perspectives of learning align with my work, how they shape my lens on learning, and how funds of knowledge as a theoretical framework foregrounds individual and communal assets in my research. Finally, I provide a brief overview of literature from critical pedagogy scholars that have informed how I see education as both oppressive and liberatory.

2.1 Conceptualizing Equity

I draw on existing literature across disciplines to conceptualize how others are talking about issues of equity and the ways in which people frame their equity-oriented work. This section is important for my dissertation because as I develop my theory of equity-oriented approaches for design I situate my work across how other scholars are framing issues of equity. Through my equity praxis in Chapter 7, I contribute to the existing research on equity by arguing that individuals (designers, researchers, educators) can take on the responsibility of noticing how moment to moment interactions have a profound effect on contributing toward equity or inequities in the learning spaces we are a part of.

I conceptualize equitable learning environments as co-created with people. My research contributes to the co-creation of learning spaces where everyone has the support and tools to learn, make, and envision while leveraging technology. I envision environments that center conversations of race, class, and gender. I aim to create spaces that support learning as a cultural process and as places where knowledge can be shared and remixed. I seek to be a part of programs that spark and sustain youth's interest in technology, design, and engineering to support the design of a just world. I continue to refine my conceptualization of equity through the development of my tenets.

When discussing equity in research processes, Vossoughi et al. write that an equity-oriented design and research approach “*must begin with a clear analysis of educational injustices and how they shape the lived experiences and pedagogical needs of young people and their communities*” (Vossoughi et al., 2016). Nasir et al. discuss equity in the context of facilitating learning experiences stating, “*equity is not about offering or producing sameness, but about enabling youth to appropriate the repertoires they need in order to live the richest life possible and reach their full academic potential*” (Nasir et al., 2006). To distinguish equitable learning environments, scholars argue that a deep sense of social belonging is a key marker (Nasir et al., 2006; Vossoughi et al., 2016). In the context of designing health solutions for older African American adults, Harrington et al. state that equity is about considering what communities need versus just giving communities what everyone else has (C. N. Harrington et al., 2019).

Jurow and Shea write that equity efforts are ones that aim to redistribute access, resources, and power in more equitable ways within an inequitable system (Jurow & Shea, 2015). To create new forms of STEM participation for everyone we must understand diversity as an asset for human knowledge (Bang & Medin, 2010). Furthermore, we must consider broad systems of oppression (macro-level) and individual interactions (micro-level) (Esmonde & Booker, 2016).

I argue that when students, participants, and parents trust us with their story through our research methods, we must uphold the responsibility of changing the learning environment to be responsive to their lived ways of knowing. I recognize the challenge to learn about each of our students, shift our educational practices, all while teaching engineering and design content. Through a design lens, my research approach engages in the challenge of creating equitable learning environments that connect in deep ways to students’ lived experiences.

Furthermore, equitable futures involve people from marginalized communities having greater control over resources to design their own futures (Jurow & Shea, 2015). People’s self-determination and ownership of knowledge are also important outcomes (Bang & Medin, 2010). To create transformative futures, I take seriously the raced and cultured ways of learning that have been oppressive for historically underachieving groups and take everyday actions through my research to shift power toward each person’s voice being heard and their story being told.

2.2 Sociocultural Perspectives of Learning

Here, I detailed concepts from education research that includes sociocultural perspectives on learning. Sociocultural theorists see learning as cultural processes that people engage in through everyday activity within communities (Rogoff et al., 2014). Education researchers engaged in sociocultural historical approaches with children from non-dominant backgrounds explain that learning is an ongoing process that is not divided into separate characteristics of individuals and contexts (Gutiérrez & Rogoff, 2003). Therefore, my work seeks to understand the learning that occurs in intergenerational, bilingual, information problem-solving family collaborations. Through Site 2 in Chapter 5, I contribute to existing research on funds of knowledge by showing how the online search and brokering process involves the collaboration of the family's funds of knowledge to solve critical family needs. Thus, I extend our understanding of the role of learning and funds of knowledge through a collaborative, sociocultural, and sociotechnical lens.

Sociocultural scholars understand learning as a process of participation in communities of practice (Lave & Wenger, 1991). In this way, learning is a cultural process for everyone regardless of race, class, or gender (Nasir et al., 2006). When we view learning as dynamic cultural processes, we recognize that people make sense of and shape their world in different ways (Bang et al., 2016). Scholars further note that learning is as much about shifts in participation as it is about shifts in ways of thinking (Nasir & Hand, 2006). Learning takes place when people engage in practices with members of their communities just as they come to understand different phenomena in formal schooling. Bang and Medin argue that, "*the current state of knowledge about human learning and motivation has yet to adequately understand the ways in which culture is integral to learning*" (Bang & Medin, 2010, p. 7)

Importantly, sociocultural learning scholars discuss taking a cultural-historical approach when researching learning (Bang & Vossoughi, 2016). Learning cannot be divided into separate characteristics of individuals and contexts (Gutiérrez & Rogoff, 2003). Scholars argue that it is important to know about the histories and practices of cultural groups instead of trying to broadly teach unexamined generalities about groups (Bang & Medin, 2010; Ladson-Billings, 1995). A learning engagement with an individual must include consideration of the person's histories.

Funds of knowledge theoretical perspectives foreground individuals' assets, community assets, and historical assets. Funds of knowledge perspectives are informed by community cultural wealth (Yosso, 2005) which can be traced back to critical race theory in education (Matsuda, 1991). Funds of knowledge offers a framework from which to understand and leverage individuals' perspectives and experiences from an asset-based lens in education. Smith and Lucena (Smith & Lucena, 2016) use Moll et al.'s (1992) definition of funds of knowledge to refer to the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being (Moll et al., 1992).

In Moll et al., researchers drew upon the knowledge and skills found in local households. Implicitly, Smith and Lucena (2016) extend the concept of funds of knowledge beyond the home to include students' internship experiences. Smith and Lucena's (2016) research is premised on the assumption that in order for funds of knowledge to make a difference in minority students' engineering experience, they must be converted to different forms of capital (social, cultural, and financial) traditionally recognized in engineering. In my dissertation work, the use of funds of knowledge as a theoretical perspective supports understanding the breadth of youth and families' funds of knowledge developed across their participation in online search and brokering practices. It gives a lens through which we can support surfacing and acknowledging the invisible knowledge each person is leverages when searching for critical information online.

2.3 Critical Pedagogy

Critical pedagogy perspectives are grounded on notions of emancipation (Freire, 2018), values (Morrison, 2001) and culturally relevant learning (Ladson-Billings, 1995). Critical pedagogy scholars write from the tension that education can both be oppressive and liberatory (Hooks, 2014). Yosso writes about the contradictory nature of education, where schools often *"oppress and marginalize while they maintain the potential to emancipate and empower"* (Yosso, 2005). Similarly, bell hooks writes, that we must also approach education, teaching, and education research with an openness of the mind and heart that allows us to navigate the present while imagining a just future (Hooks, 2014). Holding true the emancipatory and liberatory potential of education provides a theoretical framework for this dissertation work toward developing an equity-centered approach that is localized and can be generative for others to leverage in their

contexts. As a researcher and educator in informal spaces of learning, in this dissertation I argue that we have the chance to change social structures through the learning environments we create. Through Site 3 in Chapter 6, I build on the existing literature of critical pedagogy by demonstrating the ways in which the teen led computing program was a site of transgression where we moved beyond the boundaries of what is acceptable in computing spaces.

Holding constant the belief that the classroom remains the most radical space of possibility in the academy, hooks (2014) writes to celebrate teaching that enables transgressions. To teach to transgress means to think and rethink, to create new visions, to move beyond and against the boundaries of what is acceptable. Inspired by scholars in critical pedagogy, hooks (2014) argues teachers who transgress are those that move beyond the boundaries of traditional rote learning approaches to teach in a manner that respects and cares for students.

Critical pedagogy scholars argue that we perpetuate, mimic, and mirror social interactions through our actions in the classroom. hooks writes, *“The academy is not paradise. But learning is a place where paradise can be created. The classroom, with all its limitations remains a location of possibility. In that field of possibility, we have the opportunity to labor for free, to demand of ourselves and our comrades, an openness of mind and heart that allows us to face reality even as we collectively imagine ways to move beyond boundaries, to transgress”* (Hooks, 2014, p. 207).

3 Chapter 3. Approach

Here, I describe my participatory design approach, my case study approach, my epistemological stance, how I came to study the topic of equity across sites of knowledge, and my positionality.

3.1 Participatory Design Approaches

My work builds on participatory design approaches and specifically follows the cooperative inquiry method (Druin, 1999; Yip et al., 2017) which aims to position children as design partners through a dynamic process that shifts between balanced and unbalanced with designers and other adults. In cooperative inquiry, time is segmented into four types of activities 1) snack time spent getting to know each other through snacks (or with questions virtually), 2) circle time with

everyone getting to share their name and answer the question of the day that is related to the design objectives, 3) design time spent working collaboratively to design something, and 4) share outs with each small group sharing to the larger group what they design. The cooperative inquiry method is appropriate for my work given the intergenerational co-design groups I bring together and my focus on centering the voices of children and those at the margins.

To inform my approach to running co-design sessions, I draw on aspects of feminist design in HCI to “*resist any single, totalizing, dominant, or universal point of view*” in design (Bardzell, 2010). I extend the idea of pluralist design of artifacts in HCI (Bardzell, 2010; Ogbonnaya-Ogburu et al., 2020) to pluralist designs of educational experiences. By engaging in situated research of the needs of students of color we can develop human-centered equity-oriented approaches as a “*generative integration of specific feminist perspectives in HCI and interaction design, that is, ways that feminism can support creative activity and novel problem-solving approaches*” (Bardzell, 2010). My positioning of feminist perspective for HCI as generative, and not solely as critical, opens the conversation beyond pointing out what is wrong but sets up a space for collaboration and creativity to discover alternative solutions. HCI education is well positioned to take up feminist interdisciplinary ideas for pedagogy to support the development of future designers and engineers.

I believe technology design is one way to imagine and create an alternative future. As Womack writes, “*the imagination is a tool of resistance*” (Womack, 2013, p. 24). I extend the idea of the classroom to informal learning spaces (like libraries and makerspaces) where youth develop knowledge of and envision new emergent digital technologies. Collectively imagining with research participants and by leveraging technology, I hope to transgress the ways in which we imagine equity-oriented approaches to research.

3.2 Case Study Approaches

Next, I outline my case study orientation that informs the design of my research projects and informs the cross-case analysis I conducted of my past projects to articulate the tenets of equity-oriented work in design. Yazan (Yazan, 2015) compares three of the most prominent case study methodological approaches in education as articulated by Yin, Merriam, and Stake (Merriam,

1998; Stake, 1995; Yin, 2017). Due to my epistemological commitment of seeing knowledge as co-constructed with participants and of understanding reality as multidimensional and ever changing, in my dissertation work I align the most with Merriam's (1998) orientation toward case study methodology. At times, I leverage Yin's (2017) case study approach to inform my data gathering tools and Stake (1995) approach for validating data through triangulation.

From a constructivist epistemological orientation, Merriam (1998) defines a qualitative case study as "*an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process or a social unit*" (p. xiii). Merriam (1998) articulates the three defining characteristics of a case study: particularistic (focuses on a particular situation), descriptive (offers a thick and rich description of the phenomenon under study), and heuristic (illuminates the reader's understanding of the phenomenon). In my work, these characteristics show up based on the bounded focus of my projects, the descriptive nature of the data I collect and analyze, and the orientation toward generating new insights on the phenomenon under scrutiny. I also appreciate the four defining characteristics Stake (1995) outlines of a case study: holistic (considering the relationship between phenomenon and contexts), empirical (based on data collected from the field), interpretive (focusing on the interactions between researcher and participants), and emphatic (highlighting the experiences of participants through an emic perspective). In my work, Stake's defining case study characteristics also show up through my holistic emphasis of the participants and their surroundings, based on the empirically driven evidence in my research findings, a focus on outlining how my interactions with participants inform the data collection process, and my priority to amplify the lived experiences of participants.

With respect to designing case studies, gathering and analyzing the data, and ensuring validity of the work, I align with Merriam and Stake's constructivist case study approach due Yin's positivistic orientation. In contrast to Yin (2017), I do not follow a tight and structured design for my case study method and do not prepare a detailed design at the beginning of the research. Due to my interpretivist nature, my research approach for designing a case study follows Merriam and Stake's approach where each stage of the project becomes clear as the investigation unfolds, and the problem area becomes more and more defined (Yazan, 2015). With respect to gathering

multiple sources of data to capture the case under study in its complexity and entirety, Yin's approach does inform my work due to the six types of data he suggests researchers gather: documentation, archival records, interviews, observations, participant observations, and physical artifacts. In analyzing data, I follow Merriam's (1998) orientation which argues for a simultaneous analysis of data gathering and data analyzing by writing analytical memos throughout my research. In my orientation toward gathering and analyzing data, I also align with Stake's (1995) emphasis on what skills researchers need to conduct a case study investigation, *"Knowing what leads to significant understanding, recognizing good sources of data, and consciously and unconsciously testing out the veracity of their eyes and robustness of their interpretations. It requires sensitivity and skepticism."*

As a scholar engaged in this research, I have developed an emergent capacity to notice, to question, and to synthesize key insights from the robust and rich data I collect in each case study. Merriam's (1998) approach to data analysis is the process of making sense of the data which involves consolidating, reducing, and interpreting what people say and what the researcher has seen and read. With respect to ensuring validity and reliability of the data analysis, I do not align with Yin (2017) who describes the need for tabulating and testing both qualitative and quantitative evidence to address the research question. Rather, I align with Merriam's strategies to enhance internal validity through triangulation, member checking, long-term engagement, peer examination, participatory research, and disclosure of researcher bias. I also follow techniques to ensure reliability through audit trails, triangulation and disclosing researcher positionality and to enhance external validity through thick description and multi-sited designs.

3.3 Epistemological Stance

To situate my work, I use Dr. Palen's table of empirical epistemologies for human-centered computing research (Figure 1). I follow an interpretivist line of inquiry where I build new knowledge about my contexts, not prove knowledge. Central to an interpretivist paradigm, my values are inherent in all phases of the research process. The goals of my knowledge claims are both summative and formative. My summative research questions ask "how" to understand the experiences of students (Site 1), family members (Site 2), and youth (Site 3). When my research participants were engaged in the participatory design process, this work was formative, to inform

something subsequent. My second type of research questions are formative asking “what” the perceived value was to inform future HCI course iterations (Site 1), what online search and brokering processes we can design technologies for (Site 2), and what the implications of teen-led computing programming mean for justice-centered computing education (Site 3).

EMPIRICAL FORMS OF INQUIRY		RESEARCH DESIGN COMPONENTS	
Positivist	Interpretivist	<p>Research Objective Are the broad aims to prove something within an existing area or set of knowledge, or to create a new area or set of knowledge? Which parts of this will be reported on formally? These choices determine whether the empirical research program is positivist or interpretivist.</p> <p>Research Questions (RQs) Depending on the size of the research program, there may be multiple sub-research questions under the governance of the meta-research question or objective. Individual sub-research questions might be positivist or interpretivist, and summative or formative in nature. Often interpretivist inquiry will precede positivist inquiry.</p> <p>Units of Analysis Do the bounds of observation match the scope of concern? The bounds of observation are the “units of analysis.” In interpretivist research, units of analysis can be large, but are still bounded. Do RQs, procedures, methods & participant selection match units of analysis appropriately at each stage?</p> <p>Procedures Positivist research will require an experimental apparatus that controls for variables using within- or between-subjects design and so on. Interpretivist research will require careful selection of participants in ways that match objectives, units of analysis, and methods. Procedures may vary for each sub-component of a larger research program.</p> <p>Participants Do participants need to be selected to be representative of a larger sample (this matter can be asked in both positivist or interpretivist inquiries)? Do they need to be selected to deliberately pursue understanding of a new behavior (this is more common in interpretivist/formative research)? Are they co-designers (participatory design, usually interpretivist/formative), or co-researchers (action research, which can be either positivist or interpretivist), or more classically treated as “subjects”?</p> <p>Methods The applications of methods and the use of their results can vary greatly and so therefore on their own cannot be inherently positivist or interpretivist. Methods can include: Interviews, Surveys, Participant or Non-Participant Observation, Diary Studies, Experimental Sampling Method, Eye Tracking, Field Deployments, Social Graph Analysis, Data Mining & Modeling and so on...</p>	
<p>Empirical Goals: hypothesis testing proving knowledge</p> <p>Related Terms (but not necessarily synonymous): hypothesis-driven scientific method experimental design deductive “quantitative research”</p> <p>Warning: All research, including positivist research, requires interpretation of results.</p>	<p>Empirical Goals: thesis formation building knowledge</p> <p>Related Terms (but not necessarily synonymous): data-driven ethnographic inductive “qualitative research”</p> <p>Warning: The “qualitative research” term is misleading. Data-driven research can be highly numerical.</p>	<p>Summative Research whose purpose is to explain something that is preexisting or has already occurred, without deliberate intervention (other than what the research might incur on its own simply by being conducted, as in ethnographic research)</p>	
<p>Positivist/Summative Example: How many people affected by a disaster turn to social media during the warning period of a hurricane?</p>	<p>Interpretivist/Summative Example: How do people make use of social media during the warning period of a hurricane?</p>	<p>HCC-ORIENTED GOALS</p>	
<p>Positivist/Formative Example: Did the intervention to improve warning messages change the number of users by comparing a regional sample?</p>	<p>Interpretivist/Formative Example: Are there ways to improve information access during the warning period of hurricane disasters through social media?</p>	<p>Formative Research whose purpose is to inform something subsequent, including design of artifacts, policies, procedures or more refined RQs. The aim of formative research is what drives Human-Computer Interaction commitments to iteration</p>	

Figure 1. Empirical epistemologies for human-centered computing research

My methods align with an interpretivist form of inquiry because I leverage video observations, naturalistic observations and interviews with participants to make interpretations of what I see, hear, and understand (Creswell & Poth, 2016). (Guba & Lincoln, 1994) propose four paradigms (Figure 2), which they define as the basic worldview that guide researchers in their investigations. My methods fall under constructivism given my alignment to reconstructing, understanding, and offering a more sophisticated understanding of my sites. Participatory design approaches and qualitative interviews are also methods associated with constructivism. My methods allowed for knowledge to be created in interaction between me and my participants in a dialectical manner to collaboratively construct a meaningful reality (Cohen & Crabtree, 2006). In a constructivism paradigm, I am orchestrating and facilitating the inquiry process with my participants through my methods.

TABLE 6.2 Paradigm Positions on Selected Practical Issues

<i>Issue</i>	<i>Positivism</i>	<i>Postpositivism</i>	<i>Critical Theory et al.</i>	<i>Constructivism</i>
Inquiry aim	explanation: prediction and control	critique and transformation; restitution and emancipation	understanding; reconstruction	
Nature of knowledge	verified hypotheses established as facts or laws	nonfalsified hypotheses that are probable facts or laws	structural/historical insights	individual reconstructions coalescing around consensus
Knowledge accumulation	accretion—"building clocks" adding to "edifice of knowledge"; generalizations and cause-effect linkages	historical revisionism; generalization by similarity	more informed and sophisticated reconstructions; vicarious experience	
Goodness or quality criteria	conventional benchmarks of "rigor": internal and external validity, reliability, and objectivity	historical situatedness; erosion of ignorance and action stimulus	trustworthiness and authenticity and misapprehensions;	
Values	excluded—influence denied	included—formative		
Ethics	extrinsic; tilt toward deception	intrinsic; moral tilt toward revelation	intrinsic; process tilt toward revelation; special problems	
Voice	"disinterested scientists" as informer of decision makers, policy makers, and change agents	"transformative intellectual" as advocate and activist	"passionate participant" as facilitator of multi-voice reconstruction	
Training	technical and quantitative; substantive theories	technical, quantitative and qualitative; substantive theories	resocialization; qualitative and quantitative; history, values of altruism and empowerment	
Accommodation	commensurable	incommensurable		
Hegemony	in control of publication, funding, promotion, and tenure	seeking recognition and input		

Figure 2. Paradigm positions on selected practical issues

3.4 Coming to the Research Plan

I came to study the topic of equity by noticing moments of inequities in my lived experience. I also arrived at this research topic by recognizing the moments when I was given the resources I needed to succeed. Growing up in Chicago, I experienced the inequities that youth of color, youth of immigrant parents, and youth from low-income families live on a day-to-day basis. Today, research and theory has given me the language to name what I experienced and saw but growing up I did not see myself as coming from a "disadvantaged background". I was always surrounded by ingenuity, by creative problem solving, and by collaborative community practices.

When I was in elementary school, I was part of the "gifted program" (Siegle et al., 2016). These were the students that were placed into groups of what were considered advanced learners. In the gifted program, they gave us talks about high school and selective enrollment school. As the first in my family to go to high school in the U.S. we knew little about selective enrollment public high schools, but we knew they would offer more than my neighborhood high school and that we could not afford private school. At the time, seventh grade felt like the most important year of my entire childhood. I needed to have perfect attendance, straight As, and I needed score highly on the selective enrollment test. I needed to be part of a selective enrollment public high school so that I could have access to necessary resources to make it. I was stressed, but I got in. In the Fall of 2009, I started at a selective enrollment high school on the northside of Chicago (Quiroz & Lindsay, 2015). On my first day, I noticed that I had visibly gone from a diverse

elementary school with people from many races, ethnicities, and income levels to a “selective” place. A place where the only people I could speak Spanish to were employed as cleaning staff. A place where my classmates came from selective enrollment elementary schools and where their parents had gone to college. How could I have gained access to academic opportunities when my family and I did not even know the opportunities existed?

My high school’s population (like the academic spaces I would later become part of) was predominantly white. The transition to high school was hard but I understood that I was gaining access to opportunities people in my elementary school neighborhood did not get. My high school encouraged after school activities while teachers and counselors actively participated in them. It was “cool” to be involved. School ended at 3pm but the buzz continued from 3-5pm as students practiced sports, took on tutoring opportunities, or led the honors society. In contrast, from what I observed, at my neighborhood school students left after the lunch period and did not come back. Instead of investing into student enrichment opportunities, teachers and staff engaged in heavy policing of Black and brown teenagers. To illustrate the stark contrast between high school environments, my high school had one police car with two police officers during school hours while my neighborhood high school had three police cars always surrounding the building.

As I read and experienced more, I began to recognize that there was an obvious difference in how school treated students, but I did not have answers as to why this was the case. Compared to the people I grew up with, I had a very different experience in high school. I was given opportunities that others did not even know about, and I was offered resources to thrive. Why me and not others? This was not fair. It was not equal nor equitable. My experiences in high school propelled me to see myself as someone who could go to college and to know that I was someone that others would invest in to be successful. In contrast, from my perspective, the people I grew up with were instead sent signals that they were not smart, and they were not given access to what the future could hold for them; they were not given the tools necessary to succeed.

Next, I attended Northwestern University where I again noticed the inequities at play during my first year when my peers talked about their summer camps, their neighborhood resources, and their family background. I learned my peers had SAT tutoring coaches, people who helped them

write their college admission essays, and parents who had also gone to Northwestern. As the first in my family to attend college, everything felt foreign. I felt the stark contrast between how we had all grown up differently and how we were being treated the same in our engineering classes.

In the engineering college classroom, I constantly felt the pressure to catch up. Taking the most advanced math classes in my public high school was not enough to understand what was happening on the first day of my college engineering analysis class. My peers were ahead of me in knowing about matrices, about statistics, and about engineering principles. Looking back, I can now name that I needed more support. When we bring students from underrepresented backgrounds into institutions of higher education, we need to foreground equity in our initiatives so that they can reach their fullest potential. My peers and I did not start on the same playing field; I was behind because of systemic reasons, and I needed additional help to catch up. And I caught up. Like my experiences in high school, thriving at Northwestern was not easy, but I found mentors and people both in and out of the classroom that invested into me to succeed.

Once I had a grasp on my engineering coursework, I also began to wonder about the delivery of my curriculum. I wondered why so many of my courses were using cars as examples. I asked why most of my classes were taught by white men. And I questioned why I constantly felt like I did not have anything valuable to contribute to the conversation. Why did I feel like I did not belong in the classroom?

Discovering research and design gave me a platform from which to explore these questions. As an undergraduate student and with the close support of my mentor Dr. Julie Hui I crafted an independent research project, obtained funding, and published a paper in the international journal of engineering education about how women feel a sense of belonging in university makerspaces. As an undergraduate student I also got a glimpse of the courses being offered in the school of education and social policy and wished I had taken more of those courses to understand learning beyond grades and evaluations. All my questions led me to start graduate school at the University of Washington to study equity in engineering spaces, to further develop my understanding of learning in engineering settings, and to seek answers to my questions about why few people gain access to the resources they need to succeed in engineering and design.

In this dissertation, I detail the research journey I designed to study equity across sites of knowledge. I set out to notice what equity could look like in informal afterschool spaces like libraries, in formal learning spaces like classrooms, and in the home. Not only did I want to see equity, but I wanted to trace and document my equity enactments for others to use as they also transformed the world around them. Sociocultural theorists like Dr. Vossoughi, Dr. Bang, and Dr. Nasir taught me that learning was happening in all spaces of my lived environment, not just in my classrooms so I set out to study learning across sites (home, libraries, and school). I turned to the research on reflection from scholars like Dr. Turns and Dr. Sengers to guide me in systemically noticing, documenting, and making sense of how equity was showing up in my engagements. I drew on research on noticing from teacher education and on reflection from engineering education to both be present in my research engagements, to look back on my projects, and to connect forward to the next project I would do.

I also wanted my research process to be fun and full of joy. I used visual notes to make sense of my ideas, I included metaphors in my publications to make sense of complex topics, and I used physical materials to represent ideas. I worked with children to try to understand how they saw the world, I met with Latina moms to listen to their stories, and I heard from students about their experiences in the classroom. I actively tried to not only focus on challenges I saw people experience, but on foregrounding the assets they leveraged to make it work. Developing my research ideas with people across ages, races, ethnicities, languages, and income levels gave me a chance to explore my questions of equity from multiple perspectives, across sites of knowledge. In what follows, I share with readers the research that has taken me across sites of knowing with people from beautiful backgrounds to document how equity efforts in design are challenging but possible when done intentionally and in partnership with one another.

3.5 Positionality Statement

“... our positionality and intersectionality shape how we see the world, live in the world, experience the world, and respond to the world.” - (Carter & Legleitner, 2021)

My identities, my lived experiences, and my positionality in the world has influenced how I crafted the contents of this dissertation. In research spaces, I show up as a small, loud, Latina

woman. I hold close my identities as a daughter of immigrants, an older sister, and as someone who wants to pave the way for others who have been marginalized in STEM environments.

As I have previously written (Roldan, Gao, et al., 2020), the positionality of the researcher affects all facets of the research process – in the field, in data analysis, and in the text. My positionality has influenced the research opportunities I have access to and the barriers I faced. Different aspects of my research were influenced by my positionality and thus requires reflexivity. Here, I disclose how my positionality informed my dissertation research.

Showing up as my full self. I see qualitative research as personal and do not believe any research project is neutral. As such, I have always shown up in my projects as my full self while always foregrounding my positionality as a researcher collecting data from the people that I am also building relationships with. My core values of humility, family, and empathy show up when I build partnerships, when I collect and analyze data to foreground lived experience, and when I take time to truly listen to people's stories. In my project engagements, I have often disclosed my invisible identities as someone from a low-income background, a first-generation college graduate, and as a sister when I feel it helps me establish a connection with my research participants and partners. Having grown up with a strong Mexican cultural identity while being a citizen of the United States, being an engineering student with a social justice component in my work, and being part of my sites while foregrounding my stance as a researcher means that I write this dissertation from the place of *nepantla*, which Anzaldúa (Anzaldúa, 2013) writes as, "*the site of transformation, the place where different perspectives come into conflict and where you question the basic ideas, tenets, and identities inherited from your family, your education, and your different cultures.*"

Having access to institutional resources. Since the beginning of my research career, I have been supported by institutions of higher education with great privilege. As an undergraduate researcher, I had access to the financial resources to fund my independent project, pay my summer salary to conduct my research, and the institutional resources to work closely with leading scholars in engineering, design, and education. As a graduate researcher, I have had access to the resources and clout of a large, research university. Access to these institutions has

also helped my work be funded by the Gates Millennium foundation and the National Science Foundation. As such, I have had the opportunity to dive deep into my field work and to conduct multiple projects without having to repeatedly search for funding.

Constantly leveraging multiple perspectives. My undergraduate and graduate degrees are from a school of engineering. This in turn means that throughout my research engagements I have a desire to change the state of the world, through an intervention, a design implication, or a policy shift. The schools of thought that I have been trained in have directly influenced the kind of design implications I generate from each of my studies. My engineering training also means that I have had to actively look beyond the historical implications of engineering's post-positivist epistemology and read about interpretivism, constructivism, and critical theory to develop my own epistemological stance that defends the type of methods I employ. Importantly, I do not solely rely on my own interpretation of data, rather I constantly consult scholars from multiple fields and disciplines to help me make sense of the knowledge claims I am generating. As an interdisciplinary scholar, I have been influenced by multiple schools of thought including but not limited to ideas from human computer interaction, computer science, design, education, learning sciences, and communication. Additionally, I am constantly engaged with emergent Latinx critical theory, Black feminist thought, and critical pedagogy as theoretical perspectives to give me frameworks that shape my thinking, my research design, and my writing.

Commitment to social transformation. I started my PhD to generate new knowledge about how we could create more equitable engineering environments. Fundamentally, my work has always had a social justice component that influenced the kind of projects I prioritize, the kind of voices I elevated, and the type of research contributions I sought to make. Through my research, I seek to change the world of design and computing such that more people who have been marginalized know they can pursue a STEM career because they belong. What this means for my dissertation research approach is that when I collected and analyzed data, I was looking for themes that disrupted the dominant notion of who designs, who gets to create, and who gets to generate knowledge. Ultimately, the words in this dissertation represent my own kind of praxis and transformation; giving language to the things I have known and lived and offering a theory as a framework of liberatory activism through my scholarship (hooks, 2014).

4 Chapter 4. Site 1 (Noticing in HCI Education)

4.1 Overview of Site 1

Over the course of three years, I have explored the challenges and opportunities of engaging end-users in formal HCI education. This work was done in collaboration with a one year HCI+design master's program at a large research university. Dr. Yip, Dr. Froehlich, and I have collaborated with master's students and KidsTeam UW to co-design a STEM learning experience with children as part of their course. My hypothesis in this work was that by analyzing the interactions between designers and children we could surface the challenges faced and strategies used by designers when working with a population that was not "a traditional user." Leveraging a Research through Design approach (Zimmerman & Forlizzi, 2014), over time my hypothesis in this project shifted to not only understand how students and children were interacting with each other in the design sessions but also to propose novel ways in which we could use video to support students' reflective practice during the course.

Findings from our first year of this research contributed to HCI education a nuanced understanding of how designers navigate working with end-users within the constraints of a formal course (Roldan, Gao, et al., 2020). Findings from our second year of research highlight the importance of implementing and studying HCI education research recommendations into pedagogy and the utility of reviewing and reflecting with curated video clips to support designers in their reflective practices (Roldan et al., 2021). The findings from these investigations inform my dissertation because this project has developed my capacity to lead and facilitate intergenerational co-design engagements between youth and adults. This investigation has supported my understanding of an equity-oriented approach in a formal education context.

Title: Pedagogical Strategies for Reflection in Project-based HCI Education with End Users

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4.2 Abstract

As HCI pedagogy research grows, so too does an emerging set of evidence-based teaching and curricular recommendations. Yet, few studies have implemented and examined these recommendations in the classroom. In this paper, we present a Research Through Design investigation of a studio based HCI course, which was revised based on HCI education literature. Drawing on reflection surveys, video recordings of student-led user sessions, final project artifacts, and student interviews, we explore how students responded to key educational changes, the strategies that supported and hindered their reflective practices, and how reflection afforded new student insights. Our findings highlight the utility of video-based reflection exercises to support student learning in designing and running user sessions, the importance of multi-faceted reflection prompts, and how students noticed moments of inclusion and exclusion by attending to users' non-verbal cues. Additionally, we empirically demonstrate the importance of implementing and studying HCI education research recommendations in the classroom.

4.3 Introduction

As the field of HCI and interaction design matures, there have been increased efforts to actively reflect upon, investigate, and propose pedagogical approaches and curriculum (*Diversifying HCI Curricula – EduCHI Living Curriculum*, n.d.; *Future of Design Education*, n.d.; St-Cyr et al., 2020). For example, prior work recommends curriculum that responds to the dynamics of socio-behavioral contexts (Hollan et al., 2000), supports a multidisciplinary science (J. M. Carroll, 2003), and bridges design philosophies and practice (Koepfler et al., 2014; Watkins et al., 2020). While valuable for informing “best practices”, little work exists in actually studying these recommendations in the classroom—perhaps because HCI education research is still in its infancy (Koutsabasis & Vosinakis, 2012; Vorvoreanu et al., 2017; Wilcox et al., 2019). Scholarship on the translation of research to HCI classroom practice presents an opportunity to:

understand student learning experiences, support educators in making informed pedagogical choices, and explore how best practices must be adapted based on context. *Research through Design* (Zimmerman et al., 2007; Zimmerman & Forlizzi, 2014), a well-established method in HCI, offers an approach to conduct scholarly research on implementing recommendations into HCI education by employing methods, practices, and processes of design practice.

Building on calls for more research contributions on HCI pedagogy (Wilcox et al., 2019), we present a Research through Design investigation (Zimmerman et al., 2007) of a studio-based HCI course, which was revised based on HCI education recommendations in the literature (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005) and investigate how these changes seemed to impact students' educational experience—with a specific focus on how students prepared for, learned from, and reflected upon their user study sessions. During the course, 42 graduate-level HCI students grouped into 12 teams worked to design an interactive digital game with a social impact component. To inform and test their prototypes, students engaged in two participatory design (PD) sessions with children using *Cooperative Inquiry*, a PD method supporting design partnerships (Druin, 1999; Yip et al., 2017).

User studies, like PD methods, are critical to design practice but difficult to teach without experiential learning. To help students develop the skills necessary to plan, execute, and learn from user studies, we scaffolded their study plan preparation, provided, and discussed curated video examples of user study sessions, and added reflection activities. Reflective practice, as fundamental to learning, can help designers make sense of the many complex, messy, and unstable situations they experience. Drawing on Sengers *et al.*'s (Sengers et al., 2005), Roldan *et al.*'s (Roldan, Gao, et al., 2020), and Cook *et al.*'s (A. Cook et al., 2020) recommendations for incorporating reflection into HCI pedagogy, we introduced written reflection activities at the beginning and middle of the quarter and, most critically, incorporated video recording, expert analysis, and discussion of student-led user study sessions. In this paper, we examine the impact of these revisions on the HCI student learning experience, including:

- **RQ1:** How did the educational experience of HCI students seem to be affected based on course revisions as suggested by previous literature?

- **RQ2:** What strategies seemed to support and/or hinder students' reflective practices?
- **RQ3:** Did students gain insights while being engaged in reflective practices in their HCI education? If so, what insights?

To address these questions, we draw on four sources of data, including: reflection surveys, video recordings of student-led PD sessions with children, artifacts from final project documentation, and semi-structured interviews with 20 students. Our findings suggest that our course revisions helped better prepare students for their user-study sessions, think through best- and worst- case scenarios, and identify opportunities for growth in their second session. We surface pedagogical characteristics that support and hinder students' reflective practices, including *multi-faceted prompts*, *curated video clips*, *ongoing engagements* as well as *uncomfortableness of watching oneself*, *activity timing*, and *buy-in*. Finally, we present insights that students gained in our course: *attending to moments of inclusion/exclusion*, *attending to body language*, *navigating engagements with users*, and *naming future actions*.

Our contributions to the HCI community are twofold. First, we incorporate educational recommendations from prior research into our classroom and analyze their impact on pedagogical outcomes. Through this contribution, we address a gap in the implementation of evidence-based pedagogy research in HCI education. Second, building upon previous recommendations in HCI (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005), we call for the notion of “*noticing*” and “*reviewing tape*” for HCI education in a peer-led setting—such practices are common in the learning sciences (Derry et al., 2010), teacher education (Gaudin & Chaliès, 2015; Gibson & Ross, 2016; Tripp & Rich, 2012; van Es & Sherin, 2010), sports psychology (Carson, 2008; Ives et al., 2002; Tracey, 2011), and healthcare (K. Carroll et al., 2008; Crenshaw, 2012; Iedema et al., 2006), but uncommon in HCI pedagogy. Our findings extend the concept of *noticing* for HCI, as encompassing the ways in which designers observe important details in users' feedback and body language, interpret user input, and dynamically adapt during user sessions.

4.4 Related Work

4.4.1 HCI Education

In 1992, the ACM SIGCHI Curriculum Development Group published the “Lime Green Report” outlining the ACM curricula for Human Computer Interaction (SIGCHI (Group : U.S.), 1992). The report proposed four courses for HCI oriented toward: technology, humans, practice, and research. Notably, the report also called for HCI to actively reflect on, study, and further develop its own curriculum. Since then, there have been only intermittent attempts to study HCI pedagogy (Sears, 1996) but recent development are promising. From 2011-2014, ACM SIGCHI community members investigated the present and future of HCI education (Churchill et al., 2013). More recently, St-Cyr *et al.* formed a community of practice for HCI education (St-Cyr et al., 2018), CHI 2019 introduced a subcommittee on learning, education and families (*Selecting a Subcommittee – CHI 2019*, n.d.), and a working group was established to rethink the future of design education (*Future of Design Education*, n.d.). Furthermore, over the past two years the DIS community has increasingly embraced scholarship on HCI education (A. Cook et al., 2020; Oguamanam et al., 2020; Sellier & An, 2020; Vermette et al., 2020; Watkins et al., 2020; Wilcox et al., 2019).

In the HCI education literature, prior work has explored how disciplinary perspectives (Gutierrez et al., 2019; Wilcox et al., 2019) and student experiences (A. Cook et al., 2020; Wong-Villacres, Alvarado Garcia, et al., 2020, p.) shape HCI pedagogy. For example, Watkins *et al.* call for design philosophies that support student industry trajectories (Watkins et al., 2020) while Oguamanam *et al.* investigate how studio-based learning conflicts with cultural norms in computing (Oguamanam et al., 2020). Scholars also offer recommendations to support students’ competencies (Carlson et al., 2020; C. M. Gray, 2016), tools to support educators (Sellier & An, 2020; Vermette et al., 2020), and ways to expose students to authentic design settings (Churchill et al., 2016; Koutsabasis & Vosinakis, 2012; Reimer & Douglas, 2003). Importantly, while scholarship has led to recommended guidelines for HCI educators, we could find no specific examples of follow-up work that integrates and studies these guidelines in the HCI classroom. One reason may be that most research on HCI education has taken place in the past five years (Churchill et al., 2016; Oguamanam et al., 2020; Vorvoreanu et al., 2017; Wilcox et al., 2019), which has provided fewer opportunities to further implement and study pedagogical recommendations. In contrast, in teacher education (van Es & Sherin, 2010), it is common for researchers to implement and study research recommendations in their courses. In this paper, we

apply an iterative, self-study ethos to HCI education responding to Wilcox et al.'s (Wilcox et al., 2019) call for more concentrated research efforts to inform and shape the everchanging landscape of HCI design education.

4.4.2 Reflection in Education & HCI

Additional opportunities for reflection was a key focus in our course revisions. Reflective practice can be understood “*as the process of learning through and from experience toward gaining new insights of self and/or practice*” (Finlay, 2008). In education, a reflective approach is necessary for students to make sense of the many complex situations they experience. Importantly, students do not engage in reflection automatically, they need support to learn from the situational complexities they face (Veine et al., 2020). Although definitions of reflection in education vary (Lousberg et al., 2019; Rogers, 2001), common attributes include surfacing unconscious aspects of previous experiences, thinking about the biases that drive one's actions, and formulating a plan for the future (A. Cook et al., 2020; Lousberg et al., 2019; Rogers, 2001; Sengers et al., 2005). In HCI, reflective design can support designers to surface assumptions embedded in their technologies (Sengers et al., 2005). Sengers *et al.*'s (Sengers et al., 2005) work inspired other HCI researchers to further define (Fleck & Fitzpatrick, 2010) and explore reflective design for sustainability (Brynjarsdottir et al., 2012) and critical making (Ratto, 2011). In 2020, Roldan *et al.* (Roldan, Gao, et al., 2020) and Cook *et al.* (A. Cook et al., 2020) separately conducted investigations that concluded with similar reflection-oriented pedagogical recommendations. Roldan *et al.*'s (Roldan, Gao, et al., 2020) work extended Sengers' reflective design principles for HCI pedagogy while Cook *et al.*'s (A. Cook et al., 2020) work presented guidelines to support reflection on peer feedback. In this paper, we implement and study Roldan *et al.* (Roldan, Gao, et al., 2020), Cook *et al.* (A. Cook et al., 2020), and Sengers *et al.*'s (Sengers et al., 2005) reflection guidelines into the HCI classroom.

4.4.3 Scaffolded Techniques and Tools to Support Reflection

Education scholars propose a range of techniques and tools to support teaching reflection, including weblogs (Wopereis et al., 2010), journals (Lorenzo & Ittelson, 2005; Rogers, 2001), and portfolios (Sööt & Leijen, 2012). With the emergence of low-cost video equipment and the ability to easily capture, edit, replay, and critique interactions from a third-person perspective,

video has been increasingly used to support learning, growth, and reflexive practices in teacher education (Gaudin & Chaliès, 2015; Tripp & Rich, 2012; van Es & Sherin, 2010), sports psychology (Carson, 2008; Ives et al., 2002; Tracey, 2011) and healthcare (K. Carroll et al., 2008; Crenshaw, 2012; Iedema et al., 2006). In the context of training pre-service teachers, video enables educators to focus on their students in-the-moment while supporting *post hoc* review and reflection (Gaudin & Chaliès, 2015; Marsh & Mitchell, 2014; Tripp & Rich, 2012) and has been shown to shift teacher's behaviors in the classroom (Wang & Hartley, n.d.). In sports, video reduces reliance on memory, allows for rewinding and re-analyzing key moves, and supports understanding viewpoints for both athletes and coaches (Carson, 2008). In healthcare, video is used to “feedback” curated aspects of a clinician's practice and thereby engender reflexivity, with the aim of improving practitioners ability to deal with problematic aspects of work (Iedema et al., 2006).

While beneficial, using video requires equipment, training, and the time and expertise to clip appropriate video snippets that highlight “teachable” moments. Researchers describe curating video clips based on key moments (Van Es & Sherin, 2008) and the intentionality behind using video as a tool to promote future action for improvement (K. Carroll et al., 2008; Groom et al., 2011). In practice, teachers record themselves delivering lessons and use video annotation tools to document their observations, while external educators (e.g., teacher mentors) scaffold their attention to specific aspects of their instruction (Coffey, 2014). Similarly, dancers video record their routines, select video fragments of their movements, upload clips online, respond to guided prompts from their dance instructors, and receive feedback from peers on their clips; this in turn supports dancers in developing a more realistic view of their dance experience (Leijen et al., 2009). In sports, athletes watch video clips of their performance curated by consultants to show technique, positioning, or team plays (Ives et al., 2002).

Common across contexts is the use of video in group settings to see peers' practices (K. Carroll et al., 2008; Carson, 2008; Crenshaw, 2012; van Es & Sherin, 2010), the inclusion of scaffolds such as prompts to encourage discourse (K. Carroll et al., 2008; Tripp & Rich, 2012), and the opportunity to interpret the same moment from multiple perspectives (K. Carroll et al., 2008; Middlemas & Harwood, 2018; Tochon, 2007; Van Es & Sherin, 2008). van Es and Sherin (van

Es & Sherin, 2010) highlight that video is only a tool for learning, and that pedagogical scaffolds in contexts are necessary to leverage what video has to offer (Le, 2003). As much as video has been used in other contexts, video is rarely used as a tool to support student and educator reflection in HCI pedagogy. Investigations that do involve video ask students to submit project videos as a form of assessment (Vasilchenko et al., 2018) or educators to video record their lectures to support active learning (Hornbæk et al., 2002). Informed by research from HCI education, reflective practice, and techniques and tools to support reflection, we made key changes to our HCI course that included an intentional focus on scaffolding student reflection. We examine the role that scaffolded reflection strategies on video plays in how HCI students make sense of their engagements when designing with children in their studio course.

4.5 Methods

We examine a 10-week master's level HCI+design studio course taught between January and March 2020. During the course, 42 HCI students grouped into 12 teams worked to design an interactive digital game with a social impact component. To inform and test their prototypes, students engaged in two PD sessions with children. We video recorded all PD sessions and annotated them for analysis. Informed by prior work (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005), we asked students to engage in reflective exercises. After the course ended, we conducted 20 semi-structured interviews with students about their experiences and collected artifacts from four teams. Through these methods, we gained unique insights that foregrounded students' perspectives about our process of implementing key course components and how those changes influenced student insights about working with users.

We take a design inquiry approach (Zimmerman et al., 2007). Zimmerman et al. (Zimmerman et al., 2007) draw on Frayling's (Frayling, 1994) concept of *Research through Design* to describe the process by which design researchers generate knowledge intended to transform the world from current state to preferred state. In our work, we saw an opportunity for more evidence-based practices in HCI—reflection in particular. Therefore, we implemented five key course revisions in our classroom as informed by prior HCI and education literature and observed the value of supporting design students to notice in their user studies. Our investigation has undergone an active process of reframing how to support design students in their engagements

with end-users during user study sessions. This paper details our inquiry into how to support students in conducting user studies and how to scaffold their reflection on engagements with end-users.

4.5.1 Context

Course. The HCI+design course is required curriculum for an interdisciplinary design master's program at a large research university and introduces prototyping and evaluation methods via project-based learning in a studio environment. Over the 10-week quarter (Figure 1), HCI students worked in teams of four to design a socially relevant, multi-player video game for children with a custom, tangible input controller made from Arduino. We intentionally designed course assignments, lectures, and studio time to scaffold students through the design process. In the course, students learned principles of programming, physical prototyping, and the human-centered design process. Specifically, the learning goals were: (1) Students will engage in the human-centered design process from ideation to lo-fidelity implementation to building and evaluating an embodied interactive prototype; (2) Students will develop, learn, and use varying physical prototyping techniques; and (3) Students will learn techniques to seek, synthesize, and incorporate user input and accommodate feedback from multiple stakeholders (including users, guest critics, and instructors).

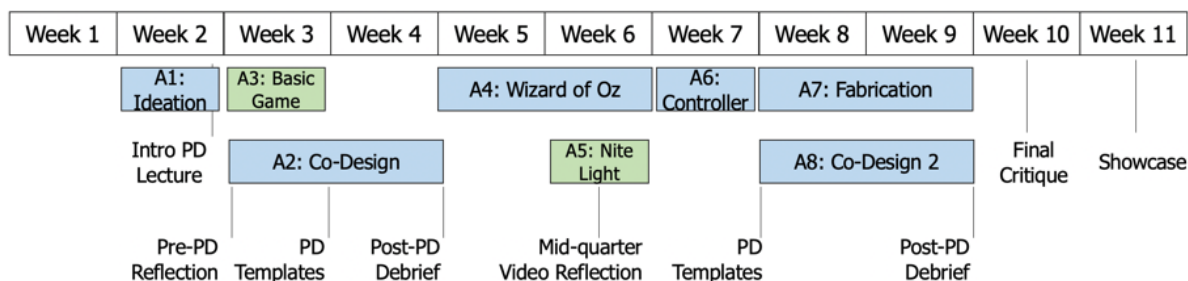


Figure 1: Course Timeline. Blue boxes are team assignments while green are individual or paired assignments.

Participatory Design Team. For the PD sessions, we paired with *WeDesign* (pseudonym), an intergenerational co-design group of children and adults. Prior to the COVID-19 pandemic, *WeDesign* participants met twice-a-week afterschool on a university campus to design new technologies for children, with children. *WeDesign* follows the *Cooperative Inquiry* method

(Druin, 1999) where children are positioned as design partners through a dynamic process which shifts between balanced and unbalanced interactions (Yip et al., 2017). 10 children (ages 7–11) and 8 adult researchers from WeDesign worked with the HCI students.

Participatory Design Sessions. Students engaged in a total of two, 90-minute PD sessions with children. Sessions began with snack time and circle time (30-minutes) where everyone shared their name and answered the question of the day. During design time (45-minutes total, 15-minute rotations), students engaged the children in round-robin design activities (Figure 2). Student teams were given autonomy to use their design time as desired and adults took notes of key takeaways. After design time, everyone reconvened and shared their experiences with each station. We video recorded, time-stamped, and annotated all eight PD sessions for key moments of engagements between students and children.



Figure 2: Images from PD sessions

4.5.2 Key Changes

Our investigation builds on recent research that supports reflection in HCI pedagogy (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005). In Table 1, we provide an overview of the changes made from our Year 1 (2019) course offering described in (Roldan, Gao, et al., 2020) to our Year 2 (2020, pre-COVID-19) course offering. Key changes include an expanded lecture on PD with children, the use of reflection exercises and curated video clips, example PD session templates, and post-PD session debriefs to support the course learning goals. We made multiple changes from our Year 1 course (Roldan, Gao, et al., 2020) to our Year 2 course. We do not intend to make explicit connections between the changes made and the outcomes we present in the findings.

Table 1. The curricular and process changes between our 2019 and 2020 course

Course Component	2019	2020	Rationale
Introductory PD lecture	A presentation by PD facilitator	Augmented with historical video clips	Show students examples of prior student-user interactions ranging from successful to challenging
Pre-PD session reflection	N/A	Reflection prompts to brainstorming strategies	Support HCI students in considering and articulating their plans for Session 1
Pre-PD session templates	N/A	Session templates: goals, materials, time	Support HCI students to thinking through their research goals and how to meet them
Post-PD session debrief	Student-led debriefs	15 minute debrief session with facilitator	Support HCI students unpack the interactions and name top-line takeaways
Mid-quarter video clip + reflections	N/A	Curated Session 1 clips and reflection prompts	Support students to remember, notice, and reflect on what they learned from Session 1
Project goal	Client-based	Social impact based	Support HCI student choice and bring video game focus to designs
Session timing	Weeks: 2,3 -- 8,9	Weeks: 2,3 -- 7,8	Allow more time for changes to be implemented into students' final designs

Introductory PD Lecture. In Week 2 of the course, we gave students a lecture on PD with children in WeDesign, offering an introduction to *Cooperative Inquiry* (Druin, 1999) and insights from previous research (Roldan, Gao, et al., 2020). We included video clips from prior user study sessions that showed both successful and challenging instances of students and children designing together. We shared an overview of who would be in the room during the sessions (children and facilitators) and offered insights on who the children were (their motivation to participate). We also handed out quotes of advice from students who had previously worked with WeDesign children. The goal of this lecture was to provide students with strategies for engaging in the human-centered design process (course learning goal 1) including building rapport, communicating with the child designers, and using their design time efficiently (e.g., moving between methods, alternating between materials, attending to the child to adult ratio, and being flexible).

Pre-PD Reflection. Before their respective sessions, we asked each design student team to fill out a pre-session reflection. Via Google forms, we asked students what they were most excited about for their first session, what strengths they had for working with children, what artifacts they planned to bring to the sessions, how their team planned to work through unexpected challenges, and what concerns they had going into their sessions. In alignment with the third course learning goal of students learning techniques to seek user input and accommodate feedback from multiple

stakeholders, the rationale of the pre-reflection questions was to scaffold students to think in more detail about how they would approach PD and to think about contingencies and to gather information on them through processes as they approached their design sessions.

PD Templates. Prior to each PD session, students filled out a detailed session template with their goals, plans for achieving those goals, and materials they would bring (Figure 3, left). The template also asked them to break down how they would use their time and what they would do for their round robin activities to support students in developing techniques to seek user input for their designs. The templates were intended to help students plan how they were going to structure their session to meet their goals. We added these templates to our course this year because we found that without this scaffold (in previous years) students did not fully think through the entire process of how their design sessions would help them meet their design objectives for their game.

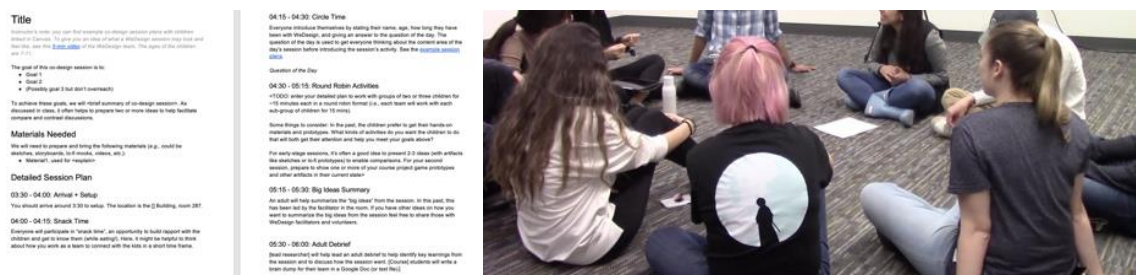


Figure 3: PD Templates (left); Debrief from Session 3 (right).

Post-PD Session Debrief. Following each PD session, the lead author led a 15-minute reflective debrief exercise which we also video recorded (Figure 3, right). The goals of the debriefs were to help students unpack their PD session and to collectively make sense of their takeaways from the session to synthesize and brainstorm how the user input gained would inform their final design. We followed a semi-structured protocol that asked: How did it go? What surprised you? What was expected? What was challenging? What were some moments of pride?

Mid-quarter Video Clip Showing + Reflections. Informed by literature on the use of video to support reflection (K. Carroll et al., 2008; Ives et al., 2002; Roldan, Gao, et al., 2020; van Es & Sherin, 2010), between Session 1 and Session 2 we sent students curated video clips from their

first session. Via Google Forms survey, we sent teams two curated video clips from their session and we asked them view both but pick one to reflect on. Each team's clips were curated by researcher that met the selection criteria: multiple HCI students were notably engaged with children and two researchers decided there were multiple interpretations to the engagements. The burden of curating clips was solely on the researchers. After watching the videos privately, we asked students to reflect on observed behaviors, their interactions with the children, and to consider what they would change for Session 2 via written prompts.

We expected that an outcome from this course component would be mutually beneficial to students, educators, and researchers. After watching their videos and answering reflective prompts, we expected students would compare their goals and plans for the session with the reality of what played out in the video data. In making this explicit comparison, we hoped students could reflect on the need for flexibility in the design process as they learned techniques and strategies to engage user input for their embodied interactive prototype. From the perspective of their future self as a professional designer, we asked them what they felt was successful and what was challenging from the interactions in the clip. In the form, we also asked students to describe to us what they observed was happening during the clip and to rate how satisfied they were as a team with the interactions they had watched. This course component was a chance to compare how students saw themselves in the video with how educators and researchers interpreted the clips.

4.5.3 Interviews and Material Artifacts

After the course ended, we conducted hour-long semi-structured video interviews with 20 (of 42) students who received a \$25 gift card for their time. We asked participants (Table 2) about their experiences in the course and with the PD sessions. Similar to our mid-quarter reflection, we showed them a clip from Session 2 that showcased a notable moment between them and a child. In contrast to our mid-quarter reflection, where we were focused on the team's engagements, these clips focused on engagements that involved the interviewee. Following interviews, we collected and analyzed design documentation from four (of ten) student teams.

Table 2. Participant Overview. *All names are pseudonyms. Team 2 and 5 did not attend Session 2 due to COVID-19.

Team & Session	Project Prototype Ideas	P#	Participant	Background, prior design experience
Team 1 (1 & 8)	S1: Feather blowing Boat steering (counting fish) Constellation lighting S8: Tree planting	13	Bailey	Computer science, web design
		3	Caelen	Product, graphic, motion, and production design
		8	Hadley	Industrial design, prospective UX designer in IOT
		14	Vega	Product design, hand letterer
Team 2 (1)	S1: Cleaning ocean garbage (Wheel navigating and net throwing)	16	Avery	Sound design, accessibility researcher
		12	Wase	Environmental, exhibition design, architecture
		15	Nell	Graphic design, marketing, and user researcher
		11	Aria	Design research, accessibility researcher
Team 4 (2 & 5)	S2: Designing koala habitat S5: Submarine	20	Mason	Interactive media arts, multidisciplinary designer
Team 5 (2)	S2: Reaching stars	9	Niki	Industrial design, wearable technology, sports
Team 6 (2 & 8)	S2: Racing, alien laser S8: Alien trash collector	6	Nao	Brand design, freelance web design
Team 8 (3 & 7)	S3: TikTok & Tetris S7: Laser reflection	5	Yan	Psychology; IT consultant and music enthusiast
		7	Hunter	Math and Visual arts; product designer (3+ years)
Team 10 (4 & 5)	S4: Cat puzzle, wizard spells S5: Cat in the forest	2	Max	Art theory, digital humanities, inclusive tech
		1	Wren	Computer science, studio arts, cognitive science
Team 11 (4 & 7)	S4: Embodying shapes S7: Catching nutrients using your body to navigate controller	4	Ollie	Computer science, editorial design; visual design
		10	Randi	Production designer
		18	Ray	History, UX designer
Team 12 (4 & 6)	S4: Blowing bubbles S6: Helping endangered animals	17	Kali	Management science, UX researcher
		19	Willow	Architecture, healthcare

4.5.4 Data Analysis

We followed qualitative research approaches aligned with interpretivist lines of inquiry (Cohen & Crabtree, 2006; Creswell & Poth, 2016; *NC00303 (6745): Interpretivism, Social Constructionism and Phenomenology*, n.d.; Schwandt, 1994); where knowledge is seen as interactively constructed between researchers and participants (Guba & Lincoln, 1994). Our dataset included student responses to two reflection surveys, video recordings of eight student-led PD sessions, artifacts from project documentation, and professional transcripts of semi-structured interviews with 20 students. These four data sources provided a rich and thick description of the students' experiences and allowed for triangulation (Shenton, 2004). The lead author also kept reflective and analytical memos throughout the research process (Miles & Huberman, 1994). Six researchers independently open-coded the reflections (N=24), the video annotations (N=8, 720 minutes), the video interview transcripts (N=20), and the design artifacts (N=4).

For three months, the six researchers engaged in weekly peer debriefing sessions following each open coding of the data. Iteratively, we developed a codebook with 10 high-level codes and 122

sub-codes. At this stage, our high-level codes included course cadence, key changes, adaptation, and expectations. After open coding, each researcher wrote analytical memos of the high-level codes, which were discussed during weekly meetings. Informed by ongoing engagement with our related work, these analytical memos helped us conduct axial coding between core themes. Following the identification of core themes, we used a visualization software (*Miro / Online Whiteboard for Visual Collaboration*, n.d.) to map our codes and data (Figure 4) and arrived at our findings. Following standard practices of qualitative research (Campbell et al., 2013; McDonald et al., 2019), we do not report exact participant counts of each theme for two reasons: (1) our semi-structured interview approach meant questions were not asked in the exact same manner to every interview participant and (2) we do not aim to generalize from a small set of data points.

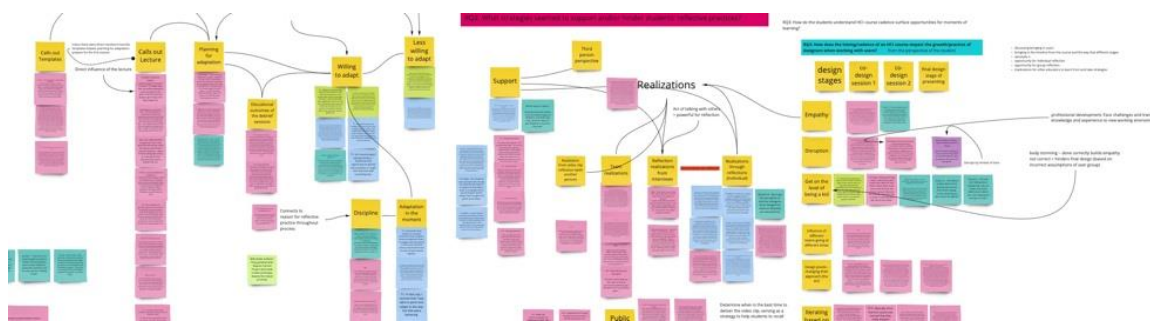


Figure 4: Snapshot of data analysis process.

Positionality Statement. The researchers on this project are students and educators who have previous experience conducting research in a similar study, thus allowing for discussions which connected past experiences and current research. These discussions surfaced subjective perspectives that required validation through analyses of thick description data (Shenton, 2004). We also draw on the course instructor’s knowledge who is a co-author and taught both in 2019 and 2020. Some researchers are HCI students and volunteers WeDesign and their perspectives are informed by their personal experiences. As a research team, we have built trust with each other through previous collaborations. These perspectives and experiences influenced our analysis (Savin-Baden & Major, 2010).

4.6 Findings

In this section, we present students' educational experience from our course changes as informed by HCI education (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005), the pedagogical strategies that supported and hindered students' reflective practices, and the insights students gained as a result of being engaged in reflective practices as part of their studio-based HCI course.

4.6.1 Students' Educational Experience from Implementation of Course Revisions

We describe how students experienced our key educational changes from Year 1 (2019) to Year 2 (2020): introductory PD lecture, PD templates, pre-PD session reflections, post-PD session debriefs, and mid-quarter video clips and reflections. For each course revision, we provide an overview, a synthesis of students' educational experience, and key takeaways.

Introductory PD Lecture. We extended our introductory PD lecture in Year 2 to include curated video clips from past PD sessions and a handout of "recommendations" from previous students. Year 2 students stated that the lecture provided insights into the complexity of working with children designers, set expectations for session dynamics, and provided pragmatic strategies for working with children. For example, Niki suggested not just monitoring user behavior but asking them "*why are we doing that?*" Bailey said watching the video clips, "*was helpful for my team to get on the same page of what to expect*" and that the lecture directly informed their session planning. Despite the lecture, after their first session students commented on the children's energy, experimental nature, and "mis-use" of prototypes: in Session 1, a child put a plastic feather in their mouth. In short, the lecture scaffolded students into a previously unknown design context, provided real-life examples of successful and challenging interactions between designers and users, and helped reduce anxiety about "perfectionism" and "control." Students recommended showing user-session video clips to future courses.

PD Templates. In Year 2, we provided session plan templates and protocol examples to student teams (not provided in Year 1). In general, students felt that the templates helped them think through their session, "*know how everything was going to work out*" (Nao), set concrete goals, and establish a plan for meeting those goals. For instance, Hunter said, "*It's directly related to*

what we're going to do during the co-design to understand what we're going to achieve, and how are we going to use different activity question(s) to achieve that goal." The templates included timings both to help structure student's time allocations and to help highlight the rapidity of the session. In contrast to Year 1, the teaching team and PD facilitators felt that the teams were better prepared, particularly with regards to having age-appropriate design activities, rapport building, and the variety of physical materials for each session. While students appreciated the scaffolds and the example session plans, they felt that the templates were less useful for their second sessions. As Vega described, *"it was not like doing these different activities or asking these different questions that could help us in narrowing down or anything..."* Vega's quote also helps emphasize an additional concern: how to analyze the rich session data to inform prototypes and make design decisions—an opportunity for further scaffolding focused on analysis.

Pre-PD Session Reflection. In Year 2, we added pre-session reflection exercises, which asked student teams to think about, discuss, and report on what they were excited about, their concerns and team strengths, how they planned to build rapport, and work through unexpected behaviors. In their reflective writings, students expressed excitement about creating an interactive prototype and learning from the children but also shared concerns about the understandability of their games, session length, keeping the children engaged and safe, and anxiety about how to interact with their co-designers. Team 8 said, *"We have prepared easy to understand and short summaries of each game; in case if the children get confused with our games. We also plan to demonstrate..."* Students listed multiple session-handling strategies including being approachable, patient, and respectful as well as designating clear roles for the adult and children co-designers. Team 3 wrote, *"... to engage with them early equally. By this, we mean getting to them very early during the co-design sessions, as well as treating the kids as intelligent human beings."* When discussing their strengths, teams identified their complementary personalities, prior experience with usability testing and facilitating design sessions, and their flexible approach. In Year 2, we observed how having students brainstorm a list of strategies and assets they could rely on meant they had a repertoire to pick from while in their sessions. In sum, the pre-reflection exercise helped students envision their session, think about "best" and "worst"

case scenarios, identify key team strengths, and articulate a plan for working through unexpected behaviors.

Post-PD Session Debriefs. In Year 2, we added debrief sessions which enabled students to reflect on and discuss surprises, challenges, and key findings. Because they occurred immediately after the PD session, students were both exhausted and energized and used the debriefs to work through and articulate their thoughts, collectively make sense of particular moments, and share strategies, concerns, and insights. Students also appreciated hearing from the lead author about her observations, as an expert. After their first session, students synthesized features that engaged the children (*e.g.*, healthy competition), brainstormed improvements, and unpacked strategies for their second session. Max said, "*In the first session, we couldn't always keep it in focus. So, by externalizing that in the debrief, we knew we were going to have to set up our research session differently next time.*" After the second PD session, student commented on the durability of their prototypes and the changes they would have to make before the final design. Students learned from each other and were able to see multiple interpretations of the design session. Hunter noted, "*Knowing what is happening to their team can also give us some insights.*" Interestingly, we learned this year student teams still held a second round of debriefs without the facilitator to synthesize key insights for next steps.

Mid-quarter Video Clip Showing + Reflections. In Year 1, we showed students PD session video clips after the course's completion as part of our research study. In Year 2, we made these "video reviews" a key part of the curriculum, following Roldan *et al.*'s recommendations (Roldan, Gao, et al., 2020). When comparing their session goals with the video, Year 2 students noted that they were successful in establishing a relationship with the children, gathering exploratory information about their interests, and observing their interactions. Team 3 wrote, "*...our biggest success was engaging with the kids in a way that made them feel comfortable and able to express themselves openly.*" Students felt less successful in predicting how children would use their prototypes and found that the children struggled with game narratives and mechanics. For example, Team 9 said, "*...a lot of game mechanics did not play out the way we wanted it to be. For example, the spinning bamboo copter didn't have anything to do with the game and the spinning action was not intuitive at all.*" Students said it was challenging to keep conversations

going and to keep children's attention when giving game instructions. Team 11 wrote, "*The challenge for me is learning how to work with a sensitive and unpredictable user group, being flexible with the plan, and responding quickly to the different conditions.*" In response to what they would change, students said they would spend less time giving instructions and simply observe, would change their activities to gather more targeted input, or would respond dynamically. By preparing and showing key PD session video clips to teams, students had an opportunity to see their interactions from the "third person", talk about and replay key moments, and identify opportunities for improvements for their second session. Team 2 wrote, "*our protocol was designed to treat all the kids the same, but in reality, we need to adjust what type of questions we ask, and our voice and tone based on who we are talking to.*"

Pedagogical Characteristics that Supported/Hindered Students' Reflective Practice

Next, we outline the pedagogical characteristics that supported and hindered students' reflective practices from our revisions, including *multi-faceted reflection prompts, curated video clips, ongoing engagements* as well as *uncomfortableness of watching oneself, activity timing, and the lack of buy-in*.

4.6.2 Pedagogical Characteristics that Supported Reflection

Multi-faceted Use of Reflection Prompts. We presented students with holistic multi-faceted reflection prompts, including within-team reflections (watching videos, writing pre- and mid-reflections), cross-team reflections (conversational debriefs), and individual reflections (writing pre- and mid-reflections). We found that this avoided repetitiveness and offered different ways for students to relay their thoughts. For instance, Wase noted: "*There are just so many things that you could miss in your notes, especially with this kind of designs [PD]. You have to see what their actions are...especially putting it alongside with the reflection, like watching it [the clips] and writing stuff after to reflect upon it.*" Wase explained how having multiple ways to reflect supported sense-making.

Curated Video Clips. We found that the curated video clips supported students' reflective practices by considering multiple points of view from students, instructors, and researchers. For students, the curated clips provided a structure for what they should focus their attention to and surfaced nuanced interactions (that might go unperceived) for reflection. Mason said, "*If you ask*

me to think about our design process out of my head, I can only think of the moments where I struggled the most...” When watching the clips in a group setting, the teams saw their own behaviors and collectively interpreted the clip which in turn allowed them to generate critiques and compliments on individuals or groups’ behaviors. For instructors, the clips allowed us to work closely with the HCI students, slow down, and carefully review their sessions for subtle cues of their interactions.

Ongoing Engagements of Reflection Prompts. We consistently scattered multiple reflection points throughout the course rather than one larger activity. As a result, students made reflection a part of their design process. Max said the prompts “...sort of force people to be like introspective about how they communicate with our co-designers and also the other WeDesign facilitators”. Compared to Year 1, students took a positive attitude towards children’s distraction as a sign of needing to try a new strategy. Randi noted, “*I think just leveling that expectation of they [the children] are not going to design this thing for you. it’s more like reading between the lines and just trying to understand where they’re coming from.*” Furthermore, persistent reflection prompts allowed students to not only reflect on their user engagements with users but also how they engaged as a team.

4.6.3 Pedagogical Characteristics that Hindered Reflection

Uncomfortableness of Watching Oneself. Students commented on the uncomfortableness of watching themselves on video. Yan stated being emotionally disrupted but finding the video clips helpful, “*Even though it was cringy being watched, then we realized some things that we were trying to pay attention in the second session.*” On the other hand, Hadley said they enjoyed watching the clips with her team, “*We had lots of fun looking through that. Super embarrassing...Then we all sat down together and watched that video, and we all had this, oh sh**, moment...it really grounded us in okay, what do we need moving forward?*” While it is not a surprise that students had uncomfortable moments watching themselves, we need to consider ways to be respectful and provide a psychological safe place for reflection and critique.

Timing of Reflection Prompts. Students spoke to the importance of when we prompted the reflections. Some students preferred to have video clips sent after some time had passed from

their session while others preferred to see them right after. Nao said, *“I feel like if we had to do that just before our second session, it might have been more useful, because then I would have just done that activity and remembered what we wrote.”* Given the conflicting opinions about the timing, it is important to make reflection due dates variable and aspire to a faster turnaround of curating clips for students to watch when they think it is most valuable to them.

Buy-in. Buy-in relates to the students’ perceived value of course activities and is important for sustainable implementation of reflective practices. Students said some of the exercises felt like “busy work.” Others did not see the connection between the activities and the course objectives. Hunter stated, *“that clip might help us to have better behavior for the second co-design session. But I feel like the video wouldn’t impact our big picture.”*

Student Insights from Being Engaged in Reflective Practices as Part of their HCI Curriculum

We present insights that students gained as part of our reflective exercises: attending to moments of inclusion and exclusion, attending to body language, navigating engagements with users, and naming future actions.

Attending to Moments of Inclusion/Exclusion. After watching their first PD session video clips, student teams commented on opportunities to actively keep their users focused and create opportunities to involve all of the children during their session. In watching their videos (Figure 5), student teams noticed that most of their games were 1- or 2-player and often that meant *“having one person do the activity and the others watch”* (T1). Team 5 wrote, *“In the next session, we would like to think of a couple ways the kids can be involved while not currently playing...For example, we could have the children not playing help the kids who are with the strategy to get through the levels, or they can help remind them of rules...”* Here, the team noticed a lack of engagement from all the children and proposed actions to keep the children’s attention. In their final artifacts, Team 8 described how they changed their game design after noticing children were being excluded by the two-person feature.



Figure 5: Moments of Exclusion - Session 3 (left), Inclusion - Session 4 (middle),
Exclusion/Inclusion - Session 1(right)

Attending to Body Language. When watching their video clips, students commented on opportunities to interpret non-verbal cues from users and to improve their body language, whereas in Year 1 they focused more on the chaotic nature of the sessions. Nell wrote, “*not every single utterance from a participant is valuable... While it’s important to not treat sessions like interrogations, I think it’s important to note these dubious moments and use them to better understand your participants versus taking their word as gold and designing something they asked for verbatim.*” After their first session, Nell reflected on the importance of knowing users versus taking users' words verbatim. In our video observations, we noted an instance during the second PD session when a child said he did not like the game and a student responded, “*but you’ve played for the third time, what does it mean?*” Students also noticed their body positioning and intentionally shifted themselves to be at eye-level with the users. Randi said, “*I think later a few minutes down the road or even before maybe, like looking at this, I’m seeing my body language was very authoritative.*” Ollie extended this observation to note the ways video helped them attend to micro-movements, “*It also showed how they just in general interact. Like sometimes they sit on the floor. So, this is why it was helpful, because during the session you just focus trying to control everything, and you don’t notice all those details.*” Here, we argue that our findings emphasize what other contexts have seen in the use of video showings to become “*a way of saying the unsayable*” (K. Carroll et al., 2008; MacDougall, 2005) but for HCI. Attending to body language is supported by the video visualization which enlarges sociocultural practices (K. Carroll et al., 2008) that might previously be unnoticed. In this way, for our students, video clips became a way to foreground background aspects of activity occurring during their design sessions.




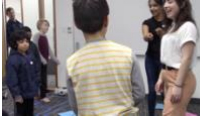


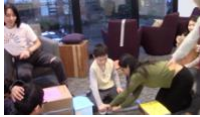



Successful					
	T2 starting their activities with a sitting check-in	T3 letting the children figure out the game	T4 playing with the game with the children	T5 convincing a child to wait their turn using jokes	T6 designating roles among team members
Challenging					
	T2 asking the children to stay in front of the prototype	T4 trying to give instructions while children start playing	T6 closing the laptop and asking the child to re-focus	T8 reacting to children mis-using the game materials	T12 helping a child, while he says "it is difficult to balance"

Figure 6: Key moments from curated video clips that were sent to students.

Navigating Engagements with Users. Students also reflected on two strategies that they found were successful in their engagements with users: being eye-level with users and investing into relationship building. Caelen reflected on the value of being at eye-level with children to mitigate power dynamics. They said, *"I think I tried at times, to get more down on their level to talk to them, to be able to look at them, but it's hard because they're so fast moving."* In their mid-quarter reflection, Team 10 wrote, *"A tactic that was successful was talking to kids in a personable manner where there is a back in forth conversation of sharing experience. Kids specifically like to hear how they relate to you and it helps them build on the conversation."* We found that during the sessions, students were intentional and showed genuine interest in getting to know the children. During *snack time*, students actively put themselves out there and introduced themselves to the children. Students also incorporated fun tools for children to play with like a silly hat, bubbles, or wands to both generate user input for their digital games and allow for whimsical connections. In our Session 6 video annotation we wrote, *"The two adults convey moments when they realize something about her drawing, and both show genuine interest in learning about [child]'s picture. After asking several questions, one of the adults adds to the drawing to fit with [the child]'s story."* Hunter also commented on the role of the video clips to show both children's and adult's reactions, *"...it's kind of a reminder for us of what is happening during the session and kind of showing us not only how kids react to our game, it also reminds us how we reacted to the kids."*

We observed students name their learnings and shift their initial perception of the user group as a homogenous group of children to recognizing every child was unique. Compared to Year 1, where students named perceptions of children, this year design students articulated the ways in which their perceptions changed over time. Reflecting on a moment when their team brought a wizard of oz prototype that the children knew was not real, Nao articulated her learning that the children were much smarter than expected, *“I feel like that was all our bad, because like I think we really thought the kids might be really stupid or something...”*

Naming Future Actions. Beyond remembering their interactions and noticing key engagements with users, students commented on how our reflective strategies helped them become better designers. Max said, *“I think it is kind of funny to watch yourself retrospectively, and then you can identify, wow, I probably could have done this differently.”* Wase named explicit actions for their future career as a designer to build rapport with users, *“I would perhaps include an icebreaker game that can stimulate some creativity in them...”*. Max said, *“The clip shows that I expected more answers from the participants, and it's obvious (to me, at least) that I ad-libbed my later questions...In the future, I should come prepared with a research activity in the event I am dealing with a participant(s) who may not have much to say in order to elicit conversation.”* T5 drew connections between their engagement with children in this course and their future engagement with other vulnerable populations, they wrote, *“I notice that I was watching a lot in this clip...this relates to the future of my career in trying to understand how to get the most out of time designing/researching with children or another hard to reach group.”* Across their reflections, we saw students translate their learnings into their next PD session and to their future as designers.

4.7 Discussion

Prior work in HCI education recommends more opportunities for students to reflect (Roldan, Gao, et al., 2020; Sengers et al., 2005). Overall, our findings suggest that revisions in our HCI pedagogy supported multiple ways for HCI students to reflect during user sessions and to name actionable ways to improve on their engagements in the future. We offer pedagogical characteristics that support and hinder students’ reflective practices, including *multi-faceted prompts, curated video clips, ongoing engagements* as well as *uncomfortableness of watching*

oneself, activity timing, and the lack of buy-in. Our work demonstrates how, through scaffolded reflection, HCI students can attend to moments of inclusion and exclusion, attend to body language, navigate engagements with users, and name future actions. We propose *noticing* as an important practice for design students to develop when engaging with others in user studies and highlight opportunities for future research to study how to support noticing for students in the classroom. Our findings extend the concept of *noticing* for HCI, as encompassing the ways in which designers observe important details in users' feedback and body language, interpret user input, and dynamically adapt during user sessions. Below, we discuss opportunities in HCI education to develop scaffolds for *noticing*, pedagogical implications for training reflexive design students, and design recommendations for advancing reflective HCI pedagogy.

4.7.1 Scaffolding Noticing for HCI

Reflecting on engagements with end-users in authentic design settings is complex. In user studies, designers must be mindful of contextual cues, user behaviors and interactions, and their own self (*e.g.*, affect, emotion, body language, bias, gestures) to support positive engagements. We cannot ask students to simply pay attention to moments occurring during their sessions. Just like teachers in education and athletes in sports, design students need scaffolds to know what to look for in the context of user studies and practice looking for those interactions. In this paper, we offer insights into how we translated prior research recommendations to design new course components that helped students engage in *reflective practices*. By supporting students to review their engagements with users by leveraging video and providing tools for students to unpack what they noticed, our investigation shifts how HCI education can scaffold *noticing* and reflection during complex user sessions (Zimmerman & Forlizzi, 2014).

The Process of Noticing. Reflection in CHI relates closely to the concept of *noticing* (Gaudin & Chaliès, 2015; Gibson & Ross, 2016; Sherin et al., 2011; Van Es & Sherin, 2002). While *noticing* is new to HCI, the connection between noticing and reflection has existed since the 1960s (Sherin et al., 2011). In teacher education programs, educators teach students how to look back on what happens in the classroom, think critically about previous interactions, and then translate their learnings to the next time they are in the classroom and have to make quick decisions (Fadde & Sullivan, 2013; Sherin et al., 2011; Van Es & Sherin, 2002). *Noticing* occurs

in the moment. Expert teachers can recognize, react, and act on complex stimuli automatically (Sherin et al., 2011). Prior work offers an iterative model of teacher noticing in the context of a classroom where a teacher may: be bombarded with sensory details, attend to elements of the sensory data as the *noticed* thing, interpret, makes sense of, and reason about the *noticed* thing and then take action based on the noticed thing (Sherin et al., 2011). Similarly, in sports, coaches replay clipped moments from games to help athletes attend to their body positioning and make changes to their plays (Ives et al., 2002). In these settings, sensory information passes fast, decisions need to be made quickly, and teachers and athletes must prepare for next time they are in that context. Sports and teacher education settings are analogous to user studies where multiple sensory inputs to reflect are present.

While the role of a teacher managing a classroom and a designer managing a user session can be similar, designers need to be attuned to different things such as usability problems, design suggestions and methods to solicit actionable feedback. In contrast to existing literature on *noticing*, our findings are situated within the context of HCI where design students must learn to engage in the human-centered design process, move an idea from low-fidelity mockups to a physical interactive prototype, and incorporate user input throughout. By adapting existing strategies for *noticing*, we can support students in learning how to conduct and learn from their user sessions. For example, in Seidel *et al.* (Seidel et al., 2013) the use of video clips helped preservice teachers observe how expert teachers facilitated student group work, posed questions, and gave feedback in the classroom. In contrast, in our investigation, video clips helped design students observe how they implemented their study protocol and made the necessary adjustments for their second design session to elicit the desired user input.

The Process of Translational Work. A core contribution of our work is translating insights from teacher education on *noticing* and reflection in pedagogy—particularly how educators learn to pick up subtle cues of their instruction and student engagement—to HCI pedagogy where similarly designers must learn to notice the nuanced moment-to-moment interactions with users. The translation from teacher pedagogical reflection to HCI education is not a simple task. Most HCI educators have been trained in engineering and design programs and have not been exposed to teacher literature. Therefore, this paper connects existing research in other disciplines to HCI

and provides empirical evidence of the strategies that support and hinder students' reflective and noticing practices throughout their design process when working with users. Our contribution is a novel integration of theories on noticing and reflection with the technology affordances of video in the context of a studio-based HCI classroom (Zimmerman et al., 2007).

Our design inquiry has *broadly* explored involving end-users in HCI classrooms and this paper *specifically* names reflective strategies to support students during user studies. From our 2019 course offering (Roldan, Gao, et al., 2020), we learned that reflection could support students in conducting user study sessions. Thus, we revised our 2020 course with the intention of scaffolding reflection for students. By implementing and studying our changes to the course, we became aware of the value of *noticing* to help designers make in the moment decisions through an ongoing process of recognizing, reacting to, and acting on complex user interactions. Our contribution is valuable given the prominent role of user studies in HCI practice, the complexity of stimuli present during user studies, and the opportunity we present to support students in learning how to reflect on their sessions through video-based reflection.

In this paper, we shed light on the process of adapting research in teacher education to HCI practice (Hansen & Halskov, 2018; Zimmerman et al., 2007; Zimmerman & Forlizzi, 2014). This work has brought together an interdisciplinary team of researchers, educators, and PD facilitators to implement and study best practices in the HCI classroom. The translational process has involved negotiations to ensure added course components prioritized students' educational experiences. Future work might explore how framing classroom interactions as design practice creates opportunities for HCI pedagogy. This framing surfaces opportunities for doing user testing with students, seeing curriculum design as iterative, and innovating on the design of curricular activities. We see potential in the HCI classroom as a design site to explore wicked problems with a range of stakeholders through the integration of *true* knowledge (e.g., design skills and techniques to conduct user sessions) with the *how* knowledge (e.g., supporting reflective practice for designers) (Zimmerman et al., 2007).

4.7.2 Implications for Pedagogy & Design

Training Reflexive Design Students. In the past, HCI designers have focused more on functionality and usability of technologies. Today with the third wave of HCI, the field is exploring more ethical and critical questions about doing design (Bardzell & Bardzell, 2011; Bødker, 2006). This investigation has led us to ask, what is at risk if we do not train reflexive human beings through our classroom practices? We propose that HCI is not just about understanding how to engage the end user, but about the human who is leading the engagement with the end user to design something for other users.

We have found that the process of noticing can prompt critical thinking about design situations that seem ephemeral in the moment; where the process of noticing is no longer just noticing flaws or design changes that need to be made in the interactive technology but about noticing opportunities for improvement of our interactions through design processes. We offer three ways that educators can scaffold noticing for their students in their classroom: through the use of multi-faceted reflection prompts, curated video clips, and ongoing reflection prompts. Informed by HCI literature on reflection in HCI (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005), we augmented the original course structure and provided multifaceted reflection prompts, curated video clips, and ongoing reflection activities. Moreover, beyond showing what aspects of how scaffolded noticing worked and did not work in our findings, we highlight what is possible when educators take the time to encourage noticing in the classroom. We encouraged students to go deeper into their engagements with end users to strengthen their ability to *notice* in the moment. By teaching them where to look, as design educators, we were supporting students in developing their own instincts of what is a key moment in an interaction during a user session.

Designing Pedagogy to Support Students to Curate and Interpret their Video. To support reflective practice and noticing, skilled educators, facilitators, and students can collaborate to curate and interpret video. For educators who may not have the time and resources to curate video clips for students, we propose a spectrum of solutions: On the lighter end, educators can send out the full video clips and have teams watch and annotate them. Students can also record moments using their smartphones, use those clips as sources of inquiry and reflection, and have conversations with the teaching team for feedback. On the higher effort end, educators can watch the recording and pull out “teachable moments” for teams to watch, as we did in our work.

Students could also support each other in interpreting their clips during designated course time—a strategy that enables peer learning. Peer feedback requires rapport, trust, and respect such that peers can direct and receive critiques in a positive manner.

Additionally, HCI educators can pause, reflect, and notice moments within their teaching. Educators (experienced and new) could review clips from their courses and share successes and opportunities in group settings. Given the recent shift to remote learning due to COVID-19, reviewing clips recorded from Zoom or online lectures can more easily become a common practice. In a virtual setting, educators can record themselves, curate clips of their teaching engagements, and then use those clips for viewing and discussion with another instructor. This might also be an opportunity for cross-discipline collaboration between educators (e.g., computer science, interaction design, art) who all teach project-based learning and share strategies.

Designing Technologies to Curate Video. For HCI educational technologists, we also see an opportunity to innovate on the tools and techniques that can be used to scale video-based reflections. In professional sports, technology and coaching staffs have grown significantly to do rapid review of game play, clip key moments, and facilitate video sessions even during the game itself (e.g., at half time) (*The Game Within the Game: Life as an NBA Video Coordinator*, n.d.; *Use Video to Boost Halftime Adjustments and Maximize Intermission | Hudl Blog*, n.d.). In HCI education contexts where there are limited time and resources, we envision tools that can quickly curate moments or distribute the process of curating clips among students. Toward this vision, a teaching center created an initial tool that records classroom interactions in 2-minute segments for review (Fisher & Solomon, 2016). Video annotation tools also support students in quickly tagging, clipping, and describing their interactions (Rich & Hannafin, 2009). Future work that seeks to design technologies to support HCI pedagogy and reflective practices can involve a range of HCI educators and students to consider the ethical implications of recording and reviewing video.

4.7.3 Limitations & Future Work

Effort to Curate and Distribute Video Clips. There was considerable effort from the team to curate and distribute the video clips to students which including properly consenting every

student to be recorded during their PD sessions. During the course, six researchers looked through video recordings to identify two clips that could be sent to each student team (24 clips total), annotated the key moments, and named whether it was a successful interaction or a challenging interaction. We understand that not every educator might have access to the resources our researcher team had. We see an opportunity for future work to design tools that can support the curation of clips for reflection. Due to the COVID-19 pandemic many interactions now take place in the online space which provides more opportunities to easily record user studies for review and reflection at a later time.

Context. The students in this study come from a highly selective master's program with a strong cohort-based culture. This influences the ways in which they reflected with each other and reviewed their video clips together. Future work might explore how to ensure reflection in groups is done in a psychologically safe space.

COVID-19. Our university implemented stay-at-home measures for COVID-19 during the last portion of the course, preventing students from completing the last of their testing and iterations on projects. We conducted interviews virtually at the height of the pandemic in March 2020. This limited the experiences we heard from students after we shared a link to their video clip given their health and safety concerns on the state of the world.

4.8 Conclusion

There is increased momentum in HCI education to actively investigate, reflect on, and propose implications for pedagogical approaches (*Diversifying HCI Curricula – EduCHI Living Curriculum*, n.d.; *Future of Design Education*, n.d.; St-Cyr et al., 2020). In this paper, we present a Research through Design investigation (Zimmerman et al., 2007) of a studio-based HCI course, which was revised based on HCI education research recommendations (A. Cook et al., 2020; Roldan, Gao, et al., 2020; Sengers et al., 2005). We describe how students experienced key changes from Year 1 to Year 2 of our course: introductory PD lecture, PD templates, pre-PD session reflections, post-PD session debriefs, and mid-quarter reflections. Our findings suggest that our course revisions helped scaffold students into a complex user-study context, consider best- and worst-case session scenarios, and collectively identify opportunities for future action

for their second user-study sessions. We present the pedagogical characteristics that supported and hindered students' reflective practices from our revisions, including *multi-faceted reflection prompts*, *curated video clips*, *ongoing engagements* as well as *uncomfortableness of watching oneself*, *activity timing*, and the *lack of buy-in*. And we present insights that students gained as part of our reflective exercises: *attending to moments of inclusion and exclusion*, *attending to body language*, *navigating engagements with users*, and *naming future actions*. Our work highlights how students can practice reflection and noticing during user study sessions similar to the ways in which teachers, athletes, and healthcare workers review their practice using video. This paper translates insights from existing literature *noticing* and reflection in pedagogy to the context of HCI where designers must attend to moment-to-moment interactions with users throughout the human centered design process. Future work might explore the sustainability of the strategies for reflection we found, investigate the long-term impact of design students' experiences working with end-users, and embrace reflective practices for HCI pedagogy.

4.9 Acknowledgments

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4.10 Site 1 Afterword

Positionality. My commitment to this research site for three years meant that I developed a close partnership with the educator to study his class and with the lead facilitator to bring the children's co-design team to the course as users. My positionality as a close collaborator to the course instructor and co-design facilitator meant that I had access to interview the design students, I was trusted to facilitate the sessions with the child users, and I was able to propose key changes to the course. As evidenced in our methods, core to the success of this project were the key changes we made over time as we learned more about how we could support design students in working with these end-users and about the role of reflection to support noticing during user sessions. Given my positionality in the space, I was able to leverage the multiple perspectives from engineering, learning, teacher education, design to inform the key changes we

proposed each time. Over time, showing up as my full self in this project meant becoming a part of the course teaching team, openly discussing with the design students that this class was being studied for a research project, and becoming friends with the children to make sure they always had a friendly face in the sessions as we introduced new design partners weekly.

Equity Tenets. This project has explored equity by placing a critical lens on HCI education to consider who we engage in classroom-based projects and by offering tangible design implications for educators to take up (Creatively informing design implications). Through my research in this site, I have surfaced opportunities for how HCI pedagogy can support reflection and noticing when executing design sessions. This research allows for future opportunities to study how we can support designers to be more inclusive in their approach with users. This work has also centered equity by shifting power from the traditional user voice of an adult to listening to children's voices in the design of technologies (Respectfully treating people like people). In this project, I have engaged others in conversations about who else designers can involve and what our responsibilities are as designers to intentionally involve a range of users in our projects. This project has further helped me develop the tenet that equity is not a solo endeavor. This project required collaboration across classroom practices, students, project clients, stakeholders, and children co-design team stakeholders (Regularly recognizing equity is collaborative).

Sites of Knowledge. This project allowed me to further develop and enact my equity tenets in the context of a prestigious, one-year HCI+design master's program at a large research university. This project also took place in the context of a multi-year research project that centers children in the design of technologies where children and adults meet weekly to design together on a university campus. The affordances of this site meant that both the master's students and the children from the co-design team had existing knowledge about design, design partnerships, and about university campuses. It also meant that I was able to expand my understanding of what it meant to enact my equity praxis in the context of a formal institution of higher education. In this site while developing the tenets of my equity praxis I had to adhere to university policies, I had access to university resources, and I was generating new knowledge about HCI education against the backdrop of the historical implication of how design is taught in formal school settings.

5 Chapter 5. Site 2 (Funds of Knowledge in Online Search and Brokering)

5.1 Overview of Site 2

I co-authored three published papers on research that each explore the process of online search and brokering with English language learning families through in-home visits and interviews (Gonzalez et al., 2020; Pina et al., 2018; Roldan et al., 2019).

The first paper was led by Dr. Pina, where we outlined the ecological systems factors that influenced online search and brokering in a CSCW 2018 publication. This investigation demonstrated the ways in which online search and brokering processes are influenced by familial values and resources at an individual, family, community, and digital infrastructure level and how parent-child dyads problem-solve family needs through online search and brokering practices. This work demonstrated to the CSCW community a new purpose for technology use in families, one that was intergenerational, bilingual, online, collaborative, and used to solve for critical family needs. Although this work identified the ecological factors that impacted online search and brokering, research had not yet distilled the specific learning processes behind such family collaborations therefore I led a second analysis of the data to publish a paper on the role of funds of knowledge in online search and brokering at CSCL 2019.

I led the second online search and brokering paper which explored the learning processes as family members collaboratively search for information online through a funds of knowledge (FoK) theoretical lens. I chose to revisit the data collected for our CSCW 2018 paper to understand the funds of knowledge each adult and youth used during online search and brokering (OSB). My hypothesis was that from a sociocultural, asset-based perspective, I would be able to surface computer supported collaborative learning processes that happen during OSB. This project was a chance to make visible the learning processes such that educators could recognize the funds of knowledge their students develop in the home during OSB.

Our third paper was led by Dr. Gonzalez with a focus on health literacy challenges. This work was published in the journal of health communication where we show how intergenerational

online health information searching and brokering reveals family level strengths that can be leveraged to promote health and digital literacy among people who have been marginalized.

Title: The Role of Funds of Knowledge in Online Search and Brokering

Published in: 13th International Conference on Computer Supported Collaborative Learning (CSCL) 2019

Authors: Wendy Roldan, Paola Vanegas, Laura Pina, Carmen Gonzalez, Jason Yip

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5.2 Abstract

Lower-socioeconomic status, immigrant parents who are English language learners often work collaboratively with their children to search the internet. Family members rely on each other's language and digital literacy skills in this collaborative information problem solving process known as online search and brokering (OSB). While previous work has identified the ecological factors that impact OSB, research has not yet distilled the specific learning processes behind such family collaborations. From a case study analysis of three families, this work explores the funds of knowledge that children and parents rely on as they engage in collaborative learning experiences through OSB. We demonstrate how in-home computer-supported collaborative processes are often informal, collaborative, social, and highly relevant to solving real-life information challenges. Our work shows how parents and children draw on their funds of knowledge when they search collaboratively, with and for their family members, to build their collective knowledge of technology and problem-solving.

5.3 Introduction

Approximately 8 million U.S. children have at least one immigrant parent who is an English language learner (Zong et al., 2018). Lower-socioeconomic status immigrant parents often rely on their children's language and digital literacy skills to address family needs (Eksner & Orellana, 2012). In these families, adults and children work with each other to search the internet, in a collaborative information problem-solving process we call *online search and brokering* (OSB) (Pina et al., 2018; Yip et al., 2016). For these families, children's responsibilities extend beyond traditional chores to holding the role as the family's primary problem-solver for critical family needs through online information searches (Pina et al., 2018). While previous work has identified online search and brokering practices (Yip et al., 2016) and the ecological factors that influence online search and brokering (Pina et al., 2018), research has not yet distilled the specific learning processes behind such family collaborations. While online information problem-solving models (Brand-Gruwel et al., 2009) contribute to our understanding of digital learning and information processing, they do not fully explain the sociocultural, collaborative learning processes that occur as families engage in online search and brokering.

Our research focuses on Latin American families, the fastest growing population in the U.S. (Pew Research Center, 2018). Latino children are projected to make up about a third of the K-12 enrollment by 2023 and with more than half of them living in immigrant families (Foxen & Mather, 2016), many of them are searching for critical information online for their English language learning family members. Education researchers engaged in sociocultural historical approaches with children from non-dominant backgrounds explain that learning is an ongoing process that is not divided into separate characteristics of individuals and contexts (Gutiérrez & Rogoff, 2003). Therefore, we believe it is important to understand the learning that occurs in intergenerational, bilingual, information problem-solving family collaborations. Previous research with families whose households have been traditionally viewed as low-resourced, applies a funds of knowledge framework to understand and nurture the strategic knowledge and skills that are often overlooked (Moll et al., 1992). Using a funds of knowledge framework (Moll et al., 1992) this work explores the learning processes that occur in Latino families, when family members collaboratively search for information online. We examine a case study of three focal

Latin American, lower-socioeconomic status, English language learner families as they engaged in collaborative, computer supported, online search and brokering. Our research questions are:

- **RQ1.** What funds of knowledge do bilingual children and their English language learner parents rely on when attempting to solve information problems using the Internet?
- **RQ2.** What are the collaborative learning processes around online information searches in English language learner families as they work together?

5.4 Background

This work builds on literature in individual and collaborative search processes, the phenomenon of search and brokering, joint media engagement, and sociocultural historical theory on learning as a cultural, ongoing activity. We draw on research that investigates how individuals search for information online to make sense of the learning that happens within individual search processes. However, in applying individual problem-solving models for online search we find gaps with respect to understanding how learning occurs in intergenerational and bilingual collaborative searches. Thus, we turn to the literature on language brokering that focuses on intergenerational and bilingual problem-solving between youth and their parents to help us fill the gaps. To strengthen our literature review on online search and brokering with families, we find that joint media engagement is a particularly useful framework to examine the learning that is happening as families use media together and in the home.

5.4.1 Individual and collaborative search processes

A rich body of work explores how individuals search for information online. Models like *Information Problem-Solving for the Internet* offer insights into the set of skills individuals need to search for information online. These skills include: defining, searching, scanning, processing, and organizing information (Brand-Gruwel et al., 2009). While we know much about the learning that happens within individual search processes, less is known about the process of how people collaborate together to solve information problems and the learning processes behind it (Stahl et al., 2006). Research on online searching as a collaborative process between individuals (Morris, 2013), shows the opportunity to reinforce and learn search skills from exposure to others' strategies (Foss et al., 2012). But much of this work has focused on skilled peer adults

searching remotely together using online tools (Morris, 2013). Further, research with families engaged in informal collaborative relationships with technology suggests that participation in these activities can nurture knowledge of managing information and promoting self-direction of one's learning (Jenkins, 2006). This strand of research provides insights into the relationship between collaboration and learning but focuses on collaborative engagement in technologically mediated activities that are not information problems. From our literature review, we conclude that research on intergenerational, bilingual, collaborative search processes and learning is limited thus we turn to the communications literature that explores language brokering with youth in the home.

5.4.2 Online search and brokering (OSB)

Recent literature explores how parents and children work collaboratively to address family information needs using digital resources, in a process known as online search and brokering (Pina et al., 2018). Research on immigrant youth shows how language brokering is part of everyday life as children and parents work together to address family needs (Orellana et al., 2003). Bilingual youth work as translators and interpreters for their immigrant parents, which opens the families' access to resources and information on education, health, and finances. As families collaborate to address family needs in everyday language-brokering events, different levels of skills and expertise are leveraged, and knowledge becomes co-constructed (Eksner & Orellana, 2012). As the digital divide narrows, scholars have also explored how children become *technology brokers* to introduce and teach their parents new technologies (Nelissen & Van den Bulck, 2018). There are significant differences in how children help their parents with technology across families from different socio-economic status (Brown et al., 2007). In high-socioeconomic status families, children drive the adoption of mobile applications, technology for entertainment, and educational purposes. On the other hand, in families from a lower-socioeconomic status, children help connect their adult family members to critical information needs (e.g., finances, health, well-being) (Nelissen & Van den Bulck, 2018). Collaborative family engagement with technology also differs significantly across families. To further contextualize our work as parents and children use technology together, we draw on literature from joint media engagement.

5.4.3 Joint media engagement (JME)

The nuanced interactions that occur as parents and children engage in online search and brokering is a form of joint media engagement that has not been previously studied (Pina et al., 2018). The phenomenon of joint media engagement helps us understand the experiences of people using media together as they view, play, contribute, search, and create with both traditional and digital media (Sobel et al., 2017; Takeuchi & Stevens, 2011). Previous research with families defines joint media engagement as the process of learning between children and parents as they co-create meaningful connections among interests, experiences, and representations using all forms of media and technologies that are present in children's lives (Takeuchi & Stevens, 2011). However, much of the research on joint media engagement emphasizes learning together through gaming, entertainment, and education (Gee et al., 2018). Our work builds on prior research with families and technology by identifying the funds of knowledge that children and their parents draw on to problem-solve and co-create meaningful connections that extend beyond play and family fun to solve critical family needs.

5.5 Theoretical Framework – Funds of Knowledge

We apply a funds of knowledge framework to examine the collaborative, intergenerational, bilingual, information problem-solving learning processes that occur during online search and brokering with an asset-based perspective. A funds of knowledge framework allows us to understand the historically accumulated and culturally developed bodies of knowledge that are essential for household and individual well-being (Moll et al., 1992). We posit that a funds of knowledge approach allows us to capture the tacit knowledge parents and children draw on when engaging in online search and brokering, knowledge that is not necessarily taught but critical to family well-being. This framework allows us to push the conversation away from deficit models of learning for non-dominant students towards honoring the learning that occurs in the household and everyday activities of Latino youth and adults as they search and broker for information online collaboratively. Previous research with families whose households have been traditionally viewed as low-resourced uses funds of knowledge to refer to the strategic knowledge and skills that exist within these families (Moll et al., 1992). A person's funds of knowledge can be described as their accumulated life experiences, the skills and knowledge they use to navigate everyday life, and their cultural-historical academic and personal background knowledge. Our

work builds on prior funds of knowledge research in learning and education, by identifying the knowledge and skills found in households that members use to solve information problems as a computer supported collaborative learning process.

As parents and children engage in everyday online search and brokering, we explore the learning processes that occur through a sociocultural lens by applying a funds of knowledge framework. Sociocultural scholars propose that the educational movement toward equity will occur, “as we create learning environments that connect in deep ways to the life experiences of all students” (Nasir et al., 2006). A sociocultural lens provides new insights on issues of race, culture, and learning (Nasir et al., 2006). Learning, as a cultural process of engagement in repertoires of practices, is a process in which individual development is understood in cultural and historical contexts (Gutiérrez & Rogoff, 2003). Building on this body of work, we recognize understanding learning requires a focus on how individuals engage and participate in particular every day activities and how they draw on artifacts, tools, and others to solve problems (Nasir & Hand, 2006).

5.6 Methods

For this study, we adhered to the standards and practices of a case study examination (Merriam & Tisdell, 2015a). We focused on three Latin American lower-socioeconomic status, English language learner families in the Pacific Northwest and their collaborative learning experiences through engagement in online search and brokering.

This exploratory, qualitative study with three focal families is a part of a larger qualitative study. Between July 2016 and June 2017, we visited 23 families in an urban area of the Pacific Northwest, U.S., within a 32-kilometer radius of our research institution. Our participants included parents, grandparents, and children aged 10-17. Most of the adults that were a part of our study were born in Mexico, did not have a college-degree, worked in service industries, and represented a lower-socioeconomic population. At the time of this study, a tense political climate existed for Latino families therefore we relied on community center networks, local cultural events, and a paid community liaison as a part of our recruitment strategies. We conducted two separate in-home family visits per family. In-home visits allowed participants to feel comfortable

in their usual search and brokering environment and allowed researchers to observe search practices within the home's digital infrastructure. In our first in-home visit (V1), we conducted separate adult and youth retrospective interviews to contextualize where and how they search. In V1 we gathered family members' perspective on their practices, strategies, and challenges when searching for information online. The interview protocol was adapted from previous work on in-home media studies (Katz & Gonzalez, 2016). Each interview (45-60 mins) was audio recorded and transcribed. Parent interviews were in Spanish and youth interviews in English. For our second in-home visit (V2), we focused on directed internet search tasks between adult-youth dyads. Visit 2 was audio recorded and screen interactions were video recorded. In V2, participants engaged in a set of imposed search tasks prompted by researchers and historical tasks of prior online searches. We take a deep dive into three specific families from this larger data set (Table 1).

Table 1. Demographics of the families.

ID	Relationship (Age)	Occupation	Adult birthplace	Grade completed by adult
2	Mother (39), Daughter (10)	Hospitality	Mexico	Primary, 4 th grade
17	Grandfather (62), Grandson (12)	Food Industry	Mexico	Secondary, 7 th grade
22	Mother (42), Daughter (15)	Housekeeping	Mexico	Secondary, 10 th grade

Our selection criteria for these three families are the following. (1) Each family offered insights into different household structures that influence the online search and brokering process. One family was a mother-daughter dyad within a single-parent home, another was a grandparent-grandson dyad within a seven-person home, and the third was a mother-daughter dyad within a four-person family home. (2) In a comparative analysis each family allowed us to see how despite the differences across family structures, we observed themes in the funds of knowledge used and the learning processes occurring during online search and brokering. (3) Each family offers insights into different types of devices used in the home to search for information.

For this paper, we analyzed data from V1 and V2 with three families to explore our research questions. To analyze the data, two researchers used open coding with constant comparative analysis (Merriam & Tisdell, 2015a). This iterative open-coding was done for both parent and child interviews and for an analysis of V2 video data. Two researchers open-coded the data

independently for themes such as technology and language brokering, information problem-solving, relationships, perceptions of learning, and strategies and challenges to searching. We coded and compared the themes to develop further categories for analysis and then systematically compared and contrasted the themes between researchers. Following open-coding, we used axial coding to make connections between funds of knowledge categories and subcategories. We performed a constant sorting and comparative analysis until theoretical saturation was reached and no new codes were generated. Finally, we looked at these themes and interpreted them using a funds of knowledge analytical lens. Data on search tasks from our second visit allowed us to triangulate interview data from our first visit to provide a rich analysis of our data.

5.7 Findings

For each family, we provide a case description for context and describe a search task in-depth. We then discuss each case using a funds of knowledge analytical lens (Moll et al., 1992) to help us document the learning and knowledge in practice that is a part of online search and brokering as a daily household routine (Gutiérrez et al., 2009). We highlight the funds of knowledge that each family member brings into the collaborative information problem search process from their home and community lives (Moll et al., 1992). Each family engages in online search and brokering differently with devices, set-ups, and strategies. All quotes are translated from Spanish. We use [] to indicate typing on digital devices. All names used in the cases are pseudonyms, with Name^A for adult, and Name^C for child.

5.7.1 Family 2. Norma^A and Mia^C

Case Description. Mia^C is Norma^A's 10-year-old youngest daughter who helps her mom with searches on a more regular basis compared to her older sisters. Mia^C is a developing yet savvy searcher, often struggling with spelling search words but consistently recognizing the need for descriptive terms to narrow her search. At the time of the study, Norma^A indicated she did not feel confident with technology but was aware of technology resources through her local community networks. In V1, we learned Norma^A and Mia^C engaged in collaborative online search and brokering when Norma^A discovered someone had taken money out of her bank account fraudulently. The woman from the bank taught Mia^C how to access Norma^A's online

banking information for her. During V2, we saw this financial search information problem revisited. For one of the tasks, Norma^A wanted to find the closest bank near her home. Mia^C clicked the search bar (Figure 1, left), and began to type using the tablet screen keyboard and her two index fingers, [*the cosest bank*]. Mia^C paused as the search engine suggestions came up for *the closest bank of america* and *the closest bank of america to me*. Mia^C continued to type into her search [*the cosest bank of america*] and pressed the search button to generate results. Mia^C scanned the results and clicked on the Google visual map (Figure 2, right). Mia^C hovered her finger over the options and explained to her mom what the results meant. Mia^C noted Option A is the closest because it appeared first.

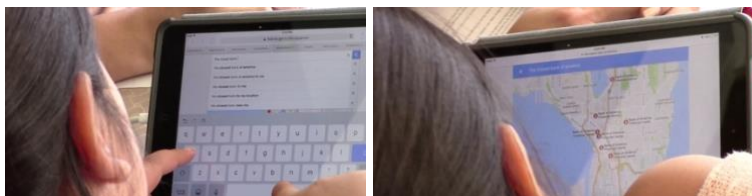


Figure 1. Norma and Mia searching for the closest bank using Google Maps.

Case Analysis. Knowledge of Linguistic Translational Practices

In this case, we notice how Norma^A and Mia^C use their funds of knowledge about each other's assets to complete their financial information search task of finding the bank nearest to them. Mia^C built on her cultural repertoires of linguistic practice as she (a) translated her mom's inquiry about finding the closest bank from Spanish to English; (b) searched using key descriptive terms in English that would narrow her search for banks nearest her; (c) scanned the information presented in English; (d) relied on visuals and maps to find answers; and (e) translated the results back to Norma^A. After the search was completed, Mia^C explained she did not understand maps, but Norma^A used her knowledge of spatial geography and relied on her lived experiences of navigating this area to understand where the bank was. Norma^A and Mia^C helped each other process, translate, and increase their collective understanding of finding and reading a map. We see knowledge of linguistic translational practices used in their intergenerational, bilingual, online search and brokering practices. In this example, we see Mia^C engaging in a range of practices that challenge deficit notions of students' repertoires developed across non-school settings (Gutiérrez et al., 2009). As Mia^C collaborative searches with and for

her mom, she uses linguistic knowledge, problem-solving and search knowledge, and translation knowledge. Each of these funds of knowledge Mia^C uses to search could become future resources for her learning across settings and practices, inside and outside the classroom (Gutiérrez et al., 2009).

5.7.2 Family 17. Carmelo^A and Mateo^C

Case Description. Mateo^C is Carmelo^A's 12-year-old youngest grandson who helps Carmelo^A with most of his searches. Carmelo^A owns a restaurant and is a lifelong learner who desires to learn more about technology. Mateo^C is a visual and audio searcher who feels comfortable with technology and uses google voice to search for information. Similar to Mia^C, Mateo^C struggles with spelling and instead prefers to say rather than type a word. In V1, Carmelo^A told us that he searches the internet to buy things for his restaurant and preferred images to make sense of information online. In V2, we observed Carmelo^A and Mateo^C search together for new industrial stoves knobs for Carmelo^A's restaurant. Carmelo^A wanted to buy goods on Amazon for his restaurant. Mateo^C clicked on the Amazon app on a smartphone and clicked on the search bar (Figure 2, left). He moved his fingers from the search bar to the keyboard. Mateo^C showed Carmelo^A how to go to the search bar. Carmelo took the smartphone and typed [*buttons for*] in Spanish. Mateo^C interrupted and asked if this was for clothing, but Carmelo^A explained this was for stoves. When Carmelo finished typing, the Amazon app returned images of what Carmelo was looking for. As the discussion continued, there was a disconnect between what Mateo^C thought they were looking for. Mateo^C typed word [*bupaten*] into the Amazon search bar (Figure 2, center). Mateo^C said the search was not giving him what he wanted. Carmelo^A took back the phone, left the Amazon app, clicked the Google app, and typed [*how do you spell buttons in English*]. Carmelo^A said, "There it is! This is how I do it. But it takes me a long time." At this point Carmelo^A asked Mateo^C to teach him how to search using voice to be more agile. Mateo^C clicked on the voice icon on Google search (Figure 2, right) and told him to just talk. Carmelo^A took the phone up to close to his mouth and said, "I want to look for buttons for the stove," but the search did not work. Mateo^C explained, "You have to push this button and then go. You push it and go." Carmelo^A used the voice assistant again, "I want to look for buttons for the stove." Carmelo^A looked and smiled at the search result images of the knobs he was looking for, having learned a new technology skill (Figure 2, right).

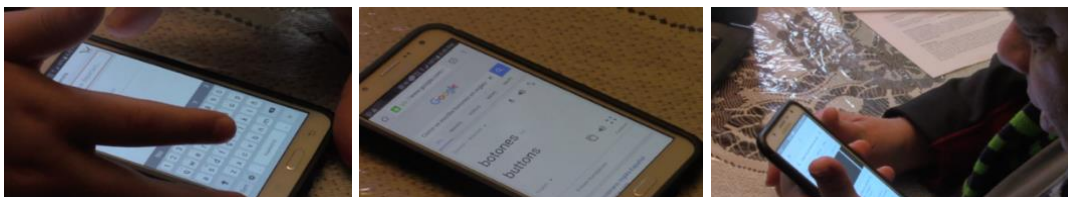


Figure 2. Carmelo and Mateo searching for stove knobs using the Amazon app and Google voice assistant.

Case Analysis. Knowledge of Problem-Solving Strategies

In this case, we believe Carmelo^A and Mateo^C rely on each other's funds of knowledge to explore different search strategies when they face the challenge of not knowing the translation between buttons and knobs in Spanish. Carmelo relies on his lived experiences running the restaurant to explain to Mateo^C what he was looking for. Mateo^C sets the search up for Carmelo^A by (a) previously configuring the Amazon app settings to Spanish; (b) showing him where to enter his search terms; and (c) clarifying what it is they are looking for to make sure the language translation is correct. When they get stuck, Carmelo^A uses his previous knowledge related to persistence to show Mateo^C how he uses the Internet to problem-solve translational challenges. Further, this example shows how each other's funds of knowledge are taken up as they explore alternative search strategies moving from the Amazon app, to Google search, to Google search voice assistant. Carmelo^A observes Mateo^C using the Google voice assistant and learns how to do it himself through Mateo^C's scaffolds. The two help each other conceptualize the problem, explore different internet resources to push away from challenges, and learn new language and technology skills. We see knowledge of alternative strategy exploration being taken up by Carmelo^A and Mateo^C as they expand their knowledge of technology to uncover the shared meaning of knobs/buttons in their multisensory (auditory and visual), intergenerational, bilingual, and online search and brokering practices.

5.7.3 Family 22. Romelia^A and Amy^C

Case Description. Amy^C is Romelia^A's 15-year-old daughter. Romelia^A is a stay-at-home mom and relies on Amy^C to search for information related to the needs of others in the home. Romelia^A watches videos on YouTube to learn how to do things like braid hair or find new

recipes. Amy^C is a searcher who uses multiple strategies in action as she searches for her mom using her knowledge about viruses, advertisements, and web browsing. When the two engage in collaborative online search and brokering together they often sit side-by-side, co-viewing on the family desktop computer. During our first visit, we learned Romelia^A wished she knew how to help her husband search for construction jobs. In V2, we observed how Amy^C and Romelia^A search for construction jobs for the father. Amy^C asked, “What jobs do you want to help find for papa?” (Figure 3, left). Romelia^A responded, “Like companies, like companies that have jobs.” Amy^C typed, [*construction companies hiring near me*] and clicked on the second search result, Monster.com. Romelia^A noted, “Make sure the search results are local.” Amy^C narrowed the search by selecting the U.S. state and typed [*construction*] in the Monster.com search box. The search results come up and Amy^C translated the job descriptions from English to Spanish for her mom. As Amy^C simultaneously interpreted, translated, and scanned the results, she also explained why she was not clicking on job postings that require a technical or engineering degree. However, Amy^C noted she was stuck. Romelia^A suggested adding the word *siding* and Amy typed in [*constructing citing (sic)*], which did not result in what they needed. Amy^C asked, “*citing*, right?” They stepped away from the computer and look for other resources to refine their search terms. Romelia^A pointed to the father’s contracting certification that showed how to spell *siding* the correct way (Figure 3, right). Amy typed, [*construction companies hiring siding installers in (U.S. state)*]. She translated the information to her mom. Romelia^A asked, “How much do those jobs pay?” Amy noted it was about \$20 an hour. Amy^C asked, “Do you want jobs for him or for his company?” Romelia^A stated, “I want to look for jobs for a contractor, not jobs that hire by the hour, I want to look for big jobs because he has his company.”

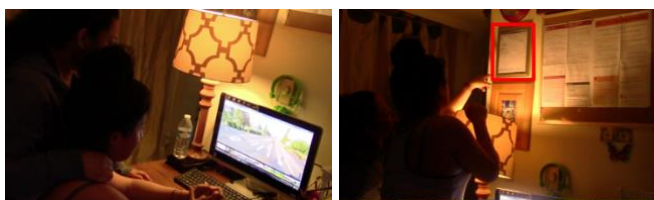


Figure 3. Romelia and Amy searching for construction siding jobs using online and physical resources.

Case Analysis. Knowledge of Search Resources

Romelia^A and Amy^C discuss, contribute, and move from online resources to resources in the home to move past challenges. When Amy^C began the search, Romelia^A used her geospatial knowledge and lived experiences of finding a job to ask Amy to narrow the search for local jobs. Amy^C used her knowledge to (a) click on a job search engine; (b) scan the job postings; (c) translate linguistically the search results; and (d) explain her interpretation of the job descriptions. When the two got stuck, Romelia^A offered new search terms (siding) while Amy^C continued to scan and interpret website search results. Using knowledge of alternative resources available to them beyond the Internet they collectively (a) step away from the computer; (b) find the father's contracting license; and (c) correct their spelling of their search terms. They build on each other's funds of knowledge to conceptualize the problem, find alternative resources to spell the search term, and explain what type of job they are looking for based on the father's qualifications. We argue knowledge of search resources moves fluidly between the two as they translate across language, across physical and online, and across technical linguistic practices.

5.8 Discussion

5.8.1 Funds of Knowledge in Online Search and Brokering.

In this study, we found that each individual family member contributes their own knowledge to collectively build household knowledge resources. Each child is a part of a larger social structure within the home where they rely and share their knowledge with siblings, parents, and grandparents. Across all families, we observed how Mia^C, Mateo^C, and Amy^C's role as the primary searcher in their home carried "the trace of prior social relations," building on their prior actions co-creating new knowledge with adults (Bakhtin, 1981; Vossoughi et al., 2020; Vygotsky, 1978). The adults usually have knowledge for the search conceptualization such as geospatial understanding, spelling clarifications, or knowledge of family resources. The children usually have critical technology proficiency and linguistic translational knowledge to search, scan, process, gather, and translate online information. During collaborative searches, each family member continually builds on the knowledge of each other's assets. This knowledge informs the ways in which children and adults set up future learning opportunities for each other within online search and brokering practices.

Further, we highlight how family members developed resilience, as they faced structural and systemic challenges to searching for information (language, access to social resources, schooling). Resilience was reinforced through funds of knowledge and resource sharing as family members relied on each other's knowledge, strategies, and skills when met with a challenge during their search process (Berkes & Ross, 2013). Across all families, we observed resilience at the level of the individual and the household as interrelated, with family members actively developing their shared resilience through capacity building and collaborative learning while engaged in online search and brokering (Berkes & Ross, 2013). The families persisted and relied on their funds of knowledge (translational practices, problem-solving, search resources) collaboratively to solve their information problems when they got stuck or tried to problem-solve through the unknown. For the majority of the adults in this study, the United States is not their home country. With this information, we can see the funds of knowledge related to resilience, problem-solving through new situations, and strategies to move beyond challenging situations while engaging in online search and brokering in our data. Building on sociocultural theories of learning, we offer this analysis as a way to help us construct classrooms that draw on the funds of knowledge that students bring from their home and everyday experiences to promote holistic and equitable development and learning (Gutiérrez & Rogoff, 2003).

5.8.2 Collaborative Learning Processes in Online Search and Brokering.

In contrast to highly individualized instructional systems (e.g., formal school), we demonstrate learning processes in-the-home are often informal, collaborative, highly social, and highly relevant to solving real-life information access challenges. Through our thematic analysis of the funds of knowledge that adults and children draw on while they engage in collaborative online search and brokering with their families, we offer a nuanced understanding of computer supported collaborative learning processes happening within the home. We contribute to studies of joint media engagement (Takeuchi & Stevens, 2011) by identifying the funds of knowledge Latino families draw on to problem-solve and co-create solutions that extend beyond play to solve critical family needs. Joint media engagement is not just about learning together through gaming, entertainment, or educational technologies. Instead, we highlight the ways that family members work together as a group to solve information problems using online connected technologies. Work within CSCL notes that group cognition forms as a result of collaborative

knowledge building in which meaning is created across the utterances of different people (Stahl, 2006). In our cases, all of the adults and youth act in a joint activity to problem-solve for their family needs. The shared construction of meaning occurs as both adult and child engage through intersubjectivity of language, technological interactions, information problem-solving, and family funds of knowledge. For many of these families, the group remains at the synchronous level, in which adult and child work together around an interactive device (e.g., desktop, tablet, laptop, smartphone) to collaborative solve their family information needs. We believe our research in this area contributes to CSCL as there is a need to identify how technology and online information problem-solving for family needs supports how people learn, and uncovering what challenges lie ahead.

5.8.3 Implications for Educators.

As online search and brokering plays a major part of family practices, our work highlights the funds of knowledge that are evident as parents and children search together, which educators can utilize in the classroom to design instructional materials that are relevant to students' family responsibilities. Overall, while our findings focus on a specific group of Latin American families with English language learner parents from a lower-socioeconomic status, family information search and collaboration happen across all contexts and ages. For example, other immigrant English language learner families might search for health information for elderly family members together. Individuals must use similar processes of finding information together, making sense of that information, and translating that information by closely drawing on their funds of knowledge at each step of the information problem-solving model. By examining a) the funds of knowledge families use in online search and brokering and b) the computer supported collaborative learning processes in online information search, we are better able to provide instructional design implications to help schools, libraries, and community centers attend to culture in understanding students' learning. Our work opens up new opportunities to bridge home and school through the computer supported collaborative learning process that are embedded in children's every day practices. Our findings can help educators consider family roles when designing curricula. Future work could examine the unique challenges of English language learning students and how their search practices might fluctuate across formal and informal contexts.

5.9 Conclusion

We argue that an intergenerational online search and brokering process is different compared to collaborative online information problem-solving that happens between classroom peers or between co-workers. Our research shows how both parents and children draw on their funds of knowledge when they search collaboratively, with and for their family members, to build their collective knowledge of technology and problem-solving. Through the metaphor of a jigsaw puzzle, we can begin to understand how collaborative problem-solving takes first, the identification of knowledge and skills and secondly, the learning processes behind figuring out how to can arrange, turn, and shift the puzzle pieces, in this case the funds of knowledge, to solve the information problem at hand. Ultimately, the CSCL community can benefit from an understanding of how online search and brokering is a form of collaborative learning around technologies given that it is the daily reality for millions of bilingual children from lower-socioeconomic communities.

5.10 Site 2 Afterword

Positionality. For this site, my positionality as a child broker myself meant that I had to constantly engage in reflexive practices to consider how my lens and my lived experience influenced my data analysis. When I reviewed the data between adult and children trying to solve an unknown problem using the internet, I often saw myself reflected in the kinds of questions and conversations between family members to figure out the solution to their problem. My positionality as a bilingual, Latina, daughter of immigrants gave me a unique lens to name the kinds of practices that parents and children were engaging in during their online search and brokering processes in the home. As a fluent Spanish speaker in this context, I was able to see, hear, and understand families' native language. Being able to see the data both in the Spanish families spoke and in professionally translated transcripts of the data meant that I had access to investigate the nuances in how families spoke about their search and brokering approach. My commitment to social transformation also meant that I chose to use funds of knowledge as a theoretical lens in this work to elevate the unique knowledges each family member possessed and push against deficit narratives of lower income, immigrant, bilingual speaking families.

Equity Tenets. This project has helped me further develop my equity praxis as informed by the community members I have worked with and the families I have learned from. Specifically, I see strong connections between the tenet about noticing knowledge that has been made invisible (Carefully noticing invisible knowledge) and the tenet about finding ways to elevate the unique problem-solving skills of adults and children (Strategically translating invisible knowledge). My research time with adults and children who use the internet to solve critical information problems for their family has shown me the resilience of families, the creative ways they work against the systemic barriers they face, and the collaborative aspect of using each other's assets for the benefit of the family collective. This work has also helped me further develop my praxis by thinking about the ways in which we can partner with community members equitably (Intentionally involving community members). At the time of our first data collection there was an increased tense political climate for Latino families and therefore we recruited participants through a paid community liaison. During the second round of participant recruitment the COVID-19 pandemic limited in-person interactions with youth and their families. Throughout, it was critical for me to be intentional about how much burden we placed on community partners, to help us recruit, to pay participants, and share back research findings.

Sites of Knowledge. This project gave me access to a range of sites where I observed how children and adults navigate complex systems to develop their collective knowledge about the internet, searching practices, and solving problems. The data was collected in the home to make sure participants felt comfortable in their environment showing us how they worked together to search for information about health, finances, and education. While the primary site where families searched for information was the home, I observed how children talked about the practices they learned in school about searching that they brought home, how parents talked about the community organizations and libraries they used to access resources, and how family members visited other people's homes to help each other with online search and brokering. In the publication I led I offered implications for formal classrooms to honor the kinds of things problem solving collaborative learning processes children are engaging in the home. I sought to bridge the multiple places where children were developing their funds of knowledge to search online for critical information with others.

6 Chapter 6. Site 3 (Justice Centered Computing in Libraries)

6.1 Overview of Site 3

The third study I include in my dissertation explores how we might disrupt informal computing education learning experiences by allowing local youth to co-construct powerful computational and design experiences for their own community in libraries. This work examines a case study across three years in the setup and implementation of an intergenerational co-design program that was held for 10 weeks in a library. Neighborhood children (ages 7 - 11) met at the library with teen leaders, librarians, and researchers to engage in a range of co-design activities and create a 3D printing library curriculum for other children in the libraries. Lena and Kevin were local Black and Asian teenagers (ages 16 - 17) who constructed and led the weekly workshops independently at KidsTeam Libraries with the support of their local librarians (Ren, Joel, Liam) and university researchers. I provide the historical context of the library as situated in a neighborhood within an urban city that has recently undergone significant gentrification from the technology sector and is home to a large number of East African refugees. Throughout my investigation, my knowledge claims were co-constructed with Lena and Kevin as authors.

To confront systems of injustices in computing directly and explicitly, the findings from this work argue we must rethink who designs computing educational experiences for youth. Following critical pedagogies this investigation writes from the tension that computing education can be both oppressive and liberatory. In this paper, I propose design implications that rethink dominant notions of adults and researchers as leading and designing computing educational experiences. I argue that justice centered computing education approaches can actively involve youth and teens of color in the co-creation of programming and learning experiences in their own communities. Through this work, I highlight that it is simply not enough to shift the burden to youth. We must continuously support and scaffold youth leaders within their community to design solutions to large-scale disparities in computing.

This investigation is in my dissertation because through it I show how I developed localized findings for the computing education research community while refining my conceptualization of equity-oriented approaches in close collaboration with teen leaders. This work also has

supported my development of how to adapt participatory design methodologies when working with Black, brown, and Asian youth.

Title: Disrupting Computing Education: Teen-Led Participatory Design in Libraries

Published in: ACM Transactions on Computing Education (TOCE) – Special Issue on Justice Centered Computing.

Authors: Wendy Roldan, Kung Jin Lee, Lia Berhe, Kevin Nguyen, Sarah Strickler, Jason Yip

6.2 Abstract

Large-scale disparities in computing exist for many youth of color. Learning in informal settings can increase the participation of youth in computing, however computing education programs have typically been developed by adults for youth. We argue computing education can contribute toward decolonization by directly involving youth from nondominant communities as design partners. When we directly involve youth voices, we can move away from focusing solely on the structural barriers faced by youth of color toward an assets-based approach. We examine a 10-week case study within KidsTeam SPL, an intergenerational digital design program where local youth conceptualize what digital learning could look like in libraries. Our qualitative data set includes over 15 hours of video recordings from participatory design sessions, six interviews with participants, ten researcher jottings, and a corpus of 25 researcher memos written by researchers, librarians, and teens. Throughout our investigation, our knowledge claims are co-constructed with the two teenagers who led the design and implementation of a 3D printing curriculum in their local library with 10 children. Our findings emphasize 1) the ways in which the involvement of teen leaders can foster and sustain community-level relationships for computing education, 2) how we noticed, enforced, and disrupted power within our computing education program, and 3) the systemic challenges we confronted in our process toward disrupting computing education. We provide empirical evidence of teen-led participatory design approaches for computing education in their community through detailed vignettes from sessions and through quotes from key participants. We contribute to the computing education community

a novel approach in which youth are positioned as design partners for reimagining a computing education experience in libraries that centers and serves community members.

6.3 Introduction

Large-scale disparities in computing exist for many youth of color. For instance, only 7% of all students who took the Advanced Placement Computer Science exam in 2018 were Black, Latinx, or Native American (McAlear et al., 2018). These disparities reflect “widespread racial and gender imbalances in learning opportunities within formal and informal STEM learning environments” (Pinkard et al., 2017). Additionally, how we consider what counts as computing education experiences can contribute toward inequities youth of color experience in this space. Research shows learning in informal settings can increase the participation of youth in computing education (Barron et al., 2014; Clarke-Midura et al., 2019; Fields et al., 2017; Vossoughi et al., 2020). However, computing educational experiences have typically been developed by adults for youth. Similarly, facilitators of computing experiences often do not reflect the identities of the youth they serve (Pinkard et al., 2017). Overall, this is problematic for computing education because it is unlikely that a homogenous adult group can grasp the unique issues experienced by a heterogenous learning group of youth. This is a justice issue because adults may have different goals, approaches, and identities than those of their intended youth audience. Adults may not understand the experiences of youth unless they directly involve them in the design of learning experiences.

We argue that the computing education community can disrupt the hegemonic ways in which we teach computing and what we consider computing by directly involving youth as design partners (Yip et al., 2017). This hegemony is reflected in Cook-Sather’s analysis of how the perspectives of those most affected by education policy and practice are students, yet they are rarely consulted (Cook-Sather, 2002). When designers partner with youth, we center youth values, their priorities, and their assets to guide the direction of a computing education curriculum that is responsive to their lived experiences and that disrupts the grand narrative that only adults have power to guide their learning. In our research, we take a design partnership approach where youth and adults engage in design through fluid and complementary roles that span four dimensions: facilitation, relationship building, design-by-doing, and elaborating together (Yip et al., 2017). Furthermore,

when we involve and value youth voice (Ryoo, 2019), we move away from focusing solely on the structural barriers faced by youth of color (McAlear et al., 2018) toward a funds of knowledge approach (Moll et al., 1992; Roldan, Vanegas, et al., 2019; J. M. Smith & Lucena, 2016). In this paper, we anchor on decolonization in three ways: as a theoretical guide for the arguments in this manuscript, as a tool for research methodological approaches, and as a tool for adapting co-design methods that center the knowledge of youth who have been marginalized.

“In a decolonizing framework, deconstruction is part of a much larger intent” - (L. T. Smith, 2013). Inspired by a decolonizing imaginary framework (decolonization as a theoretical guide), we aim to transform the inherited world of computing as being historically for White cis-men by restoring the subjugated knowledges of youth who have been marginalized (Mendieta, 2020; Pérez, 1999). We argue for disrupting the design of computing education experiences in favor of programs in which youth can co-create computing curriculum with their local librarians and university researchers through a design partnership model that elevates youth voices. Pérez proposed a decolonial imaginary, *“as a rupturing place, the alternative to that which is written in history”* (Pérez, 1999). In our context, to reimagine computing education, we deconstruct the dominant narrative of who designs computing education learning experiences (adults) and who we design for (youth).

We learn from the writings of indigenous scholars (Mendieta, 2020; Pérez, 1999; L. T. Smith, 2013) to propose decolonization (decolonization as a research methodological approach) for CS education as the *process of undoing colonizing practices* that have influenced education in the past, and are still present today through: 1) a foregrounding of history, community, and lived experiences, 2) ongoing reflection of who has power, how power shows up, and how power is disrupted, and 3) a commitment to transformation toward a just future. While responding to Smith’s call for a decolonization of methodologies (L. T. Smith, 2013), we recognize the work done by Indigenous scholars to guide us in unpacking the invisibilized structures through which we perpetuate settler colonialism in existing computing education practices (Tuck & Yang, 2012). Additionally, we take seriously Tuck and Yang’s critique that decolonization is not a metonym for social justice and as such have engaged in critical reflexive work to question whether our work is decolonizing. To do this critical self-work, we have engaged with existing

literature and with scholars to explore the implications of what it means to deconstruct colonial ideologies that privilege historical Western thought in computing. Furthermore, recognizing Tuck and Yang's critique about decolonizing work that does not name Indigenous peoples, throughout our manuscript we cite and honor the contributions of Indigenous intellectuals to our understanding of decolonizing. Our work draws on two core theoretical lineages: that of **funds of knowledge** (Moll et al., 1992; J. M. Smith & Lucena, 2016) and of **critical pedagogy** (Freire, 2018; Hooks, 2014; Yosso, 2005) to inform our research contributions.

Our work is grounded on the notion that computing education can contribute to decolonization by centering youth from nondominant communities, in creating their own computing educational experiences for their community (decolonization as a methodology for co-design). Moving computing education justice discourse beyond increased participation, we have created *KidsTeam Libraries*, an intergenerational digital design program where local youth directly inform pre-service librarians and current local librarians to conceptualize what digital learning could look like in libraries. KidsTeam Libraries is grounded on principles of Cooperative Inquiry (Druin, 1999; Yip et al., 2017), a participatory design (PD) approach that emphasizes equal and equitable design partnerships between adults and youth, offering a method to collaboratively create computing education programs. Libraries offer a rich space to study computing education because they provide youth with access to flexible learning goals, are institutions situated in multiple locations (*e.g.*, urban and rural neighborhoods), and play a vital political role in strengthening democracy by bringing together people with different identities (Goulding, 2009; Rivano Eckerdal, 2018). To strengthen our research and practice partnership, key stakeholders and patrons from the libraries have been involved throughout our efforts.

We examine a 10-week case study (Merriam, 1988) within the three years (2016-2019) of the setup and implementation of KidsTeam Libraries. The bounds of our case are between October to December 2019 for a 10-week PD program in an urban neighborhood library. Our qualitative data set includes over 15 hours of video recordings from PD sessions, six interviews with participants, ten researcher jottings, and a corpus of 25 researcher memos written by researchers, librarians, and teens. Neighborhood children (ages 7 - 11) in the role of design informants (Druin, 2002) met at the library with teen leaders, librarians, and researchers to engage in a range

of PD activities and create a 3D printing library curriculum for other children in libraries across the city. Our investigation focuses on a case of digital fabrication, specifically computer aided design and 3D printing processes, as a core aspect of a child's computing education given the many ways a child's life may be strongly affected over the next decade by 3D printing (Eisenberg, 2013). Increasingly, 3D printing practice has become an accepted element of computer science through the rise of making in computing environments (Eisenberg, 2013; Hamidi et al., 2017; Papavlasopoulou et al., 2017; Starrett et al., 2015) and the role of computational thinking in making processes (Kafai, 2016; Tenenber, 2018). Our case connects explicitly to the nature of computing education pedagogy by shedding light into the reflexive and collective work of computational making (Tenenber, 2018); that is the "participation in the social practices of making" that Kafai discusses as "the most important, compelling, and characteristic of computing" (Kafai, 2016). To emphasize the social, ethical, and political implications of computing (Ryoo, 2019; Vakil, 2018), through this manuscript we argue that a focus on users, makers, and their interactions with technology is core to computing education. Furthermore, it matters that Lena (who is Black) and Kevin (who is Asian) were local teenagers (ages 15 - 17) who constructed and led the weekly 3D printing workshops independently at KidsTeam Libraries with the support of their local librarians (Rick, Joel, Liam) and university researchers. The findings that surfaced in our KidsTeam Libraries program are different than if we had been focused on citizen-science or filmmaking because we were constantly aware of the historical implications of a computing program being offered with predominantly minoritized youth and led by two teens of color. We provide the historical context of the library as situated in a neighborhood within an urban city that has recently undergone significant gentrification from the technology sector and is home to many East African refugees. Throughout our investigation, our knowledge claims are co-constructed with Lena and Kevin as authors. Collectively, we explore three key research questions in this manuscript:

- RQ1. What design partnership relationships did we observe between librarians, teenagers, and youth as they designed their own computer science educational experience?
- RQ2. How did we notice, enforce, and disrupt power within a 10-week computing engagement among adults, teenagers, and youth of color?

- RQ3. What systems of power created barriers when we attempted to allow teenagers to lead a computing education program?

To confront systems of injustices in computing directly and explicitly, we must rethink who designs computing educational experiences for youth. Following critical pedagogies (Freire, 2018; Hooks, 2014; Ladson-Billings, 1995), this investigation writes from the tension that computing education can be both oppressive and liberatory. hooks argues teaching to transgress means moving beyond the boundaries of traditional rote learning approaches to teach in a manner that respects and cares for students (Hooks, 2014). We propose design implications that rethink dominant notions of adults and researchers as leading and designing computing educational experiences. We argue justice-centered computing education approaches should actively involve youth and teens of color in the co-creation of programming and learning experiences in their own communities. Our call to action for computing education is that we can continuously support and scaffold youth leaders within their community to design solutions to address large-scale disparities in computing. Throughout the manuscript, we broadly use the word “youth” interchangeably to refer to children and teenagers as different from adults, and specifically, the word “teenager” to refer to Lena and Kevin’s experience as design partners.

Through an in-depth analysis of our rich body of qualitative data, this investigation answers our research questions while foregrounding the perspectives of our teen leaders Lena and Kevin. Our findings show 1) the ways in which computing education can foster and sustain community-level relationships, 2) how we noticed, enforced, and disrupted power within our computing program, and 3) the systemic challenges we confronted in our process. In our first finding, we detail the micro-level relationship commitment each person made to the members of the community and how this responsibility to one another is a key component of computational participation. In our second finding, we articulate the ways in which the intersection of identity and positionality contributed to each person’s capacity to disrupt existing power structures within the computing program. And in our last finding, we distil the systemic issues we faced in disrupting power and reflexively considered how this experience can inform our future actions in computing contexts. We provide empirical evidence of teen-led PD approaches for computing education in their community through detailed vignettes from the PD sessions and participant quotes. We fill a gap

in current computing education research by contributing to the community a novel approach that positions youth as design partners for reimagining a disruptive computing education experience in libraries that served the needs of their own community members. Our core contribution to the broader computing education community through a justice-centered lens is to question who has a say in what computing is, who has a stake in how they want to learn computing, and who is given opportunities to teach it to others. Through this work we directly center the perspective of teenagers from the community to consider and have a direct impact on what computing education looks like for them and for others in the community.

6.4 Related Work

6.4.1 Informal Computing Education

We build on existing work in informal computing programs for youth (Clarke-Midura et al., 2019; Fields et al., 2017; Pinkard et al., 2017; Vossoughi et al., 2020). Research findings highlight the need for creation and delivery of curriculum that is not only administered by facilitators who are technically competent, but who also look like the youth they are serving or who are trained to be socially-just educators (Pinkard et al., 2017; Vossoughi et al., 2020). As Lawlor et al. (Lawlor et al., 2020) state, informal computing learning initiatives aimed at increasing participation are often designed and executed within university settings. This is an issue because computing learning initiatives led by community members can be more sustainable and responsive to community historical contexts. Past initiatives have focused on creating affinity-oriented learning environments, providing women role models, and teaching girls through project-based learning (Lawlor et al., 2020). Clarke-Midura et al. (Clarke-Midura et al., 2019) examined a summer informal learning program with the interest in broadening the participation of girls in computing. Their findings highlight the role of near-peer mentors in influencing a positive change in campers' interest and self-efficacy. Additionally, Fields et al.'s (Fields et al., 2017) showed that socialization itself does not lead to increased involvement in computing. Their investigation highlights a need for research that explores the pathways through which we can deepen meaningful participation for youth and support their development of computing content knowledge (Fields et al., 2017).

There exists literature on how direct involvement of teens can create a more targeted learning experience (*e.g.*, (Braun, 2001)), yet most studies focus on how adults create informal learning spaces and then invite youth and teens to participate. We flip the script and invite teens to lead from the beginning of the design process. In this work, we position the teens as design partners to co-create curriculum with a librarian and then pilot their curriculum with children in the neighborhood as informants (Druin, 2002). We fill a gap in the existing informal computing education literature to argue we can meaningfully engage youth in computing and developing computing content knowledge through PD methods. Although Pinkard et al. (Pinkard et al., 2017) emphasize the need to involve mentors in computing programs that look like the youth they serve, in their paper they focus on the adult mentors. We build on the work of Pinkard et al. (Pinkard et al., 2017), by focusing on teen mentors from the community and offer evidence of the teens' experience as computing educators. With the rise of maker technologies in libraries and the workforce, it is important for youth to learn the necessary computational skills to learn, teach, and design with computers (Eisenberg, 2013).

6.4.2 Computing Education and Design

“Computer science is the study of computers and algorithms, including their principles, their hardware and software designs, their implementation and their impact on society” (Newell et al., 1967). To emphasize the social, ethical, and political implications of technology, we argue that a focus on users and their interactions with technology is core to computing education. Specifically, our investigation follows Cooperative-Inquiry approaches (Druin, 2002; C. Harrington et al., 2019; Yip et al., 2017) to include teenagers and youth from the community as design partners. We use PD as the mechanism to disrupt and reimagine how library spaces can support computing education programs that are led by community members. PD is an effective method of including the voice of historically marginalized communities who would have otherwise not participated in the process of design (Coenraad et al., 2019; Hussain et al., 2012). PD has a history rooted from democratization where there is interest to hear and consider all voices (Björngvinsson et al., 2010). PD has had close relationships with computing in valuing how technology can embrace rather than detract from people's skills and tacit knowledge. In libraries, PD has been used to develop digital learning activities (Yip et al., 2020) for children as

there were challenges of a librarian solely creating technology related curriculum (Subramaniam et al., 2018).

In computing education, there have been numerous calls for equitable learning opportunities for people from historically marginalized communities (Ko et al., 2020; Nasir & Vakil, 2017; Santo et al., 2020). PD has been used as one approach to understand how youth of color can connect their identities in STEM. For instance, Coeraad et al. 2019 (Coenraad et al., 2019) examined African American girls' designs for their own STEM activities using PD methods. The authors show how PD can be an effective tool in broadening the participation by discussing issues of equity. Our program is different from just an application of PD principles because it points toward a justice-centered computing future where teens, as opposed to adults, oversee the design of a computing learning experience with children. In our study we explore how youth can design with librarians for other library patrons and community members through a long-term design partnership. In contrast to previous PD work, we detail a layered PD approach for computing education where teens and librarian establish a design partnership which in turn can facilitate the development of a designer partnership between teens and children.

6.4.3 Computing Education and Libraries as Community Spaces

Libraries, as community sites, allow youth, teenagers, and librarians to design their own computing learning experiences that meet their local needs and leverage their funds of knowledge. Libraries have been at the forefront of the maker movement for providing patrons opportunities to not only have access to different emergent technologies such as 3D printers and robotics but also provide a space where people can learn together (Koh & Abbas, 2016). Rather than working alone to understand technological problems, maker spaces in libraries allow for collaboration where different skill sets can come together (Kurti et al., 2014). Libraries are also considered informal learning spaces which differ from formal places like school where there is often a structured set of learning goals (Lee & Phillips, 2018). Except for progressive schools, public libraries are a place where people can direct and set their own learning goals. There exist few institutions situated in multiple locations (*e.g.*, urban and rural neighborhoods) that bring together people with different cultures, socioeconomic status, age, and ethnicities (Goulding, 2009). Furthermore, as a place that serves a range of patrons, libraries provide an opportunity for

librarians to reach out to people from multiple technology backgrounds (Liang et al., 2019). Libraries can play a critical role in providing youth access to informal mentors who can support their interest in technology, hang out, mess around, and geek out (Ito, 2013).

Recently a national push has been made for the role of libraries in computing education (Lee et al., 2017). To address inequities, more libraries have attempted to provide different access to technology. For instance, Subramaniam et al. (Subramaniam et al., 2018) revealed various ways digital and networked technologies were used to create an inclusive learning environment in the library. The study shows that while the librarians understood the importance of providing new technologies for the serving youth, the challenges they faced were figuring out how to design and facilitate technology programs (Subramaniam et al., 2018). In our study, we go in-depth of what such facilitation can look like when it is teen led.

6.5 Theoretical Lineages

We build on two theoretical lineages: 1) funds of knowledge to foreground historical, communal, and individuals' assets and 2) critical pedagogy to continuously reflect on power in learning. These theories give language to knowledge production that pushes against normative ideologies in computing education. In envisioning and enacting change in the world, these theories provide frameworks to transform informal learning situations in computing education toward justice-centered computing. Coupled, these theories present the transformative nature that is possible when community members create social change together for informal computing education.

6.5.1 Funds of Knowledge

Funds of knowledge theoretical perspectives foreground individuals' assets, community assets, and historical assets. Funds of knowledge perspectives are informed by community cultural wealth (Yosso, 2005), which can be traced back to critical race theory in education (Matsuda, 1991). In our work, funds of knowledge offer a framework from which to understand and leverage individuals' perspectives and experiences.

Funds of knowledge refers to the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being (Moll et

al., 1992; J. M. Smith & Lucena, 2016). In Moll et al., (Moll et al., 1992) researchers drew upon the knowledge and skills found in local households. Smith and Lucena (J. M. Smith & Lucena, 2016) extend the concept of funds of knowledge beyond the home to include students' internship experiences. Prior work notes that in order for funds of knowledge to make a difference in minority students' engineering experience, they must be converted to different forms of capital (social, cultural, and financial) traditionally recognized in engineering (J. M. Smith & Lucena, 2016). In our work, the use of funds of knowledge supports understanding the breadth of teens and youths' funds of knowledge developed across their participation in a wide range of community and cultural activities. Furthermore, we are interested in a bidirectional flow of change for computing education: one where we convert funds of knowledge to forms of capital traditionally recognized in engineering and one where we change how computing education recognizes new forms of capital. To do so, research must shift computing culture to validate knowledge claims from students' funds of knowledge.

6.5.2 Critical Pedagogy

We leverage critical pedagogy perspectives which are grounded on notions of emancipation (Freire, 2018), values (Morrison, 2001), and culturally relevant learning (Ladson-Billings, 1995) to critically examine power throughout our computing education efforts. Holding true the emancipatory and liberatory potential of education (Hooks, 2014; Yosso, 2005), critical pedagogy provides a theoretical framework for this work toward a justice-centered approach for computing education. In KidsTeam Libraries, we were aware that through our actions and inactions we perpetuated, mimicked, and mirrored social interactions. Simultaneously, we recognized that as educators we had the chance to change social structures through the learning environment we created. We extend the ideas of critical pedagogy in the classroom to informal learning spaces where youth develop knowledge of and envision new emergent digital technologies in libraries. Collectively imagining with research participants and by leveraging technology, we hope to transgress the ways in which we imagine computing education by rethinking existing boundaries of what is acceptable and creating new visions that move beyond those boundaries.

hooks contributes a theoretical perspective that reframes the classroom as a place where everyone feels responsible for the learning environment and educators uphold a commitment to honoring everyone's voice (Hooks, 2014). In our work, we build on this theoretical lineage to reimagine the computing education learning space, as a place where everyone is positioned to contribute to the design of the learning environment. We see great potential in the power of PD and technology design to support the inclusion of voices from students who have been marginalized (Pinkard et al., 2017). hooks contends that theory that is developed from concrete, lived experiences is what makes transformations possible (Hooks, 2014). Unpacking the significance of developing theory from lived experience reveals the centrality of teen voice in the design of computing experiences for themselves and others in their communities.

6.6 Methods

We examine a case study of a 10-week PD engagement offered between October 2019 to December 2019 (pre-COVID-19) with 10 neighborhood children (ages 7-11), two teenagers (ages 15 – 17), five researchers and volunteers, and three librarians (Merriam, 1988). A case study approach affords detailed understanding of a particular educational experience, opportunity to attend to an individual's lived experiences, and the ability to provide a rich description of the interactions taking place within a situated context (Ryoo, 2019). This case study is situated in a larger study on the use of PD with librarians to create digital activities for the neighborhood (Yip et al., 2020). To learn about 3D printing and propose learning experiences for others, everyone engaged in the Cooperative Inquiry method (Druin, 1999) where children and adults are positioned as design partners. We video recorded all ten PD sessions and annotated them for analysis. A year after the program (in 2020), we interviewed three librarians and two of the children who participated to gather additional insights about their experiences. The teen leaders, Lena and Kevin co-constructed the knowledge claims presented throughout this manuscript. All names of participants are pseudonyms.

6.6.1 Context

From 2016 to 2019, we developed a partnership between our university and the city's public libraries to expand design and computing education for community members. Following principles of Cooperative Inquiry (Druin, 1999), our partnership supports the professional

development of librarians to learn about and practice PD through a master's level course where students run programming at library branches (Yip et al., 2020). In 2018, we invited Lena and Kevin to serve as teen leaders from the community, to advise the students on their library plans and evaluate their materials. Our long-term engagement with the city's librarians led Lena and Kevin to ultimately lead KidsTeam Libraries in the Columbia City neighborhood.

This work is situated in the historical context of Columbia City, a neighborhood within Seattle, Washington that has recently undergone significant gentrification from the technology sector. Columbia City and the surrounding area is home to many East African refugees. Racial and economic divides are present across city neighborhoods which influences the patrons that visit the larger public library system. Home to many waves of immigrants, in 1980 Columbia City had several new initiatives designed to help residents and businesses clean up and revitalize the neighborhood including farmers' markets, monthly music events, and a movie theatre. In 2000, Columbia City became popular real estate as the technology sector drew higher income families to the area. This new housing wave increased rent prices and pushed out several small, immigrant owned businesses who could not afford higher rents in Columbia City. Today, still facing some of the sharpest rises in property values, the Columbia City neighborhood faces widespread gentrification, the tearing down of older homes, and the construction boom of new apartment buildings.

6.6.2 Participants

In this section, Kevin and Lena introduce themselves from a third person perspective and then provide a quote excerpt from a memo where they reflected on their involvement in the program. Table 1 offers an overview of all participants.

Kevin is an Asian senior at a STEM high school and lives in the communities of Beacon Hill and Columbia City. When Kevin was a child, he was always fascinated by engineering and technology which has now developed into a desired career path of mechanical engineering. This passion developed even further when he had an opportunity to work with KidsTeam Libraries after his librarian invited him. However, Kevin's cultural background prioritized academic courses over community involvement therefore, it was not until freshman year of high school

that he became active in his library because he needed 60 service hours for graduation. This requirement led him to his library to ask for a volunteering opportunity. This led Kevin to the path of KidsTeam Libraries where he got to interact with technologies such as 3D printers and Arduino. Kevin never imagined being involved in the program for more than two years.

Being the first teen to engage in this work with researchers, master's students, and librarians felt intimidating because they were all at least ten years older than him. He continued doing the program and became a leader. During the time of this manuscript, Kevin was in his junior year in high school taking college classes in a dual-enrollment program. Additionally, he advised a class at the university that was for KidsTeam Libraries. To make the program successful, Kevin invested two hours each week meeting with the librarian and his co-leader Lena to plan out the sessions. He wanted to make an impact in his community so although he had a difficult schedule full of classes and clubs and he tried his best to keep up with KidsTeam Libraries. This determination stemmed from what Kevin said, *"The kids made an effort to learn and be leaders in this program so I should do the same for them. I never had a chance to learn these technologies as a kid, so I should give them the best experience possible."*

Initially, I came to KidsTeam Libraries to get my service hours, however as I got more involved, I discovered that I truly loved working with both kids and technology. Seeing the kids excited when they discovered something new was an experience that I never had as a child so seeing them made me happy. Because of this, I kept coming to KidsTeam Libraries to help kids learn about new and cool technologies. In addition to helping the children, it was also a chance for me to learn about new technologies too. Before KidsTeam Libraries, I had never used 3D printers or Arduino kits, so KidsTeam Libraries allowed me to both learn new technology concepts and teach kids. After observing how masters' students engaged with 3D printers, I picked up what they were doing. For Arduino, my local librarians gave me packets and in-person training on how to use the Arduinos with other local teens. I never had a 3D printer to work with before and from school I knew the basics about circuits, but this was a chance to play with the technologies and share new technology skills. What I took away from this experience is leadership skills and a new motivation and goal in life. Before KidsTeam Libraries, I never had a passion I wanted to do outside of going to school and getting a job. After KidsTeam Libraries I realize that I love helping kids learn about new technologies. So, my goal after I get a career in my field, I want to be able to teach kids in my community cool technologies. My goal for computing education is to become someone who can use his skill that he learned in his career and share that to kids or people of all ages in my community.

Lena is a Black senior in high school also taking community college classes through a dual enrollment program. She grew up in the city and regularly spent much of her time outside of her home and school at the Columbia City library. Like Kevin, when Lena needed to complete 60 community service hours for her high school requirement, she turned to her community's library because she also knew Rick the librarian. Based on Rick's recommendation, she spent the fall visiting the library weekly with her older brother who also volunteered in the library for a different children's tutoring program. There she met Kevin, who had already participated in the KidsTeam Libraries program the previous year and spent the duration of the program working alongside him to assist kids in understanding how to program using Arduino software. Lena enjoyed the ability to actively improve library programs for future children and teens. Her partnership with Kevin created a small group where together they could critique proposed lesson plans for KidsTeam Libraries and then bring back their ideas to the larger group. This motivated her to continue working with KidsTeam Libraries the following year when multiple librarians and researchers invited her back. Lena recalls working with Kevin and co-author researcher Kale over the summer during a boot camp where they all worked on facilitation techniques alongside a group of children and researchers. Her second year with KidsTeam Libraries operated much like the first, although with the addition of participating in a weekly class at the university designed for planning sessions at other branches. Her second year, she also worked directly with Rick and Kevin leading to her having a larger impact on how the sessions were developed. Looking back, Lena compared her second year with her first year: *"I was more comfortable working with Kevin, the PI, and other researchers. They felt kind of like strangers the first year, the second year it felt more comfortable."*

I kept coming back because I needed to finish those 60 service hours, but once I completed my requirement, I didn't want to stop participating. I realized that if I stopped then I'd miss working with the kids and I'd be missing out on the development of this new program. Growing up, I used to go to the library all the time, almost every school day and on some weekends. I remember going for homework help after school to get tutoring on my schoolwork or sitting between the aisles of the bookshelves and reading or chatting with librarians. Now that I'm in high school, I see kids that are the age I was back then, and I want to talk to them. I want to work with them because these are the kids in my community and they're going to grow up in the same library environment that I did. As an older kid, it is important to me to provide as much positive influence as I can. Before my involvement in this program, I had never used Arduino software or operated a 3D printer. I had seen a printer before at my school and seen the objects it could print on display, but I

hadn't even touched the machine itself because it was not in an area for others to touch. Throughout this experience, I was learning as I went to figure it all out so that I had the proper knowledge to be able to design with the kids. Over the past three years, my involvement in this program has meant that I got to interact with other kids in my community. Working with KidsTeam Libraries and the people at university has been the biggest thing happening in my life outside of my formal schooling and family responsibilities.

Table 1. Youth, researchers, librarians, and volunteers involved

P#	Name	Age	Gender	Race/Ethnicity	P#	Name	Age	Gender	Race/Ethnicity
1	Kevin	Teen	Man	Asian	12	Fayola	Child	Girl	Black
2	Lena	Teen	Woman	Black	13	Rick	Adult	Man	White
3	Samuel	Child	Boy	Black	14	Joel	Adult	Man	Latinx
4	Nathan	Child	Boy	Black	15	Liam	Adult	Man	Latinx
5	Isha	Child	Girl	Asian	16	James	Adult	Man	Asian
6	Elliot	Child	Girl	Asian	17	Wren	Adult	Woman	Latinx
7	Eshan	Child	Boy	Black	18	Kale	Adult	Woman	Asian
8	Saaid	Child	Boy	Black	19	Stella	Adult	Woman	White
9	Zayan	Child	Boy	White	20	Thomas	Adult	Man	White
10	Maaz	Child	Girl	White	21	Savannah	Adult	Woman	White
11	Jian	Child	Boy	Asian	22	Rose	Adult	Woman	Asian

6.6.3 3D Printing Sessions

During the months of October to December 2019, Columbia City teens Lena and Kevin designed and led weekly 3D printing sessions with children at their local library. Each week, a group of KidsTeam Libraries children (ages 7-11) met at the library to engage in a range of PD activities with the goal of creating a 3D printing library curriculum for other children. To design these weekly sessions, Lena and Kevin worked closely with stakeholders across the library, their community, and the university after it had been decided by the librarians that 3D printing would be the topic of the three months. To plan for the sessions, Lena and Kevin met weekly with Rick, a long-time Columbia City librarian who had rich insights about the children, the PD process, and the community. Public librarians from other branches, Joel and Liam also served as key supporters to guide Lena and Kevin. Throughout, the design process, the teens played a major role in deciding what material to teach, how to teach it, and how it was structured. Prior to each sessions Rick, Lena and Kevin met to discuss the next week's goals and to reflect on the previous session. To not disrupt their natural way of collaboration, we did not record or document their planning discussions. Instead, we interviewed them at the end of the program and looked at their analytical memos to make sense of how everyone contributed to the curriculum. We present Figure 1 below to detail the roles of each stakeholder involved in the work: librarians, teens, and children. While the primary site of PD occurred between Kevin and Lena,

during each session the children acted as informants (Druin, 2002). Lena and Kevin took feedback from the children, but the children were not present during the weekly planning sessions between Kevin, Lena, and Rick. As such, the children cannot be seen as equal design partners of the curriculum, but we instead see them as informants of the curriculum. As written about by Druin (Druin, 2002), in the role of informant, children can play a part in the design process at different stages, based on when designers believe children can inform the curriculum. In our case, the children played a role in the design process as informants when Lena and Kevin intentionally asked the children what they thought and brought their ideas back to their meetings with Rick. The children sometimes acted as users of the curriculum so that Lena, Kevin, and Rick could observe how they responded to activities. Other times the children were testers of the curriculum so that Lena, Kevin, and Rick could see how long an activity took or if it made sense to children. The children also contributed to the curriculum by offering feedback and suggesting new activities that Kevin and Lena then took back to their weekly planning sessions with Rick.




	The role of the librarian	The role of the teens	The role of the children
Participatory Design Role (Druin, 2002)	Inviting design partnership	Becoming design partners	Becoming informants of curriculum
Phase 1 (Weeks 1-3) 	In the first few weeks , the librarian introduced a fully made house. In this case, the house was the curriculum created from the university. <i>For e.g. Rick printed out the curriculum for Lena and Kelvin to review and then share with the children.</i>	The teens looked through the fully built house and made subtle changes of the house such as selecting the lights or the type of carpet. <i>For e.g. Lena and Kelvin went over the curriculum to see what areas they wanted to make tweaks.</i>	The children experienced the curriculum in the actual sessions and gave subtle input about their experience. <i>For e.g. The children listened to Kelvin deliver instructions of the 3D printers</i>
Phase 2 (Weeks 4-7) 	In the middle weeks , the librarian provided pillars of the house which was the structure of the sessions but left most of the creation up to the teens. <i>For e.g. Rick distributed new roles for Kelvin and Lena and allowed them to adapt their approach as needed.</i>	The teens started to suggest new building materials for the house and actively changing pillars. <i>For e.g. In week 3, Lena came up with a set of suggestions and questions in the agenda she wanted to explore during the meeting with Kelvin and Rick.</i>	The children felt more comfortable with sharing what they wanted to change in the curriculum. <i>For e.g. In Week 8, Faiola stated that she did not want to do a certain activity and tried something else with the active support of the teenager.</i>
Phase 3 	In the last weeks , the librarian provided full responsibility for the teens to build their own house. <i>For e.g. Rick no longer brought the printed out curriculum to their planning meetings.</i>	The teens started to formulate their own goals based on child input and brainstormed ways to reach them. <i>For e.g. Kelvin and Lena made it a goal to use Fusion 360 and shifted the curriculum to make it happen.</i>	The children started taking on the role of a facilitator and proposing new things to do in session. <i>For e.g. A child took the curriculum from Kelvin's hands and attempted to facilitate the session.</i>

Figure 1. An overview of everyone's roles in the design partnership through an analogy of a house.

Figure 1 presents the complexity of the simultaneous design partnerships through a house analogy over time. For Phase 1, metaphorically, an existing house was provided as a starting point with everything needed to live in it. Practically, that meant Rick and university researchers

provided the teens with an existing 10-week 3D printing curriculum. In this phase, the librarians and teens were making tweaks to the existing house while still anchoring to the previous curriculum for support. In Phase 2, metaphorically, only the pillars of the house were left as the core part that still made the house stable. Rick provided the sessions structure by suggesting using techniques like question of the day and arranging the design time. Here, the teens were actively customizing the curriculum based on their experiences with the children. In Phase 3, metaphorically, the designer started bringing in their own materials and tools to change the house. The teenagers were starting to leverage their own funds of knowledge and bring them into the curriculum design and delivery of the curriculum while incorporating the children's ideas over time. We share details about the design partnership process over time with the hopes that other practitioners can translate insights from our work into their practice and context. For example, librarians in other settings can follow a similar model over time to support teen leaders within their own communities. Through ongoing support of the teen leaders, teens can then establish a closer design partnership with children to co-create computing education experiences in their community.

Using principles of Cooperative Inquiry (Druin, 1999; Yip et al., 2017), every session followed a similar structure of snack time, circle time, design time, and discussion time. During snack time, we all informally ate and talked about our days. During circle time, we sat in a circle, and everyone share their name, age, and question of the day that related to the day's design activity. During design time, we had stations set up where everyone worked in small groups. And at the end, we had discussion time where each group shared out and we debriefed on the activity. We also shared commitments throughout the program to: 1) Create a safe-space, 2) Put people before technology, and 3) Encourage the use of one microphone where everyone took turns listening and speaking. These commitments supported the creation of a computing space where everyone could be a designer. Table 2 provides an overview of the 3D printing program that was designed by Kevin and Lena and that we plan to share with teen leaders across the city's public libraries.

Table 2. The activities for the computing program designed by Lena and Kevin

Week	Date	Details
1	October 2, 2019	What can an icebreaker game teach us about KidsTeam Libraries' future success? Goal: Introduce the program, build connections, and play a human-obstacle game.

2	October 9, 2019	What questions or support do children have in introducing the 3D printer to other children? Goal: Show children the 3D printer, small groups will think of questions they have and afterward brainstorm ideas to make a child's version of the 3D printer in the library with Bags of Stuff.
3	October 16, 2019	How can designing physical objects in 2D and 3D prepare children for digital modeling? Goal: Kids will practice 2D and 3D design thinking skills first by using paper/pencil and then 3D objects similar to TinkerCad's basic shapes in preparation for later design sessions with using TinkerCad.
4	October 23, 2019	How do children Evaluate their Experience with TinkerCad? Goal: Kids get familiar with TinkerCad and practice PD through Likes, Dislikes, and Design Ideas.
5	October 30, 2019	How do children evaluate the combined process of using TinkerCad, Thingiverse, and a 3D printer? Goal: Kids will experience and evaluate the 3D printing process alongside TinkerCad and Thingiverse.
6	November 6, 2019	How can children learn TinkerCad in a fun and engaging way? Goal: Children will play "Tinkerbattle," a TinkerCad/Legos game with three levels that challenge children's 3D design skills working alone, in competition with a partner, and as a team with a partner. Children of varying TinkerCad and 3D design experience will get technical and collaborative skill development.
7	November 13, 2019	How can children understand x, y, z axis by using 3D printing design? Goal: Children will evaluate Fusion 360 software in contrast to TinkerCad with the aims of improving their understanding of XYZ axes in 3D modeling, and of understanding how TinkerCad functions
8	November 20, 2019	How can children use 3D printing to solve a problem they face every day? (Part 1) Goal: Children will create short comic strips that illustrate how their 3D printing object will help them or other kids solve a problem. Children will then work on TinkerCad to design those 3D objects.
9	November 27, 2019	How can children use 3D printing to solve a problem they face every day? (Part 2) Goal: Children will continue to work on their short comic strips that illustrate their 3D printing object. Children will also receive their prints from Week 8.
10	December 4, 2019	Party with snacks + book gift for participating. Goal: Celebrate the accomplishments of the children with their family members.

6.6.4 Data Sources

Our data set includes over 15 hours of video recordings from the PD sessions, ten researcher jottings from all the sessions, a corpus of 25 memos written by researchers, librarians, and teens, and six interviews with teens, librarians, and youth. We video recorded, time-stamped, and annotated all ten PD sessions for key moments of engagement between children, teens, and librarians. During every session, the first author researcher jotted physical notes meaning she wrote bullet points of moments that felt salient, questions and surprises that came up, and instances she wanted to review later. Immediately after every session and while still at the library site, the first author researcher transcribed those jottings into online notes and wrote reflective memos of the sessions resulting in ten jottings and ten memos. Throughout the process, we encouraged the teenagers, volunteers, and librarians to write their ideas of how the sessions were going. A month after the program ended (in January 2020), we also asked Lena and Kevin to engage in a reflective exercise to make sense of their experiences leading the 10-week program. This resulted in two, 5-page documents of reflections.

In 2021, we conducted interviews with librarians and children. We asked librarians about their impressions of the program, how they involved Lena and Kevin in this process, their motivation for involving the teens in developing computing education programming, and what justice-centered computing meant to them. We also conducted thirty-minute semi-structured phone

interviews with two children involved in the sessions who responded to our interview request in 2020 (a year after the program ended). We asked them about their overall experience in the program, why they continued to come to our sessions, their favorite moment, what they told their friends about this experience, and how they saw Lena and Kevin. We compensated the children with a \$25 Amazon gift card for their time. Our data also included a historical interview conducted with Lena and Kevin in 2017 (two years prior to the 10-week program) when they had just become involved in our research. All interviews were audio recorded and professionally transcribed.

6.6.5 Data Analysis

To analyze our rich corpus of data, we followed standard practices of qualitative research approaches following interpretivists lines of inquiry (Cohen & Crabtree, 2006; Creswell & Poth, 2016; Schwandt, 1994). In interpretivist research, knowledge is seen as co-constructed among researchers and participants (Guba & Lincoln, 1994). To ensure trustworthiness in our work, triangulation across these data sources provided thick descriptions of the phenomenon under scrutiny (Shenton, 2004). Our analysis was informed by our theoretical perspectives which led to an initial codebook of eight codes: power, technology and design, relationships, challenges, successes, support, assets, materials, and environment. For example, we coded an excerpt from Wren^R's October 10, 2019 memo as relationships: *“Rick knew them because he said hi to the mother. The kids congregated towards the back left corner of the room where Rose and Saaid joined them to sit down and talk about things. I interacted with a couple of kids about what they thought was being printed in the 3D printing machine.”* In another example, we coded an excerpt from Kevin^T's memo on October 23, 2019, as challenges: *“One key point from the question of the day was that the kids want a demonstration when learning new things. I find this very relatable but with this information, I realize it’s really hard to ever be 100% participatory design. You can’t really throw something at kids and expect them to figure it out. This especially true with the time restraint we have.”* Four researchers (lead author, second author, and Lena and Kevin) then coded all the data independently and met weekly for three months to peer debrief. We then conducted axial coding of our initial eight themes which led to three themes: community assets, seeing power, and systemic barriers. After all the data was coded by at least one researcher, we followed constant sorting and comparative analysis until theoretical saturation

was reached and no new codes were generated to arrive at the findings we present (Merriam & Tisdell, 2015b).

Positionality statement. Qualitative interpretivist research involves each researchers' lens and experiences, and thus requires reflexivity (England, 1994). Each researcher in this work is committed to centering and elevating the lived experiences of children from marginalized communities. One researcher in this work has invested time and effort into developing KidsTeam Libraries teams from 2014 - 2019, another researcher has been directly involved since the beginning of the librarian partnership from 2015-2019, and a third researcher has been engaged in equity-oriented research from 2015-2019. Throughout, the first author kept memos of the data collection and analysis to engage in constant reflexivity. Our positionality as co-authors is reflective of our commitment to strengthen our community partnership and write our paper with the teenagers as co-authors. Collectively, we are researchers who hold racialized and minoritized identities. We are people of color, Latinx, Black, and Asian, and first-generation college students. Our experiences holding these salient identities while existing in computing spaces informed our research lens, design, and analytical approach.

6.7 Findings

We report on three primary themes: the ways in which we fostered and sustained community level investments and relationships as core to our computing program, how we noticed, enforced, and disrupted power within the computing learning experience, and the ways in which hegemonic systems of power played out in our efforts to disrupt computing education norms. We provide Figure 2 below as a roadmap that shows the relationship between our decolonizing methodologies, our theoretical frameworks, and our findings. We organize each findings section by a) providing an overview of the finding; b) presenting two vignettes as descriptive narrative from our PD sessions; c) offering an analysis of the vignettes and our finding through teen, librarian, and child voices; d) presenting key questions we were left with after our analysis for researchers to consider, and e) leveraging our two theoretical perspectives (funds of knowledge and critical pedagogy) to make sense of each section in relation to disrupting and decolonizing computing education. Here, we use superscripts to denote a child^C, a teenager^T, a librarian^L, an adult volunteer^A and a researcher^R.

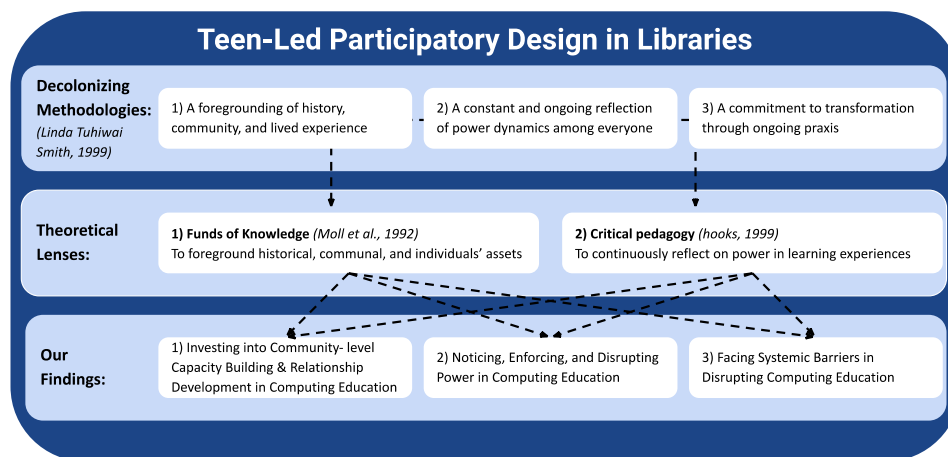


Figure 2. Overview of the relationship between our decolonizing approach, our theories, and our findings

6.7.1 Foregrounding Relationships

Overview. We detail the micro-level relationship commitment each person in the project made to the members of the community. We know from past research that relationship building between design partners is crucial before designing together (Clarke-Midura et al., 2019; Yip et al., 2020). Computing education has traditionally focused on teaching students how to improve technology rather than explore ethics, identity, and politics (Vakil, 2018) in technology. Recently, many scholars have begun to explore the politics of computing in learning experiences. Within this trend there has been an emphasis on the educators (Ryoo, 2019), yet few have focused on the relationships between participants and mentors during computing education experiences and specifically those of teens. In our program, we started by asking how we might center the experiences of the children learning 3D printing. In this way, the design of our program foregrounded relationships, reflecting a recent trend in the literature to focus on people over technology (Ko et al., 2020). We present two vignettes that capture the relationship between the teen leaders and the children that provides insights into how relationships matter to elevate child voice.

Vignette 1.1. During Week 3, Lena^T, Fayola^C, and Nadir^C were in a group. The children and adults were drawing 2D robots and then using physical blocks to create 3D representations of their robots to collectively explore the affordances and limitations of creating objects on the

TinkerCad software. After they made their robots in small groups, everyone had a chance to present their process. When it was Lena^T, Fayola^C, and Nathan^C's group, Lena^T explained, “we had multiple robots we couldn't decide. This is our second draft. We drew the dragon, and we were like how are we going to break this up into shapes?” Lena^T then whispered to Fayola^C (who was to the right of her in Figure 3) “do you want to talk about it?” Fayola^C responded, “Okay this one we made for the trapezoid cause we thought it would be more different if we made it a trapezoid. We did ideas of more different robots that have never been made. And this is supposed to be a human arm. This is supposed to be claws. And I tried to make those claws that you use in the claw machine that grab the animals. But I didn't make it that well, so I just turned it into a palm tree!” (Everyone laughed). Fayola^C continued, “We did a scooper arm” to which Wren^R asked “[a scooper] for ice cream?” At the same time, Fayola^C and Lena^T both responded “no ... you know in construction. Just to scoop stuff.” Lena^T then said, “Nathan^C's turn” to which Nathan^C responded, “I randomly did this.” Wren^R asked, “does it have eyes?” Nathan shook his head and said, “no it has sensors.”



Figure 3. Lena^T and Fayola^C working together during Week 2 (left) and Week 8 (right)

Vignette 1.2. In Week 8, everyone worked together on a PD technique using a comic boarding activity where they sketched or wrote a story of their choosing that outlined the problem and the solution of what they wanted to 3D print. For example, children and adults drew comic board stories of a car chase, a pencil case, and how chess pieces were missing from the library. Again, this week, Lena^T and Fayola^C were in a group together (Figure 3, right). At the beginning of the session, Fayola^C expressed she was not interested in any of the comic board templates that the adults and teens had provided. Lena^T responded to her, “if you do not like any of the templates, you can work on a separate piece of paper.” Lena^T gave her a blank piece of paper and said to Fayola^C, “you should be creative.” Lena^T told Fayola^C that they should select one of the templates and they started talking about the template. Lena^T took the sharpie and started to draw

on the blank paper with Fayola^C's ideas. Fayola^C then drew on the box design that Lena^T had created, and they both worked on adding sketches to the same drawing. We observed how Lena^T held side conversations with Fayola^C and shared stories about school, her friends, and informal topics. Only at the very end of the time allotted to the activity, did Lena^T lead or direct the conversation explicitly to how they were going to fill in the blanks in the comic board.

Analysis. Importantly, upon reflection of these vignettes Lena^T explained how she had developed a sisterly relationship with Fayola^C. This sisterly relationship was based on their shared cultural Ethiopian and Eritrean background which enabled Lena^T and Fayola^C to foster a unique relationship. In the vignettes we present, both girls did not need to use explicit words to communicate their design ideas to each other because there existed implicit ground rules among them. Based on their underlying cultural expectations, they both understood the cultural norms that came with a younger child working with an older child to both learn together and challenge each other. In the first vignette, we see how Lena^T subtly sets up Fayola^C and Nathan^C to share their creations with the group. Lena^T started the large group share out by describing their process of going from 2D and 3D and then created space and opportunity for Fayola^C and Nathan^C to share their projects for the group to ask questions. One might ask, how is this instance a microcosm of the multiple ways in which Lena^T set children up for them to speak up, share their ideas, and learn from each other? In the second vignette, we call attention to how Fayola^C rejected all the templates the adults made, and Lena^T found a way to allow Fayola^C to create her own template. Six weeks passed since their first engagement in a group together, and one might ask: How did Lena^T balance conversations about her life and her school experiences while bringing the conversation back to the comic boarding? The relationship we observed between Fayola^C and Lena^T was one of many that showed up in our program.

We observed the ways in which each member of this work developed relationships and felt a responsibility to support each other. This observation within the context of 3D printing, builds on what Kafai proposes as a key component of computational participation (Kafai, 2016). In the two vignettes, we see how with a critical mass of not only “like-minded creators” (Kafai, 2016) but a group of children and teens that were all students of color in computing was key to resisting dominant narratives of who engages in computing. In her analytical memo, Wren^R wrote about

the ways in which children, adults, and teens were all sharing personal stories during snack time and circle time, “*Samuel told me that he had gotten in trouble at school and the teacher did not believe him. Rick also shared with me that his toddler had been waking up earlier and that he was feeling a little tired.*” When reflecting on his role throughout our efforts the teen librarian Rick^L articulated, “*I don’t know what proportion, but for much of their time [librarians’] is building interpersonal relationships with teens and 10-year-olds... but I really think you’re not a family member, you’re not an uncle, but there is not really a word in English for it. I can’t think of one. But you’re really just kind of building relationships. I mean, it sounds so stale. Like everybody says ‘build relationships’ but it’s much more important than knowing, cataloging, and... I think for a lot of librarians it’s actually a huge part of their relationship, building the teams.*” Rick^L later also articulated how every member support each other was critical, “*I would have never done it without Liam^L and Joel^L, and it’s not because I didn’t see its potential, but it really would have been too much. It would have been too much for the context of the plate of things to do for a youth librarian.*”

Researchers and teenagers talked about college, teenagers and children talked about school projects, and everyone checked in on how they were experiencing the program during snack time and circle time. We observed how community driven the librarians were to bring computing education to their branches while centering the people, not the technology. We also observed how committed the teenagers were to be with the children during the PD sessions, while emphasizing relationships over technology content knowledge. In our analysis, we saw how each person cared about fostering relationships with others and wanted to contribute to helping someone else learn and grow. This care and support for one another was not one-directional where adults wanted to help children or teenagers, but rather multi-directional where teenagers wanted to help adults, children wanted to help teenagers, and teenagers wanted to help children. In this way, our data shows evidence of how we foregrounded relationships at the community level throughout this work, rather than centering the computing education curriculum. We also noticed the focus was on teaching content knowledge about 3D printing, cultivating children’s interest in design, and investing into understanding each other’s assets. Although children improved their understanding of 3D printing, (many for which was their first time seeing a 3D printer and creating a 3D printed object to take home), the project was about the people. In his

interview the librarian who oversaw KidsTeam Libraries across the city (Joel) reflected, *“I also think that when you come into this community and then you’re asking them to work with you and then you want them to have this voice, we should not forget also about what we bring. I think for me the beauty is that what I bring works with them...You as a researcher, me as a practitioner, and they bring their community assets. So, when we bring them together, I think that’s what makes this really strong.”* From this findings section, we ask:

- What assets could these young black women leverage in other computing education sites to negotiate and assert power in similar ways?
- How might other computing education programs support the collective’s growth and development?
- How did foregrounding relationality in this work afford for each child to feel like this was not a traditional computing educational space?

Theoretical Connections. With a **funds of knowledge** perspective (J. M. Smith & Lucena, 2016), we asked ourselves ‘What assets do the teens bring to this experience?’ and ‘How might we connect what they know with what they are doing?’. In this vignette, Lena^T had assets of understanding her and Fayola^C’s cultural background and had knowledge of the norms needed to work with children of different age groups. Prior literature on funds of knowledge, emphasized the importance of converting an individual’s assets into forms of capital that are recognized within the computing and engineering space. From Lena^T’s asset of knowing the ways to communicate with Fayola^C and Nathan^C who were children from historically minoritized backgrounds, she was converting her assets into facilitating the relationship building which led to children feeling recognized and valued in the session and ultimately to help shape the computing curriculum.

Prior work has emphasized the value of relationship building in informal learning spaces (Azevedo, 2013), but fewer have described the role of intergenerational relationships with mentors that share their identities in computing education. In both vignettes above, we see how Lena^T positions herself as a mentor in this space by leveraging her existing funds of knowledge around cultural implications of sisterly relationships. Specifically, we argue that to shift computing education toward a decolonial imaginary (Pérez, 1999), we must start by

communicating the value of relationships before, throughout, and after teaching the computing content in a way that draws on cultural knowledges. Yosso (Yosso, 2005) presents a kinship approach to funds of knowledge theoretical perspectives that upholds the importance of maintaining a healthy connection to our communities and its resources beyond one's household or immediate family.

Through our vignettes, we extend a funds of knowledge theoretical perspective for a computing education future that foregrounds healthy connections among community members to collectively build on each other's funds of knowledge. We argue that computing education can reimagine the ways in which we help students learn about computing topics in informal learning spaces by not only focusing on the content of the curriculum but also about the delivery of that content and the relationships that are strengthened among learners in the community in the process.

Similarly, Vakil (Vakil, 2014) writes about how critical pedagogy principles in the design of new technologies can show up by respecting and giving voice to student concerns and interests throughout. In Vignette 1.1, we show how the learning environment we created positioned children to have agency and confidence in asserting their design ideas. When Wren^R asks Fayola^C a clarifying question about the scooper in her design, Fayola^C responds with the knowledge she already had about how scoopers are used in construction sites and how it inspired her design feature. Furthermore, bell hooks (Hooks, 2014) writes that to teach to transgress is to *"...create new visions, to know beyond the boundaries of what is acceptable, and to move against and beyond those boundaries."* In Vignette 1.1, we see how Fayola^C describes making robots *"that have never been made."* Extending these theoretical perspectives of critical pedagogy toward disruptive computing education, we observed interactions between mentors and children we are pushing against existing social structures of whose voices, ideas, and contributions are valued in a computing space that was created by and for members of the community.

6.7.2 Noticing, Enforcing, and Disrupting Power

Overview. We take a deeper look into moments where we noticed, enforced, and disrupted power during our 3D printing program where children were solving problems and engaging in digital activities. Within computing, the dominant culture reinforces that who is seen as having power is a white, middle-class, able-bodied, heterosexual, man (Pawley, 2019). Through a decolonizing lens, we argue it is critical to notice power, to be conscious of the ways in which we as individuals reinforce problematic power dynamics in the context of computing, and to celebrate the moments in which power is disrupted toward moments of liberation against the historical implications of computing. To disrupt power, we need to see power and take responsibility for that power especially in a context of computing and making where establishing membership in the computing community is not easy (Kafai, 2016). A rich body of work has detailed specific ways that power and social identities (*e.g.*, gender, race, age, ethnicity) interact in computing education (Booker & Goldman, 2016; Nasir & Vakil, 2017; Pinkard et al., 2017). This work is fundamental to understanding how we support children toward finding identity within computing. Recognizing that children's identities are intersectional and fluid, we build on prior work exploring how they form an identity within computing by drawing on Pinkard et al. (Pinkard et al., 2017) who outline an intersectional path forward for designing in the margins. In our work, we look at the range of power dynamics at play during our program and focus on noticing the many power dynamics that intersect, the ways in which power is enforced, and how power is dynamic through disruption. Our lens of analysis pays attention to how dominant and target identities interact with another person's identities.

Vignette 2.1. In Week 3, the children were in small groups to practice sketching their design ideas by drawing a robot made of simple shapes. The goal of the activity was to practice using pencil and paper to make complex shapes before creating the design in TinkerCad. A couple of minutes into the activity, one child (Eshan^C) left his small group to observe what was happening in other small groups. After seeing that Lena^T had her phone, the child yelled out to the room, "*Oh you're cheating, they're using the Internet.*" Eshan^C then walked over to Kevin^T who responded "*who?*" Eshan^C pointed to the group with the phone as seen in (Figure 4, left). Kevin^T did not do anything, and the child walked over to Rick^L and whispered, "*Rick Rick they are using the internet.*" Rick^L responded "*who?*" and turned over to see the group that the child was referred to. The adult's response was "*talk to Lena.*" Lena^T proceeded to review her phone and

deliberate with her group on what they wanted to draw. The small group agreed that they would draw a “*dragon robot*” using complex shapes. They used the internet as inspiration to guide their sketch.



Figure 4. Eshan^C calling attention to phone usage (left); Children deciding who will describe and design (right)

Vignette 2.2. In Week 6, the children were working in small groups focusing on a game in TinkerCad to understand what considerations there needed to be when the game was used to teach other children about 3D printing. For each group, there needed to be one person who described the idea (the shape in their hand) and another person who designed the shape on TinkerCad. The designer role was to listen to the describer tell them what to do. At the beginning of the activity, Rick^L went around each group and asked, “*who is the describer?*” For every group that librarian visited, the children always pointed to the adult as the person describing. For instance, when Rick^L visited Rose’s^A group and asked the question, the child pointed to Rose^A, and Rose^A volunteered to be the describer. For the second group Rick^L visited, the same question was asked, and the children looked at Wren^R. Wren decided to volunteer as the describer. In the final small group that Rick^L visited, a similar interaction occurred where the child pointed to Joel^L as the describer (Figure 4, right). However, in this group, Joel^L responded “*No, no, no, so you want me to describe for you two? How about you both rock, paper, and scissors to decide.*” The children played the game and after Zayan^C won he decided to be the designer.

Analysis. From vignette 2.1, we notice power because the child did not directly address the teenager about her phone. Rather, the child chose to tell the other teenager and when that teenager did not do anything, the child turned to the adult. Once the situation had been explained to the adult, the adult chose not to address it and rather suggested that the child talk to the person. We argue this is a form of power being shifted back to the teenagers after the child turns to the

adult to mitigate the situation. The librarian knew that in this space it was challenging for the teenagers to be seen by the children as responsible for the learning environment just like the adults. Here, we might say that Rick^L was disrupting power structures by using his power as the adult in the room to redirect the concern to the teenager. During their interview, Nathan^C described how they perceived Lena^T and Kevin^T, *“I think they were helping. I knew Rick was the one leading the program the whole time. He was the one who literally organized it. Like, my mom she even told me that Rick was the one that texted everybody, told them that he organized a new KidsTeam Libraries.”*

In vignette 2.2, we noticed the accustomed roles that the children and adults took on. By default, the children assumed that the adult would take the role of leading. For all groups, children were not comfortable speaking up and preferred to have the adults be the describers. Even though the session was designed for flexibility of assigning roles, both the children and the adults defaulted to the adult being the describer without questioning why this was. Most of the adults did not have a problem taking the lead. However, in this vignette, we notice that only Joel^L pushed against the normative power. Rather than calling out a child to be the describer he suggested a game to delegate the role in a fair and playful manner. Joel^L disrupted the taken-for-granted interaction of the adult being the describer. After Joel^L disrupted this norm and gave agency to the children, the winning child of rock-paper-scissors had the chance to decide whether he was the describer or the designer. The child chose to be the designer, taking on the responsibility of creating the Lego shape on his computer while he described the Lego shape that the librarian handed him.

In their reflections, Lena^T and Kevin^T articulated three ways in which power showed up in their efforts: the lesson plans, the guiding community norms, and the ways in which their identity influenced interactions. For the lesson plans, they tried to come up with general guidelines to be prepared for each week but also to position children as design partners and not create a traditional classroom environment where children turned to the teenagers and adults for answers. The guiding community norms were helpful for making sure it was a safe space. The norms were written by Rick^L, Lena^T, and Kevin^T, but over time the children started reminding others of those norms in the space. In this way, the community norms served as material artifacts that held power to create a safe or unsafe space. Lena^T and Kevin^T also emphasized of promoting

confidence among each other. In a memo, Lena^T wrote, *"It's good to build confidence in young people when designing with them so that when they run into issues they don't just give up."*

Third, Lena^T articulated the ways in which the intersection of age and racial/ethnic background contributed to disrupting existing power structures. In another memo, Lena^T wrote, *"I think it's worth mentioning that the two teens involved are both people of color while the librarian the kids thought was leading it is white and so are two adult volunteers."* In Ryoo's study (Ryoo, 2019), educators of color made it more comfortable for students to discuss racial norms in computing education. In her memo, Lena^T explained how her closeness in age and familiar background as the children opened pathways to the new kinds of conversations about pushing against dominant norms in computing.

In the teens' analytical memos, we also noticed ways in which they were constantly reflecting on how they were supporting children to learn about 3D printing without doing it for them. After Week 4, Kevin^T wrote, *"For the design session, I felt that in my end, there was too much directing and showing. I really wanted the kids to explore TinkerCad, but they kept demanding that I show them how to do everything."* Similarly, after the first session, Lena^T wrote, *"I also got very frustrated when the kids couldn't/wouldn't follow directions...they would listen for a minute and then go right back to doing what I told them not to."* Reflecting on why he may have gotten frustrated, Kevin^T explained, *"For me and maybe Lena^T this was probably one of the first time in our lives where we were the one that was 100% in charge with power. Therefore, since there were other adults in the room, we wanted to show the adults we could handle it and that's why we got annoyed when we were losing control."* From these memos, we emphasize the challenges that every member of the design team faced when trying to resist enforcing behavior norms and when taking intentional actions that encouraged children teaching each other and not relying solely on the adults for information about computing.

We also noted moments when children took on adult roles by design (as in a facilitator intentionally thought about it) and organically (as in the children did it on their own). By design, we noticed two ways in which Rick^L, Kevin^T, and Lena^T intentionally shifted power back to the children by letting them ask the question of the day during circle time and to provide them with a copy of the paper schedule that was going to be used for the program. During Week 6, we

observed how Elliott^C held the paper copy of lesson plan and wanted to ask the question during circle time to the group. After this, we continued to print multiple copies of the lesson plan and allow children to follow the guide as a way of taking up traditional roles that adults hold. For the second level (organically), we observed two instances where the children took up power without being prompted by adults or following adult guidelines. For example, in Week 4, we observed how Samuel^C modeled the adults, saying “*five minutes left*” to signal that the activity was almost over.

In his interview, Rick^L reflected on his approach to disrupting power, being dissatisfied and seeing this work as ongoing. He said, “*There are easily ways that I could have figured out if Kevin^T and Lena^T could have more power in the room...and I’m dissatisfied about that. I think that’s okay. It’s okay to be dissatisfied with it but KidsTeam is not one series, like it’s just sort of this ongoing, annual, a couple times a year.*” In our interview data, we observed a tension across the librarians who were engaged in this work where they were intentionally cognizant of the ways that power showed up in the space, actively took steps to mitigate that power and had invested time into educating themselves, but still knew they had slip ups and highlighted areas where they could improve for the next time. We see this tension as healthy toward disrupting existing power structures within computing education because it emphasizes an iterative nature. We present this finding to show other adults in computing education that they should be constantly reflecting on how power shows up, how efforts to shift power are fruitful such that we can continue that practice, and where our efforts to shift power break down such that we can emphasize change and relentless dissatisfaction with how we shift power. From this section, we ask:

- How can we foster future moments for children to learn from, model after, and reimagine what their roles in learning spaces are?
- How can we support librarians and adults to actively reflecting on how they reinforce power?
- How can we step back after every engagement with a young child and have a conversation to learn from how they saw power?

Theoretical Connections. We argue attending to the ways power shows up and the ways we disrupt power is a critical step toward disrupting computing education because power needs to be not only acknowledged and talked, but critically questioned by all people (not just adults). Here, we draw theoretical connections to decolonizing imaginaries (Pérez, 1999), where shifting power in unexpected ways is a movement toward liberation. We must critically question the unexpected ways in which power shows up in our everyday engagements with children and teens because those unexpected ways are what we reinforce to maintain the status quo. In our work, we relied on every person's expertise, lived experiences, and funds of knowledge around what felt problematic to then collectively surface, name, and unpack how power was showing up to our engagements. When people feel empowered to identify and challenge when systems of power are permeating into our everyday engagements, they become active participants of transforming the existing situation (J. M. Smith & Lucena, 2016). We observed how Lena^T and Kevin^T leveraged their funds of knowledge as teens of color and as members of the community to actively work against dominant norms in computing. In turn, computing education might consider a future where students feel a stronger sense of belonging to computing when their funds of knowledge are vindicated and validated to actively resist power structures (Elenes et al., 2001). Through this manuscript, we also make connections to power in the invisible curriculum, that is the ways in which the design of and delivery of informal computing education reinforced power dynamics or introduced additional barriers to disrupting power.

Freire (Freire, 2018) presents critical pedagogy as an approach to education that helps students question and challenge systemic oppression through praxis. Students' critical consciousness develops as they think critically about their educational situation, become aware of the ways in which social and political power dynamics play out in the classroom, and act against the oppressive aspects of their education. From a critical pedagogy perspective, we were supporting the teenagers in rethinking what was acceptable in computing education settings. They were changing and taking up new educator and learner roles to enact new visions of computing learning environments. We observed how Lena^T and Kevin^T were making explicit their awareness and critical consciousness resist oppressive practices and explicitly take actions to push against power dynamics between adults, teen, and children. Furthermore, Freire writes that central to the development of students' critical consciousness is the dialogical nature of praxis,

reflection and action directed at the structures to be transformed. Extending Freire’s ideas of critical pedagogy, in analyzing our data, all co-authors reflected on how power showed up despite everyone’s commitments to co-creation.

6.7.3 Systems of Power Getting in the Way of Change

Overview. The third theme that surfaced throughout our data analysis was around the macro-level systemic challenges we faced on an everyday basis as we intentionally sought to disrupt the way computing was taught. We distinguish this section from section 5.2 where we discuss issues of power that we noticed, reinforced through subtle actions, and disrupted through intentional actions (*e.g.*, how we give feedback, lesson plans, and behavior management). In this section, we focus on the larger systemic issues that seem out of individual control but are power dynamics that we argue we must be attuned to in computing education (*e.g.*, the influence of the librarian’s and the local library’s culture, the role of the institutional review board, and how perceptions of age influence actions). In this section, we offer empirical evidence of the ways in which societal-level systems of power (that might have been out of our control), influenced our everyday interactions. Previous work by scholars has named the larger systemic issues present in computer science and engineering that exclude youth from marginalized backgrounds from identifying with computing (Cheryan et al., 2015). We offer this finding toward a justice-centered computing education research agenda where we can recognize the systemic powers at play in our interactions and creatively adapt to work against them or circumvent them in our engagements with each other. We do so in the context of design and 3D printing which can facilitate the development of computational thinking elements such as abstract and algorithmic thinking, pattern recognition, and decomposition (Chytas et al., 2019).

Vignette 3.1. Week 6 started with Kevin^T and Lena^T doing a demonstration of the activities the children would do in their small groups (Figure 5, left). Kevin^T and Lena^T sat at the front of the room while the children stood in a semicircle watching their computer screen being projected. Kevin^T said, “*I am going to show you three levels of designing Legos in TinkerCad. You guys are going to try to make this in TinkerCad*” [*referring to Lego pieces*]. Kevin^T showed his screen while he built two blocks and added them together. A child interrupted Kevin^T’s demonstration and asked, “*wait do you have to match the colors?*” Kevin^T responded, “*no but you could*” and

moved on to continue adding his blocks on TinkerCad. Rick^L then asked Kevin^T to show everyone what happens when you group things together in TinkerCad. Kevin^T grouped the pieces together on his TinkerCad file and the children observed that even if you change the color of the pieces, when you group them, they become one color. Kevin^T then handed it over to Lena^T so that she could explain level 2 of how the children would collaboratively build their Lego pieces on TinkerCad.



Figure 5. Lena^T and Kevin^T demonstrating to the children (left); An end of session debrief circle (right)

Vignette 3.2. At the end of every session, after all the children had left the room, the adults participated in a group debrief about the day. During Week 7's debrief (Figure 5, right), Wren^R, Lena^T, Rick^L, Joel^L, Stella^A, Thomas^A, and Kevin^T all stood in a circle and reflected on how the session went by saying their "plusses" and "deltas." Plusses were things they thought went well and deltas were areas for improvement. During her turn, Wren^R shared that her plus was how collaborative the activities were, and her delta was a suggestion of how Kevin^T and Lena^T could present themselves as a team when they are doing demonstrations. Rick^L picked up on Wren^R's comments and stated, *"The demo from last week to this, I could see how you huddled beforehand and tried to progress. Ideally, we would have more time to do that on off days, but you know how it is."* Rick^L explained that a big plus was the progress Kevin^T and Lena^T were making to present during the PD sessions in general. Another adult volunteer in the group said his plus was seeing everyone draw together. As his delta, Thomas^A addressed to the teenagers and stated, *"I want you guys to speak louder. We all have confidence in what you are doing. Exude that."* Following this comment, both Thomas^A and Joel^L suggested techniques for the teenage leaders to practice projecting their voice.

Analysis. From vignette 3.1, we highlight the ways in which the teenagers fell back on traditional patterns of teaching and learning where an educator stands in the front of the room and the children observe, as opposed to the children being co-creators of the learning experience. The teenagers could have explained the activities differently by asking more questions or allowing the children themselves to explore how changing the color of their shape would be impacted when they grouped the shapes together. In computing education, it may be easy or the default approach for the most knowledgeable person in the room to model their use of the software and hardware for others in the room to learn. Although our program was grounded in design partnership principles, where everyone was positioned as a designer, we present this vignette to surface how easy it is to slip into traditional power structures that are the norm when explaining and learning new digital technologies.

In vignette 3.2, we highlight that the feedback offered during the debrief was directed at the teens and little to no feedback was directed toward the adults. After noticing the interactions from our debrief in vignette 3.2, we reviewed closely video from our other debriefs and noted that most times when we referred to suggestions for improvement during the adult debrief, they were always targeted toward the teenagers. Although these suggestions came from a place of care and from an intention to help the teenagers grow, we emphasize that it is an issue that the adults did not create space for the teenagers to give adults feedback. This vignette highlights how easy it was for everyone to forget about the principles of our design partnership when it came to the debrief session. The adult debriefs became a form of discussing the teenagers' performance and re-positioning them in a lower role within the program. From this finding, we reflected as a research group with the teenagers on how we missed this opportunity to also direct power back to the teenagers and have a bidirectional conversation where everyone could give each other feedback. Leveraging their power, the adults could have created opportunities for feedback to be given and received in all directions. One idea could be to build a structure where children also give feedback on how the session went and provided their input on how the adults in the room could improve their interactions during the sessions.

This findings section shows the dominant narrative of adults are in power, while children and teenagers are not. Despite the intentionality of equal partnership, at times people still solely

positioned Rick^L as in charge. Although Lena^T and Kevin^T talked about the logistics of the sessions, Rick^L would still facilitate the group such as calling on children or taking back the devices when they were not supposed to be using them yet. At the same time, we recognize that parents allowed their children to participate in this program knowing there would be responsible adults there to take care of their children. A grant gave the library 3D printers knowing adults would be responsible for taking care of the technology. Our institutional review board granted the researcher permission to video record knowing a professor would be responsible for ensuring the privacy of that data. In these ways, hegemonic systems of power were continuously embedded throughout our efforts and thus require reflexivity for computing educators to consider.

We noticed the normative actions we took for granted that are often rendered invisible to those in less powerful positions (like the children and teenagers). We observed the ways in which the existing library system allowed for a community-based program and provided the infrastructure for supporting the program while bringing with it a historical lineage of how things are usually done in the library. During our interviews Rick^L and Joel^L discussed the challenges of introducing a new way of doing programming at the library where for many librarians the old way was working “*just fine*”. Joel^L shared, “*I feel that when you are introducing these new models into a culture that has been working in a certain way. There’s this culture at the library, and I’m coming in and it’s like introducing a new way of doing things, right? My approach, which is different, somebody might want to say why do we need to change now? Right? That’s how I started when I came in. I was like, you need to start leading workshops with the Connected Learning framework and parents were like, what are you talking about, right?*” Furthermore, as written about in Yip et al. (Yip et al., 2017), roles during design engagements between children, teens, and adults shift dynamically going back and forth. As we see in our data, although we positioned teens in places of power, at times everyone still expected power to come from the adults and we as adults continued to place Lena^T and Kevin^T in roles that we did not place ourselves in.

As articulated by Nasir and Vakil (Nasir & Vakil, 2017), computing education has shielded exclusionary practices through claims of politically and culturally neutral knowledge and

practices. Through shielding, computing education has often avoided grappling with conversations that surface larger systemic issues within computing education. For example, the narrative of a “technology-focused” computing project makes it easier to silence conversations of identity, race, or gender. In current literature we see the impacts of avoiding such conversations related to systemic change such as low numbers of children of color taking the Advanced Placement CS exam, few women graduating with CS degrees, and algorithmic bias influencing what skin colors technology recognizes. We posit that these conversations have long been avoided for three reasons: 1) Assumptions of technology being neutral create a disconnect between a feature of a tool and identities which results in making it easier to ignore systemic issues, 2) When we start talking about gender, race, and ethnicity, it makes it uncomfortable for others to engage and therefore, they shy away or feel it is too high level for them to take action, or 3) There are many systemic issues we take for “normal” and as such they become invisible practices that perpetuate dominant narratives. Here, we ask:

- What forms of invisible existing societal power structures did we take up when we did not create space for the teenagers and children to give feedback to the researchers and the librarians?
- How do existing society roles and forms of power interrupt our progress toward a decolonizing computing education imaginary?
- How does knowing these systemic challenges while seeking to create change support our intentionality in every engagement we have with others?

Theoretical Connections. In *Toward a Decolonial Feminism* (Lugones, 2010), Lugones writes “*When I think of myself as a theorist of resistance, it is not because I think of resistance as the end or goal of political struggle, but rather as its beginning, its possibility... Resistance is the tension between subjectification (the forming/informing of the subject) and active subjectivity, that minimal sense of agency required for the oppression ← → resisting relation being an active one, without appeal to the maximal sense of agency of the modern subject.*” What this means for our work in a computing program is that resistance is not the end of our movement toward disrupting computing education, rather **resistance is the place of tension** from which we recognize these oppressive systems of power and actively create our own subjectivity. Later, Lugones writes “*In our colonized, racially gendered, oppressed existences, we are also other*

than what the hegemon makes us to be.” With our work, by elevating the voices of two teenagers to tell their story, researchers who are not traditional computer scientists, librarians who are committed to community, and diverse youth who engage in designing computing learning experiences for themselves, we each aim to become more than what the hegemon (of computing) wants us to be.

In vignette 3.1, although Kevin^T and Lena^T were relying on traditional ways of rote instruction to teach the children about the 3D printing device, they were also leveraging their existing funds of knowledge of computers. This lesson was an opportunity for them to showcase to the children how their knowledge about Legos and 3D printing machines and TinkerCad coupled with their knowledge of how to teach others was valued in the space. This makes us think about how we as educators create opportunities to rethink what is valuable knowledge, and what is valuable information to share in a computing education space. During the debriefs, we could have shifted power from us as adults to them as community members and to honor the lived experience of Lena^T and Kevin^T as near-peers to the children. Furthermore, we could have created a circle time where we included everyone from the program (not just the teens but also the children) to name the funds of knowledge they were bringing to the experience and help them draw connections between the things they were good at and the things that we were teaching them about computing.

From a critical pedagogy perspective, our actions of giving feedback to the teenagers perpetuated problematic norms where there is one directional way of learning. Rather, we could have relied on Lena^T and Kevin^T's funds of knowledge and connections to the youth to learn from them about how we could improve the program. Here we call attention to the value of noticing power so that we can disrupt power dynamics. In this paper, we noticed it until after the program had ended and we were analyzing the data from the debriefs. In the future, computing education can build on critical pedagogy perspectives where we create learning environments where we can *“recognize the value of each individual voice”* (Hooks, 2014) and create a community of learners that feel a relationality and responsibility to one another. In an alternative future, vignette 3.2 would have explicitly valued the perspectives of Lena^T and Kevin^T to give feedback to the adults and their actions. When reflecting on the implications noticing power and actively

resisting traditional norms by both giving and receiving feedback, Lena^T wrote that we must, “*Make sure the people who will be leading/teaching are willing to be flexible. The methods of teaching [computing] that they are using cannot be too ingrained [in them] that they won’t try teaching using an informal/nontraditional method.*”

6.8 Discussion

Few opportunities exist for youth from their own communities to design and even fewer opportunities exist where teenagers oversee computing experiences. To create a socially just future, we must provide opportunities for youth to learn computing and to actively involve youth from those communities in designing those opportunities for themselves. In our research, justice-centered computing education meant not only telling youth from non-dominant backgrounds that they can be designers of their own technology but inviting them to lead computing initiatives *for* and *with* their community. By investing in teen-led PD approaches to computing education we disrupt grand narratives of who can and cannot engage in computing and support sustainable, community-led change *by* and *for* youth of color.

To confront systems of injustices in computing directly and explicitly, we argue we must rethink who designs computing educational experiences for youth. The core contribution of our paper is to support reimagining who gets to define what computing education is and how we create computing education experiences with and for community members. Computing programs have high barriers of entry for youth of color because of their historical nature of being predominantly white and male in terms of who participates and who teaches (Pinkard et al., 2017).

Traditionally, when we think of computing, we think of coders sitting at a desk writing complicated algorithms. In co-creating this learning environment for themselves, we highlight how the teens and children positioned themselves as a new kind of computer scientist, one that was engaged in computation thinking by creating 3D models on software and by thinking through the implications of the designs they built with computers. For a justice-centered computing education future, we need to create more opportunities for people to develop their own sense of identity to redefine what a computer scientist looks like and does.

Following critical pedagogies (Freire, 2018; Hooks, 2014; Ladson-Billings, 1995) this investigation writes from the tension that education can be both oppressive and liberatory. Inspired by the work of scholars in critical pedagogy, hooks (Hooks, 2014) argues teaching to transgress means to move beyond the boundaries of traditional rote learning approaches to teach in a manner that respects and cares for students. We propose design implications that rethink dominant notions of adults and researchers as leading and designing computing educational experiences. We argue justice centered computing education approaches can actively involve children and teens of color in the co-creation of programming and learning experiences within their own communities. Yet, we highlight it is simply not enough to shift the burden to teens. We must continuously support and scaffold youth leaders to design solutions to work against inequities in computing. In our paper, we show how the two teenagers we worked with had the technology and relationships building funds of knowledge, to create a new way of learning design and computing with children from the neighborhood. Ultimately, through their contributions to this program Lena^T and Kevin^T make a statement to the computing education community to rethink who gets to compute by taking on the identity of computing educators in their local library.

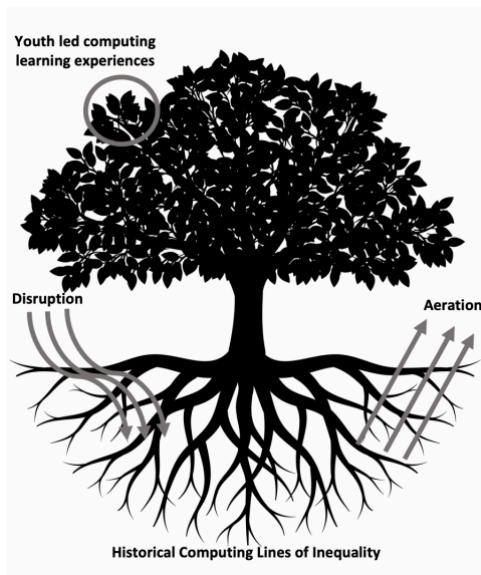


Figure 6. Metaphorically Disrupting Computing Education. Adapted from “Tree with the roots” icon by 1arts, ID, from thenounproject.com. Creative Commons license attribution 3.0

We have come up with a metaphor to make sense of our efforts and what future work might explore. In design, metaphors support the translation of complex matters into the familiar that can support conversations with people (Roldan, Bipat, et al., 2020). Disrupting computing education is a big effort. Computing education can be described as a big overpowering tree (Figure 6). The tree is held back by the fundamentally grounded traditional computing lines of inequality that are post-positivist (Clear, 2004), that see knowledge as a-political, and that emphasizes the development of technology as a global economic necessity. To allow for future growth, we must aerate the tree to allow new nutrients to flow into the roots and unbind the roots so they can grow to their full potential. To aerate it we must dig up the foundation by disrupting what is considered traditional computing education. Our work tried to do this by fostering relationships with our teenage leaders in our community to serve in designing and piloting curriculum for computing education. We created a space that allowed the roots to be exposed to new ideas from youth, new opportunities for the community, that were blocked by the original soil. To untangle the roots, we built close relationships with our community and the youth. As we build more relationships, each root became untangled and spread further than ever before to create innovative pedagogical opportunities for the future of computing education. Yet even though aeration created new opportunities, the tree still needs water to continue to grow. We must use a proper watering technique to create sustainability with a focus on the teenagers' growth. We must continuously support youth who have been marginalized in computing in leading more computing education experiences in their own communities. Computing education can focus on how we provide youth with the needed competencies to create their own products and design. We envision future computing pedagogy that provides youth with the opportunity to move beyond consumers of technology to creators of technology.

6.8.1 Reflections on Teens Leading Computing Education in their Community

We focused on supporting teenagers from the community that resembled the youth they were engaging in design partnership with. This focus was intentional because as Pinkard et al. (Pinkard et al., 2017) write, computing mentors in informal settings must have a level of competence in supporting the computing curriculum but more importantly must resemble the youth that they serve. It is important that Kevin^T and Lena^T saw themselves in the children they were working with and that the children in the program had leaders who they could see

themselves in. To reach a decolonizing imaginary in computing education, we emphasize the value of adults investing resources into supporting teenagers and children to lead the co-creation of the educational experiences they need and for adults to move aside to let them guide the direction of their learning. We saw how Lena^T and Kevin^T's confidence increased after every session. After continued positioning as design partners, the children started to push back against the things that adults would say. What this shows is the possibility of a decolonizing computing education effort that is led by children and teenagers, a process which guides and positions the students to have a voice, a say, and a role in the kind of learning space they want to be a part of.

Toward a decolonizing perspective, we propose that informal computing educational experiences can ensure that the people leading programming are people who have experience working with and have a commitment toward working with children and are leaders within their neighborhood. Through this experience, Lena^T and Kevin^T built knowledge about 3D printing, how to change the extruder, and how-to post-process a print. We argue these competences can be learned through a webinar or a technology training session where the teenagers observe and model how to set up the machine. Yet the ways in which they supported the children through question exploration and pushing back against the curriculum can only be experienced. We supported Lena^T and Kevin^T in attending trainings to learn about 3D printing while constantly emphasizing their role in setting the tone for an equal design partnership model with the children. We hypothesize that one reason to exclude teenagers from leading informal learning experiences is that they lack competency in teaching and computing skills. Through this work we saw how quickly their design and computing skills developed and sharpened by teaching it to others. We saw the many possibilities that surface when we push against systemic norms that we take for granted of who gets to design computing experiences. Our findings build upon what Vakil (Vakil, 2018) argues in a justice-centered approach in computing education where we move beyond the dominant pedagogy of the “knowledgeable other” for computing (in our case moving beyond defined by age) and computing expertise to value teenager leadership in supporting children to learn about 3D printing.

We argue that children and teenagers can lead us forward in our path toward rethinking what computing pedagogy looks like. We have thought about one counterexample to our approach,

what if we had invited someone from a big technology company to lead this after school program, how might they have supported Fayola^C? Extending funds of knowledge theoretical perspectives towards computing education, we emphasize the unique assets that Lena^T held to be able to facilitate that kind of conversation and engagement with technology with Fayola^C. We could have brought in the professor guiding this work to offer workshops on design and 3D printing and maker technologies. Yet that professor would not have had the built-up relationship and rapport that Rick^L did with all the children and teens involved. What if we had brought in an expert on 3D printing, how might they have taught the processes and backend of the machine to the youth? Maybe the children would not have felt comfortable pushing back, asking questions, and challenging that experts' ideas in the way that the children pushed against Kevin^T because they did not have the near peer age that Kevin^T and Lena^T did. We propose that many can teach 3D printing, but the hard part is finding people from the community to lead a program that is grounded on PD principles, centered on community assets, and that constantly invites conversations about the critical real-life problems in youths' everyday lives that computing can help address.

6.8.2 Implications on the Process of Decolonizing Computing Education

Computing education has just started to foreground lived experience, to focus on teaching computing as apolitical as opposed to foregrounding the people, and to emphasize how technology can help the global economy as opposed to how technology can help youth and their local communities (Vakil, 2018). To analyze our data, we have leverage the writings of indigenous scholars to propose a decolonizing imaginary (Pérez, 1999) where we envision a disruptive computing education process that first invests into community-level capacity building and relationship development, always focuses on noticing, enforcing, and disrupting power and surfaces the systemic barriers faced in efforts toward decolonizing ends.

Recently, scholars such as Vakil (Vakil, 2018), Nasir (Nasir & Vakil, 2017), Vossoughi (Vossoughi et al., 2020), Pinkard (Pinkard et al., 2017), and Ko (Ko et al., 2020) emphasize the importance of discussing ethics, power, and identity in computing education. These scholars have paved a path forward that enables new scholarship in computing education that takes up their ideas. We build on their research efforts by contributing a path forward. In this paper we

have described our process of aiming for a disruptive perspective, the successes and challenges we ran into, and the ways in which others can begin to take actionable steps toward disrupting computing education. Our work makes visible the practice of disrupting power structures in computing education by detailing the ways in which relationships were always emphasized thus opening opportunities for conversations of identity and power. In naming the power we saw, enforced, and disrupted from our program, we engaged in a dialogue about what else needs to happen to move us forward. In naming the systemic barrier we faced, we named the challenges we ran into that we want to continue working toward dismantling. We offer three implications for educators, scholars, and adults seeking to shift power toward youth creating the learning experiences they want to see in their own communities:

1. Be intentional about community and relationship building. Develop and strengthen relationships between youth and adults that support question asking, encourage youth to push back, and support a community of intergenerational learners. In our work, this meant identifying and supporting teen leaders from within the community that share identities with the children they serve through a long-term partnership engagement.
2. Shift power to those not in power and step back. Invite community members (*e.g.*, teenagers, adults, elders) in informal learning spaces (*e.g.*, public libraries, community centers) to collaborate not only by participating but also by designing a computing curriculum informed by their lived experience. In our work, this meant positing everyone as an equal partner through design techniques that invited children's voice and created opportunities for the inclusion of multiple voices in the design of computing activities for the community.
3. Be persistent and resilient. Reflect and commit to consistently noticing how power is reinforced through our actions and how our actions can disrupt systemic norms in computing. In our work, this meant not giving up and encouraging each other to resist traditional conceptions of teaching, learning, and leading in computing education to imagine a new educational experience where youth lead.

6.9 Limitations and Future Work

Several limitations exist in our investigation. First, we recognize that the voices centered in this work are primarily those of the teenagers, the researchers, and the librarians. The focus of this work was to trace the story of the teenagers positioned as design partners of computing educational experiences. We were limited in the how many children we could interview because we lost contact with some, and we were conducting interviews at a time that was full of uncertainties in the world. Future work could focus understanding how the children saw themselves as co-creators.

Second, we recognize that the context of this work is a unique case study of one library partnership that we invested into fostering and cultivating for three years. Although others in computing education might not have access to a library partnership like ours, we believe our findings are useful for anyone designing computing education curriculum to partner with children, teens, and adults in the design of activities. Future work can explore how positioning teens as co-creators of educational computing experiences across learning contexts compares to ours.

Third, we call attention to the unique positionality and commitment that the teenagers and library leadership had. Kevin^T and Lena^T had a heightened level of maturity and thoughtfulness such that we were able to build trust with them to lead the program. Future work could incentivize teens to stick around, emphasize opportunities for obtaining letters of recommendation, networking opportunities and access to the institutional resources from a research university. Future work might also explore how to best support the career paths of Kevin^T and Lena^T by helping them translate the experiences gained through this work to gain social capital within the computing education space.

Finally, we note that the long-standing relationship between the principal investigator of this work and the librarians influenced how we were able to let the teenagers lead this work and provide their ongoing support. Rick^L was a motivated librarian who actively reached out to marginalized groups and invested into the teen's growth. Rick^L was also part of our graduate program and then became a librarian which influenced how he brokered our entry into the

community. Future work might explore how we can incentivize more librarians to offer computing education programming that shifts power to children and teens as co-creators given the amount of time and energy required on the librarians end to support the entire efforts. We call for more computing education research that is situated across diverse neighborhoods in the United States (rural, urban, suburban) with a range of public service opportunities for computing education learning experiences (libraries, community centers, homes) actively shift power to let youth voice direct the kinds of computing educational experiences they want to take part in.

6.10 Conclusion

Computing educational experiences have been traditionally designed by adults, for youth. This paper argues that experiences designed only by adults is a justice issue because adults cannot fully understand the lived experience of youth and do not see the world through their eyes. We directly involve and elevate youth voice in this work by positioning Kevin^T and Lena^T, local teenagers from their community to guide the design and execution of a 10-week 3D printing experience for children in their community. Our findings emphasize 1) the ways in which computing education can foster and sustain *community-level relationships*, 2) how we *noticed*, *enforced*, and *disrupted* power within our program, and 3) the *systemic challenges* we confronted in our process. Through our investigation, we conceptualize decolonization for informal computing education, as the process of undoing colonizing practices that have influenced education in the past and are still present today through 1) a foregrounding of history, community, and lived experience, 2) ongoing reflection of power, and 3) a commitment to transformation. To begin to conceptualize the process of decolonizing informal computing education, our empirical research approach builds on three theoretical lineages: 1) funds of knowledge to foreground historical, communal, and individuals' assets, 2) critical pedagogy to continuously reflect on power in learning, and 3) critical perspectives from human-computer interaction to support the design of an alternative future for computing education. Collectively these theories give language to knowledge production that pushes against normative ideologies. Future work must center the experiences and knowledge of Native children and family members toward analyzing the ways in which settler colonialism exists within computing education and how we can disruptive normative perspectives (Tuck & Yang, 2012). This work argues that computing education approaches should actively involve children and teens of color in the

creation of learning experiences in their own communities. We call for future scholarship that consistently supports and scaffolds youth leaders within their community to design solutions to large-scale disparities in computing.

6.11 Acknowledgements

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6.12 Site 3 Afterword

Positionality. I showed up to this research site as an outsider to the Columbia City neighborhood. As a graduate student living in Capitol Hill, I was also contributing to the gentrification that was pushing out Black, brown, and indigenous communities who were in Seattle before the tech burst that I discuss in my paper. My positionality as someone who was not from the area but was committed to social transformation meant that I invested heavily into not only spending time in the neighborhood for my research but also to hang out in the library before and after our program, spending money at small businesses around the library, and getting to know the parents of the children who came to our program. Additionally, my positionality as a researcher in the space meant that I was representing my advisor who obtained the research grants to advance knowledge about how we can support design in libraries led by children and youth. This meant that I was the connection between the institutional resources and the library program in this neighborhood which in turn influenced how the program participants interacted with me.

Showing up as my full self-meant always asking the children about their day, having snacks together as a community member with them, and staying in touch with community members beyond the program end date.

Equity Tenets. Tenet 12 around foregrounding history (Deliberately foregrounding history and context) directly stemmed from this project. I learned from the teen leaders, the librarians, and the youth that there was a lot of history in how this neighborhood had changed over the past couple of years and the ways in which families had actively resisted the change. Through this work, I wanted to foreground the historical backdrop in which we were offering this computing program for youth of color, by youth of color. While centering the two youth leaders and intentionally involving the librarians I was constantly thinking about what it meant to actively do equity (Humbly supporting those on the ground). Since I first met the youth and teen leaders, I upheld a commitment to social justice that meant not only using the participants for research purposes by developing meaningful relationships with them as a mentor and as someone with access to resources that I could connect them with (Actively doing equity with care). I kept in close contact with the two teenagers who were part of this work, and this project shows how equity is ongoing when I continued to involve them in writing this manuscript based on their bandwidth and when they texted me about being the first ones in their family to go to college.

Sites of Knowledge. This project took place in the community meeting space of a library in the Columbia City neighborhood in Seattle. Through this work, I was able to see the knowledge the teenagers held about their community, about computing, and about their near peers that the other adults in the program did not possess. This project allowed me to hear about the children's experiences in school with computing and how those experiences contrasted with the kinds of design activities they were doing as part of our program. The site of knowledge from which I write this paper was reflexively and collaboratively constructed with the teen leaders Lena and Kevin as we made sense of how the time-bound case of this project informed our futures as leaders in disrupting what is considered computing and who gets to teach computing.

7 Chapter 7. Developing an Equity Praxis

7.1 Abstract

Researchers' and designers' commitments directly influence their scholarship and the types of technologies they design. Often those commitments are not articulated in the process of generating and publishing localized knowledge. While there are many people who do equity focused work, little research exists on the process of developing an equity praxis. That is, naming the tenets of an equity-oriented approach and documenting what it means to act in accordance with those tenets while conducting research on specific topics.

Existing scholars take on different approaches to address issues of equity including proposing curriculum materials, theorizing equity frameworks, and offering policy implications. Based on my theory of social change, I chose to study equity from the perspectives of the individual responsibilities and actions we each have agency over. I argue that any individual can notice how equity shows up in their unique practice through intentional reflection that calls attention to the kinds of knowledge that have been made invisible, the existing community relationships that exist, and the historical implications of their work. In this chapter, I demonstrate the process to develop my equity praxis through a reflexive analysis of the core commitments present in my projects, rigorous documentation of how I enacted my equity tenets in practice, and a visual representation of the components in my praxis. I contribute a novel process for researchers and designers to intentionally name, notice, and reflect on their equity commitments.

7.2 Introduction

There exist many designers, scholars, and activists who have a commitment to equity and seek to positively influence the world with their design implications. Researchers' and designers' commitments directly influence their scholarship and the types of technologies they design. Yet often those commitments are not articulated in the process of generating and publishing localized knowledge. It takes intentional effort for researchers and designers to document their commitments, notice how they enact them, and reflect on their commitments in action.

As I have breadcrumb throughout the dissertation, a desire to name and unpack the key characteristics that drove my research is how I came to develop my equity praxis. To develop an

equity praxis of my engagements as a researcher across sites of knowledge, I generated three versions of the tenets that make up my equity praxis over the course of twelve months. First, I named the key elements of my equity praxis (Phase 1); Second, I rigorously documented how I lived those tenets while in the field as a researcher (Phase 2); Third, I created a visual representation of how I enacted those tenets as my praxis (Phase 3). Through this work, I contribute theoretical implications toward the development of an equity praxis for design and methodological implications of my process to generate my praxis. Documenting the process to develop my praxis opens up generative opportunities for others to iterate on their own praxis; in their own contexts, while engaging with their sites of knowledge, and with their commitments.

7.3 Related Work

7.3.1 Existing Equity Frameworks in Design

In this section, I provide an overview of the breadth of knowledge and information within design communities that define equity in their own way, that exemplify how they enact equity in practice, and that propose guides to doing equitable design. It is against this background of existing work that I propose my equity tenets not as a replacement to existing literature of equity frameworks in design but as augmenting existing literature toward equitable futures.

Non-profit organizations that are committed to doing on-the-ground work with communities have published field guides (Creative Reaction Lab, 2018; The Annie E. Casey Foundation, 2014), toolkits (Tessa Finlev, Director, Future for Good Fellows Program; et al., 2019), and blog posts related to their equity approach in design (Aye, 2017). The Creative Reaction Lab offers their field guide for others to use to *“become a new form of leader: an equity designer”* (Creative Reaction Lab, 2018). In the guide, they describe what they mean by equity, by design, and they name what mindsets need to shift to establish a safe and equitable space. To the Creative Reaction Lab, equity-centered community design is *“a unique creative problem solving process based on equity, humility-building, integrating history and healing practices, addressing power dynamics, and co-creating with the community”* (Creative Reaction Lab, 2018).

The Creative Reaction Lab (Creative Reaction Lab, 2018) uses a visual (Figure 1, left) to represent the components that they see as part of the design process focused on social and

cultural solidarity for all. Figure 1 (left) shows how the components of equity design come together through the people, power, systems, actions, and history & healing. The authors argue the equity-centered community design model in action is a flexible system of intersectional issues and that integrating ‘*history + healing*’ and ‘*acknowledging + dismantling power constructs*’ is critical at every step of the way. The authors of the field guide explain what each component means, why it matters, tips on how to implement the component, an example activity that encourages that component, and space for reflection to connect the component to your life.

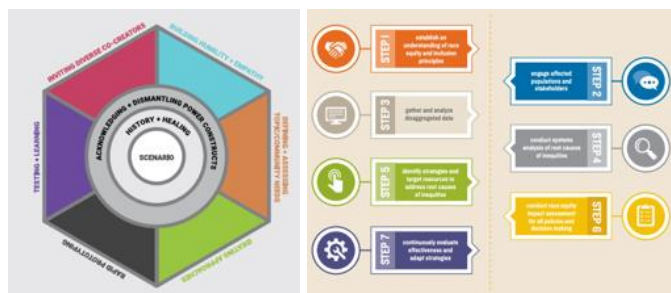


Figure 1. Equity-Centered Community Design (left), 7 Steps to Advance and Embed Race Equity and Inclusion Within Your Organization (right)

The Race Equity and Inclusion Action Guide published by (The Annie E. Casey Foundation, 2014) offers seven steps to advance and embed race equity into your organization (Figure 1, right). The authors offer the guide to add to the resources already created by partners who are committed to creating equitable opportunities that help all children thrive. The seven steps within their framework include: 1) fundamentally understanding race and inclusion principles, 2) involving affected stakeholders, 3) gathering some form of data, 4) conducting an analysis of the root causes of inequities, 5) identifying ways to address these root causes, 6) conducting an assessment, and 7) continuously evaluating the effectiveness of the strategies put in place. Within each step, the authors explain why the step is important as it relates to racism, when and how to do each step, and provide suggestions of questions to explore. At the end of the guide, the authors invite readers to believe that “*everyone can be a race equity and inclusion leader and champion*” by starting where you are with the people around you (The Annie E. Casey Foundation, 2014). I see parallels from this guide with my praxis to go out into the world and gather data while conducting continuous evaluation of how our equity approaches are influencing stakeholders.

There exists a couple of overlaps and key distinctions between my equity praxis and existing field guides like that of the Creative Reaction Lab and the Race Equity and Inclusion Action Guide. Similar to my approach, field guides often note that equity-centered community design is not a linear process; rather, it requires integration of each step as we approach different scenarios in our design practice. Additionally, the Creative Reaction Lab field guide includes a place for designers to reflect on how they would apply each step along with guiding questions for people to consider. Reflection is at the core of my equity praxis given my argument that the tenets cannot solely exist on paper or in theory but must be taken up in the world and then reflected on.

Common across these frameworks is also the need to define key terms used for shared understanding. Language setting helps ground conversations of equity approaches given the range of meaning behind terms that often get used (Creative Reaction Lab, 2018). In both the Creative Reaction Lab field guide and the Race Equity and Inclusion Action Guide, the authors explain what they mean by inclusion, equity, access, racialization, oppression, diversity, and liberation. In Chapter 1 of my dissertation, I have also included a list of key terms used throughout my chapters (equity, praxis, sites of knowledge, tenets) to provide readers a lens into what I mean when I use these words and to be intentional about the history behind the term.

The key difference between my equity praxis and existing equity centered design frameworks is that my praxis is not a guide. The words and visual representations I present in this dissertation of my praxis are a product of the equity engagements that I lived and experienced. I offer the equity tenets and the synthesized figure of my equity praxis in my findings section as a tool for others to use as inspiration to develop their own praxis. As I write in my discussion, the tenets and my equity praxis figure allow me to have a dialogue with others about my approach, but the tenets are only part of my contribution. It is both the naming of- and writing about- the doing of my equity approach that distinguishes my contribution to existing equity scholarship.

7.3.2 Reflections on Equity Approaches

In my dissertation Introduction section (Section 1.4.2), I explained what I mean when I use the term equity. In my dissertation Related Work section (2.1), I detailed how I came to conceptualize equity in my research by building on existing equity scholarship. In this section, I

shift away from seeking to define equity from a scholarly perspective toward offering an overview of how individuals and organizations reflect on what it means to take an equity centered approach in their lives. Although not everyone I reference below uses the term equity in their work I see a relationship between their social justice commitment to put their principles into action. Here, I hope to center the voice of people who are taking equity approaches.

During a talk about Understanding Identity, Power, & Equity in Design Leadership, Antoinette D. Carroll stated, “*Acknowledge that you’re on a journey and learning while doing. (And, equally, so is everyone else.)*” (99U, 2020). Similarly, the National Equity Project (*National Equity Project*, n.d.) wrote on their website, “*Leading for equity requires us to redesign structures and processes to consciously redistribute power across role groups and institutions.*” The Center for Black Equity (“Mission Statement: Center for Black Equity,” n.d.) explain in their mission statement that they believe “*coalition building and collaboration with allies and supporters is key to achieving equal rights for all.*” Shelby Zink wrote on LinkedIn (Zink, n.d.) as a takeaway from a panel discussion on equitable design in practice that, “*You don’t have to know everything to practice equity work but you must acknowledge your bias, be willing to ask the hard questions and recognize that as practitioners we’re in a constant place of learning.*”

In a post for the Equity Alliance Blog, Shirin Vossoughi (Vossoughi, n.d.) wrote about the relationship between designing for equity in educational spaces and enacting intellectual respect. She noted, “*In my experience, classrooms that embody intellectual respect invite young people to use real tools to work on real problems. They both presume that all students can engage in sophisticated forms of disciplinary thinking, and treat students’ histories, ways of speaking and knowing as resources for questioning and expanding disciplinary boundaries.*” In the book *Design Justice*, (Costanza-Chock, 2020) Sasha Costanza-Chock wrote, “*It is my hope that design justice as a framework can provide tools to support existing and emergent critiques of design (from images to institutions, from products to platforms, from particular practitioners to professional associations), as well as encourage the documentation of innovative forms of community-led design, grounded in the specificity of particular social movements.*” In the *Feminist Data Manifest-No* the authors wrote (*Feminist Data Manifest-No*, n.d.), “*We commit to a feminist data ethics that explicitly seeks equity and demands justice by helping us understand*

and shift how power works.” Here, I notice how others speak about the relationship between power, tools, respect, and equity approaches.

Think Rubix and Pierce Gordon published five misconceptions people have about equity centered work where they refute the idea that equity is an end goal (Think Rubix, n.d.). Think Rubix wrote, *“When our clients come to use for help with their equity work, we always tell them that equity isn’t the goal – it’s the process. Listening to, affirming, and uplifting the voices of the people closest to the pain is how you get closest to the solution.”* Finally, in a blogpost about research and racial justice in industry, Stacey Houston II and Randy Illum wrote (Houston, II, 2021), *“We need to deeply interrogate how the historical and continuous mistreatment of underserved communities intersects with our identity as a people, as employees, and as companies to influence whether and how we travel the path of equity and justice.”* Doing equity is a process, one that requires deep and intentional self-reflection.

These quotes are a small sample of voices from people who take equity-oriented approaches. From being engaged in equity conversations for more than five years with others, I have noticed how people see equity efforts as ongoing, as never ending, and as a constant intentional process that we must engage in. I have heard how equity is intimately linked to conversations of power, diversity, inclusion, respect, and justice. I have paid attention to how people engaged in equity work constantly center the collaborators, allies, and community members who this work is done with. And most importantly, when people talk about their equity-oriented approach, I have felt the humbleness, the vulnerability, and the passion from which they do equity.

7.3.3 Equity Praxis as Transformation

At the time of writing this dissertation, although many scholars and activists are engaged in equity work, a Google Scholar search of the term “equity praxis” generates only 106 results. Perhaps one reason to explain this is the uniqueness of the terms equity and praxis when placed in relation with the prominence of terms like pedagogical praxis and the prevalent association with Paulo Freire’s ideas of praxis. Other combinations of search terms that include Freire, the pedagogical praxis, or only the word praxis generate more Google Scholar results. Alternatively, the small number of Google Scholar search results might speak to the notion that scholars have

been focused on developing guides and frameworks from an omniscient third person perspective to do equity work. Few researchers and designers write about the lived experience of enacting equity commitments through our actions and inactions. Finally, another explanation for the few numbers of Google Scholar results from the term “equity praxis” may be related to the ways in which research communities gatekeep what is valuable, publishable, and credible knowledge generation. In this section, I synthesize how scholars currently discuss praxis as research and argue how the development of my equity praxis is valid and transformative research work.

In her essay, *Research as Praxis*, Patti Lather wrote about how our research paradigms directly relate to the beliefs we have about the world that we live in and the future worlds we envision (Lather, 1986). Lather writes about how critical the shift in scientific inquiry from positivism to post-positivism was to make room for different possibilities of making sense of human life. Lather calls for empowering approaches to knowledge generation; ones that engage in full reciprocity between the researched and the knowledge generated. Lather argues theory can be derived from the messy complexities of lived experience rather theory as an abstract framework.

Specifically, Lather writes that praxis-oriented research is fundamentally connected to *“transformative action and egalitarian participation guided consciousness-raising”* (Lather, 1986). For praxis to be possible Lather argues that *“not only must theory illuminate the lived experience of progressive social groups; it must also be illuminated by their struggles”* (Lather, 1986). Historically, academia has tended toward validating some forms of knowledge at the sake of others; often those without social and economic power tend to not be given legitimacy in their pursuit of new knowledge (Bunn & Lumb, 2019). Similar to the work of Vossoughi and Gutiérrez (Vossoughi & Gutiérrez, 2014) to create an expansive understanding of learning and Lather’s work (Lather, 1986) to create multiple ways of sharing research, I offer my equity praxis as a way of pushing the boundaries of how we legitimize scholarship that names a researcher’s commitments and their process of taking up those commitments in action.

My equity praxis is in line with what Lather (Lather, 1986) calls research that moves in many different and contradictory directions in the hope that more interesting and useful ways of

knowing will emerge. In the next section, I describe how I “*got on with the task*” (Lather, 1986) to not only write my equity tenets but to live my praxis through action and reflection.

7.4 Methods

I have organized the development of my praxis into three phases within a twelve-month period. At a high level, to develop my praxis and iterate on it, I engaged in similar tasks within each phase. I constantly kept methodological memos of the ways in which my thinking about the praxis shifted over time and documented my rationale for the choices I made. My approach to developing my praxis can be described in four iterative and continuous actions (Figure 2). I named my commitments around my phenomenon of interest (equity); I went out into the world with the named commitments; I noticed how I enacted those tenets in situ with my research participants by reflexively memoing; and I reflected and iterated on the named commitments.

Following an autoethnographic spirit, I investigated my lived experience from within. I kept written notes throughout my twelve-month process to name my equity praxis over three phases. Researchers in HCI have proposed how first-person autobiographical methods have the potential to reflect rich nuanced details of a person’s interactions in the field and to allow for ever evolving adaptations to our approach in the field (Jain et al., 2019).

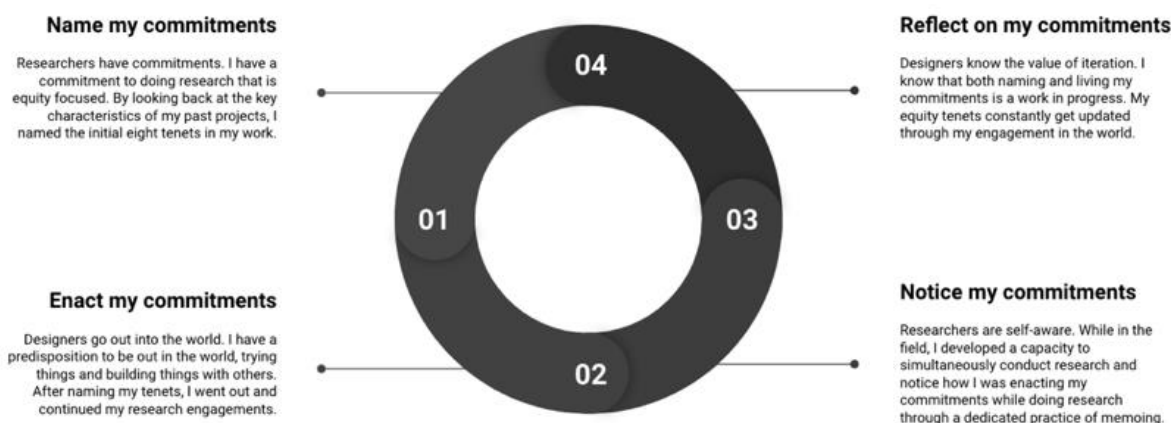


Figure 2. Overview of my methodological approach to develop my equity tenets

7.4.1 Phase 1 (September 2020 - December 2020)

In the first phase of developing my equity tenets I stepped out of my past projects and looked back to name the key characteristics present in each of my engagements. I used the tenets I named during Phase 1 to write memos on how I lived the tenets while doing new projects during Phase 2. To name my tenets, I started a table of the characteristics my past projects shared (Table 1). I then collapsed, affinity mapped, named, and described what those characteristics meant by adding to the “code” column.

Code	Like others from community x, I...	Some distinctive elements of my work...	My work includes x contributions...	If I engage in project x, I can explore...
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Table 1. Table used to reflexively look back at the key characteristics of my work

Next, I mapped the tenets to my past projects, like qualitative coding, using the tenets as tags and I identified one project per tenet that best matched the description of that tenet. I shared my tenets, in a talk for my dissertation proposal, in a 5-minute ignite style talk for the university libraries Scholars Studio (University of Washington Libraries, 2020), and in conversation with other researchers and designers. I also meticulously wrote about the tenets and my approach through researcher analytical memos that I referenced often throughout my process. At this phase, each tenet had a short phrase, a long description, and a project associated with it which stemmed from my own reflexive practice of looking back at my approach.

7.4.2 Phase 2 (December 2020 - June 2021)

In Phase 2, I took the original tenets I had named in Phase 1, and I positioned myself in the field as a researcher and a participatory design facilitator to notice how I lived the tenets in action. During this time, I was the lead researcher on three projects situated in unique contexts and maintained analytical memos after every participatory design session.

I simultaneously led three project engagements between the months of January and March 2021; eight participatory design sessions with master’s students and children to develop ideas for technologies that maintained connection across distance, six participatory design sessions with teenagers and adults to develop ideas for supporting finding critical information online related to

health, finances, and education; and six participatory design sessions with parents and researchers to develop ideas for playful learning landscapes that promoted early childhood STEM learning. These sessions were part of larger research agendas where I was a collaborator.

While I led the participatory design engagements with each community, I was intentionally focused on documenting the ways in which I saw myself living the equity tenets I had named in Phase 1. Over the course of my three months leading these projects, I wrote eight memos about my time with the master's students and children in a formal school setting, six memos about my sessions with the teenagers and adults in an afterschool community setting, and nine memos about my sessions with the parents and researchers in a community and home setting. This resulted in a total of 23 memos that spanned 28 pages.

To write each memo, I maintained a couple of rigorous practices while also allowing myself flexibility to write from my positionality in the field. I wrote every memo within 48 hours of having conducted the participatory design sessions and working directly with the partners. I made this choice to best capture my emotions, experiences, and realizations from the engagement with others. For each memo, I started by free writing what was top of mind after that session and then I created prompts for myself based on what I noticed. Sometimes I would write what happened and my reaction to what happened. Other times, I would write based on the three emotions I felt (*e.g.*, surprised, frustrated, eager) and then name why I felt those emotions based on my interactions with the participants and the topics we were discussing. Often after I wrote my reflections from the session, I would write one more paragraph with explicit connections to the tenets I had named in Phase 1. I would write methodological reflections of trying to enact the tenets in practice or the ways in which my participants stretched my thinking about the tenets. While writing, I kept in mind that others would read my memos later for collaborative analysis.

Between the months of April 2021 and June 2021, once I had the 23 memos from my three months in the field, I brought together a team of twelve people (including myself) to collectively analyze my memos and surface themes from the data. I offered a directed research group (DRG) which are similar to research seminars in my department and recruited participants with the following blurb: *"In this DRG, we will collectively explore these questions to develop a praxis*

for engaging in equity-oriented design approaches. Over the course of DRG, we will: (1) Create a shared understanding of equity through reading related work and reflecting on lived experience, (2) Analyze existing analytical memos of a researcher's attempt to document her equity commitment across projects, and (3) Translate the process of documenting and noticing equity enactments to your own practice." Participants came from a range of academic backgrounds including education, computer science, and design. Participants included 9 undergraduate students, 1 master's student, 1 PhD student, and one professor. Participants received academic credit for participating in the DRG and met weekly for 90-minutes on Zoom.

Over the course of 12 weeks, I designed activities that invited participants to analyze my memos written across my research sites. The seminar was structured around the teaching philosophy of creating a community of learners (Hooks, 2014) therefore we spent the first three weeks discussing our positionality coming to this research and developing a shared understanding of equity. We spent three weeks analyzing my memos and the last three weeks participants wrote and analyzed their own memos about how they were noticing equity.

Each week we analyzed one set of memos from one of my sites. For every set of memos, I gave participants a brief overview of the project to contextualize the content of the memos. Then, participants were divided up so that each memo had four readers. Between sessions, participants read the memos on their own to get familiar with the data. Then during our 90-minute synchronous session, each person went to their assigned memo and commented on them via the visualization software Miro (Figure 3).

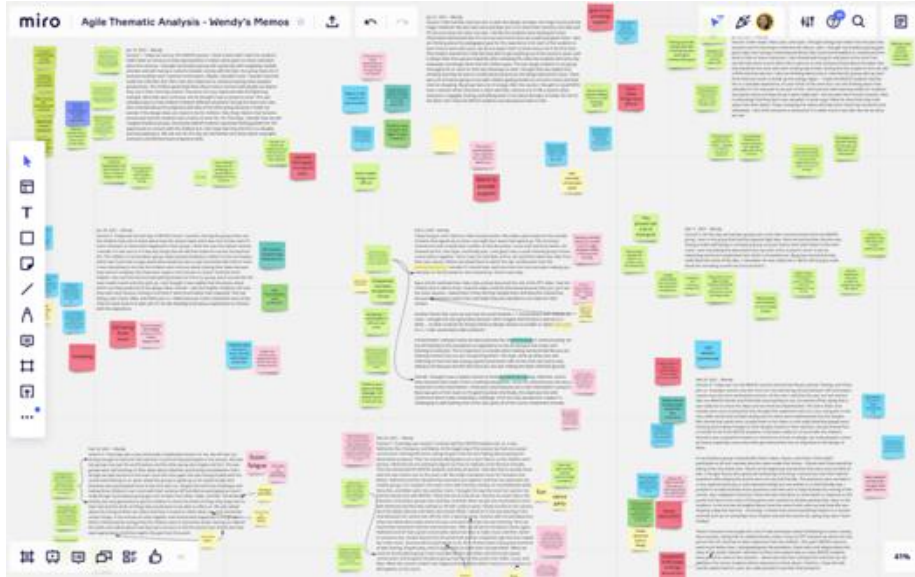


Figure 3. Snapshot of the agile thematic analysis process of my memos done with others

Following a design sprint, we spent 10 minutes noticing across the memos, placing post-its of our ideas, and reading other people's post-its. Next, we spent 10 minutes naming candidate themes that emerged from that set of memos, we affinity mapped the themes, and then sent participants into breakout groups to develop the theme out. Once in their breakout groups, participants were given 30 minutes to develop the theme by finding passages from the data related to their theme, discussing, and then developing a succinct statement of the theme. Next, participants selected excerpts from the data that illustrated the theme, added a statement about the significance of the theme, and named explicit connections from the theme to the tenets. Finally, participants shared out key takeaways from their theme development. We repeated this process weekly for all three sets of my memos and for the memos that students developed themselves. At this phase, the tenets were stretched, expanded upon, and rigorously examined by twelve people weekly through an analysis of the memos we each wrote about our lived experience trying to enact an equity praxis.

7.4.3 Phase 3 (June 2021 - September 2021)

In Phase 3, I explored ways to communicate my praxis visually (Figure 4). I started by reflecting on three versions of tenets I had created, noticing the ways in which I acted on each tenet, and looking for gaps between the tenets and my actions.

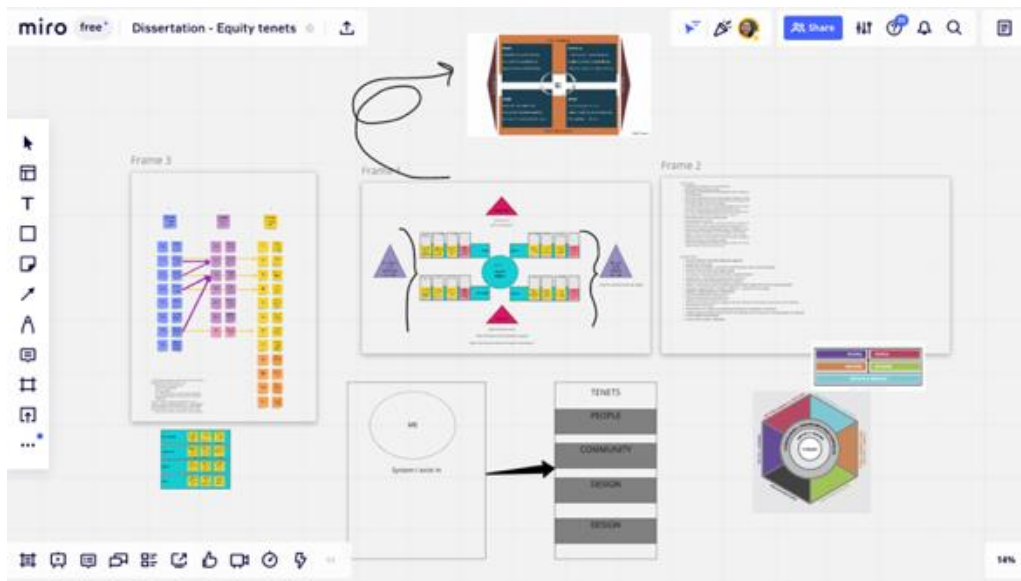


Figure 4. Iterative process to create the visual representation of my equity praxis

Next, I mocked up a visual that placed my tenets into groups based on similarities with each theme. I realized that I could affinity group all twelve of my final tenets into four pillars: people, community, design, and change (Figure 4, middle). I also traced each of the tenets to a theoretical lineage or methodological approach. After I created this mockup, I shared it with colleagues in design, communication, information science and with nonprofit leaders. Through dialogue with others, I iterated on the tenets to be situated within a system, to be enacted by an individual, and to be a constant process of action and reflection. Through multiple conversations with others, reflection of my own process, connections to my positionality, my research engagement across sites, and by referencing existing literature I arrived at the third version of my praxis that I offer in this dissertation.

7.4.4 Validity and Trustworthiness

In this section, I address questions of rigor, validity, and trustworthiness in my process. I see the process of developing an equity praxis as generative and foundational research that necessitates critical qualitative approaches to research. My epistemological commitments that I name in this dissertation call for developing knowledge claims that are fundamentally co-constructed with others as opposed to creating new knowledge that is proved. I employed a range of strategies to

ensure validity and trustworthiness in my process, both in making the data and handling the data (Walther et al., 2013). In making the data that I present across my three sites and my praxis development, I ensured validity was embedded across stages of my research design and that I was engaging in genuine dialogue with my research participants (Walther et al., 2013). In handling the data, I ensured I engaged in iterative analysis procedures and rigorous documentation of my research decisions (Walther et al., 2013). Through the detailed examples from my projects of how I enacted equity, I offer thick description of the phenomenon under scrutiny and ensure credibility in my work (Shenton, 2004). To ensure validity, I engaged in triangulation procedures, seeking convergence among multiple and different sources of information, a range of methodological approaches, and a number of theoretical foundations to inform my tenets and praxis (Creswell & Miller, 2000).

My process also involved a great number of researcher reflexivity statements where I documented how my ideas were being developed from, how I was thinking about my process, and how I was considering my positionality at every stage (England, 1994). To ensure trustworthiness, this work has gone under a great number of peer-scrutiny procedures (Shenton, 2004). To engage in member checking, I constantly conversed with other researchers, designers, and community members about my praxis (Lather, 1986). I sought opportunities for peer scrutiny of the research project by giving scholarly presentations to the academic community about my praxis through job talks and scholar studio events, and I shared my memos and process openly with the students in the twelve-week seminar I designed (Shenton, 2004). Through discussion with others, I engaged in frequent debriefing sessions with my advisors, peers, and researchers to widen my vision of the project (Shenton, 2004). Finally, my approach to developing my equity praxis has catalytic validity, that is the process reoriented and energized me and participants toward knowing reality in order to transform it (Lather, 1986).

7.5 Findings

Like my methods section, I organize my findings into three sections that show the chronological order in which I developed my equity praxis. For each phase, I *name* the tenets and I share how I *noticed* the tenets in action. In Phase 1, I also share how I arrived at the tenets, in Phase 2 how I enacted the tenets with others, and in Phase 3 how I chose to represent the praxis.

7.5.1 Phase 1 – Eight Original Tenets and How I Came to Them

In this section, I share the original eight tenets I developed through a cross-case analysis of my past projects, and I describe the research process that led me to these tenets.

Naming the tenets. After engaging in a reflective cross case analysis of my past project, in December 2020 I publicly shared the first version of my equity tenets (Figure 5).



Figure 5. Original Eight Equity Tenets named in December 2020

At this phase, the eight tenets were:

1. **Carefully noticing invisible knowledge.** I am interested in knowledge, specifically the kinds of knowledge that are made invisible by power structures. Of that invisible knowledge, I am interested in how we notice that invisible knowledge and exploring why it is that knowledge goes unnoticed. Throughout this process, I am careful about the framing of the invisible knowledge, how I notice that knowledge, and how I acknowledge those invisible knowledges. I pay attention when assets are hidden and call attention to the underlying historical reasons for why those assets have long been suppressed.
2. **Humbly listening to lived experience.** I focus on understanding experience and specifically lived experience- as opposed to described experience or idealized

experiences. I leverage theoretical perspectives to listen for felt experience. I listen to experiences through methodologies of interviews, focus groups, and workshops. I approach each opportunity with a participant or community member to listen humbly.

3. **Respectfully treating people like people.** I engage with people as people, rather than engage with them based on stereotype or intentionally biased. To me this means treating people in a specific way, a variety of ways, or in particular ways. Throughout my research engagements I start with respect as the frontmost value and see every engagement with people as an opportunity to learn and be surprised.
4. **Creatively informing generative design implications.** Through my research, I create implications, specifically design implications that are generative. This means my work results in implications that help others think about something, not just critique but provoke curiosity to creatively inform practice.
5. **Cautiously thinking about practitioners.** I am always thinking about the person who will be served by the research. Often, I consider a range of practitioners including educator, designer, and policy maker. I focus on those who might not be in traditional power roles but have connections to making a change. I aim to supporting practitioners without telling them what to do while recognizing that they have situated knowledge about the setting in which my research implications will be implemented.
6. **Intentionally involving community members.** I intentionally involve diverse community members, not just those who are actively visible but all who have a say in what happens in their community. I am intentional about how I involve them and what I ask. I make sure to ask how they want to be involved throughout the project.
7. **Strategically translating invisible knowledge.** Related to the tenet about carefully noticing invisible knowledge, I am actively engaged in the translational work that takes place when listening to lived experiences, naming the knowledge, surfacing the knowledge, and re(presenting) it in a way that others want to listen to. When translating the invisible knowledge to others I focus on having the public feel a connection to the lived experience and how we can improve ways of life for others.
8. **Actively doing equity.** I see equity as ongoing and doing equity as intervention given my design orientation. I do equity to make a change because our communities cannot wait for

change to happen. I feel an urgency to support others through my work here and now given the inequalities I see people in my life experience.

Noticing the tenets. Tenet 1 (Carefully noticing invisible knowledge) is best illustrated by my past work on online search and brokering (Roldan, Vanegas, et al., 2019). In that work, youth are engaging in a collaborative learning process with their families to solve critical family problems using online resources. I argue this tenet in action means noticing moments of resilience in those interactions of familial bonds that exist when adults and children solve critical issues together and learning together. In action, this tenet means analyze the research data with a lens that allows me to see the unique problem-solving skills that are happening rather than allow a deficit lens to overshadow the many systemic challenges families face.

Tenet 2 (Humbly listening to lived experience) is evidenced in the methods I employ. I listen to lived experience through interviews, focus groups, home visits, participatory design sessions, and reflective activities (Roldan, Turns, et al., 2019). In action, this tenet means ensuring every research participant has the chance to tell their own stories about themselves in the format that they feel most comfortable.

Tenet 3 (Respectfully treating people like people) was the most salient when working with an incarcerated youth population to use virtual reality and create art (Patino et al., 2021). This tenet meant treating every person I met through as a person with their own history, passions, and dreams. In this project, I made sure to uphold all the responsibilities we had as researchers in this setting while also treating the teenagers as teenagers. Equity in this setting meant giving the participants a chance to interact with technology, with art, and with us as people.

Tenet 4 (Creatively informing generative design implications) is best illustrated through the kinds of products I generate after projects. For example, in my work with university makerspaces I translated my research findings into considerations for a hiring process that was focused on inclusion (Roldan et al., 2018). In my work with visual notetaking, I generated design implications to inform higher education to support student success when taking notes in their engineering classes (Roldan, Lin, et al., 2020).

Tenet 5 (Cautiously thinking about practitioners) has to do with the ways I recognize my positionality in different contexts as a researcher and not as the expert of the setting. This tenet is best illustrated by the ways in which I approach partnerships to make sure someone on the ground is embedded in the work because I will never have the kind of rapport and the kind of experiences practitioners do when leading initiatives within their own communities and organizations. For example, through my work with coordinated outreach efforts (Roldan, Bipat, et al., 2020) that extended design charrette opportunities to public schools across Chicago, Seattle, and San Antonio I always thought about how to involve the teachers, the principals, and the city level leaders to ensure this work was sustainable beyond our one-time visits to schools.

Tenet 6 (Intentionally involving community members) relates to the ways in which I foreground community partners in all aspects of my research. In action, this tenet means considering the work that I as a researcher with funding and with access to university resources can take on to remove any unnecessary burden to community partners and making sure community members have agency with respect to the length of their engagement.

Tenet 7 (Strategically translating invisible knowledge) is evidenced by how I translate the knowledge I learn from my participants to various audiences. In action this means writing blog posts, tweets, and representations that make it easier for others to listen and learn about people's experiences while maintaining the emotional and personal component of that knowledge.

Tenet 8 (Actively doing equity) has to do with the ways I have seen people in my life be pushed to the margins, be discriminated against, or made uncomfortable based on their identities. I argue that my work actively supports them by always remembering this is years of work, work that must be done because people's lives depend on it. In practice, actively doing equity means constantly being self-aware of the implications of my day-to-day interactions with others.

Arriving at the tenets. I developed these tenets by engaging in projects where I: Centered the lived experiences of marginalized people including but not limited to Black, brown, and Asian youth, families from a lower socioeconomic background, English language learners, and women; had multiple touchpoints with participants through co-design workshops and interviews; and engaged intergenerational groups of people in design. The lived experience and identities that the

people I have had the privilege of working with in each of my projects is not happenstance; in each of my projects I partner closely with youth that remind me of my sisters and parents that remind me of my aunts and uncles. I see design as the mechanism through which my tenets can be carried out with people who share a similar approach to doing equity.

7.5.2 Phase 2 – Seven Tenets and How I Shared Them with Others

In this section, I describe how I took up the tenets while being engaged in three new research projects in the field and how I shared my memos with others.

Naming the tenets. In this phase, I decided to collapse a couple of the tenets given the similarities I saw between them, and I added one more tenet.

At this point, the seven tenets were:

1. Carefully noticing invisible knowledge
2. Respectfully honoring people's lived experience
3. Strategically translating invisible knowledge to design
4. Humbly supporting selected practitioners
5. Intentionally involving community members
6. Actively doing equity
7. Recognizing equity is not an individual effort (*New*)

I saw similarities between Tenet 2 (Humbly listening to lived experience) and Tenet 3 (Respectfully treating people like people) related to how I approached working with participants. I also saw overlaps between Tenet 4 (Creatively informing generative design implications) and Tenet 7 (Strategically translating invisible knowledge) given the designer and researchers roles I played in each of the sites and the ways I translated the knowledge I heard from participants to become generative design implications. My rationale for collapsing the tenets was toward simplicity when sharing the tenets with others. Yet soon after collapsing them I decided to bring back the original tenets to maintain the nuance of each. In the research group, we used the original eight tenets to draw connections between my praxis and my memos.

I also added Tenet 7 (Recognizing equity is not an individual effort). In leading my last studies, I realized that my previous tenets were centered on me and the work I do. Through reflection, I recognized that equity efforts are collective and in doing so I was supporting larger team development to do this work across more sites. A team of people who share commitments toward equity is necessary to continue the work sustainably. I realized that there was significant work that needs to go into capacity building within my own team and with our community partners. Equity meant bringing others along and building a team grounded on relationships.

Noticing the tenets. By leveraging the power of our twelve-person crowd in the directed research group seminar, we drew connections between the memos I wrote and the tenets I shared. There were three themes that surfaced across our reading of the memos and our collaborative analysis, connecting the equity tenets to: my interactions with participants, how I contextualized my approach, and the design ideas being generated from my three sites.

Connecting the equity tenets to my interactions with participants. We noticed as a group that I humbly listened to lived experience by intentionally creating space and time for students and children to voice their opinions through multimodal formats (e.g., chat, visual, verbal). We concluded that I also acted on the tenet of humbly listening to lived experience by not requiring anyone to share during design sessions even though energy was low. In my memos, I often wrote about the awkwardness of silence on Zoom but instead of interrupting the dynamic, I simply waited until people felt ready. Overall, we noticed the tenets that felt easiest to see from my memos were *humbly listened to lived experience* and *carefully noticing invisible knowledge*. This is perhaps because of the central role of funds of knowledge in my work and my orientation to actively listening to people when they share their stories.

Connecting the equity tenets to how I contextualized my approach. Given that the design sessions I led during Phase 2 occurred in the middle of the COVID-19 pandemic and during the presidential election, we noticed that the tenet about treating people like people meant always foregrounding the idea that people have a life outside of that session. In action, it meant recognizing when research participants were burned out and acknowledging that there was so much going on in the world. Across the memos, we also noticed the role of respecting emotional

boundaries depending on the topic being discussed during the design sessions and how it related to the tenet of respectfully treating like people.

Connecting the equity tenets to the design ideas being generated. The group drew connections between the way participants' design ideas were being taken up into mockups and were actively being iterated on. We discussed how strategically translating invisible knowledge meant involving research participants in the ways they wanted their ideas represented and working collaboratively to find ways to honor the perspectives shared. Strategically translating invisible knowledge also meant helping participants express their ideas in their own way.

Sharing the tenets. By openly sharing my process, I modeled for participants of my research group the ways in which they could name their own equity commitments, document how they lived their commitments in their everyday life, and to collectively analyze the kind of memos they each wrote. Over the course of three weeks, the participants generated 51 memos (Figure 6).

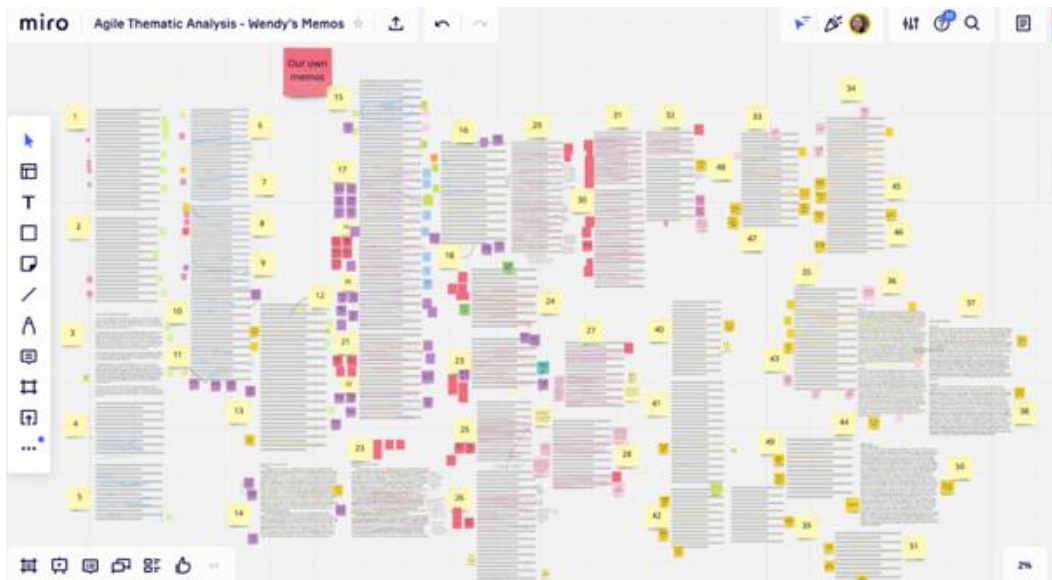


Figure 6. Snapshot of the memos that students wrote and how we collectively analyzed them

Participants wrote about how they noticed equity in school, with family members, on social media, when volunteering, and in conversations with friends. Their emotions within the memos were widespread; participants expressed sadness about systemic inequities, empathy for others,

puzzlement about equity conversations, confusion about equity in action, empowerment, and awe. When collectively analyzing participants' memos, the themes that surfaced were clustered around the role of family and friends in shaping our understanding of the world, the role of time and intentionality to notice equity, the importance of knowing our positionality and privilege, and the value of reflection as a tool for advancing our understanding and actions about equity.

7.5.3 Phase 3 – Twelve Tenets and How I Represent My Equity Praxis

In this section, I describe the third iteration of my equity tenets that I created nine months after my first version, organize the twelve tenets into four pillars, and situate the tenets.

Naming the tenets. Figure 7 is a visualization that succinctly summarizes the twelve tenets that make up my equity praxis. Figure 7 situates my processes to develop and enact my equity praxis by considering my positionality, the systems within which I tried to enact my praxis, and the reflective work before and after living my equity praxis.

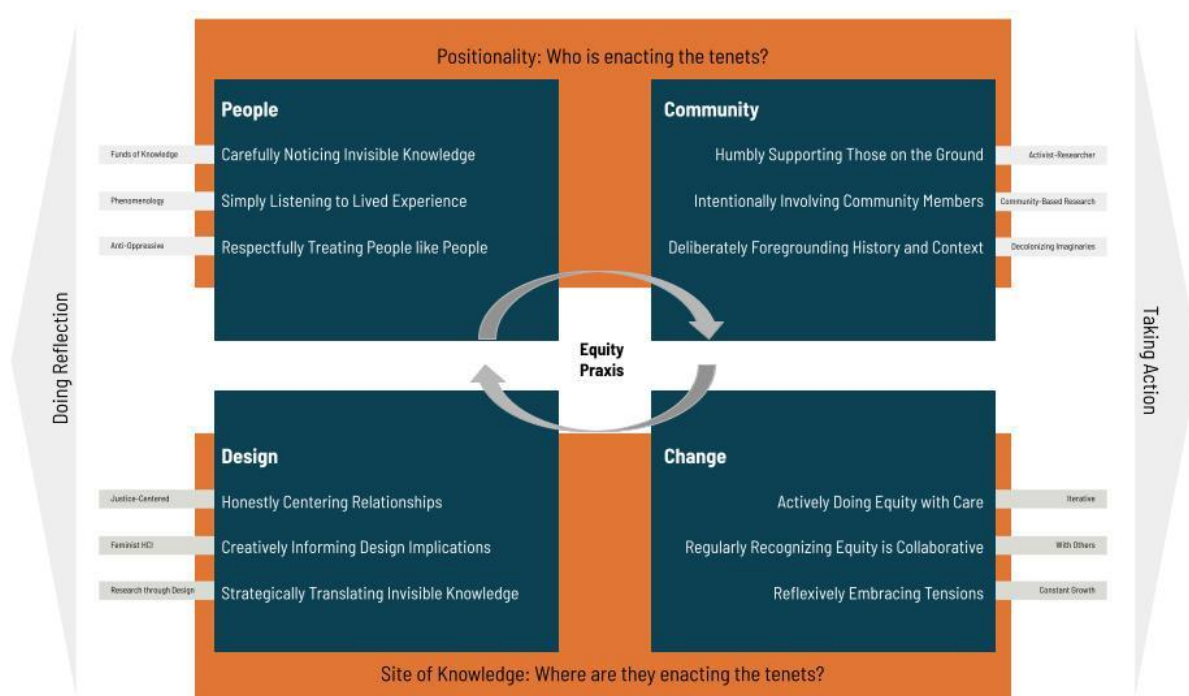


Figure 7. Visualization of my Equity Praxis

The twelve tenets that make up my equity praxis are:

1. Carefully noticing invisible knowledge
2. Simply listening to lived experience
3. Respectfully treating people like people
4. Creatively informing design implications
5. Humbly supporting those on the ground
6. Intentionally involving community members
7. Strategically translating invisible knowledge
8. Actively doing equity with care
9. Regularly recognizing equity is collaborative
10. Deliberately foregrounding history and context
11. Honestly centering relationships
12. Reflexively embracing tensions as opportunities

Noticing the tenets. Tenet 8 acknowledges the invisible work that is placed on predominately those who have been marginalized to do equity work. I added the words with care to Tenet 8 to highlight the importance of doing equity, while centering the wellbeing of people.

I added Tenet 10 (Deliberately foregrounding history and context) to foreground the people, the stories, and the existing knowledge that comes with a place in our equity initiatives. People leading equity efforts must honor the historical stories, people, and trauma within communities when attempting to lead new initiatives. Foregrounding context in our equity endeavors requires intentionality to learn about the history that often goes untold.

Tenet 11 (Honestly centering relationships) has to do with the ways in which we must honestly center relationships with each other, with ourselves, with our ancestors, and with the places we do equity work in. I added this tenet after conversations with my research participants and community leaders about the value of simply getting to know each other and the critical role of developing and sustaining relationships throughout the design process.

Tenet 12 (Reflexively embracing tensions as opportunities) represents how I see myself as a researcher that is always trying to do better, to try new approaches, and as a human that will inevitably be wrong. It means always taking time throughout project engagements to ask myself what went well, what was challenging and why was it hard, and what could we do better next time. This tenet honors the fact that change is hard, but we must continue our efforts.

For each tenet, I have also chosen to link key theories and key concepts that have directly informed the ways in which I have come to conceptualize each of those tenets. Tenet 4 (Deliberately foregrounding history and context) stems from my engagement with decolonizing imaginaries theory while I was making sense of the knowledge that I observed in Site 3 with the teenager in libraries project. Tenet 6 (Simply listening to lived experience) has a theoretical connection to funds of knowledge. Tenet 7 (Humbly supporting those on the ground) comes from my commitment to being an activist-researcher where I see both my responsibilities as helping generate new scholarship and helping drive social justice commitments along the way. Tenet 8 (Intentionally involving community members) relates to the existing literature on community-based research and activist oriented research approaches. Other tenets are informed by feminist HCI principles, research through design approaches, and the idea of constant growth.

Representing the tenets. After I reflected and developed my final 12 tenets of my equity praxis, I decided to affinity map them into higher level categories that would be easier to digest for myself. I noticed that many of my tenets had to do with my participants and how I as a researcher, designer, and activist engaged with them. Therefore, I put three tenets into the people category: #2 Carefully noticing invisible knowledge, #6 Simply listening to lived experience, and #11 Respectfully treating people like people. I also noticed that a subset of my tenets had to do with groups of people or cultural associations of groups. I placed three tenets into the community category: #4 Deliberately foregrounding history and context, #7 Humbly supporting those on the ground, and #8 Intentionally involving community members. Third, I created a group of tenets that had to do with my design process, the ways in which I developed research agendas, engaged people in my human-centered design process, and how my praxis informed the kinds of design implications I generated. There are three tenets in the design category: #3 Creatively informing design implications, #5 Honestly centering relationships, and #12 Strategically translating

invisible knowledge. Finally, my last group of tenets had to do with the kinds of elements I foregrounded throughout my projects related to social justice and creating change. Within this grouping, I noticed that some of my tenets have to do with changing myself as an individual to consistently exercise and iterate on my praxis while other tenets had to do with working in collaboration with others to enact change. The three tenets I placed in the change category include: #1 Actively doing equity with care, #9 Reflexively embracing tensions as opportunities, and #10 Regularly recognizing equity is collaborative.

7.6 Discussion

The core contribution of this chapter is the *process* through which I engaged in critical self-reflexivity, how I interrogated issues of equity, and how I looked within myself and out into the sites I was part of to connect the personal with the cultural (Griffin, 2012). The cross-cutting theme present in this dissertation is the *synergistic* relationship between advancing my theoretical understanding of equity while also advancing knowledge from my research sites. My praxis fills a unique opportunity to explore how we as agentic individuals notice the ways in which we promote equity while going about our everyday professional work. In this section, I reflect on my contributions to document and enact my equity praxis, on the implications of my process, and on the significance of my approach. I close the discussion by explicitly naming connections to existing theories of equity, of critical pedagogy, and of design and engineering.

7.6.1 Praxis Contributions

Overview. What distinguishes my contribution from existing equity-oriented design frameworks is that I not only name the tenets, but I also write about the nuances of enacting these tenets in the messiness of the real-world and how the development of this praxis transformed me as a researcher and designer. My praxis makes three contributions: theory building, reflecting, and history making. First, theory building gives name to the lived experiences of my research participants and how they have reciprocally changed me (Lather, 1986). Building on Lather, I argue that naming an equity praxis is transformation of the researcher, as well as their relations with others. Second, my praxis is intentional action and reflection; that is the process of being and becoming (Freire, 2018) through which I was part of while immersed in my sites. I argue that individuals can engage in critical reflexivity to intentionally notice how they enact equity or

how they are further perpetuating inequities through their everyday actions. Third, I propose my praxis is a history-making contribution by helping shape how research communities recognize new forms of knowledge through critical self-reflection and dialectical theory-building with others (Kemmis, 2010). I argue that my praxis pushes the boundaries of how we honor scholarship that traces how a researcher takes up their commitments in practice while simultaneously advancing knowledge about specific topics. Theoretically, by looking across my sites I distill the tenets of an equity praxis to notice how I enacted my commitments while in the field. Methodologically, by sharing my model through which I developed my praxis process, I offer a process through which others can document, trace, and reflect on their commitments.

Connections to nepantla. As described in Ch 3, this dissertation is written from a place of *nepantla* (Anzaldúa, 2013), a place of interdisciplinarity and of cross-pollination of methods, theories, and epistemologies from human computer interaction, learning sciences, design, engineering education, and computing education. Through the perspective of *nepantla*, my work is neither here nor there, not speaking to only one specific community but rather embracing the richness that comes from belonging to multiple scholarly communities. I see beauty in the ways my work draws on theories from education, leverages design methods, and uses critical epistemologies to develop my equity praxis iteratively and collaboratively. Yet, I also acknowledge the implications and potential risks that come with bringing together theories and ideas from multiple research communities. I recognize the historical contexts of design and engineering research, work that has often forgotten about indigenous knowledges or sought ways to suppress lived experience in exchange for scale and optimization to maintain those in power.

I take into the account the tensions that might arise when connecting ideas from scholars across a range of communities and the potential limitation in breadth versus depth of knowledge to further my understanding of an equity praxis. To address these tensions and limitations, I envision future work that closely interrogates the choices I have made when I adapt my design methods to meet the lived experience of my participants and when I put education theories and human computer interaction theories in conversation with one another. In paying close attention to the choices I made, I hypothesize that I will be able to surface my criteria for when I felt it was or was not appropriate to look across research communities based on my knowledge of the

community, the theoretical lineage, and the scholarly context. Toward this future work, I again leverage the words of Anzaldúa, “*your reflective mind’s mirror throws back all your options, making you aware of your freedom to choose*” (pg. 542) (Anzaldúa, 2013) to closely attune to why I saw opportunity in the cross-pollination of multiple communities, of seeing knowledge, and with a range of people to inform the development of my praxis across design sites.

In this dissertation, I have intentionally chosen the word *nepantla* to harness Anzaldúa’s (pg. 548) (Anzaldúa, 2013) powerful words of being caught in the “*remolinos (vortices) of systemic change across all fields of knowledge.*” My process to document, trace, and enact my equity communities across design sites of knowledge has been one where my “... *passion to know, to deepen awareness, to perceive reality in a different way, to see and experience more of life...*” (pg. 543) motivated me to embrace the overlapping space and connect the multiplicity of knowledge I gathered from my participants, my research sites, and from within.

Believing the praxis. Given the interdisciplinary nature of my work that invites scholars from multiple research communities based on their research training some may ask, *How is this chapter scholarship? What makes this work more than a diary entry to be seen as meaningful knowledge contributions?* In response to those anticipated questions, I return to the ideas from feminist scholars on research as praxis (Lather, 1986) and from research on multi-sited approaches (Bjørn & Boulus-Rødje, 2015; Marcus, 1999; Vossoughi & Gutiérrez, 2014). In this chapter, I have answered my second research question (*What does the process of documenting the development of an equity praxis across sites of knowledge uncover?*) in a trustworthy and valid way. This is evidenced by the multiple strategies I employed (Creswell & Miller, 2000; Shenton, 2004; Walther et al., 2013) to develop my equity praxis through rigorous documentation of the choices I made, the constant peer scrutiny that my tenets went through, and the catalytic validity (Lather, 1986) of how the praxis changed myself and my participants. In answering this research question through a multi-site approach (Marcus, 1999; Vossoughi & Gutiérrez, 2014), I have created an expansive view of equity across sites that encompasses how people’s actions look different across contexts to enact their commitment to equity. The development of my praxis gave language to the actions I was already taking to enact my commitment to equity and offered a framework for coming to realize the future actions I would

take to transform the reality I came to know (Freire, 2018). To this end, I aim to push the boundaries of how we legitimize scholarship in academia that names a researcher's commitments and their process of taking up those commitments in action to be valid and meaningful research.

7.6.2 Praxis Implications

Future vision. I propose a vision in which researchers can simultaneously explore both advancing their local knowledge about their topic and noticing the ways in which their equity commitments show up while doing that work. For example, perhaps a researcher who has maternal health as their focus topic can become inspired by my process to develop their own equity praxis as they continue to advance knowledge about maternal health. I argue that when researchers simultaneously generate localized knowledge and advance their understanding of equity, they transform in three ways. First, they notice how their actions contribute to or limit equity initiatives within their sphere of influence. Second, they become attuned to the challenges of what it means to enact equity through their actions or inactions. Third, they allow the process of research to change them. Through my equity praxis, I demonstrate the implications of taking a critical, self-reflective stands on how equity shows up as we go about our everyday practice. I argue that tracing my praxis, noticing how I enact equity, and iterating on my tenets has changed the way I see the world and the way that I influence others around me.

Using the praxis. If you find yourself asking, *How do I use this?* I would respond that you can use my praxis as a starting point for your own. I intentionally did not name this as a guidebook or a step-by-step approach to doing equity. Rather, I see my work as inspirational for others to begin their own journey of naming what their praxis is and being able to live it fully in their own sites of knowledge. I would invite readers to consider the parts of my process that they appreciated while I engaged in this multi-sited, reflective practice of noticing equity. Perhaps also ask yourself, *What resonated with me from this process?* I envision it might be how I wrote memos, the ways in which I publicly shared the development of my equity tenets, or the face validity from the tenets and praxis visualization. I propose that by engaging in the process of noticing how we enact equity; it becomes possible to both honor the ways we are currently contributing toward resources being distributed equitably in our communities and to surface opportunities where we can take on additional responsibilities to create more equitable spaces

around us. I want to emphasize that I offer my process to document my equity praxis for others to use as a tool *to think with* while they develop their own praxis. (England, 1994) writes that “*The intersubjective nature of social life means that the researcher and the people being researched have shared meanings and we should seek methods that develop this advantage.*” I see my process contribution as responding to England’s call for methods that support the development of new knowledge through researchers’ reflection and attunement to how our commitments show up in our actions.

Another important consideration when using my praxis is the fact that my praxis was shaped by my research sites and my positionality in the field. I argue that only individuals can name their commitments because each person is uniquely shaped by their research sites and community spaces. Core to the development of my praxis was the unique nature of my positionality (Carter & Legleitner, 2021) that gave me access to my research sites. This notion of a praxis as situated in the kinds of unique experiences we have aligns with how sociocultural scholars write that learning is a process of participation in communities (Lave & Wenger, 1991). While I anticipate that others might have similar commitments to my own, my hope is that every person who chooses to read this chapter feels inspired to document their tenets, to live their own praxis, and to consistently find ways to build coalitions with others seeking to transform the world they inherited for the better. In this way, I frame my contribution as a process of theory building, a reciprocal process between my lived experience of self-discovering my equity approach, toward collective liberatory, and naming a theory I knew and lived for myself (Hooks, 2014).

I highlight that although I see my research as contributing toward the development of a tool that can support others to engage in this reflexive accountability to notice how they enact equity, my praxis cannot be fully captured in Figure 7. Essential to the idea of praxis is the connection between theory and practice (Freire, 2018; Lather, 1986). I invite readers to take my visualization and use it as inspiration for their own praxis. I invite people to name their commitments, go out into the world, into research communities, into conversations with others, and to notice how they live those tenets. Ask yourself, *What feels hard when trying to live these tenets in action? What must give to fully commit to these tenets? What might you need as additional support to truly embody those commitments through your everyday interactions?* In

this place of constant naming, acting, reflecting, and iterating is where I see the potential for real transformation that each of us can take on to make world a more equitable place (Hooks, 2014).

Methodological reflections. In proposing a vision for others to use my praxis and naming considerations to consider when using the praxis, here I reflect on my methodology as it might work for multiple people, in multiple sites. One consideration might be how other researchers with different methodological approaches might take up my process to notice how they enact equity while perhaps employing machine learning techniques, quantitative statistical methods, or when building prosthetics. On the surface, it might seem challenging for those who do not capture video data in the way that I do to re-watch their actions or those who do quantitative methods to notice how their actions are an enactment of their equity commitments. Yet I posit that in the same way I was able to write memos after facilitating my design sessions, a researcher who is collecting quantitative data or who is creating data sets might also write memos about the ways in which they are noticing equity play out in their process. My iterative approach to name my commitments, trace them in action, and reflect on how I was upholding my commitments was possible because of the scaffolds I created for myself to name, memo, and notice. I hope the structure that I created for myself to engage in this process serves as a starting point for others. I argue that noticing equity is possible across qualitative and quantitative methodological approaches, it simply requires diligence to invest into tracing how our commitments show up in our actions whether those are interactions with people, with data, or with technology.

I am also aware that doing this type of reflexive work to noticing how we enact our commitments is a challenging, taxing, and a vulnerable process. Here, I draw on the ideas from funds of knowledge (Moll et al., 1992; Roldan, Vanegas, et al., 2019) and from asset-based design (Wong-Villacres, Gautam, et al., 2020) to inform how my process takes a generative and expansive approach to doing equity. I imagine that my approach might resonate well with people who are already pausing while going about their everyday to unpack a moment that simply felt wrong, an interaction that triggered a powerful emotion about their identity, or an instance where they second guessed their response to the world. In this way, my approach honors that *pausing* of that moment and takes it a step further to ask how that moment was an enactment of an equity commitment and how might I address it in the future. I also know that my approach might be

increasingly challenging for researchers and practitioners who are already navigating working in environments that require increased emotional labor. Perhaps my method requires increased care when being taken up by those who work with survivors of sexual assault, with people seeking to improve their mental health, or with those who have a trauma that influences the way they see the world. I advise those who take up my process to consider the support systems they rely on when doing challenging work that taps into our emotions and identities. I also highlight that when doing this work for myself there were moments when questioned the impact of my process to truly shift oppressive systems toward a more equitable state. In these moments, I reminded myself of the duality between how important it is to recognize the value of our individual actions while also recognizing the enormity of systems of oppression that have existed for decades.

For readers who might be nervous about doing this reflective work to name, notice, and enact their commitments to equity I emphasize that my process surfaces the things that you are currently doing to promote equity and the places where you can improve on your approach. I invite readers that take on this critical, self-reflective work to embrace a suspended disbelief that there will be moments where they are drawing on their lived experience, on their historical knowledge, and on their assets to promote equity. Likewise, this process might also surface moments where researchers might have to take on smaller experiments to try something that promotes equity, reflect, and realize their approach was not the best, and ultimately try again leveraging their newly gained knowledge. Although it may seem daunting, I propose that if individuals take up my invitation to do this process, they might come to realize the micro-moments when they are contributing to creating more equitable spaces in the communities that they are a part of. Engaging in this intentional process of noticing equity across our sites is important for everyone to do so that we take on individual responsibility and accountability.

Future work. I also name some potential next steps for the equity praxis and tenets that I hope scholars from multiple research communities take up. One future direction is the ability to scale this process with others. I believe there is an opportunity to host more spaces like my research seminar where people write about noticing their commitments in practice, collaboratively analyze their memos, and individually develop their own tenets. During my research seminar that I describe in Phase 2 of my process, I saw the value for students to come to realize the way

equity showed up in places they had never thought about and to see the connections among their memos as a grounding experience. Another potential future direction could be focusing more intentionally into the emotional experience of noticing in the moment what it is like to live that commitment and to later reflect what are the ways we can decrease barriers to enacting the tenets. Perhaps there are tools and new methods to capture living the tenets; for example, through pictures, with others, by leveraging video or audio modes for future reflection and iteration.

I speculate that the next steps for my work are translating the insights from my process into a toolkit or a design artifact that can remind individuals to synergistically advance knowledge about their research topics while advancing the development of their own praxis. In packaging the insights from my process for others to take up, I would include the key considerations I have outlined above around the praxis being uniquely shaped my positionality and I would also include prompts for researchers and designers to ask themselves to structure their memos. I think that the act of writing the memos played a critical role in my ability to disentangle the connections I was seeing between my actions and my commitments. I also believe that there was unique value in creating a visualization of my praxis and my equity tenets over time to have conversations with others about my process to notice and enact my commitments while engaged in my sites. As such, when sharing my approach with others I would emphasize the importance of doing this work collaboratively, in conversation with the world around you and with yourself. Finally, when reflecting on how I might share my process with others, the serendipitous and optimistic nature of my process comes to mind. I sought out to do employ rigorous research methods, to answer unique research questions, *and* to make the world a better place. Along the way, I trusted myself and what the people around me were telling me. I trusted the moments when my gut told me that it was time to reflect or the moments when I felt it was too much and I needed to step away given the emotional labor that comes with this work. In this way, design was living me throughout the way I designed my methodological approach toward my praxis – a desire to change the current state of the world toward a future that is more equitable.

7.6.3 Praxis Significance

Movement toward personal accountability as researchers and designers. In this chapter, I have contributed a reflexive account of my experience attempting to enact a commitment to equity and

of noticing the tensions and challenges of enacting my commitments. In doing so, this chapter provides a raw account of my lived experience trying to do equity through the lens of personal accountability while conducting research. Here, I articulate the value of research that follows a reflexive and autoethnographic spirit (Ellis et al., 2011; Griffin, 2012; Jain et al., 2019).

Following feminist and critical perspectives of research, movements toward reflexivity examine the ways in which our actions have implications, our scholarship is political, and our presence in the field has a role in the co-construction process of knowledge (Finlay, 2002). Importantly, design, engineering, and computing communities have also begun to engage in and make visible critical self-reflections of doing research (K. L. Gray, 2020; *Hope and Joy*, 2021; Rankin & Thomas, 2019). Current equity frameworks and approaches offer a third person perspective that foregrounds what we need to do (Creative Reaction Lab, 2018; The Annie E. Casey Foundation, 2014), while making the process to achieve these goals invisible. I propose that through attunement to the lived experience of what it means to enact a commitment to equity, people can take on individual responsibility to reflect on what they are currently doing and how they can shift their actions and approach to be more equitable in research and design efforts.

Seeing the praxis in multiple ways. I see three ways to name the kind of process I engaged in to develop my equity praxis: a reflective practice, an audit, and an autoethnography. For some, my approach to constantly writing the ways in which I saw connections between my research sites and my tenets may resemble the work of feminist and ethnographers engaging in reflective practices while in the field. Here, I see connections from my approach to the work of Dr. Turns who argues reflection is the process of stepping out, looking back, and connecting forward (Roldan et al., 2019). For others, my approach may resemble the work of auto ethnographers who embrace subjectivity and engage in critical self-reflexivity to critically question and interrogate life. Here, I see connections between my approach to trace my commitments, to attune to the lived experience of enacting the commitments, and to take my passion for equity into praxis (Griffin, 2012). Finally, my process can also be seen as a type of audit toward looking back at the action we take, meticulously and intentionally taking a lens to recognize the moments within our practice when we enact or do not enact our commitments to equity (Raji & Buolamwini, 2019). Here, I want to emphasize that I invoke the notion of an audit to paying

close attention to existing records to surface places where equity is or is not being enacted. I offer these three connections to existing literature to help readers see different lenses to my process as they take up my invitation to reflexively notice their equity approach while simultaneously advancing their other research and design goals.

Process and outcome. I also reflect on whether the tenets and visualization in Figure 7 is the answer I sought when trying to name the components of my equity praxis or whether the answer is the journey that I have been on to name the tenets. The kinds of conversations I have been able to have about my praxis have been afforded by the visual representation and succinct phrases I created for each tenet. There are parts of my process of naming this praxis that cannot be captured because they are between my participants and me. Perhaps the answer I have been looking for when doing equity work is in both the representation and the journey, synergistically helping me engage in the process of learning how through my actions and commitments I help others have access to the resources they need to succeed and to live their fullest lives.

7.6.4 Praxis Connections to Existing Literature

Connections to conceptualizing equity. Doing equity cannot have a linear, one-size fits all approach. I argue that doing equity looks different based on who is enacting the commitment to equity, what their commitment is grounded on, and where they are enacting that commitment. Doing equity also is an ongoing, iterative process of recognizing the moments that matter and promoting the distribution of resources based on people's lived experiences. It means paying attention to moments where actions need to be taken to truly live up to our equity commitments. Equity scholars write that to do equity is to transform institutions and social settings such that everyone has what they need to design their own futures (Gutiérrez & Jurow, 2016; Gutiérrez & Vossoughi, 2010; Jurow & Shea, 2015). Through my theory of social change, I propose that equity efforts can be advanced as individuals take on the responsibility and accountability within their sphere of influence to redistribute resources and power in meaningful ways.

Connections to critical pedagogy. hooks writes that we must approach education, teaching, and education research with an openness of the mind and heart that allows us to navigate the present while imagining a just future (Hooks, 2014). I suggest that my contributions toward the

development of an equity praxis, one where individuals take on the responsibility of noticing how they perpetuate equities or inequities in their sites, extends the emancipatory and liberatory potential for education, research, and design. Building on the words of Anzaldúa, I propose that by intentionally and systemically engaging in the twelve-month process to notice how my commitments were showing up as I designed with Latino families in the home, with teenagers in libraries, and with master's students in an HCI classroom, I was both creating and become part of my site of transformation (Anzaldúa, 2013). My site of transformation was the place where I was coming to know my reality, allowing my reality to change me, and thus reaching critical consciousness to create the tools necessary to change the reality I came to know (Freire, 2018). I argue that naming an equity praxis transforms the researcher as well as their relations with others; a process of action and reflection of agentic people upon their world to transform it toward more equitable futures.

Connections to design and engineering. Design as a lens and my training as a designer is present across my sites and in the development of my praxis. Fundamentally, my work takes a design approach that means I seek to change the world around me. Through my research sites and the development of my praxis, not only was I documenting my observations of the phenomenon under study, but I was also trying to change the current state of the world. Through a design approach, my praxis seeks to change the world around me, transform with the sites I am a part of, and push the system that I am studying. It matters that design as a lens and that my design approach cuts across my sites because they all have to do with changing the state of the world from one state to another, hopefully to make the world a better place. The role of sociotechnical systems in my dissertation is that I take the lens of design to become part of my sites and seek to change the world around me, not simply observing but nudging.

I also see strong connections between the development of my praxis and existing participatory action research approaches in design. Action research (Olson & Kellogg, 2014) is an approach to research that involves seeing people as experts in their own lives and engaging them in some way to address a community problem. In doing so, the problem-solving process is seen as a way to generate scholarly knowledge and solve community problems (Hayes, 2014). Hayes writes that as designers and researchers, *"We can, in fact, create positive social change and*

simultaneously do good research.” (Hayes, 2012). Action research as an approach builds on the democratic and inclusive approaches that exist within design, engineering, and computing to involve end-users in the problem-solving process as opposed to creating solution for them or about them. Similar to action research approaches, multiple opportunities that have come from doing this work through a design lens where I have simultaneously conducted research that was “*socially meaningful and scientifically rigorous*” (Hayes, 2012). I embrace the ethos that comes with developing my equity praxis in the context of design, engineering, and computing communities; that is one where we center the lived experience of users throughout our process, we iteratively come to the research plan of action, one where we strongly support collaborative processes, and one where we find knowledge through action.

It also matters that I developed my equity praxis while embedded in sites that were situated within the context of STEM, human computer interaction (Site 1), information science (Site 2), and computing education (Site 3). In doing so, I was studying the phenomenon of equity from within the community of STEM. As both a researcher and a member of the communities that I was seeking to notice equity, I could propose research implications from within as opposed to being an outsider studying equity and coming into the sites. Additionally, I highlight that given the STEM situated nature of my sites, I was developing my equity praxis against a backdrop engineering, design, computing, and information science as spaces that have been historically dominated by privileged, white, heterosexual men. In Site 1, the context of partnering a master’s-level HCI course with a children’s co-design team influenced the development of my equity praxis where children had the opportunity to influence how future designers created new technologies. In Site 2, the context of exploring how families leveraged digital media technologies influenced the development of my equity praxis where the tools and technologies were not being used for leisure or educational purposes, but for family wellbeing. In Site 3, the context of doing design and exploring justice within a 3D computing printing program influenced the development of my equity praxis with youth and teens who come from backgrounds that do not often get to participate in computing programs. Across all three sites I show evidence of the power of design approaches to support the inclusion of voices from students with non-dominant backgrounds (Pinkard et al., 2017) and to develop my equity praxis. Through the lens of systemic oppression (*National Equity Project*, n.d.), we know that injustice

is created by people and therefore can be undone through people's actions. I propose that my design perspective parallels an optimistic perspective toward creating more equitable futures. Given my design lens, the people I worked with had the opportunity to imagine an alternative world with technologies that consider their lived experiences, and I had the opportunity to imagine a new world with them.

7.7 Conclusion

Our commitments influence the kinds of narratives we center, the type of technologies we design, and the knowledge we create. Yet, little scholarship exists that documents people's named commitments and the way they act on their commitments in practice. In this chapter, I provide empirical evidence of my approach to name, enact, notice, and reflect on my commitment to equity through my research. My findings present three versions of the tenets that make up my praxis and demonstrate how I tried to uphold each of those tenets when engaged in different research projects. This work makes methodological and theoretical contributions about equity-oriented approaches in design by proposing a novel way to trace researcher commitments over time. In this chapter, I argue that critical self-reflection within and dialectical theory-building with others can lead to the development of each person's own praxis.

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8 Chapter 8. Closing Thoughts

The commitments we hold are present in the actions we take every day as designers, as researchers, and as citizens of communities. It is important to notice and document the ways in which we enact our commitments to collectively move equity initiative forward from words on pages to directly influence people's lives. Doing equity means being present with others, it means taking actions that feel challenging but are the right thing to do for the greater good. While studying the topic of equity in design and engineering contexts, I have learned about the importance of listening to lived experience, of bringing together people who center equity in their work, and of taking theories from academic communities to neighborhoods and individuals. To me, this journey has been about both about contributing new scholarship and about allowing myself to be changed by the people I had the privilege of interacting with through my research.

Contributing to the state of scholarship. In this dissertation while developing my equity praxis, I present three research projects where I generated new knowledge about reflection in HCI education (Site 1), funds of knowledge present during online search and brokering in the home (Site 2), and a teen-led computing education experiences in their neighborhood (Site 3). Through these sites, I offer multiple research contributions to a range of scholarly communities including theoretically extending the notion of noticing for HCI to support design students when leading and designing user sessions, empirically demonstrating how adults and children draw on their funds of knowledge to solve critical family problem using the internet, and methodologically offering a novel approach to position youth as design partners for reimagining computing education experiences that are led by community members.

Simultaneously in this dissertation, I have distilled my process to document the key tenets that make up my equity praxis while I produced scholarly contributions to the research communities of HCI education (Site 1), learning sciences (Site 2), and computing education (Site 3). By engaging in reflexive practices of naming, enacting, noticing, and reflecting on my equity commitments throughout my research approach, I have shown how I engaged in projects that *both* advanced our understanding of a certain phenomenon *and* advanced the development of my equity praxis. Through my equity praxis, I offer a methodological contribution for others to become inspired by my process to notice equity. I make a theoretical contribution toward the

development of other researcher's equity praxis through intentional documentation of researchers' commitments, how they enact those commitments in practice, and the tensions present in enacting tenets of a praxis while simultaneously generating local knowledge.

In this dissertation, I argue that to move equity initiatives forward in research and design it is important to *both* focus on advancing our understanding of equity in our work while simultaneously advancing knowledge about the key concepts in our work. In Chapters 4, 5, and 6 I have shown how it is possible to both research topics of reflection in HCI education (Site 1), learning in online search and brokering (Site 2), and in a teen-led program in computing education (Site 3) *and* to notice equity while doing that research. In doing so, I propose that equity initiatives become part of our research, not an add-on or a separate thread of work.

The cross-cutting theme present in this dissertation is the synergistic relationship between advancing my theoretical understanding of equity through reflection *and* putting my equity tenets into practice through my actions in research sites. My first research question asks, "*How might we conduct research projects across sites of knowledge that both generate localized knowledge and center equity?*" I answer this research question in Chapters 4-6 by showing how my positionality in those spaces gave me access to explore specific kinds of questions, by tracing how each project influenced the development of certain tenets, and by explaining the ways in which the site was contributing toward my generative and expansive understanding of equity. In these sites, I was both a researcher exploring specific topics and a researcher interested in equity.

The richness in developing my equity praxis in Chapter 7 comes from being embedded in my research sites where I published situated research papers while simultaneously noticing how my equity tenets played out across sites in my everyday actions as a researcher in the field. While some scholars may focus on only exploring the phenomena of equity, other scholars may only focus on their topic of interest and later think about equity. In this dissertation, I show how I developed my equity praxis in a way that was informed by existing literature, iteratively developed over time, and grounded by my research sites. My hope is that this dissertation serves as a catalyst for others with shared equity commitments to engage in this movement collectively.

Allowing myself to be changed. Documenting, living, and theorizing my equity praxis has been my attempt to develop a theory of equity through an analysis of my past projects and by constantly putting myself out into the field with community members to iterate on my praxis. In this dissertation, I have proposed a set of tenets for an equity praxis while engaged in my research and shown how noticed how I enacted those tenets in action.

My second research question asks, “*What does the process of documenting the development of an equity praxis across sites of knowledge uncover?*” I answer this research question in Chapter 7 by documenting my process to develop my praxis. The visualization of my praxis not only involves the tenets but also includes the role of action, reflection, positionality, and recognizing the site in which the tenets are being enacted in. The twelve tenets I propose are: Carefully noticing invisible knowledge; Simply listening to lived experience; Respectfully treating people like people; Creatively informing design implications; Humbly supporting those on the ground; Intentionally involving community members; Strategically translating invisible knowledge; Actively doing equity with care; Regularly recognizing equity is collaborative; Deliberately foregrounding history and context; Honestly centering relationships; and Reflexively embracing tensions as opportunities. Importantly, the contribution I make is the process from which I developed these tenets by looking back at my sites and naming how I enacted those tenets to highlight the lived experience of what it means to do equity across sites of knowledge.

My equity praxis was shaped by my research sites, participants’ stories, and the design ideas I created with others. Only individuals can name their personal commitments because each person is uniquely shaped by their research sites and community spaces. My equity praxis is still being developed because equity work is active and ongoing. As I change, grow, learn new theories, and am changed by the world around me – my tenets and the ways in which I visualize my praxis will continue to evolve. Freire (Freire, 2018) wrote that praxis is about transformation, “*Knowledge emerges only through invention and reinvention ... as human beings pursue being in the world, with the world, and with each other.*” I see developing an equity praxis as a step toward liberation, it is action and reflection of agentic people upon their world to transform it.

I conclude my dissertation with a reflection inspired by Dr. Gutiérrez & Dr. Vossoughi's words: *"From this perspective, change necessarily and fundamentally includes transformation of the researcher; her or his methods, tools, and dispositions; as well as the relations with participants in the focal activity and community."* - (Gutiérrez & Vossoughi, 2010). The research approach I describe in this dissertation to both generate localized knowledge across multiple design research sites and develop my equity praxis in STEM contexts has fundamentally transformed me, the tools I use, the ways I notice the world around me, and how I listen to people's stories. In this way, I also accept the ways in which I have transformed those around me, by becoming part of their communities, by interviewing people about sensitive topics, and by working with children to develop design ideas. I have been transformed to think about the responsibility of working with people from Black and brown communities and the importance of leading design sessions intentionally with members from the community. I have come to appreciate the moments where I am actively working against systemic oppression people who have been marginalized experience every day when others tell stories for them as opposed to with them. And I have been transformed to take seriously the commitment I make when I enter a community space for research as a continuous partnership that extends beyond the research scope. Through this dissertation, I propose that equity movements in research and design are made possible when individuals take the time to notice when their actions are contributing toward equity or inequities, reflect on how their actions live up to their commitments in their every day, and try again the next day to make the world a better place through their actions.

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