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Investigating an Equity-based Participatory Approach to Technology-rich Learning in Community Recreation Centers

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ABSTRACT

Understanding how to design and implement equity-based approaches to technology-rich learning can lead to increased and diversified participation in computing. Do-it-yourself (DIY) and maker approaches to interactive technology learning have been hailed as potential equalizers of science, technology, engineering, and math (STEM) education for underserved youth, a narrative challenged by scholarship that has shown that if not designed carefully, making can be exclusionary and hegemonic. Equity-based approaches to making have identified the crucial role of community educators to prioritize community assets and learner participation. We studied educators' strategies and youth outcomes in four afterschool maker programs in urban recreation centers. Community educators used several equity-based strategies to engage youth that included: identifying their interests through direct conversation and indirect signaling, customizing program activities to respond to interests, and encouraging self-expression and authenticity. These strategies led to increased social connections among youth, and increased technology self-efficacy and project ownership.

CCS CONCEPTS

• **B7; Human-centered computing** → Human computer interaction (HCI); Empirical studies in HCI.

KEYWORDS

makerspaces, informal learning, afterschool youth programs, urban settings, underrepresented minorities, equity, technology education, workforce readiness

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1 INTRODUCTION

Self-directed maker/DIY approaches to technology learning have been lauded as potential equalizers of science, technology, engineering, and math (STEM) education for underserved youth since first popularized by MIT's Fab Lab in 2001 and the initial launch of Make Magazine in 2005. Making is largely thought to be driven by student interests [1] and open to most youth, including those who may not have prior experience with STEM disciplines or think of themselves as being "good at science" [2]. However, dominant narratives of making have been challenged by scholarship, including within the CHI community, that has shown prevalent practices can be exclusionary and disregard the cultural, social, and political nuances hidden in simplistic understandings of making [3-6]. In the past years, the HCI research and practice community has called for efforts to increase equitable participation, including through maker-based initiatives, in technology design and learning [7-9]. Much of the existing research around learning through making has focused on understanding learning outcomes, the physical environment, and technology tools and experiences [10-14]. However, educators and facilitators play crucial roles in deepening learning outcomes through facilitation and guidance, maker activity selection, and incorporation of tools and technology [15]. Our project focuses on understanding the role of community educators as both facilitators of equity-based making and co-designers of equity-based strategies for engaging youth in technology-rich learning in urban contexts.

In addition to recognizing the crucial role of educators in deepening learning outcomes [15], research has shown that appropriate professional development can support educators' own learning, as well as comfort and confidence with activities and tools [16], and help them overcome reluctance in using unfamiliar technologies/activities [17]. These previous efforts, however, often studied top-down programs in which the educators were given the curriculum, rather than being invited to directly create or intentionally modify it themselves. Furthermore, with few notable exceptions (e.g., [15, 18]), previous work does not explicitly focus on the roles of educators as implementers of equity-based or participatory practices. Finally, it is unclear how the local community characteristics of the program sites can serve to localize programs (i.e., customize their format and content to better fit the communities they serve).

In this study, we seek to understand the following research questions:

1. What equity-based localization strategies are used by community educators in informal contexts (e.g., community recreation centers) to engage youth in technology-rich learning?
2. What is the impact of these strategies on educator and youth engagement and technology self-efficacy?
3. What tensions and opportunities for program localization do community rec centers offer as sites of technology-rich informal learning?

To investigate these questions, we provided training and curriculum support to community educators in four recreation (rec) centers in two mid-sized cities in the Eastern United States. Four community educators without prior experience teaching maker content to youth delivered the curriculum to approximately 50 youth from January through May 2022. The curriculum was organized into a set of modules (each taking two weeks to deliver) and included graphic design, interaction design (using the Scratch programming platform), 3D modeling and 3D printing, and game development. Our project focused on training community educators on the principles of equitable pedagogy as described in [15] and technology skills. The training's goal was to empower the educators to deploy strategies to engage youth in technology-rich learning experiences that result in youth learning outcomes, including increased technology self-efficacy, technology project ownership, and team working skills. The selected rec centers were in historically underinvested urban areas. We worked with government administrators managing the sites to implement site preparations, community educator hiring and training, and ongoing program support. Rec centers were chosen, as these community-focused sites have considerable geographic reach and community participation in historically underserved communities in the US. This makes them ideal for investigating equity-based approaches for engaging youth from diverse populations in technology-rich learning.

In this paper, we contribute empirically informed findings on how to implement equity-based technology-rich learning programs in urban rec centers with a specific focus on developing and understanding community educators' equity-based pedagogical strategies. This knowledge contribution adds to the literature on the participatory design of learning experiences [19]. The educator training was structured as a combination of professional training on delivering technology-rich learning activities utilizing basic curriculum and an explicit focus on an equity-based participatory approach that invites educators to incorporate community assets and youth interests into the program. This allowed us to develop an initial understanding of the strategies that emerge in practice and their impact on youth and educators in these community contexts. We describe our observations, feedback from the community educators who participated in multiple interviews, and design ideas generated by them during participatory design sessions used to iterate on curriculum. Our findings provide insights on how to support equity-based pedagogy in practice within a community rec center and the supports needed at the educator and administrative levels to enable youth learning outcomes.

In the following sections, we will first contextualize our study by drawing on previous research into equity and participation in learning through making, the role of educators in makerspaces, and formal assessments in informal learning environments. We then describe the educator training and curriculum and describe our data collection and analysis procedures. Next, we report findings from our study through stories and direct quotes from community educators and administrators. We conclude with a discussion of a descriptive model of equity-based technology-rich learning that captures educator and administrator strategies in engaging youth and their impact on youth and educators and identify directions for future work.

2 RELATED WORKS

2.1 Equity and participation in learning through making

The HCI community has been investigating participatory approaches to technology-rich learning, including through working with hands-on self-directed projects in the context of makerspaces or maker-based learning programs, for several decades (e.g., [7, 11, 20, 21]). These activities have been shown to engage a diverse population of learners and to increase technical and social skills in formal and informal learning environments [22-24]. Research has shown that participating in maker activities can have several positive learning outcomes, including technology self-efficacy [11, 25], technological awareness and confidence [9], and general and declarative knowledge of technical systems [13, 14]. Making is largely thought to be driven by learner interests [1] and open to all participants, including those who may not have prior experience with STEM disciplines or think of themselves as being good at science or technology [2], leading to an increase in learner agency [26] and overall STEM learning [13].

While makerspaces have been lauded as potential equalizers of STEM education for underserved youth since first introduced, research has shown that prevalent maker practices can be exclusionary and inequitable [2, 27, 28]. Specifically, researchers have pointed out that makerspace education often ignores the history of making in native, working class, and people of color's communities, resulting in a lack of recognition of forms of making and creativity that do not follow prescriptive mainstream images of innovation [27, 28]. This lack of recognition can result in challenges for underserved youth to see themselves as makers and assumptions by educators of a lack of interest in making within these communities [15]. Researchers also cite the basis of some of these issues in centering capitalistic values [28], with makerspaces historically catering primarily to the interests of middle-class white males with disposable income and time [15, 27, 29]. Therefore, while critics of making acknowledge its potential for engaging diverse populations and resulting in desired learning outcomes, they also posit that these successes are possible, only when equity is an explicit goal when designing makerspaces and maker-based learning programs [30-32], community members provide input into the content and format of the programs and serve as educators [33, 34], and when creating for the makerspace follows an assets-based approach that values and incorporates community and cultural assets [7, 18, 35]. This ensures that the making that is already being done within the

community is integrated and highlighted by the introduction of new technologies. These practices have been proven to be effective for encouraging involvement and increasing self-esteem for diverse populations, including women [36], ethnic minorities [37], and youth in urban contexts [18].

Another related HCI research direction is investigating participatory design approaches for creating learning experiences for youth, children, and adults [19, 21, 38-40] and creating innovative interactive systems used for learning experiences [20, 41, 42]. By extending the domain of Scandinavian Participatory Design from the workplace to learning contexts, this direction aims to support practice by "addressing the needs of learners in ways that learners can identify with, that teachers or facilitators find useful, and that are consistent with the culture of the community [19]." Key questions in this space are concerned with how to effectively incorporate direct stakeholder input into program designs and how to ensure findings are transferable to different sites.

In order to build on what is currently known about how to incorporate equitable and participatory practices in designing technology-rich learning experiences, research needs to investigate specific equity-based localized strategies that educators and administrators can use to engage youth in diverse community contexts and understand their impact on all direct stakeholders (youth, educators, and administrators).

2.2 The role of the educator in makerspaces

Much of the existing research on learning through making, including the majority of the studies mentioned previously, has focused on student learning outcomes, the physical environment, and technology tools and experiences [10-14]. However, educators play a crucial and understudied role in enabling and deepening learning outcomes for youth in these environments, through facilitation and guidance, curriculum and activity selection, and incorporation of tools and technology [15]. Furthermore, educator roles become even more pronounced when issues of equity and participation are central. For example, in discussing an equity-based approach to learning through making, Vossoughi emphasized the need for crucial analysis of educational injustice, a historicized approach to making as a cross-cultural activity, explicit attention to teaching philosophies and practices, and ongoing inquiry into the sociopolitical values and purposes of making [15]. Based on this research and for the reasons outlined in this paper, it is our belief that this work is best done in collaboration between educators and learners in makerspaces.

Educators can also play a crucial role in creating equitable informal education spaces [43]. Rightful presence in these spaces arises when youth and educators work together to disrupt the unjust narratives and practices that are prevalent [44, 45], such as an assumption that certain students are more interested or skilled in technology without being given equitable opportunities. Additionally, research has shown that when educators see themselves as an engineer or a maker, it is easier for them to imagine and implement justice-oriented pedagogy [46]. However, in informal learning spaces, such as afterschool programs, summer camps, and others, this can be a challenge due to high rates of educator turn over and diversity of training and experience leading to inconsistent pedagogical practices [47, 48].

The continuing digital divide has also shifted from a lack of technology to a lack of ownership and educator confidence in many contexts, such as K-12 public education, historically disinvested communities, medium-sized midwestern towns, and large metropolitan cities. This is exacerbating the continuing negative impact of lack of access to infrastructure (e.g., broadband access), maintenance knowledge, and general access to technology [49-53]. Ownership of programming has been shown to increase sustainability [54-56] and functioning as an educator in these spaces leads to skill development [57-59]. Addressing these issues with culturally cognizant professional development that centers educators' existing assets and support them taking ownership of programming is a promising direction and a goal of our project. Furthermore, we anticipate learning more about what supports are most helpful in this approach and how and when to provide resources that advance the localization of content and experiences.

Some work on educator's role in facilitating learning experiences in makerspaces has emerged. Early research identified facilitation roles that were more supportive than didactic [10, 16, 60], and emphasized pedagogical strategies to deepen learner engagement [61-63]. However, these were often studying top-down programs in which the educators were given, not creating, content and they lack an explicit focus on equity and professional development that covers content creation. Previous professional development efforts where educators participated in maker-based activities as learners helped support their own learning, as well as increase their comfort and confidence with activities and tools [16]. Additionally, previous work has shown that without skills-based training, facilitators may be reluctant to engage participants in unfamiliar technologies/activities [17]. Other previous studies have focused on how to facilitate trainings for educators but did not analyze in depth the pedagogy implemented in the makerspaces [64].

Our project addresses the role of the educator both as leaders and co-learners with youth and promotes a better understanding of their role in supporting youth who are engaged in equity-focused maker-based learning experiences. It does so by supporting community educators through training in equity- and assets-based practices, focusing on employing technology skills in ways that are consistent with learner and community practices and results in both educators and youth ownership over projects as well as technology self-efficacy and engagement.

2.3 Formal assessments in informal environments

Conducting quantitative assessments, such as surveys, of youth learning in informal learning environments has proven to be a difficult problem. Specifically, youth are resistant to the introduction of formal evaluation in these environments resulting in negative attitudes towards surveys preference for methods that require creativity and self-expression [65, 66]. Additionally, research indicates that assessments that focus on isolated skills or attitudes lead to systematic undermeasurement of learning since they do not view learning activities holistically and as accomplished by participants drawing on material and human resources in their environment [67]. Furthermore, previous research has recommended using observations to assess the level of excitement, how well youth are

understanding the content, the conversations and social interactions in the space, and the youth's reflections on the new concepts to assess learning outcomes [66, 68].

Despite ongoing efforts to develop more context-sensitive approaches to assessment, existing tools are not created to be used within community recreation centers or with an explicit focus on equity. In our study, we also aimed to combine multiple data collection methods to better understand program learning outcomes and identify context-sensitive, equity-focused assessment tools for measuring them in the future.

3 METHODOLOGY

To answer our research questions, we used a Participatory Design Research (PDR) method [69] where we developed a mutually beneficial relationship with the rec center administration and staff working "toward joint activity across researchers and communities, rather than being led by one or the other" [69]. Also, in line with PDR, "the domain of the 'researched' in this project was expanded to include the relational, pedagogical, and design-based activities of the researchers themselves" [69]. To this end, we simultaneously designed, implemented, and studied a learning environment, centering educators' direct experiences within the makerspace served as the impetus for iteration. This paper describes the first iteration based off of an initial curriculum developed by our community partner as described in section 3.2. To capture these experiences, and those of multiple stakeholders in the project (i.e., youth, administrators, and educators), we used a mixed method approach, where we collected data from three groups of participants (educators, administrators, and youth). We used a combination of interviews, focus groups, participatory design sessions, observations, and surveys. While we did collect youth data and intend to explore publishing on this at a later time, the focus of this paper is primarily on the adult community educators and administrators. We will describe our sites, participants, and data collection and analysis methods in detail in the following subsections.

3.1 Sites and participants

The sites were located in two mid-sized cities in the Eastern United States. Two sites in City 1 and two sites in City 2 were selected based on socioeconomic criteria for this project. The sites were selected after assessing community need, lack of technology opportunities in the neighborhoods surrounding both rec centers, and the geographic reach of technology opportunities. All rec centers chosen were primarily minority serving centers (> 50%) and some or most of the children live below the poverty line. All neighborhoods chosen also experience crime levels above the national average. Rec centers were required to have: a dedicated space for the program, to serve youth in grades 6-12, basic technology readiness, accessibility by transportation, community interest, and staff capacity. Due to organizational restructuring unrelated to this project, City 1 site 2 was taken over by an organization outside the government during programming. Because of this, that site was not able to complete programming. The research and implementation team determined that a new site serving youth with similar demographics should be chosen for future program delivery.

In total, there were 4 community educators (Table 1) who were trained and began programming across the two cities, five administrators (Table 1) and 50 youth who took part in some part of the program. Six educators were recruited, but two of them found other jobs before the program started so they are not included in the table. Educators 1 and 4 were rec leaders in rec centers in City 1. Educator 1 was working on a degree in civil engineering and Educator 4 was working on a degree in social work. Educator 1 was a self-described "techie" and spent time fixing cars and tinkering with video game systems. He also led many tech-focused programs in the rec centers. Educator 4, on the other hand, did not have much experience with technology and did not have experience serving as the main educator in a rec center program. Educator 2 was a full-time college student working on a degree in computer science. Educator 3 was a full time IT professional and also worked in the film industry in City 2. Educator 4 did not complete the program and withdrew as a teacher after 2 weeks. All admins had a say in selecting the program and locations and participated in multiple meetings. However, admins 1 and 2 were particularly involved with implementation. They provided program support by expanding the curriculum, providing additional tech training, and working in the rec centers with the educators. Given the importance of administer roles, we also provide their demographic information in Table 1.

There were 50 youth total who attended at least 1 day of programming. Sixteen youth were at City 1 site 2 which was removed from City 1's rec and parks departmental control. They, therefore, were unable to complete the program. Overall, sixteen youth completed more than 80% of the program. In City 1 there were 6 youth who completed most of the program (ages 8-12, 3 male, 1 white, 5 African American), in City 2 site 1 there were 3 youth (ages 8-12, 2 male, all African American), and at City 2 site 2 there were 7 youth (ages 4-12, 4 male, all African American). The youth within one rec center did not attend the same school consistently because of how districting works in each city. This meant that they had inconsistent exposure to tech, but a majority had minimal experience. Though not all youth knew each other well, most regularly attended their rec center's programming and had some familiarity with each other and rec center staff.

3.2 Program structure

At the core of our research project was a holistic, scaffolded program for supporting the expansion of technology-rich maker learning experiences in informal afterschool settings, specifically underused recreation centers in urban contexts. The program is developed by a nonprofit organization, Digital Harbor Foundation (DHF), with more than 8 years of experience in providing out-of-school-time learning programs to more than 5,000 youth in City 1 in the Eastern United States. DHF itself was founded by transforming an underused recreational center in an urban setting into an inclusive and dynamic maker learning hub where youth from different areas of the city participate in hands-on, technology-rich courses and activities.

DHF developed the expansion program in response to demand by community partners for a structured and scaffolded capacity-building strategy to replicate this model of transformation in new sites and with educators with limited prior experience in delivering maker content. Part of the intention of situating the programs

Table 1: Administrator and Educator Demographics

Participant	Age	Gender	Ethnicity	Location
Admin 1	47	Female	White	City 1
Admin 2	38	Male	African American	City 2
Admin 3	45	Male	White	City 1
Admin 4	55	Male	African American	City 2
Admin 5	35	Female	Puerto Rican/White	City 2
Educator 1	33	Male	African American	City 1 – site 1
Educator 2	23	Female	African American	City 2 – site 1
Educator 3	40	Male	African American	City 2 – site 2
Educator 4	40	Female	African American	City 1 – site 2

in recreation centers is their proximity to underserved neighborhoods and familiarity with communities who are historically underrepresented in STEM, including African American and LatinX communities.

While the program has gone through several iterations, the current version, developed in collaboration with the research team, utilized a participatory equity-based approach. In our previous research, we studied different modes of educator training (remote, in-person, and hybrid) in a pilot study with three sites. We found that a hybrid training approach is most suitable as it combines flexibly in attending professional development sessions with community building activities. We further found that adopting a participatory approach that encourages educators to customize and localize the curriculum to best respond to the assets and needs of their communities would improve program quality and sustainability. These insights motivated the current larger-scale study.

The capacity-building program consists of three phases. During the first phase, DHF staff worked with participating sites to identify spaces suitable for equipment set up and program delivery. The sites then received equipment, including 3D printers, laptop and desktop computers, and digital prototyping materials.

During the second phase, all community educators and administrators took part in a week-long virtual training prior to delivering programs that covered introductory topics on the technologies that they would be teaching throughout the program. Topics included graphic design, interaction design (using the Scratch programming platform), 3D modeling and 3D printing, and game development. They were also given an overview of equity-based approaches to making by a member of the research team. The module was based on work by Vossoughi [15] and introduced the community educators to the history of the maker movement. It then went on to describe the equitable making framework presented by Vossoughi and gave case study examples of how this framework could be applied in the classroom.

This virtual training ran for 4 hours every evening for 5 days in January 2022 (2 weeks before the beginning of programming in City 1 and 6 weeks before beginning of programming in City 2). The community educators were given an overview of each of the technologies taught (GIMP, Scratch, TinkerCAD, Makey Makey, and HTML) and completed example projects. The training will be iterated on with feedback from the administrators and educators for the next iteration as well.

After completing the training and as part of the third phase of the program, the community educators delivered the curriculum as provided to them. The program ran for 14 weeks and consisted of seven modules. Module 1 consisted of introductions to makerspaces, a creation of expectations for the space, and a small project of either creating LED name tags or vibrating bug toys depending on the age of the youth present. Module 2 consisted of learning the basics of graphic design and creating designs in the GIMP software. Module 3 consisted of an introduction to Scratch programming and the creation of a simple game. Module 4 was an introduction to TinkerCAD and had the youth create and print their own 3D printed items. Module 5 included an introduction to circuits and musical projects with Makey Makey devices. Module 6 introduced the youth to web development and had them create their own websites. And the final module, Module 7, involved putting together a final presentation to share with their community what they had created. Each module lasted for 2 weeks and during each week there were sessions on Tuesday and Thursday that both lasted 2 hours. The program culminated in a showcase where the Youth presented a slide about themselves and projects they had created over the program to their friends and family members.

While the programs were delivered, educators, administrators, DHF staff and members of the research team met on a weekly basis to discuss upcoming modules and any issues or questions that needed to be addressed before content delivery. Additionally, all adult stakeholders met on a monthly basis to discuss logistical issues, share experiences, and troubleshoot any unexpected concerns. Finally, the research team and DHF staff met separately on a weekly basis to discuss any research or implementation issues. These sessions were all conducted remotely and each lasted approximately an hour.

3.3 Data collection

We conducted several data collection activities, including interviews, observations, participatory design sessions, focus groups, and surveys at each site that we will describe in this section.

All community educators participated in semi-structured pre-interviews before the program began. During the pre-interviews, we asked participants about their previous work experience, previous experience with tech, and previous teaching experience. Three educators also participated in post interviews after the program completed. In the post interviews, we asked participants about

their reflections on the program, observations on youth learning and their own professional development as a result of the training and conducting the program, and ideas for how the program components could be improved (with a focus on localization) in the future. All administrators participated in one interview in which they were asked about their role in the government of their city, what their hopes were for technology education in rec centers in the future, and general information about the rec centers. We decided on semi-structured interviews because we could follow up on interesting answers and probe deeper with additional questions. The pre-interviews were conducted remotely with the research team and lasted 20 minutes on average. The post interviews with the administrators were also conducted remotely. The post interviews with the community educators, however, were done in person and lasted an hour on average.

The first author used a participant observer approach where she attended the majority of the sessions that took part in City 1 site 1 for the entirety of the program. During this time, in addition to collecting data, she assisted with teaching during program sessions every Thursday and met with community educators to discuss the week ahead every Monday. She also spent time getting to know the support staff at the rec center as well as the parents who would pick up or drop off the youth. In total, she attended 13 class sessions, only missing days when she was observing at other sites. In addition to observations in City 1, she observed classes twice throughout the program in City 2. As many of the projects included the use of laptop computers, she was able to keep notes without being a distraction to the class and still participating. Because she was involved as a participant during the sessions, she had built in additional time after the youth left for the day to complete the notes.

Given that the research sites were spread across four different locations in two cities, it was logistically difficult for our team to conduct observations at all sites. Therefore, we decided to focus in-person observations at one site with the first author visiting other sites regularly. Before site 2 in City 1 stopped the program, the first author visited 2 times and the third author visited once. After that, the first and third authors each visited the second City 1 site once a week on alternating days. The only session not observed in City 1 was Thursday of week 4 when the first author was observing in City 2. The first author saw the City 2 sites two times each. Spending time every week at the site provided opportunities for trusting relationships to grow organically between the first author, program educators and administrators, and youth. This led to the educator asking for support from the first author as an assistant teacher after the first few sessions. From there, the first author was quickly able to develop relationships with many people within the rec center in City 1 who were willing to share their passion and frustrations with the organization. While these relationships were strongest in City 1, many of her insights and observations there, enabled her to recognize similar patterns or issues as they arose at the sites in City 2.

The first author also led 2 focus groups with the youth at site 1 in City 1. These sessions lasted on average 30 minutes and were conducted in the rec centers during the last week of programming. The focus groups asked the youth to discuss their favorite and least favorite activities, their hobbies outside of school, and what sort of technology they knew about but were not exposed to during this program. The purpose of these sessions was to gather feedback from the youth to inform additional curriculum changes for the next iteration of programming.

The first author also led 3 participatory design sessions with the community educators. These sessions lasted on average 1 hour and were conducted in the rec centers on the last day of the program. During each session, she would walk participants through a redesign activity of each week's curriculum and lesson plan and ask what they would add, change, extend, or remove. She also asked for any new ideas and for feedback on specific projects that worked well in their space. The purpose of these sessions was to both provide further insight into the perspectives and experiences of the community educators and also to adjust the curriculum at their site based on the interests of the youth and their experience with the first iteration of this program. These changes were noted and will be implemented in the next iteration of the program. These sessions were audio recorded and transcribed later for analysis.

The youth at each site completed a pre-survey that consisted of three components: The first component included questions about demographic information. The second component consisted of a modified Upper Elementary School and Middle/High School Student Attitudes toward STEM (S-STEM) Surveys (Technology and Engineering and 21st Century Skills) [70]which consisted of questions about youth's confidence and efficacy in STEM subjects, 21st century learning skills, and interests in STEM careers. The third component consisted of an Alternative Uses Test (AUT) [71] activity which is known to measure divergent thinking. The surveys were either conducted using an online form or paper forms depending on the preferences of the site.

3.4 Data analysis

For interviews, focus groups, and participatory design session data (that were recorded and transcribed), we conducted thematic analysis, using an inductive approach where we developed themes based on participant input [72]. After all interviews were completed, three researchers worked to transcribe and read the interviews. From there, all three researchers coded one educator interview using open coding. They then met to discuss which codes were created and agreed on a codebook together. From there, the rest of the interviews were coded using open coding. Finally, the three researchers had discussions about the data and developed themes using axial and selective coding. For the participatory design sessions, we also collected a list of suggestions for changes, what problem they solved, and for what site they were suggested to inform the curriculum iteration that occurred over the summer of 2022.

We analyzed written observation notes using a deductive analysis approach. Every week, as the researcher at the sites completed their observations, another researcher who was not on site would read through them and organize the observations using the learning dimensions framework [61] which was augmented to include categories for equity and positive youth development observations.

Surveys were conducted and collected by the research team and a descriptive analysis was conducted. The survey data will not be discussed in detail, as the educators and the administrators are the focus of this paper but used to describe the rec center atmosphere in more detail.

3.5 Research team positionality

Our research team worked closely with DHF staff and the administrators and community educators at each site. Our research team consists of one faculty and four student researchers, including Caucasian, African American, and LatinX members and four females. The first author who led and conducted the majority of the data collection and analysis activities is a PhD student with an undergraduate degree in computer engineering. She is a white woman who has also worked as an after-school teacher in two different non-profits in City 2 that served diverse youth for 6 years.

4 FINDINGS

4.1 Educator equity-based strategies

Throughout the course of the program, we identified and documented a series of equity-based strategies used by the community educators to engage and empower the youth.

4.1.1 Identifying and incorporating youth interests. One of the most important skills practiced by educators through the program was the confidence and ability to pivot and change curriculum elements in the face of technical difficulties or youth disengagement. A dynamic that enabled educators to implement this strategy effectively was figuring out how to identify specific youth interests and adapt the program activities accordingly. For example, in City 1, Youth 4 struggled to engage consistently with the content. Before programming began each day, Educator 1 gave the youth time to freely use their computers. He noticed that Youth 4 would regularly watch horror videos on YouTube, focusing specifically on a character called "siren head." During a session when the youth were independently working on their Scratch programming projects, Educator 1 noticed that Youth 4 was not participating. He suggested that Youth 4 make a "siren head" story using Scratch which resulted in Youth 4's immediate engagement with the activity and asking questions about inserting sounds and images related to his interests. Every project that he worked on from then on was about "siren head", and Youth 4 was consistently engaged with the content. During post interviews with Educator 1 in City 1, he stated about Youth 4, "*I could see [Youth 4] being maybe the next Rob Zombie film maker or something like that, you know what I'm saying? You see...It's like you understand their imagination, you don't stifle it.*"

Identifying the interests of the youth became important to all of the educators within the program. Paying attention during breaks between activities or during unstructured time given before class while students arrive was one way for them to observe these interests. Another way, as brought up by two educators, was through signaling through their fashion. For example, Educator 1 explained, "*I'll come in with certain colors. I come in with certain t-shirts. Like when I'm here [his home rec center], I have my One Piece shirt on the other day...which was an anime. The moment my boys see me and they saw Luffy on my back, they could not stop. Like...what else do you watch? Do you do this? Yeah, I do that and play video games.*" Relating to the youth through fashion (e.g., wearing shirts with pictures of characters, current sneaker shoe trends, etc.) was an important way that the educators were able to start conversations with youth and learn about their interests.

4.1.2 Creating comfort and encouraging authenticity. These strategies on finding creative ways to relate to the youth highlight an important goal that these educators brought to the space: creating comfort to encourage authenticity and foster a sense of belonging. Consistently, each educator used different strategies to make the youth feel comfortable within the space that they had created. One strategy involved the educators modeling vulnerability and authenticity through their behavior which the youth responded to by opening up and sharing about their thoughts and feelings with the educators. For example, Educator 1 would always make "dad jokes" throughout the program. The youth would playfully make fun of him about his jokes. Youth 3 would often lead making fun of the educator. When this youth would push the boundaries and was unkind to the educator, he would stop and explain how that was hurtful. A few weeks into the program while other youth were arriving, Youth 3 shared with Educator 1 and the first author that she was bullied at school. Educator 1 then took the time to gather all of the youth before the lesson started and watch some videos educating the youth about how to deal with bullying. They all shared their own stories and discussed with Educator 1 how best to deal with these issues in the future.

Educator 1 highlighted the infectious effect of creating comfort and how when some youth feel comfortable, this will start to spread to others: "*It's like a chain reaction, once you get them interacting with each other, no matter how silly it may sound...they will start talking because they're comfortable with their peers to know that regardless of what comes out of my mouth, it's going to be accepted. That's kind of like that thing that you want because once you're at that level with the kids, you'll see [Youth 1] just gets up to help somebody, [Youth 2] will help [Youth 3]. You know, [Youth 4] doesn't mind saying whatever comes to his mind because where he's at [during the school day] he will probably be judged for it, but now he's here.*" This educator highlights that comfort in a space gives the youth the confidence to learn from and help each other without fear of judgment. This comfort comes partially from identifying the interests of the group and allowing them to pursue them in this space.

4.1.3 The role of identity. Educators often shared identity markers with the youth. We saw evidence that other identity markers, such as race, culture, age, and gender are important factors in youth having a sense of belonging in the space and engaging with and feeling ownership over their projects. For example, Educator 3 from City 2 felt that Educator 2, who was younger, could engage with the youth better because "*they're close to her age. So, it's like a more of a relation.*" Educator 2, herself, brought up the importance of having black women in these spaces. She described how once one of the youths began inquiring her about what she does for school and expressing her excitement about visiting her at her university. The female youth's interest in the educator led her to say, "*I want to teach computering.*" This exchange created a new conversation about higher education and technical career paths. Again, the comfort that the female educator created allowed for students to feel inspired, speak up, and open conversations beyond the program itself. During the program, when seeing the youth's engagement with Educator 2, Admin 2 expressed excitement about educator representation in technical programs by rhetorically asking, "*When will these young black girls have the opportunity to be taught computer science by a*

woman of color again?" In her post interview, Educator 2 stated she has been thinking about also pursuing a degree in education because of these interactions. Educator 1 also observed the positive impact of having female educators present on female youth. He specifically commented on how when the first author would "*chime in with them, they'll definitely open up to you and want to take initiative to at least try it [the technical activity of the day].*" He stated that the "*girls immediately catch you doing it. So, it makes a big difference having our presence there.*" Although this is a small interaction – just the first author participating in a project with the youth – it is very meaningful. We observed that when youth experienced adults being engaged and interested in them, for example when presenting their work as shown in Figure 1, this in turn, increased their engagement and interest in both their relationships to the adults and each other and to the learning activities.

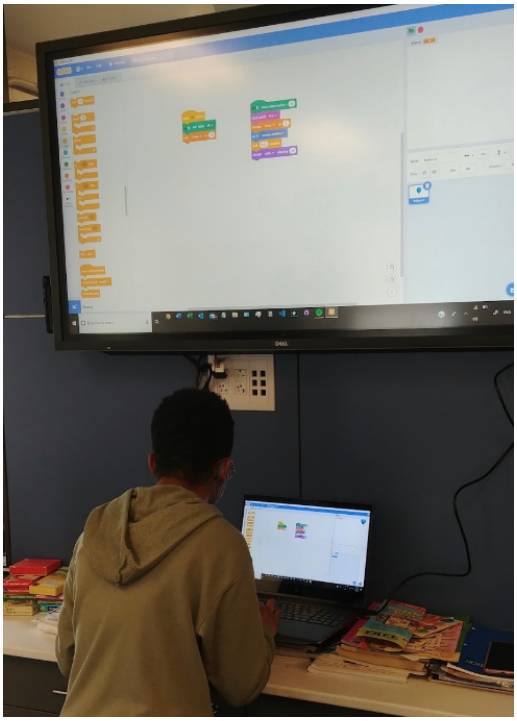

Figure 1: A youth presenting while working on a coding project in the Scratch program.

4.1.4 Rec centers as a safe space to learn. We found that the quality of relationships and connections between educators and the youth are related to the surrounding environment of the rec centers and their social climate. Most of the rec centers are in urban areas where communities may not have historically had economic and political investments to build long-term programs and services targeted at youth. The rec centers often served as a haven for the youth where they could feel safe and have access to calm and positive spaces that contrasted with some of the realities they experienced on the streets. Admin 2 explained that they used data to analyze if the youth in the neighborhood felt safe and comfortable in the rec centers. He shared that when a homicide happened in a neighborhood with a rec center, they would track attendance in the days afterwards closely to see if it went up, leading them to believe that the community felt the rec center was a safe place. Educator 3 emphasized that the rec centers need "a*dult figures doing positive things in general*" because "*they're surrounded by negative stuff.*" He emphasized that "*just being around and being present*" will help increase engagement among the youth. He saw consistent and regular face-to-face time with youth as important and suggested that it would be better to have the program three times a week instead of twice a week "*because like you see them on Tuesdays and Thursday, we don't see them again until [next week].*" According to Admin 2, the youth's attendance also relied on other programs happening at the rec centers as well. Educator 2 also mentioned that "*if there's a cancellation after school program, they usually want to come here.*" Educator 2 also stated "*[they] tended to have other random kids just show up like they were not part of the after-school program.*" We found that important aspects of rec centers were that they allow for flexibility for the youth and what the admin and educators are realizing is that they need to be reliable and accessible on their end.

4.2 Educator and youth self-efficacy

All educators stated that the formation of social connections among the youth and between them and the adults in the program, and a sense of belonging that resulted in authenticity were the most important youth outcomes. This comfort and a sense of belonging amongst the youth had the result that Educator 1 had anticipated and increased youth's technology self-efficacy in the program. For example, Youth 1 was working on a circuit project using snap circuits 10 weeks into the program. At this point, this youth was comfortable with other people in the space. As he was reading instructions and tinkering with a snap circuit board, he made comments showing confidence and creative exploration. For example, he stated "*The book says this [connecting piece] is a two [in length], but I think it is more of a three. I am just gonna go off my imagination.*" Throughout his exploration, Youth 1 would take his entire project apart whenever any part of it did not function as expected. By doing this multiple times, he began to understand the task enough that he could help other students who were working with the same circuit for their own projects. Youth 2 was testing her fan and could not get it to work the way it worked in Youth 1's project. She asked him to show her how to fix it which he agreed to do and copied his set up into her circuit. They tested the circuit together and could not get it to work. Though after tweaking Youth 2's fan didn't launch as high as Youth 1's fan, Youth 2 commented that it was going significantly faster than before. This anecdote shows how tinkering, in combination with being comfortable within the space, allows the students to develop ownership over their projects to the point that they feel confident teaching others. We observed similar dynamics several times throughout the course of the program with different youth taking the lead based on their interests. For example, Youth 5 loved to work in TinkerCAD and taught everyone how to make Pokémon. Youth 3 enjoyed making stories with Scratch and worked with Educator 1 to figure out how to use the camera feature within her stories and games to insert herself into the narratives (Figure 2). Throughout these moments of Youth-led instruction (as seen in Figure 3), the educators within the space would fall into the

background and allow the youth to lead, assisting where they were needed for tools or complicated questions. Educator 1 expressed that in these moments, *"I let my kids teach me. [Youth 1] taught me a lot."*

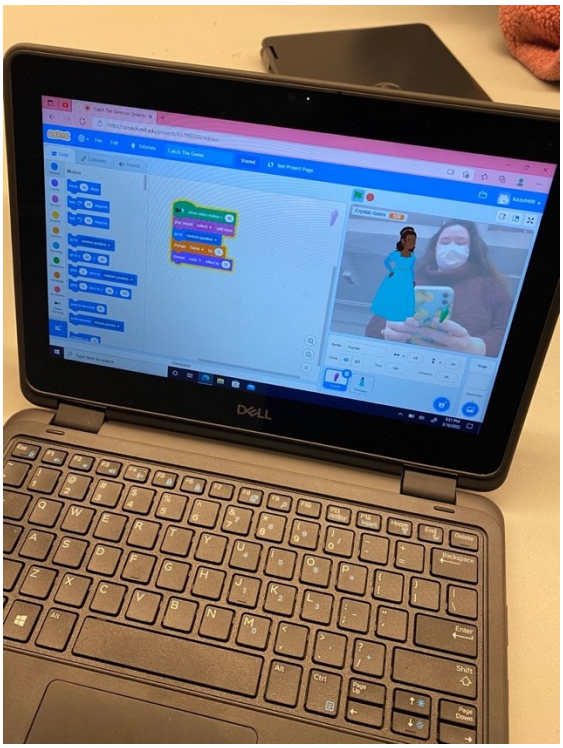

Figure 2: The first author interacting with a game designed by Youth 3 in which the player is inserted into the game. The avatar chosen on the screen is a black princess that was chosen by this youth because of the correspondence to their ethnicity. The camera allows the youth to see themselves physically depicted alongside this avatar.

In addition to the youth, we also saw increased signs of both technical and teaching self-efficacy in educators. Throughout the program, all three educators expressed a renewed or newly found confidence in their teaching ability. To illustrate this shift, we highlight Educator 3's experience. During his initial interview, Educator 3 expressed a large amount of confidence in his ability to handle technical problems in the classroom because of his technology degree and job in IT. However, when discussing teaching, he stated, "*I don't see me as the teacher. I see me as kind of like assisting the teacher.*" Because of difficulty in recruiting an additional educator at this site, Educator 3 did not have a co-teacher in his space. Despite initial hesitation about being an effective technology teacher, Educator 3 took the challenge and was successful in effectively delivering content. For example, by week 4 we already started to observe that Educator 3 had developed a strong sense of rapport with the youth. He described that he made it his mission to create a comfortable atmosphere where the youth were just "hanging out," and could be themselves. In one session, when he sensed that the youth were not engaged, he turned graphic design into a competition of who could make the best snowman figure. He then invited members of the rec center staff as well as the first author who was present in that session to act as judges for the competition. This example illustrates several aspects of this educator's approach to teaching: first, he dynamically and confidently changed the format of the curriculum module to engage the youth. Second, by creating a competition and involving other rec center staff, he incorporated some aspects of rec center practices that he knew the youth would respond well to. In his post interview, Educator 3's concluding comments about his experience with the program were, "*It was fun. When you usually deal with adults, kids are easy.*" We saw similar shifts in other educators, including in the case of Educator 2, a newfound interest in possibly pursuing a teaching career. She stated, "*I think this opened up. . .another opportunity that I can take into consideration. Like I actually just recently talked to my cousin, she graduated with a teaching degree and I was like 'Hey, what does a minor in teaching look like?'...So I'm already looking into even going down that path once I finish my degree first.*"

In contrast to the positive experiences described above, one of the educators (Educator 4) had a difficult experience and decided not to continue the program. After teaching three sessions in City 1, she resigned as an educator within the program. On the first day of programming, Educator 4 told the first author that she was "*so nervous.*" She would not even start the lesson independently and had first author begin class and help set up the technology (i.e., computers, including various software packages and opening PowerPoint, projector) in the room. While she did not participate in a post program interview, we observed that several factors impacted her differently compared to other educators who successfully completed the program. First, Educator 4 was extremely uncomfortable with the technology used in the program. Second, the training provided did not adequately prepare her for teaching in the rec center. While other educators who persisted throughout the entire program showed signs of increased teaching and technology self-efficacy during their experience, Educator 4 was not adequately prepared by the training, support structure, or previous experience and eventually decided not to continue as an educator within the program. Shortly after their departure, the site's management changed, and the program was discontinued due to unforeseen organizational factors unrelated to the research project.

4.3 Strengths and limitations of rec centers as a context for delivering technology-rich learning programs

Several characteristics of rec centers had an impact on the programs, making these community sites an intriguing and unusual context for technology-rich learning. In addition to providing recreational equipment and space, these centers provide an informal and safe place for youth to receive help with homework, eat dinner or snacks, and play games with their friends and relatives, among others. The informality of these spaces contrasted drastically with the regimented, test-driven structure of learning at school and other similar contexts. These characteristics resulted in both strengths and limitations which we will elaborate on in this section.

Figure 3: This figure depicts two instances of the same youth teaching his classmates (left) how to insert photos into the graphic design software (GIMP) and teaching Educator 1 and his mother (right) about the racing game that he created in Scratch.

4.3.1 Strengths of the rec center space. An important aspect of the rec centers where the programs were delivered was their focus on being welcoming and inclusive of members of their surrounding communities. The rec centers we worked with were situated in city neighborhoods where a wide variety of individuals with many creative, social, and technical skills could visit them. These centers regularly hosted sporting events that traditionally take place in rec centers, such as soccer or basketball games, but also were home to a number of creative activities, such as dance and costume design. This focus on welcoming diverse activities provided many benefits to the technology-rich programs we focused on. For example, in the City 1 rec center, many family members and center staff joined the end of the program showcase where youth presented what they had created over the course of the program. After the showcase, one grandparent expressed interest in offering her advanced sewing skills for future programs, such that they can be combined with electronics and digital fabrication skills when creating the final project.

Many of the youth at the rec centers were also provided meals there. In City 2 in particular, the youth would always have a scheduled mealtime directly after programs. The meal was prepared in the same room as programs in City 2 site 2. The smells of food cooking created almost a domestic feel in the space. Educator 3 explained that this schedule and taking care of needs provided a routine that comforted the youth stating, "*when you're dealing with kids it's in this bubble, this bubble is structure. There'll be very few people who's going to buck out of this bubble. They're going to, for the most part, remain in this bubble. . .So it's always like a little more chill.*" He emphasized how the youth's tendency to like routine and comfort within this space made it easy to work with them.

Another important strength stemming from the community-oriented nature of the rec center was that they have the potential for engaging youth on a long-term basis. Admin 2 from City 2 explained he sees the rec center as a place that can take youth on a life-time journey of technology appreciation. He explained his vision, "*. . . you started when you're 10 years old. So, we got you to programming sufficiency by 16. Now, we're working with you on trying to get you into one of these universities. We get you at [local university], you major four years of computer science degree. You come back into the ecosystem working at Google, and then you mentor back at the recreation center that you grew up in. That would be a full circle, perfect 'we did our job' for me.*" This vision describes a long-term engagement with the rec center that is not only focused on technology learning and workforce development but also giving back to the community and creating role-models who come from the communities that they can serve as mentors in the future. This vision also connects with the importance of having role models that represent youth's own life experiences in this space.

The educators in the rec centers were deeply ingrained in the community, which also proved to be a strength as they knew all of the resources available to them. Whenever educators suggested activity ideas, they would often suggest projects based on shared community resources to increase how "cheap" and "easy" some activities could be. For example, Educator 1 describes an activity to improve the graphic design module by incorporating fashion design activities that the youth were interested in. He proposed using an existing laminator machine to laminate the pixel art made in the graphic design module and then using a 3D pen so the youth could make 3D versions of their pixel art. He stated, "*I think with that kind of stuff, they'll take it more seriously, because, like the 3D pen party is awesome.*"

4.3.2 Limitations of the rec center space. The contextual factors of the rec center, in addition to resulting in strengths also caused some limitations that we will discuss next. An important limitation was the lack of access to robust broadband connectivity that sometimes caused delays in youth accessing cloud-based software products. Similarly, some of the computers used at the rec centers were older machines with limited capacity to support some of the required software programs. While the program design included providing laptop computers to all learners, some of the procurement procedures were delayed which required administrators finding

alternative ways of, for example, borrowing computers from other programs to enable program implementation. Finally, there were limitations in having access to technology experts to troubleshoot technical issues or maintain purchased devices. While DHF had dedicated staff to help with troubleshooting issues and answering questions, coordinating all these efforts efficiently and during program times proved difficult.

Educators often came up with creative ways to deal with technical limitations. For example, in City 2 site 1, the 3D printer was jammed on the day that youth were planned to print their designed objects. Educator 2 worked alone in that center and could not troubleshoot the machines while also leading her session. To pivot, she set up "scratch forts" using cardboard as seen in Figure 4 where the youth were able to simulate and play games developed in scratch that they remixed utilizing the camera. When the youth became busy with the games, she fixed the 3D printer and was able to continue with the rest of the activities.

Figure 4: Two Youth from site 2 in City 2 playing their Scratch games in a fort designed by Educator 3. These forts were created so that the camera function would work better. The forts were designed to keep the youth occupied while Educator 2 was troubleshooting the 3D printer but ended up being an activity that the youth responded with excitement to.

Another limitation of rec centers was restriction on purchasing material resources beyond what was provisioned originally, for the programs. During a City 1 meeting Admin 1 mentioned how increased paperwork and bureaucratic measures needed for successful organizational audits had made it "*really hard to buy*" materials in a timely manner for the program. This was emphasized during an observation where the Admin 1 described how "*they could easily do fashion stuff with prints*" but it was difficult to purchase blank shirts for such an activity. There was also another instance in a group meeting where she stated she was unable to easily purchase food for the program. She also expressed shock that a director was present at a meeting for the City 2 site because of her experience with City 1 where "*there was no way they would ever get those people on their calls" and how she "can't get an email back from anyone*". She suggested that having more flexibility with money meant that they could do more without needing her involvement and approval.

In the participatory design sessions, educators elaborated on these technology issues. City 2 had issues with the technology and activities selected for the program due to the wide variety of ages present. In City 2, site 1 served young participants (average age 5) and at site 2, they served older participants (average age 12). This led to an interesting dilemma where some of the equipment and content were too complicated for one site and not complicated enough to engage the youth at the other site. Educator 3 expressed frustration with the software product for video game design not being age-appropriate for the youth he worked with who were older on average (around 12). He stressed that youth at this age have often grown up around or using technology. They often utilize technology in every aspect of their lives. He explained, "*They didn't want to do the step-by-step [instructions] for the Scratch [game design activity] because it was just like, 'Ok, how do I make this thing work', but I play PlayStation now at home and it's way more [advanced]. . .So, it's like hard to get the kids to engage with that.*" In our observations, the youth had a high expectation of technology compared to the capacity of introductory programming platforms used in the program, and, especially, as they get closer to high school age, they expect that the tools they are using are of high quality. In some of the educators' views, technical issues were a major hurdle of the program. For example, When Educator 3 was asked what would make the program better, he stated, "*I mean like, just a functional laptop. . .because when you have inadequate materials you have inadequate products.*"

The final issue that was encountered within the rec center was staffing. This issue was presented most fully by both administrators. Admin 1 commented on the fact that within the government structure, rec leaders cannot have two managers. Therefore, to participate in this program, the staff members had to reduce time spent in their own rec center and volunteer their time for this program. Rec leaders who were educators and those who worked at site 1 in City 1 shared with the first author that the high rate of turnover is due in part to the fact that without a college degree, the rec leaders cannot move into higher positions within the government. This means that when they achieve a certain level within their centers, the only way to continue growing in their careers is by leaving.

4.4 Tensions created by imposing structure in an informal space

Some of the contextual factors mentioned previously, including the rec centers' comfortable, almost domestic feel for many of the youth and their relaxed and flexible planning contrasted with the traditional scaffolding and structure of technology-rich maker learning programs. This manifested in tensions over how best to incorporate the program into the surrounding context. These tensions became clear in the different ways that some of the administrators and educators viewed program structure. For example, Admin 1 has a formal education background and has spent many years working in the public school system. Because of this, she often wanted to introduce a formal structure for presenting the information to the youth. Educator 3, however, stated that he felt this would not work in the informal learning space of the rec center. He said of the PowerPoint

slides and structured lessons, "*I think they are the dumbest thing ever. And the reason why is when you engage in on the thing, it's not a slideshow that you're doing. So, I say, you know, practice how you play it, right? So instead of doing a slideshow, just do a tutorial or we all do some hands-on things.*" This negative view of formal presentations was shared by most, but not all, educators. While all three educators who remained in the program moved away from using PowerPoint slides, Educator 4, who dropped out of the program, greatly relied on them during sessions. She showed more confidence in delivering the programs when detailed PowerPoint slides were available.

Another tension between the informal context of rec center and programmatic needs manifested in relation to survey-based program assessment. As part of the initial research plan and as a way to document shifts in attitudes and learning in the youth as part of participating in the program, we had planned for them to complete pre- and post-program surveys. However, after the first author with support from other research team members administered the first set of pre-surveys, the administrators and educators implored the research group to consider other methods of data collection. They stated that the youth were so resistant to those forms of data collection that they worried they would not want to return to attend the program. These concerns about these forms of assessment were confirmed by our observation of youth becoming dis-engaged when surveys were deployed and mentioning them as a least favorite part of the program in follow up focus groups. Lack of interest in surveys is also reflected in the low completion rates for the post-surveys. The first pre-survey administered was completed by 38 youth while the research team only received 6 completed post-surveys. The first author also noted a specific change in the attitude of the youth when administering surveys or even conducting focus groups. Over the course of the program, the youth became comfortable with the first author as an educator and helpful adult in the space. However, when she began to ask questions or administer a survey, the youth would not want to engage. They avoided eye contact and many simply would not participate. During the focus group, when asked what their least favorite part of the entire program was, one youth responded, *"I liked everything. . .so probably doing this survey.*" Conducting pre and post surveys also proved to be an unreliable method due to the inconsistent attendance of youth within the programs. Furthermore, we saw inconsistencies in the survey outcomes with no statistical changes shown even though our observations pointed to technical and social gains as a result of participating in the program. After working to gain the trust of the youth and developing relationships with them, the first author felt unhappy to negatively impact the youth's comfort in the space and breaking their trust by introducing a formal assessment in their informal, comfortable space.

With respect to program structure, participating administrators mentioned that the program was too long for the rec center context. At 14 weeks it did not fit into the usual rec center structure which runs programs for 8 weeks in between school breaks (i.e., Spring break, Christmas break, Thanksgiving break, etc.). This is due to a sharp drop in attendance seen after these breaks. Admin 1 and Admin 2 both suggested shortening the program so that it takes 8 weeks. Admin 1 also suggested clarifying the length of 2-week modules so youth could decide to join or leave during the program. Rec centers operate in a "drop in" manner and imposing structure and expectations of attendance proved to be difficult.

Another issue brought up in both sites was that the program needed to feel less like school. The educators had several suggestions for how to avoid creating a school-like atmosphere during the programs. For example, educators from both sites suggested explicitly giving youth permission to break or remix things. Instead of expecting the youth to create new projects for every module, educators at both sites suggested incorporating reverse engineering broken or defective technology to create a deeper understanding of their underlying concepts. For example, for the module with the Makey Makey controller, Educator 1 suggested, "*So even if you all came in and got old games systems and you brought it in now and broke it apart, that's probably the best way to show Makey Makey stuff. . .You take an old console, break it apart, and you'd be like. . .this looks exactly like the Makey Makey. . .You just kind of want to intertwine what they love, what you want them to do, and they'll naturally love it.*" Educator 3 had another suggestion for furthering the program from a school-like atmosphere: introducing creative artistic elements to each project. For example, with 3D printing, he suggested that the youth work together to print something and then sand it down and paint it – taking the youth through an entire creative process that each of them could contribute to based on their differing interests.

Several participants, including both administrators and educators, commented on how having a more detailed and expanded professional training prior to delivering the program would be helpful. On the administration side, it was suggested by Admin 2 that a comprehensive training program such as a "booklet and guide" would be useful and also reduce the need for frequent group meetings. Educator 3 also expressed that "*it's not really like the training is inadequate, it's just we just need more of it.*" Because of delays in programming, this educator had begun the program 6 weeks after the training. He commented that having this gap was difficult and having a shorter time between training and delivering the program would be helpful in remembering the content. He also suggested how receiving a "preview" of what needed to be done in the program would be helpful prior to teaching the materials. He drew on a sporting metaphor to describe a preparatory process: "*you have your training but it's that after training, just like in football, you got your head coach, but you really get your coaching from the coordinators and position those players, and that's what it looks like. So, like, yeah, we get our coach, but we get a dumbed down version of it from [Admin 2].*" In this quote, Educator 3 is suggesting receiving multiple descriptions of what the sessions should look like at different levels (i.e., DHF and local administration) to help educators calibrate and prepare for content delivery appropriately.

During the participatory design sessions, admins and educators at both sites stressed the importance of providing a seat at the decision-making table and ensuring that the community has a say in conversations on program and content design. They stated that these participatory practices would make technical programs appealing in community contexts. For example, Admin 2 said, "*I believe the way to truly empower people is by providing the opportunity to provide for themselves.*" He went on to say, "*It's just better when you let them speak for themselves. . .We need more of everybody in the room to make decisions about what we should be doing with*

programming." This sentiment was echoed by Educator 1 in City 1. After a participatory design session, he shared with the first author that over the course of his 10 years working in rec centers, he has seen many universities and organizations come into their space to implement programs. However, he had often felt frustrated with their reluctance to listen to and implement the rec center staff's recommendations in their research. Educator 1 concluded with pride, a phrase that he repeated several other times during the program, "*I just, I know my kids.*"

5 DISCUSSION

Our findings answer our research questions presented in the Introduction and by doing so lay the foundation of a descriptive model that describes equity-based pedagogical strategies and their impact on youth engagement in the context of community recreation centers. In our research, community recreation centers serve both as exemplars of community organizations that can serve as a setting for youth learning about emerging technologies, and as distinct contexts that bring with them particular cultural, social, and political characteristics that often result in creative tensions that need to be considered when working in them. These results contribute to existing research on technology-rich learning in informal settings by providing insights into strategies, tensions, and outcomes present when utilizing an equity-based localized approach for creating these programs in community settings. In the following sections, we will revisit each of our research questions and discuss how our study answers them and provides knowledge contributions to existing research in this area.

5.1 Towards a Model of Equity-based Technology-rich Learning in Community Settings

In this section, we discuss answers to our first two research questions. Our first research question (RQ1) asked, what are equity-based localized strategies used by educators in informal contexts (e.g., community recreation centers) to engage youth in technology-rich learning? In section 4.1, we outlined several strategies we observed our community educators and administrators employ to engage youth throughout the programs. These included the confidence to adjust the program to better suit youth's interests, the ability to identify youth's interests through signaling and direct questions, creating comfort and authenticity within the learning space, and choosing educators that shared identity markers with the youth.

Our second research question (RQ2) asked: What is the impact of these strategies on educator and youth engagement and technology self-efficacy? We answered this question in Section 4.2 and identified increased social connections that led to youth helping one another with projects, increased self-efficacy and ownership of technology projects from the youth, and an increase in educator confidence as outcomes.

We have synthesized these findings into a descriptive model of equity-based technology-rich learning in informal community settings (Figure 5). This model extends previous work on informal learning (e.g., [61]) by focusing on equity-based practices and program localization using community assets. This model builds on and extends Vossoughi's equitable making framework [15], by specifically addressing the need for explicit attention to pedagogical philosophies and practices, and provides empirical evidence for how community educators can implement and deploy them in community settings. Vossoughi discusses how social belonging is instrumental to making learning equitable [15], an idea that we expand on in our model described below. It also extends the work of Barton. After years of working within makerspaces, Barton offers that "equity in STEM-rich making is possible when cocreated in locally centered, community making spaces where youth can be empowered to collaboratively frame problems and design solutions to authentically address real injustices in their everyday lives [32]." Also, in a summary of work in the field, she emphasized "the importance of creating opportunities for our youth to deepen their STEM learning and experiences in ways that both validate their knowledge and perspectives while providing scaffolds that support their success across the range of STEM education, career, and interest pathways [2]." Our model supports these ideas and expands them by offering practical implementation methods for community recreation spaces.

Through our findings, we have identified programmatic and administrative strategies that can support equity-based learning (Row 1 of Figure 5). These include (1) recruiting educators from youth's communities, (2) providing educators with training that covers not only technical and educational topics but also brings attend to equity-based practices that values community assets and cultural diversity, (3) inviting educators to take a participatory approach where they can change curriculum in response to youth interests, and (4) ensuring that educators are familiar with the informal and domestic environment of rec centers. This project utilized community members to serve as educators which resulted in the youth being taught by people who: (i) were from a similar background to the youth (e.g., shared some identity markers) and (ii) the individuals who were making program decisions knew their community interests, strengths, and weaknesses. This meant that when making decisions about projects or how to introduce different concepts, youth interests and community assets were more readily emphasized. This allowed for the youth to more easily see how technology might be a career for them. It should be noted that these youth self-selected to be in this space and, therefore, might be more open to creativity and technology than some of their peers.

We also documented several engagement strategies that the community educators employed to connect with the youth and invite them to participate in the program authentically and collaboratively (Row 2 of Figure 5). These strategies included educators sharing their own interests with youth (both explicitly talking about their interests and implicitly, for example, through wearing style that was related to anime), inquiring into youth's interests, and making sure youth's needs beyond learning (e.g., food, transportation) are also met. We found that educators deployed these strategies consistently and with specific goals in mind. For example, an important strategy used by educators was to be authentic with youth and embody shared cultural and community practices. Repeatedly, educators stressed the importance of comfort in ensuring that youth would engage with the material presented to them. The educators stated that their own vulnerability led to the youth responding in kind and created a comfortable space. Being authentic and vulnerable

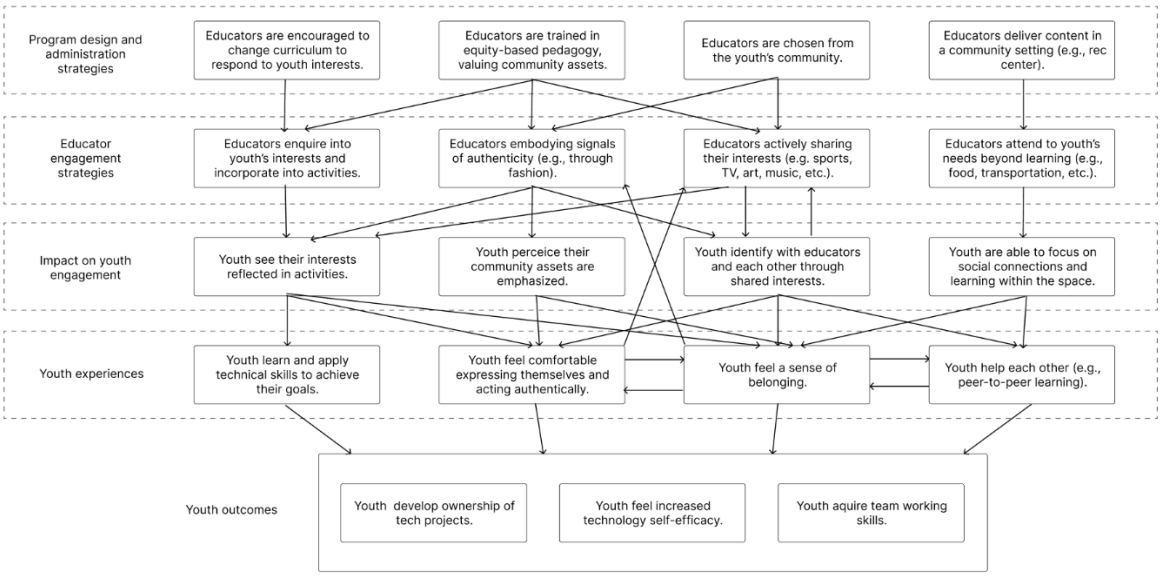

Figure 5: Descriptive Model of Equity-based Technology-rich Learning in Community Settings

could be a risk for the educators, as they might not be accepted by the youth leading to disconnect and discomfort. However, by taking this risk, they encouraged the youth to take risks and be authentic themselves, a practice that was contagious and mutually amplifying (for both youth and educators). While much of this dynamic started by identifying shared interests, over time educators expanded the range of topics to new interests introduced by the youth. In addition to engaging youth, paying attention to their interests and specifically incorporating them into projects also values community assets and encourages self-directed learning, since projects embody youth's specific interests.

Encouraging authenticity also led to increased social connections among youth. Educators expressed that the social connections formed in the space were crucial in youth developing technology self-efficacy. The educators looked for and encouraged instances where the youth taught each other and even the educators themselves. Youth's confidence in their technology skills was expressed and strengthened through helping each other with tasks and being comfortable in sharing experiences and knowledge when teaching others. This confidence was an important learning outcome in the rec center.

The focus on self-directed projects and developing social connections was strengthened by another strategy in the rec centers: attending to youth's basic needs beyond learning activities. In the rec centers, youth were helped with homework and provided meals in a similar manner to what is often found in the home environment. This was part of the practice at the rec centers independent of the technology-rich learning programs and continued during the programs, resulting in the youth being able to feel comfortable in the space. When these needs were attended to, the youth were free to focus on their social relationships and learning within the space. This also led to the youth helping one another with projects and expressing a sense of belonging, ultimately leading to increased technology self-efficacy.

Another important outcome we identified was youth ownership of technology projects. As described above, educators used several strategies to identify youth's interests and incorporate them into projects. They also encouraged the youth to act authentically and take risks expressing themselves. These factors led to youth being engaged with their projects as they saw their interests reflected in them. This engagement led to the youth seeking technical skills that allowed them to implement their projects and a sense of ownership of their projects.

Beyond specific applications for implementing future community-based learning programs, the strategies and outcomes outlined in the model have implications for initiatives, including those focused on HCI, for broadening participation in computing in other contexts and for different populations. For example, we can envision computing literacy programs at city libraries that recruit educators from the local community to authentically incorporate community assets and needs into program activities. These community educators could also structure and localize programs to respond to specific community members' needs. Based on our findings, explicitly using an equity-based approach may result in increased community buy-in and engagement and, ultimately, participation and learning. We further anticipate that many of our findings can transfer to adults, although future studies are needed to verify and refine the model for populations other than urban youth. Furthermore, the flexibility in the design of the technology-rich activities used in this project makes the approach suitable for exploring specific areas of interactive computing that might be of particular interest to community members and organizations (e.g., wearable computing, social computing, etc.) in the future.

5.2 Community recreation centers as sites of technology-rich informal learning

Our third research question, investigated the characteristics of the program contexts: What tensions and opportunities for program localization do community rec centers offer as sites of technology-rich informal learning? We provided answers to this question in Sections 4.3 and 4.4, and here discuss our study's implications for researchers and practitioners planning future programs in similar contexts. These include the need for scaffolded training tools available to support diverse levels of educator preparedness, availability of a wide variety of customizable projects that can engage diverse rec center membership, and provisions for alternative assessment methods. We will discuss these next.

A focus of our study that is distinct from previous research on maker approaches to learning is on the experiences and practices of community educators. Informal learning programs often attract educators with a wide range of backgrounds and professional experiences [73, 74]. We found that two factors are important to educator practices: their comfort with technology and their previous teaching experience. Based on our findings, being comfortable with using technology is incredibly important to educators' successful program deployment. Among all educators who participated in our program, Educator 4 who did not complete the program had experience in rec centers with youth but did not have enough training on the technology to be successful. As stated previously, educators are more successful when they see themselves as makers [46]. Therefore, the struggle for this educator to see themselves as a maker is likely to have contributed to them dropping out of the program. Step-by-step tutorials on every aspect of technology used in the program could have better supported and prepared this educator for success. Having said that, there are limitations for how much one training program can prepare educators to deliver technology-rich experiences for youth and additional customized modules may be needed to strengthen specific skills.

The second factor is educator experience with working with youth. To better support those without experience teaching youth, practice sessions might be appropriate to gain confidence in teaching the material in a low-stakes environment. An ideal scenario could be over time, a community of practice that serves as a support system for educators running makerspaces in rec centers and other community settings could form and help initiate new educators in developing relevant experiences and skills. Additionally, forming a community of practice with educators who share interest, knowledge, and experience in teaching in these spaces would help with the challenge of recruiting and training educators from each rec center. In our study, in addition to training DHF provided connections with other local community organizations, educators, and youth with previous informal learning experiences. It additionally organized monthly meetings with educators and administrators to check in with each other and share experiences and resources. We found these activities supportive of creating a sense of community in the stakeholders and recommend that they be continued with new educators and veterans of the program in the future. As a long-term goal, participants also described how a community organization bringing together youth who have previously participated in the program, especially if they have continued interest or careers in technology-rich fields, can be an ideal resource of youth mentors and educators for this program.

Another important aspect of our study is its focus on program customizability and localization. The flexibility of informal learning programs is one of their most important strengths as it allows them to tailor their format and content in response to community needs [19, 33, 45]. However, this flexibility also puts a burden on the rec center educators and admins, as it is difficult to pivot and tailor programs dynamically to support the wide array of youth who attended the sessions as well as to accommodate the casual "drop-in" culture of rec centers. Formal learning contexts (e.g., schools) usually have a requirement of attendance; however, rec centers are designed to be flexible community spaces in which youth are encouraged to come and go as they please. This tension between need for flexibility and curricular support requires an approach that is aware of this culture and incorporates it into program design. Based on our findings, we recommend developing a highly customizable curriculum in which educators are provided with multiple project options that are adjustable by age, number of sessions attended, and interests of the youth. To support localization and sharing of resources, we recommend developing a repository of project ideas that educators at different sites can contribute to and can also easily use to search and find projects appropriate for technical topics and interests of the youth in their centers. The educator training also needs to teach educators the skills to search for, select, and customize lessons and projects efficiently depending on their youth's interest.

Finally, our findings confirm that assessment methods developed for formal learning contexts, such as surveys, are not appropriate in informal spaces [65, 66, 75]. Often, research and funding opportunities for community spaces require survey data to prove effectiveness. However, our findings show that youth feel uncomfortable switching from the informal and domestic environment of the rec center to an activity that reminds them of their time in school. This causes them to attempt to finish the survey as quickly as possible and not provide meaningful results, causing issues both with survey completion rates and validity. Therefore, there is a need for the development of context-sensitive assessment approaches for collecting data about the effectiveness of maker programs in informal environments.

Our findings contribute to a rich body of work in HCI that collectively interrogates and subverts the hegemonic culture of making by altering program design and implementation, specific making activities, and participation models, among others, to better serve diverse community contexts [4, 6, 27, 28]. Rec centers can serve as an example context that has not historically been used for technology-rich learning but, as evidenced by this work, can serve as a productive site of engagement. In addition to underlining educator roles, our study shows that the local context matters, and practitioners need to work with multiple stakeholders to continuously identify and enact ways to localize program content as well as structure to augment and enhance, rather than replace and erase, what works well in these contexts. We hope that these findings motivate and inform future efforts to broaden efforts to integrate computing and design learning activities in new settings and increase community outreach and participation.

6 LIMITATIONS AND FUTURE WORK

While the current iteration of the program provided insight into educator strategies and their outcomes, we plan to extend our model using future iterations of the program, where we incorporate educator feedback directly into the curriculum design. We also plan to verify our model using data from more youth and community educators in future iterations of the program.

Another future goal of our research is to capture our lessons learned and takeaways from our descriptive model into an online resource, i.e., a localization toolkit, that would allow other rec centers across the country to adopt a similar approach to implementing technology-rich learning experiences in their spaces. Once developed, we plan to assess and refine the toolkit with feedback from stakeholders (administrators, educators, and youth) from multiple sites. Future iterations of the program will incorporate changes to the curriculum as informed through the participatory design sessions. We envision these changes to inform the design of the localization kit.

We are currently investigating alternatives to surveys for assessing youth outcomes and engagement in future iterations of the program. We are developing new interactive methods that let youth express themselves using a range of media (e.g., video, images, typing, etc.) to make them more aligned with overall informal learning approaches that emphasize flexibility and aim for increased learning as an additional assessment outcome. We will also provide more opportunities for youth to provide feedback on the content and format of assessments and elements in the curriculum, more broadly, and iterate on the design of youth evaluation tools with the youth in our program.

7 CONCLUSIONS

In this study, we investigated an equity-based approach to technology-rich learning in urban community contexts with a focus on understanding community educator strategies and their impact on youth learning outcomes. We have synthesized our findings into a descriptive model that captures strategies and outcomes with respect to administrators, educators, and youth. We found that the program encouraged educators to utilize a participatory approach to changing program content to better match youth's interests. Additionally, choosing educators from the community increased the chances of finding common interests between youth and educators and the incorporation of community assets into program design. Educators inquired into youth's interests, through signaling and direct questions, and by incorporating them into the program created a sense of comfort and authenticity within the learning space which in turn increased youth's engagement and sense of belonging. These strategies further led to increased social connections among the youth which resulted in them helping one another with projects, increased their technology self-efficacy and ownership of technology projects. Increased youth engagement, in turn, increased educator confidence. We also found that professional training in equity-based and participatory pedagogy was important in providing educators with knowledge and confidence. In the future, we plan to verify and extend our model with additional data from participatory design sessions with educators and youth to better inform how to iterate upon the curriculum in these spaces. Additionally, we plan to use the model to inform a localization resource for designing and deploying similar programs in other urban contexts.

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