Disrupting Computing Education: Teen-Led Participatory Design in Libraries

WENDY ROLDAN

University of Washington, wr4@uw.edu

KUNG JIN LEE

University of Washington, kjl26@uw.edu

KEVIN NGUYEN

University of Washington, nkevin10@uw.edu

LIA BERHE

University of Washington, lberhe@uw.edu

JASON YIP

University of Washington, jcyip@uw.edu

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 Libraries, 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.

CCS CONCEPTS • Computing Education • Informal Education

Additional Keywords and Phrases: participatory design, decolonizing imaginaries, teen-led

1 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 [39]. These disparities reflect "widespread racial and gender imbalances in learning opportunities within formal and informal STEM learning environments" [50]. 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

1946-6226/2022/1-ART1 $15.00
http://dx.doi.org/10.1145/3484494

the participation of youth in computing education [2,8,19,67]. 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 [50]. 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 [69]. 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 [12]. 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 [69]. Furthermore, when we involve and value youth voice [55], we move away from focusing solely on the structural barriers faced by youth of color [39] toward a funds of knowledge approach [43,54,59]. In this paper, we anchor on decolonization in three ways: as a theoretical guide for the arguments in this manuscript [40,49], as a tool for research methodological approaches [60], and as a tool for adapting co-design methods that center the knowledge of youth who have been marginalized [60].

"In a decolonizing framework, deconstruction is part of a much larger intent" - [60]. 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 [40,49]. 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. In this way, we leverage Pérez's definition of a decolonial imaginary, *"as a rupturing place, the alternative to that which is written in history"* [49]. For us 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 [40,49,60] 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 [60], 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 [64]. Additionally, we take seriously Tuck and Yang's critique that decolonization is not a metonym for social justice [64] 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. Specifically, we see ourselves as *thinking with* decolonizing theory [71]. Furthermore, recognizing Tuck and Yang's [64] 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** [43,59] and of **critical pedagogy** [20,25,70] 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 [14,69], 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 [21,51]. 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 [41] 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 [15] 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 [16]. Increasingly, 3D printing practice has become an accepted element of computer science through the rise of making in computing environments [16,23,47,61] and the role of computational thinking in making processes [28,63]. Our case connects explicitly to the nature of computing education pedagogy by shedding light into the reflexive and collective work of computational making [63]; that is the *"participation in the social practices of making"* that Kafai discusses as *"the most important, compelling, and characteristic of computing"* [28].

To emphasize the social, ethical, and political implications of computing [55,66], 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 is 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 co-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 [20,25,32], 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 [25]. 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 distill the systemic issues we faced in disrupting power and reflexively consider 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 serve 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.

2 RELATED WORK

2.1 Informal Computing Education

We build on existing work in informal computing programs for youth [8,19,50,67]. 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 [50,67]. As Lawlor et al. [33] 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 [33]. Clarke-Midura et al. [8] 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 [19] 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 [19].

There exists literature on how direct involvement of teens can create a more targeted learning experience (*e.g.,* [5]), 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 [15]. 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. [50] 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. [50], 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 [16].

2.2 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" [46]. 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 [15,24,69] 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 [10,26]. PD has a history rooted from democratization where there is interest to hear and consider all voices [3]. 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 [68] for children as there were challenges of a librarian solely creating technology related curriculum [62].

In computing education, there have been numerous calls for equitable learning opportunities for people from historically marginalized communities [29,45,56]. 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 [10] 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 librarians establish a design partnership which in turn can facilitate the development of a designer partnership between teens and children.

2.3 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 [30]. Rather than working alone to understand technological problems, maker spaces in libraries allow for collaboration where different skill sets can come together [31]. Libraries are also considered informal learning spaces which differ from formal places like school where there is often a structured set of learning goals [34]. 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 [21]. 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 [36]. 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 [27].

Recently a national push has been made for the role of libraries in computing education [35]. To address inequities, more libraries have attempted to provide different access to technology. For instance, Subramaniam et al. [62] 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 [62]. In our study, we go in-depth of what such facilitation can look like when it is teen led.

3 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.

3.1 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 [70], which can be traced back to critical race theory in education [38]. 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 [43,59]. In Moll et al., [43] researchers drew upon the knowledge and skills found in local households. Smith and Lucena [59] 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 [59]. 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.

3.2 Critical Pedagogy

We leverage critical pedagogy perspectives which are grounded on notions of emancipation [20], values [44], and culturally relevant learning [32] to critically examine power throughout our computing education efforts. Holding true the emancipatory and liberatory potential of education [25,70], 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 [25]. 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 [50]. hooks contends that theory that is developed from concrete, lived experiences is what makes transformations possible [25]. 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.

4 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 [41]. 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 [55]. This case study is situated in a larger study on the use of PD with librarians to create digital activities for the neighborhood [68]. To learn about 3D printing and propose learning experiences for others, everyone engaged in the Cooperative Inquiry method [14] 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.

4.1 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 [14], 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 [68]. 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 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.

4.2 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 Bacon Vine 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, 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 Kung Jin 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	Wendy	Adult	Woman	Latinx
7	Eshan	Child	Boy	Black	18	Kung Jin	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

4.3 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 session, 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 [15]. 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 [15], 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. *For e.g. Rick printed out the curriculum for Lena and Kelvin to review and then share with the children.*	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. *For e.g. Lena and Kelvin went over the curriculum to see what areas they wanted to make tweaks.*	The children experienced the curriculum in the actual sessions and gave subtle input about their experience. *For e.g. The children listened to Kelvin deliver instructions of the 3D printers*
	Design partnership		
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. *For e.g. Rick distributed new roles for Kelvin and Lena and allowed them to adapt their approach as needed.*	The teens started to suggest new building materials for the house and actively changing pillars. *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.*	The children felt more comfortable with sharing what they wanted to change in the curriculum. *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.*
		Design partnership	
Phase 3	In the **last weeks,** the librarian provided full responsibility for the teens to build their own house. *For e.g. Rick no longer brought the printed out curriculum to their planning meetings.*	The teens started to formulate their own goals based on child input and brainstormed ways to reach them. *For e.g. Kelvin and Lena made it a goal to use Fusion 360 and shifted the curriculum to make it happen.*	The children started taking on the role of a facilitator and proposing new things to do in session. *For e.g. A child took the curriculum from Kelvin's hands and attempted to facilitate the session.*
	Design partnership		

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 [14,69], 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 shared 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 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.

4.4 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.

4.5 Data Analysis

To analyze our rich corpus of data, we followed standard practices of qualitative research approaches following interpretivists lines of inquiry [11,13,57]. In interpretivist research, knowledge is seen as co-constructed among researchers and participants [22]. To ensure trustworthiness in our work, triangulation across these data sources provided thick descriptions of the phenomenon under scrutiny [58]. 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 Wendy[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 [42].

Positionality statement. Qualitative interpretivist research involves each researchers' lens and experiences, and thus requires reflexivity [18]. 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.

5 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 [60], 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].

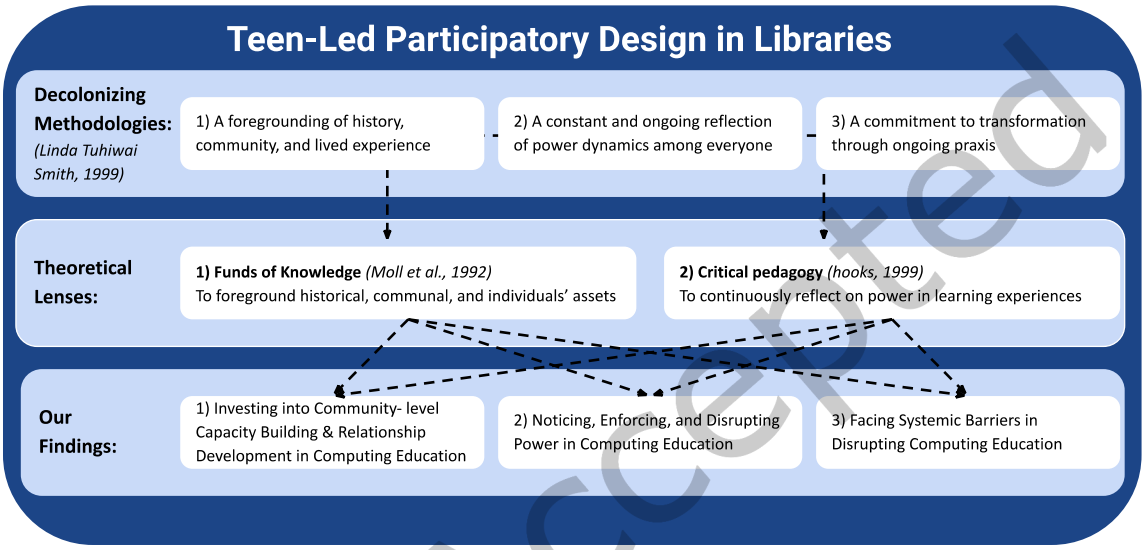

Figure 2. Overview of the relationship between our decolonizing approach, our theories, and our findings

5.1 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 [8,68]. Computing education has traditionally focused on teaching students how to improve technology rather than explore ethics, identity, and politics [66] 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 [55], 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 [29]. 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 Wendy^{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."* Wendy^{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, LenaT and FayolaC were in a group together (Figure 3, right). At the beginning of the session, FayolaC expressed she was not interested in any of the comic board templates that the adults and teens had provided. LenaT responded to her, "if you do not like any of the templates, you can work on a separate piece of paper." LenaT gave her a blank piece of paper and said to FayolaC, "you should be creative." LenaT told FayolaC that they should select one of the templates and they started talking about the template. LenaT took the sharpie and started to draw on the blank paper with FayolaC's ideas. FayolaC then drew on the box design that LenaT had created, and they both worked on adding sketches to the same drawing. We observed how LenaT held side conversations with FayolaC and shared stories about school, her friends, and informal topics. Only at the very end of the time allotted to the activity, did LenaT 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 LenaT explained how she had developed a sisterly relationship with FayolaC. This sisterly relationship was based on their shared cultural Ethiopian and Eritrean background which enabled LenaT and FayolaC 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 LenaT subtly sets up FayolaC and NathanC to share their creations with the group. LenaT started the large group share out by describing their process of going from 2D and 3D and then created space and opportunity for FayolaC and NathanC 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 LenaT 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 FayolaC rejected all the templates the adults made, and LenaT found a way to allow FayolaC to create her own template. Six weeks passed since their first engagement in a group together, and one might ask: How did LenaT balance conversations about her life and her school experiences while bringing the conversation back to the comic boarding? The relationship we observed between FayolaC and LenaT 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 [28]. In the two vignettes, we see how with a critical mass of not only "like-minded creators" [28] 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, WendyR 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 RickL 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." RickL later also articulated how every member supporting each other was critical, "I would have never done it without LiamL and JoelL, 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 [59], 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 [1], 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 [49], 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 [70] 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 [65] 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 Wendy^{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 [25] 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.

5.2 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

[48]. 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 [28]. A rich body of work has detailed specific ways that power and social identities (*e.g.,* gender, race, age, ethnicity) interact in computing education [4,45,50]. 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. [50] 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 Wendy^{R}. Wendy 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 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 [55], 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 relentlessness 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 reflect 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 that 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** [49], 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 in transforming the existing situation [59]. 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 [17]. 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 [20] 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 taking 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 [20], in analyzing our data, all co-authors reflected on how power showed up despite everyone's commitments to co-creation.

5.3 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 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 [6]. 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 [7].

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), Wendy^{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, Wendy^{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 Wendy^{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 provide 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. [69], 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 [45], 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 [37], 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 KevinT and LenaT 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 LenaT and KevinT 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 LenaT and KevinT'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" [25] 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 LenaT and KevinT 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, LenaT 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 so ingrained [in them] that they won't try teaching using an informal/nontraditional method."

6 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 [50]. 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 [20,25,32] this investigation writes from the tension that education can be both oppressive and liberatory. Inspired by the work of scholars in critical pedagogy, hooks [25] 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.

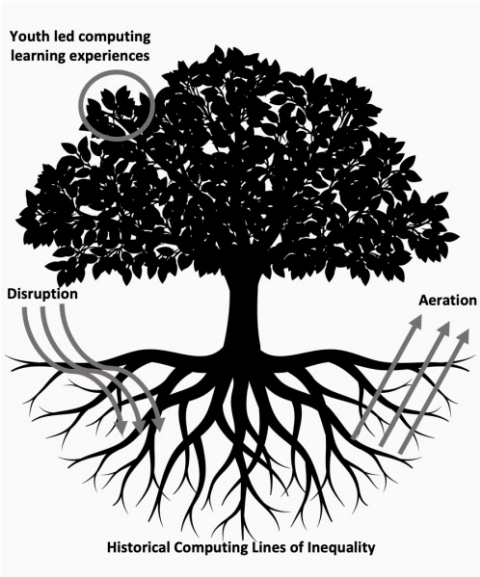

Figure 6. Metaphorically Disrupting Computing Education. Adapted from "Tree with the roots" icon by 1arts, ID, from thenounproject.com. Creative Commons license attribution 3.0

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 [52]. 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 [9], 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.

6.1 Reflections on Teens Leading the Co-Creating of 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. [50] 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, LenaT and KevinT 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 LenaT and KevinT 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 sharped 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 [66] 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 FayolaC? Extending funds of knowledge theoretical perspectives towards computing education, we emphasize the unique assets that LenaT held to be able to facilitate that kind of conversation and engagement with technology with FayolaC. 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 RickL 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 KevinT because they did not have the near peer age that KevinT and LenaT 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.

6.2 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 [66]. To analyze our data, we have leverage the writings of indigenous scholars to propose a decolonizing imaginary [49] 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 [66], Nasir [45], Vossoughi [67], Pinkard [50], and Ko [29] 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:

- 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.
- 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.
- 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.

6.3 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 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 on 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. KevinT and LenaT 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 KevinT and LenaT 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. RickL was a motivated librarian who actively reached out to marginalized groups and invested into the teen's growth. RickL 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.

7 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 disrupt normative perspectives [64]. 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.

ACKNOWLEDGMENTS

Our research and project acknowledge the Coast Salish peoples of this land, the land which touches the shared waters of all tribes and bands within the Suquamish, Tulalip, and Muckleshoot nations. We greatly appreciate every child who participated in the sessions and their parents who supported them. We also thank every librarian for their time and commitment to this work. We acknowledge the hard work of the editors and reviewers of this manuscript especially during a global pandemic. We thank Drs. Jin Ha Lee and Sheena Erete for their feedback and advice on our project and this manuscript. We acknowledge and thank Juan Rubio, Luis Gonzales, Richard Counsil, and The Seattle Public Library for their years of support. We also thank Sarah Strickler, Romaine Flor, and Troy Hilton for their efforts in KidsTeam Libraries. This research was supported by funding from a National Science Foundation Graduate Research Fellowship and an Institute for Museum and Library Services (IMLS) National Leadership Grants (LG-96-18-0041-18).

REFERENCES

[1] Flávio S. Azevedo. 2013. The tailored practice of hobbies and its implication for the design of interest-driven learning environments. *Journal of the Learning Sciences* 22, 3 (2013), 462–510.

[2] Brigid Barron, Kimberley Gomez, Nichole Pinkard, and Caitlin K. Martin. 2014. *The digital youth network: Cultivating digital media citizenship in urban communities*. MIT Press.

[3] Erling Björgvinsson, Pelle Ehn, and Per-Anders Hillgren. 2010. Participatory design and" democratizing innovation". In *Proceedings of the 11th Biennial participatory design conference*, 41–50.

[4] Angela Booker and Shelley Goldman. 2016. Participatory design research as a practice for systemic repair: Doing hand-in-hand math research with families. *Cognition and Instruction* 34, 3 (2016), 222–235.

[5] Linda W. Braun. 2001. Letting Teens Take the Lead. *School Library Journal* 47, 2 (February 2001), S26–S26.

[6] Sapna Cheryan, Allison Master, and Andrew N. Meltzoff. 2015. Cultural stereotypes as gatekeepers: increasing girls' interest in computer science and engineering by diversifying stereotypes. *Front. Psychol.* 6, (2015). DOI:https://doi.org/10.3389/fpsyg.2015.00049

[7] Christos Chytas, Alexandros Tsilingiris, and Ira Diethelm. 2019. Exploring Computational Thinking Skills in 3D Printing: A Data Analysis of an Online Makerspace. In *2019 IEEE Global Engineering Education Conference (EDUCON)*, IEEE, Dubai, United Arab Emirates, 1173–1179. DOI:https://doi.org/10.1109/EDUCON.2019.8725202

[8] Jody Clarke-Midura, Chongning Sun, Katarina Pantic, Frederick Poole, and Vicki Allan. 2019. Using informed design in informal computer science programs to increase youths' interest, self-efficacy, and perceptions of parental support. *ACM Transactions on Computing Education (TOCE)* 19, 4 (2019), 1–24.

[9] Tony Clear. 2004. Critical enquiry in computer science education. *Computer Science Education Research: The Field and The Endeavour, Routledge Falmer, Taylor & Francis Group, London* (2004), 101–125.

[10] Merijke Coenraad, Jen Palmer, Diana Franklin, and David Weintrop. 2019. Enacting identities: Participatory design as a context for youth to reflect, project, and apply their emerging identities. In *Proceedings of the 18th ACM International Conference on Interaction Design and Children*, 185–196.

[11] Deborah Cohen and Benjamin Crabtree. 2006. *Qualitative research guidelines project*.

[12] Alison Cook-Sather. 2002. Authorizing students' perspectives: Toward trust, dialogue, and change in education. *Educational researcher* 31, 4 (2002), 3–14.

[13] John W. Creswell and Cheryl N. Poth. 2016. *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

[14] Allison Druin. 1999. Cooperative inquiry: developing new technologies for children with children. In *Proceedings of the SIGCHI conference on Human factors in computing systems the CHI is the limit - CHI '99*, ACM Press, Pittsburgh, Pennsylvania, United States, 592–599. DOI:https://doi.org/10.1145/302979.303166

[15] Allison Druin. 2002. The role of children in the design of new technology. *Behaviour and information technology* 21, 1 (2002), 1–25.

[16] Michael Eisenberg. 2013. 3D printing for children: What to build next? *International Journal of Child-Computer Interaction* 1, 1 (2013), 7–13.

[17] C. Alejandra Elenes, Francisca E. Gonzalez, Dolores Delgado Bernal, and Sofia Villenas. 2001. Introduction: Chicana/Mexicana feminist pedagogies: Consejos, respeto, y educación in everyday life. *International Journal of Qualitative Studies in Education* 14, 5 (2001), 595–602.

[18] Kim VL England. 1994. Getting personal: Reflexivity, positionality, and feminist research. *The professional geographer* 46, 1 (1994), 80–89.
[19] Deborah A. Fields, Yasmin B. Kafai, and Michael T. Giang. 2017. Youth computational participation in the wild: Understanding experience and equity in participating and programming in the online scratch community. *ACM Transactions on Computing Education (TOCE)* 17, 3 (2017), 1–22.
[20] Paulo Freire. 2018. *Pedagogy of the oppressed*. Bloomsbury publishing USA.
[21] Anne Goulding. 2009. Engaging with community engagement: public libraries and citizen involvement. *New Library World* (2009).
[22] Egon G. Guba and Yvonna S. Lincoln. 1994. Competing paradigms in qualitative research. *Handbook of qualitative research* 2, 163–194 (1994), 105.
[23] Foad Hamidi, Thomas S. Young, Josh Sideris, Ramtin Ardeshiri, Jacob Leung, Pouya Rezai, and Barbara Whitmer. 2017. Using Robotics and 3D Printing to Introduce Youth to Computer Science and Electromechanical Engineering. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, ACM, Denver Colorado USA, 942–950. DOI:https://doi.org/10.1145/3027063.3053346
[24] Christina Harrington, Sheena Erete, and Anne Marie Piper. 2019. Deconstructing Community-Based Collaborative Design: Towards More Equitable Participatory Design Engagements. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–25.
[25] Bell Hooks. 2014. *Teaching to transgress*. Routledge.
[26] Sofia Hussain, Elizabeth B.-N. Sanders, and Martin Steinert. 2012. Participatory design with marginalized people in developing countries: Challenges and opportunities experienced in a field study in Cambodia. *International Journal of Design* 6, 2 (2012).
[27] Mizuko Ito. 2013. *Hanging out, messing around, and geeking out: Kids living and learning with new media*. The MIT Press.
[28] Yasmin B. Kafai. 2016. From computational thinking to computational participation in K--12 education. *Commun. ACM* 59, 8 (July 2016), 26–27. DOI:https://doi.org/10.1145/2955114
[29] Amy J. Ko, Alannah Oleson, Neil Ryan, Yim Register, Benjamin Xie, Mina Tari, Matthew Davidson, Stefania Druga, and Dastyni Loksa. 2020. It is time for more critical CS education. *Communications of the ACM* 63, 11 (October 2020), 31–33. DOI:https://doi.org/10.1145/3424000
[30] Kyungwon Koh and June Abbas. 2016. Competencies needed to provide teen library services of the future: A survey of professionals in learning labs and makerspaces. *Journal of Research on Libraries & Young Adults* 7, 2 (2016).
[31] R. Steven Kurti, Debby L. Kurti, and Laura Fleming. 2014. The philosophy of educational makerspaces part 1 of making an educational makerspace. *Teacher Librarian* 41, 5 (2014), 8.
[32] Gloria Ladson-Billings. 1995. But that's just good teaching! The case for culturally relevant pedagogy. *Theory into practice* 34, 3 (1995), 159–165.
[33] Grace Lawlor, Philip Byrne, and Brendan Tangney. 2020. "CodePlus"—Measuring Short-Term Efficacy in a Non-Formal, All-Female CS Outreach Programme. *ACM Transactions on Computing Education* 20, 4 (October 2020), 1–18. DOI:https://doi.org/10.1145/3411510
[34] Victor R. Lee and Abigail L. Phillips. 2018. *Reconceptualizing Libraries: Perspectives from the Information and Learning Sciences*. Routledge.
[35] Victor R. Lee, Carrie Tzou, Megan Bang, Philip Bell, Shelley Stromholt, Nancy Price, Meixi Ng, Yasmin Kafai, Orkan Telhan, and Richard Davis. 2017. Libraries as emerging spaces for computer-supported collaborative learning in schools and communities. . Philadelphia, PA: International Society of the Learning Sciences.
[36] Wei Liang, Zhangping Lu, Guifeng Liu, and Wencheng Su. 2019. Research on makers' knowledge space construction by libraries. *Library Hi Tech* (2019).
[37] María Lugones. 2010. Toward a decolonial feminism. *Hypatia* 25, 4 (2010), 742–759.
[38] Mari J. Matsuda. 1991. Voices of America: Accent, antidiscrimination law, and a jurisprudence for the last reconstruction. *Yale Law Journal* (1991), 1329–1407.
[39] Frieda McAlear, Allison Scott, Kimberly Scott, and S Weiss. 2018. *Data Brief: Women of Color in Computing*. Retrieved from https://www.wocincomputing.org/wp-content/uploads/2018/08/WOCinComputingDataBrief.pdf
[40] Eduardo Mendieta. 2020. Toward a Decolonial Feminist Imaginary: Decolonizing Futurity. *Critical Philosophy of Race* 8, 1–2 (2020), 237–264.
[41] Sharan B Merriam. 1988. *Case study research in education: A qualitative approach*. Jossey-Bass.

[42] Sharan B. Merriam and Elizabeth J. Tisdell. 2015. *Qualitative research: a guide to design and implementation* (Fourth edition ed.). John Wiley & Sons, San Francisco, CA.
[43] Luis C. Moll, Cathy Amanti, Deborah Neff, and Norma Gonzalez. 1992. Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into practice* 31, 2 (1992), 132–141.
[44] Toni Morrison. 2001. How can values be taught in the university? *Michigan Quarterly Review* 40, 2 (2001), 273.
[45] Na'ilah Suad Nasir and Sepehr Vakil. 2017. STEM-Focused Academies in Urban Schools: Tensions and Possibilities. *Journal of the Learning Sciences* 26, 3 (July 2017), 376–406. DOI:https://doi.org/10.1080/10508406.2017.1314215
[46] Allen Newell, Alan J. Perlis, and Herbert A. Simon. 1967. Computer science. *Science* 157, 3795 (1967), 1373–1374.
[47] Sofia Papavlasopoulou, Michail N. Giannakos, and Letizia Jaccheri. 2017. Empirical studies on the Maker Movement, a promising approach to learning: A literature review. *Entertainment Computing* 18, (January 2017), 57–78. DOI:https://doi.org/10.1016/j.entcom.2016.09.002
[48] Alice L. Pawley. 2019. Learning from small numbers: Studying ruling relations that gender and race the structure of U.S. engineering education. *Journal of Engineering Education* 108, 1 (January 2019), 13–31. DOI:https://doi.org/10.1002/jee.20247
[49] Emma Pérez. 1999. *The decolonial imaginary: Writing Chicanas into history*. Indiana University Press.
[50] Nichole Pinkard, Sheena Erete, Caitlin K. Martin, and Maxine McKinney de Royston. 2017. Digital youth divas: Exploring narrative-driven curriculum to spark middle school girls' interest in computational activities. *Journal of the Learning Sciences* 26, 3 (2017), 477–516.
[51] Johanna Rivano Eckerdal. 2018. Equipped for resistance: An agonistic conceptualization of the public library as a verb. *Journal of the Association for Information Science and Technology* 69, 12 (2018), 1405–1413.
[52] Wendy Roldan, Taryn Bipat, Jessica Carr, Elena Agapie, Andrew Davidson, and Jennifer Turns. 2020. Coordinated Outreach: A Model of STEAM Outreach Efforts. In *2020 ASEE Virtual Annual Conference Content Access Proceedings*, ASEE Conferences, Virtual On line, 34335. DOI:https://doi.org/10.18260/1-2--34335
[53] Wendy Roldan, Xin Gao, Allison Marie Hishikawa, Tiffany Ku, Ziyue Li, Echo Zhang, Jon E. Froehlich, and Jason Yip. 2020. Opportunities and Challenges in Involving Users in Project-Based HCI Education. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems - CHI '20*, ACM Press, Honolulu, Hawaii. DOI:https://doi.org/10.1145/3313831.3376530
[54] Wendy Roldan, Paola Vanegas, Laura Pina, Carmen Gonzalez, and Jason Yip. 2019. The Role of Funds of Knowledge in Online Search and Brokering. (2019).
[55] Jean J. Ryoo. 2019. Pedagogy that supports computer science for all. *ACM Transactions on Computing Education (TOCE)* 19, 4 (2019), 1–23.
[56] R. Santo, L. A. DeLyser, and J. Ahn. 2020. Negotiating Equity Priorities Within Systems Change: A Case Study of a District-Level Initiative to Implement K12 Computer Science Education. *Computing in Science Engineering* 22, 5 (September 2020), 7–19. DOI:https://doi.org/10.1109/MCSE.2020.3008434
[57] Thomas A. Schwandt. 1994. Constructivist, interpretivist approaches to human inquiry. *Handbook of qualitative research* 1, (1994), 118–137.
[58] Andrew K Shenton. 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education for information* 22, 2 (2004), 63–75.
[59] Jessica M. Smith and Juan C. Lucena. 2016. Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering. *Engineering Studies* 8, 1 (2016), 1–26.
[60] Linda Tuhiwai Smith. 2013. *Decolonizing methodologies: Research and indigenous peoples*. Zed Books Ltd.
[61] Courtney Starrett, Marguerite Doman, Chlotia Garrison, and Merry Sleigh. 2015. Computational bead design: A pilot summer camp in computer aided design and 3D printing for middle school girls. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, 587–590.
[62] Mega Subramaniam, Ligaya Scaff, Saba Kawas, Kelly M. Hoffman, and Katie Davis. 2018. Using technology to support equity and inclusion in youth library programming: Current practices and future opportunities. *The Library Quarterly* 88, 4 (2018), 315–331.
[63] Josh Tenenberg. 2018. Computational making. *ACM Inroads* 9, 1 (January 2018), 22–23. DOI:https://doi.org/10.1145/3177861
[64] Eve Tuck and K. Wayne Yang. 2012. Decolonization is not a metaphor. *Decolonization: Indigeneity, education & society* 1, 1 (2012).

[65] Sepehr Vakil. 2014. A Critical Pedagogy Approach for Engaging Urban Youth in Mobile App Development in an After-School Program. *Equity & Excellence in Education* 47, 1 (January 2014), 31–45. DOI:https://doi.org/10.1080/10665684.2014.866869
[66] Sepehr Vakil. 2018. Ethics, identity, and political vision: Toward a justice-centered approach to equity in computer science education. *Harvard Educational Review* 88, 1 (2018), 26–52.
[67] Shirin Vossoughi, Ava Jackson, Suzanne Chen, Wendy Roldan, and Meg Escudé. 2020. Embodied Pathways and Ethical Trails: Studying Learning in and through Relational Histories. *Journal of the Learning Sciences* (2020), 1–41.
[68] Jason C. Yip, Kung Jin Lee, and Jin Ha Lee. 2020. Design partnerships for participatory librarianship: A conceptual model for understanding librarians co designing With digital youth. *Journal of the Association for Information Science and Technology* 71, 10 (2020), 1242–1256.
[69] Jason C. Yip, Kiley Sobel, Caroline Pitt, Kung Jin Lee, Sijin Chen, Kari Nasu, and Laura R. Pina. 2017. Examining adult-child interactions in intergenerational participatory design. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 5742–5754.
[70] Tara J. Yosso. 2005. Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race ethnicity and education* 8, 1 (2005), 69–91.
[71] 2018. The Decolonial For: Resurgences, Shifts, and Movements. In *On Decoloniality: Concepts, Analytics, Praxis*. Duke University Press, 15–32. DOI:https://doi.org/10.1215/9780822371779-002