Qualities of Identity Resources in Creative Computing Activities

Ricarose Roque, University of Colorado Boulder, ricarose@colorado.edu

Abstract: Researchers have highlighted how access to various resources in the learning environment can influence a sense of connection to shared activity or practice. We use the lens of "figured worlds" and the framework of "identity resources" to examine the role and characteristics of resources in influencing identity development within an intergenerational program designed to engage families from non-dominant groups in computing. In this paper, we use the context of this family program to study how families accessed and leverage resources to engage in creative computing, or designing, inventing, and expressing with computing. These resources and overlapping figured worlds of family, community, and computing allowed family members to explore new possible selves in the context of computing. This study has implications for how educators and designers provide access to resources for outreach programs that aim to engage non-dominant groups in computing.

Keywords: Identity, figured worlds, creative computing, family learning

Introduction

In computing contexts, there is a persistent image of an anti-social, narrowly focused, and often white and male programmer (Margolis & Fischer, 2002; Margolis et al., 2008). In studies of college and high school students, Margolis and colleagues highlighted how this "geek identity" can discourage and prevent participation from underrepresented groups in computing. Initiatives and programs aimed at broadening participation have focused on disrupting this image and fostering the development of computing identities among youth (Pinkard et al., 2017; Barron et al., 2014). Developing a sense of self and feelings of belonging can encourage someone to persist through challenges or help foster a sense of ownership over her own learning.

Researchers have highlighted how access to various resources in the learning environment can influence this identity development. In a study of track players, Nasir and Cooks (2009) described three resources: materials, relational, and ideational resources that were made available for a track player to develop a "practice-linked identity," or a sense of self in a shared activity or practice. We build on this research to especially focus on the role and characteristics of these resources in the development of practice-linked identities in the context of creative computing, or designing, inventing, and building with computing.

In this paper, we examine the role and qualities of these identity resources and their interplay in the context of a family learning program called Family Creative Learning (FCL) where families create and learn together using creative technologies like the Scratch programming language and the Makey Makey invention kit (Roque, 2016). Our research questions are: (1) In what ways are families given access to identity resources? (2) What kinds of shared meanings and values do these resources take on as families take them up? (3) What were the qualities of the resources that influenced families' identity development in the context of computing? We collected ethnographic data from an implementation of FCL and describe an in-depth case study in this paper to highlight the interplay between identity resources and how they influenced families' identity development.

In communities of practice, to become a full participant, one must learn to master the tools and materials (Lave & Wenger, 1992), but in FCL and other computing outreach initiatives, the tools and materials were selected to welcome novices and beginners who may not identify with computing. We highlight that ways in which features of the learning environment such as facilitation and activity design allowed families to leverage these materials. In addition, the qualities of the material resources such as their malleable and familiar properties allowed families to pivot from the familiar into the unfamiliar in empowering ways. Finally, the overlapping figured worlds of FCL created opportunities for families to both develop their learning and possible selves in the context of computing.

Background

We pull from sociocultural conceptualizations of identity, particularly Holland and colleagues (1998) notion of "figured worlds." Figured worlds are socially and historically constructed cultural practices that contain norms, expectations, resources, and ideas about how one participates (Holland et al., 1998). Within figured worlds, identity is constructed based on what individuals say and do, how others recognize and position them, and what resources they utilize. Figured worlds can exist at micro, meso, or macro levels. For example, there is the figured world of a computer science classroom, which might also consist of the figured world of peers as well the wider figured world of computing. When figured worlds overlap, there may be opportunities for someone to shift perspectives in how she sees herself and how others see her (Barton et al, 2009). For example, when a young person shares a science activity from an afterschool program with family members, that young person has an opportunity to shift their family's perspective in how they see them in the context of science.

Holland and colleagues (1998) discussed how figured worlds relied on artifacts. "Artifacts 'open up' figured worlds. They are the means by figured worlds are "evoked, collectively developed, individually learned, and made socially and personally powerful" (pg. 60). They called these artifacts "pivotal objects" building on Vygotsky's description of mediating or symbolic devices that children use to "pivot or shift into the frame of a different world." In a study of members of a track team, Nasir and Cooks (2009) especially highlighted how access to "identity resources" in the form of material, relational, and ideational resources can facilitate someone's connection or sense of self to a shared activity or practice. Material resources refer to the physical context, its arrangement, and the artifacts within it. Relational resources refer to positive and strong relationships with others in a context that can strengthen a sense of connection with a practice. Ideational resources refers to how one sees oneself in a context and what is considered valuable in that context by others. Nasir and Cooks (2009) argued that these resources can be made accessible in a learning environment. When participants are able to leverage these "identity resources," they can also access practice-based identities.

For more than a decade, researchers, policymakers, and industry leaders have recognized the importance of supporting youth in learning to code, or creating and designing with computing, to become full and empowered participants in our increasingly digital society. However, there are persistent gaps among non-dominant groups such as women and groups from lower socioeconomic status (NCWIT, 2016; Zweben & Bizot, 2015; Margolis et al., 2008). A challenge faced by non-dominant groups are the negative stereotypes or narrow images of who participates in computing (Margolis et al., 2008). Many efforts have emerged to counter these stereotypes and images by engaging participants with diverse role models and mentors or by engaging youth in alternative narratives of computing (Pinkard et al., 2017). In this work, we especially recognize the role that parents and families can play in supporting youth to pursue and develop their interests in computing (Barron et al., 2009).

We aim to focus on the role and qualities of "identity resources" in a learning environment in helping non-dominant groups develop a connection and sense of self in the context of computing. Designers and researchers have developed tools that especially engage novices to learn how to code across digital and physical media (Kelleher & Pausch, 2007; Yu & Roque, 2017). While material resources certainly influence how participants make sense of their connection to an activity, we recognize the importance and interplay of relational and ideational resources in contributing to a person's identity development in a learning environment (Nasir & Cooks, 2009). As we design learning environments to engage non-dominant groups in computing, it is important to think holistically about the features of the experience which can include activity design, curation of materials and tools, and facilitation practices.

Studying participation and development in family creative learning

Context

Family Creative Learning (FCL) is a community-based program that invites families to design and invent together using creative technologies (Roque, 2016). FCL has five workshops and are held in a community center once a week for two hours each. FCL is collaboratively implemented with staff from community centers, such as Boys and Girls Clubs and centers at housing developments.

The design of FCL draws on constructionist traditions of learning, which argue that people learn best when they are building things that are personally and socially meaningful (Papert, 1980; Kafai, 2006). Constructionism builds upon constructivist traditions that knowledge is not something that is transmitted or acquired, but something that is actively constructed through experience (Piaget, 1976). As people build projects, they build ideas. To be personally meaningful, the design of FCL invites families to build on their diverse "repertoires of practices" and "funds of knowledge" (Gutiérrez & Rogoff, 2003; Moll, Amanti, Nef & Gonzalez, 1992). During the workshops, families engage in activities and create projects that build on their backgrounds, stories, and interests. To be socially meaningful, the design of FCL has also leveraged learning theories that emphasize the social aspects of learning (Brown, Duguid, & Collins, 1989; Lave & Wenger, 1991). Families are encouraged to work together as well as interact with other families participating in FCL.

The five workshops are organized as follows: In workshops 1 and 2, parents and children learn how to independently use Scratch and Makey Makey. Scratch enables families to program interactive media such as games, animations, and stories (Resnick et al., 2009). Makey Makey enables people to simulate keyboard keys using everyday materials such as aluminum foil and Play-Doh (Silver, Rosenbaum, & Shaw, 2012). With Scratch and Makey Makey, families can create digital and physical projects. Then, in workshops 3 and 4, families collaborate on a project. In workshop 5, they share this family project in a community showcase.

Each workshop is divided into four parts: Eat, Meet, Make, and Share. In Eat, workshops begin with a meal from a local restaurant, allowing all participating families and facilitators to eat together. In Meet, families split up into two groups and facilitators meet separately with parents and children to talk about their experiences in the workshops. In Make, parents and children engage in design activities with Scratch and Makey Makey. In Share, families talk about their projects to other families and receive feedback and questions.

Facilitators in FCL often include staff from the community organization and local volunteers. They play important roles in welcoming and supporting families, which include helping families get started with the technologies, encouraging families to tinker and experiment, surfacing their interests, and building relationships with family members (Roque & Jain, 2018; Roque & Stamatis, 2019). Prior to the workshops, facilitators meet as a team to become familiar with the tools, activities, and facilitation. During the workshops, facilitators supported the workshop implementation and worked with families to help them with their projects. Immediately after a workshop session, facilitators meet to debrief to discuss what went well, what questions they have, or things that could be improved or challenging interactions they witnessed.

Participants

We implemented the workshops at a public housing community center in an urban community in the northeastern United States. This community center hosted a Computer Clubhouse, which are learning centers designed for youth to engage in creative activities with technology (Kafai, Peppler, & Chapman, 2009). We recruited children between the ages of 7 and 12, but welcomed their younger and older siblings to participate.

We observed six families in an FCL implementation in Spring 2015. Families were recruited from the local community, with kids between 7 to 13 years old and parents between 35 to 82 years old. (We use parents to mean any adult caretaker including grandparents, extended family, and family friends.) Five of the six parents were women. Five parents were immigrants from countries in Latin America. All kids qualified for free/reduced lunch in school. All of the families were able to create and share a project at the showcase.

Six facilitators participated and were recruited through local universities and through volunteers and staff from the participating community center. Two facilitators were graduate students pursuing a one-year, professional masters in education, one facilitator was an engineering undergraduate student, one facilitator was a software developer, and two facilitators were staff from the community center. Facilitators' backgrounds with computer programming ranged from limited exposure to Scratch programming in a class to using programming as part of their educational and professional background. Facilitators were not paid to participate in the FCL workshops. The author served as a facilitator during this program.

Data collection and analysis

To understand families' experiences, we primarily used ethnographic methods and collected multiple forms of data to triangulate our observations, in the form of field notes, individual and group interviews, and video recordings. During the Meet sessions, we asked parents and children questions such as, "What was it like to see your parent/child create a project with Scratch and Makey Makey?" and "What was challenging in working together?" Facilitators, which included the author, wrote field notes. The Meet sessions and interviews were recorded and transcribed. To better understand participants' experiences during and after the workshop series, we conducted interviews with parents and children within one month after the series ended. We asked questions such as "How did you help your family member?" and "Why did you continue participating?" Qualitative data consisted of approximately 10 hours of video recordings, 70 observed hours total from 6 facilitator-researchers, 10 group interviews during the Meet sessions, and 19 individual follow-up interviews from 30-90 minutes.

We analyzed our data using grounded strategies (Charmaz, 2006) to uncover processes that contribute to family members' development and participation, which included parent and child interactions within families, across families, and with facilitators. We also examined participants' interactions with the tools, materials, and the physical space. The author participated with two other research assistants in data collection, transcription, coding, and analysis. They met weekly over a 6-month period to discuss our data analysis.

Findings

We first discuss the qualities of FCL as a figured world and the resources present in FCL. We then present an in-depth case study of one family to identify the material, relational, and ideational resources as well as how they accessed and took them up. This family is by no means representative of all families' experiences, but they share key experiences in how they accessed and took up identity resources. We present their experience across time and highlight both what we observed and what they shared from their perspective in interviews.

Family creative learning as a figured world

Figured worlds are socially and culturally constructed and reproduced through the participation and interactions of people taking on various roles (Holland et al., 1998). In FCL, we constructed a figured world in which families could create and learn together with technology with the support of facilitators at the community-based organization (Roque, 2016). Through their participation in the figured world of FCL, families and facilitators engage in a process of "heuristic development" where practices such as creating with technologies are taken up, internalized, and expressed to form and reform the figured world of FCL (Holland et al., 1998).

Within the FCL program, there are multiple figured worlds at play. There are the figured worlds of each family, the community-based organization, and the local community as well as the broader world of computing. Each figured world has its own sets of agents (in the world of families: parents, kids, grandparents) who have their own activities (providing encouragement, accepting support, passing expertise) and motivated to act on certain goals (taking care of one another, strengthening social bonds, taking care of children). From past discussions with parents (Roque, 2013), parents had shared perspectives that envisioned the figured world of computing as consisting of people with great technical expertise who are fluent with complex tools and specialized language.

These figured worlds overlap and produce a "lamination of spaces" which can create new opportunities for participants to see themselves and each other in new ways across their figured worlds (Barton et al., 2009). For example, some staff at the community-based organization typically interact with young people in afterschool programs. In FCL, staff might see these same young people in new ways as they participate with their family members. In the next section, we present Julia and Jorge's case study to illustrate their experiences in FCL, how they were able to access and leverage identity resources as they developed their abilities with coding and shifted their perspectives on themselves and each other in the context of creative computing.

Leveraging identity resources: Julia and Jorge case study

We present experiences from one family, a mother Julia and her son Jorge. Julia was a stay-at-home mom, who immigrated from Panama when she was 17 years old. She came to the workshops with her 10-year-old son Jorge, who is an only child. Julia and Jorge are both soft-spoken, especially Jorge who is very shy. We argue that Julia and Jorge's practice-linked identities with creative computing increased over the course of the FCL workshops. In other words, they became more connected to the practice of creating and inventing with computing. This increasing connection with creative computing is evidenced in their changes in participation during the workshops and in their reflections on their experiences after the workshops. These shifts included changes in how they took up the materials, how they saw themselves and each other, and how they spoke about their ideas and relationships with computing.

At the start of FCL, Julia and Jorge were both very nervous and shy. Julia's initial goals to participate in FCL were primarily centered around Jorge. A staff member at the community center encouraged Julia to attend to support Jorge's growing interests in engineering, which he was learning about in school. Julia felt uncertain about her digital skills but she wanted to support Jorge. She had recently taken a computer class and learned how to use email, search online, and create a PowerPoint presentation. Jorge had more experience working with computers than his mother because of activities in school. He enjoyed inventing things like playing with LEGO bricks, however, he was unsure if he would understand computer programming. In the next section, we describe their experiences in the first workshop and then highlight the identity resources that were made available to them.

Creating with new materials

In the first night, Julia and Jorge were separated into their peer groups for Meet and Make. During Meet, parents re-introduced themselves and Julia noticed that other parents also felt uncertain about their technical skills. During Make, facilitators asked parents to animate the letters of their name. Julia immediately ran into technical issues, exacerbating her nervousness. A facilitator demonstrated navigating to the Scratch website and getting started with a project. While other parents were able to start their Scratch projects, Julia was stuck at the account creation along with one other mother. They were both unsure what it meant to create a Scratch username. A facilitator Rhea explained and helped them create usernames. Once in Scratch, Rhea supported her in programming her first sprite: the letter "J" the first initial of her name. Julia programmed the "J" to move back and forth. She then created the letter "U," but, at that point, Make time was over and parents were being directed to go back to the main room to share projects with their kids.

Meanwhile in another room, Jorge was getting started on his own Scratch project. A facilitator Antonio asked Jorge what he wanted to do with Scratch and made initial suggestions such as adding a sprite or a background image. Jorge paused for a moment and then shared that he wanted to add a soccer field. Antonio verbally walked him through to use Google Image search to find a soccer field image to import into Scratch.

Afterwards, Jorge paused and changed his mind and proceeded to change the background. He googled Minecraft and added a Minecraft image. Antonio watched as Jorge added another sprite, a soccer ball. Antonio asked him what he wanted to do with that sprite and Jorge responded that the ball would represent the "O" in his name.

At the start of Share, facilitators reminded families that they were only getting started with Scratch and unfinished projects were expected. Instead, families should focus on celebrating their first attempt at a project. Parents were asked to share first and Rhea encouraged Julia to start. Everyone stood behind Julia. Jorge and other kids leaned in very close to her. Julia shared her project sheepishly, laughing occasionally. However, the kids and other parents responded with applause and Jorge tried to look at her project more closely. During his post-workshop interview, Jorge shared how impressed he was by his mom's project. He knew what it took to get started and was impressed that she made something. As Share continued, Julia saw other parents' projects. One father Angel managed to add all the letters of his name, but ran out of time to program them, while another mother made the letters of her name move and change color. When it came time to share kids' projects, Julia saw how kids had done even more and went beyond the initial prompt of animating the letters of their name. When it was Jorge's turn to share, Jorge was quiet at first. Antonio asked him how he added his background. Jorge then proceeded to explain how he used Google Image search to import the image. Another parent in the room exclaimed that she would need to ask Jorge for help in the next workshop. In her post-workshop interview, Julia noted his creative use of the Minecraft image and how she was "blown away" by his project.

> I know that he knows a lot of things, but he's very quiet and he wouldn't say a lot of things. In this environment, he was able to open up and show what he knows. That was the thing that mind blew me away, or my eyes opened up and said, "Well, he knows a lot more than I know, that he knows."

In this first night, Julia's and Jorge's perspectives of each other began to expand as they each shared their projects.

Julia's and Jorge's experiences highlight the importance of relational resources, particularly with facilitators helping them to access the computing materials and the practice of creating with these materials. A facilitator provided explanation when needed and helped Julia move forward from technical issues. A facilitator helped Jorge get started from a blank project into something he could start to shape. In addition to facilitation, the activity structure in separating parents and kids allowed each group access to the materials and creating with these materials.

FCL facilitators provided ideational resources such as encouraging families to celebrate their early projects rather than feeling bad about their initial attempts. Positive feedback through authentic interest and enthusiasm during Share from other families or encouragement from facilitators were helpful in validating their projects and reinforcing their learning experiences. In addition, an activity which invited families to bring themselves into their projects helped to reinforce that their ideas and backgrounds were valuable. In this case, families were tasked with animating the letters of their name and given space to personalize their projects.

Once they were able to access the material resources, Julia and Jorge started to personalize their Scratch projects. A key quality of their experience with Scratch was its malleability, or how families could shape, personalize, and customize it to their interests and goals. Such malleable features helped to develop more personal connections to the materials. In a study comparing students' development of identities in a basketball team and in a mathematics classroom, an important quality of positive identity development was the ability to engage in self-expression (Nasir & Hand, 2008), or how easy it is for learners to create and share their ideas in a learning environment. In the next section, we continue to focus on the qualities of the material resources, how they accessed these resources, and what kinds of shared meanings and values emerged.

Tinkering with the familiar and unfamiliar

At the start of Workshop 2, they saw a table with familiar and new materials and tools, such as craft supplies, aluminum pans and foil, and Play Doh. They were introduced to another new tool Makey Makey and Julia felt especially nervous. She saw electrical wires (alligator clips and a USB cable) and a circuit board (the Makey Makey) and heard something about electricity and conductivity. She worried about being electrocuted. Like Workshop 1, kids and parents worked separately, but in Workshop 2 they worked in the same room. Julia was paired with a parent named Angel who recently arrived from Puerto Rico, and they spoke Spanish as they worked together. A facilitator Maria helped them connect Makey Makey to Scratch and showed them how to program their project to play drum sounds. Angel teased her when she shared her concerns about being electrocuted. He playfully poked her hands with the alligator clips, which were connected to the Makey Makey. Every time he did that, she shrieked and then laughed. Instead of being electrocuted, Makey Makey triggered a key press in Scratch to make a drum sound. Angel then connected the Makey Makey to a steel sponge and asked her to touch it. The steel sponge was something she would find in a kitchen, but in this case it was a drum.

Meanwhile, Jorge worked with another participant Carlos, who started playing with the different materials and Makey Makey components. A facilitator Sam came by to help them get started. After programming a sound to play in Scratch and making their first connection to Makey Makey, Jorge expressed a soft “whoa” when their project worked. Sam encouraged them to try out different materials to connect to Makey Makey. They tried Play-Doh, aluminum plates, aluminum foil, and their own bodies (human skin is conductive) — materials they had played with before, but were using in new ways. In his post-workshop interview, Jorge shared how playing with the Makey Makey expanded what he thought he could do with computers. He did not know you could connect a computer to the physical world.

In addition to facilitators, other family members became an important relational resource in creating with the materials as well as developing shared meaning. As part of the FCL activities in workshop 2, parents worked with other parents, while kids worked with other kids — allowing families to access relationships with other families. Julia’s collaboration with another parent, who was less intimidated by the Makey Makey, helped to address and overcome her fears around Makey Makey. Instead of something to fear, the Makey Makey became something to laugh about with another parent.

Creating with Makey Makey also opened a new experience for families: the ability to connect the digital materials to the physical world. In their engagement with these materials, we highlight other qualities of the material resources: familiarity, physicality, and tinkerability. For both Julia and Jorge, Makey Makey connected their digital experiences to the physical and to familiar materials such as steel sponges and Play Doh, which were used in other figured worlds such as the kitchen at home or the art room in school. These familiar materials connected to prior experiences they have had with these materials to unfamiliar technologies such as Scratch and Makey Makey — making the unfamiliar familiar. In his post-workshop interview reflection, Jorge shared how prior to FCL he did not know that computers could connect to the physical world of tangible materials and even their bodies. Being able to experiment, explore, and tinker with many materials helped to immediately expand what was possible and create new meanings for familiar materials. These familiar, physical, and tinkerable qualities helped families to pivot their perspectives from the familiar contexts into the new context of creating with computing.

Connecting values and stories into projects

In Workshop 3 and 4, Julia and Jorge worked on a family project that they shared in Workshop 5. Families were tasked with creating a project based on the theme of “Carnival.” After brainstorming, Julia and Jorge settled on an idea to create a rollercoaster. During her post-workshop interview, Julia shared how she felt more confident, especially because she took additional time outside of the workshops to learn more about Scratch and Makey Makey. When asked why she made that time, Julia shared, “Because I am a person that if I get something and I always want to challenge myself even though it might be hard or it might be easy. I just don't give up on myself.” Julia encouraged Jorge to see himself in this way too and wanted him to understand that while challenges can be hard, he can accomplish something if he tries, experiments, and practices every day. In these later workshops, Julia helped Jorge connect the Makey Makey to Scratch as well as remember some Scratch basics such as adding sprites and connecting programming blocks together. After brainstorming together, they decided to do a rollercoaster, inspired by their experiences riding a rollercoaster at a local beach fair. Whenever they got stuck, Juila called over a facilitator to help with technical issues.

Julia’s experiences highlight the multiple figured worlds of family, community, and computing that overlap within the FCL experience. Ideas that are valued in one world such as family can be applied into new worlds such as creative computing. In Julia’s experience, she took values of hard work and persistence — values she was also trying to cultivate within Jorge — and applied it to the new challenge of learning how to program. Additionally, Julia and Jorge created and shared a family story based in their local community fair and used materials in FCL to explore and express this family story in new ways. Scratch, Makey Makey, and craft and conductive materials became tools and materials for their own storytelling.

In their post-workshop interviews, Julia’s and Jorge’s shifting perspectives on themselves and each other recognized their developing identities as creators and inventors with computing. Julia, who had just been learning computer basics prior to the workshops shared what she took away: “The experience to come in and learn with other people, to build something from nothing and create something out of nothing, that I’m going to keep for myself as an experience forever.” For Julia, she had initially entered the workshops wanting to support Jorge. In addition to doing that, she was able to see how she could "create something out of nothing." She was able to create projects and share them with others and have the first-hand experience of doing something creative with programming herself. When we asked Jorge about what surprised him about his mom in this experience, he said, "That she invented things." Jorge’s use of the word "invented" is meaningful. He used it often during our interview. He talked about how he liked inventing things, how he made inventions, and how he wanted to become an inventor. In this interview, he used the same word that he used about himself and to talk about his mom. This workshop enabled Jorge to see his mom in a new way that he had not seen before: as an inventor with technology. At the beginning of the FCL workshops, ideational resources, such as what was valued, often came from external figures such as facilitators and members of other families. For Julia and Jorge, they were able to connect what they valued to aspects of their experience and see themselves as creators with computing.

Discussion

This study contributes additional understanding of how designers and educators of learning environments might engage non-dominant groups in creative computing, or using computing to design, invent, and express their ideas. While there are increasing efforts to engage non-dominant youth in computing, there are still persistent gaps and barriers to participation. Popular culture as well as stereotypes have featured images of anti-social, narrowly focused, and often white and male participants in computing. Such expectations and perceptions of who participates and how they participate can be a deterrent for youth from non-dominant groups. Using the lens of "figured worlds" from Holland and colleagues (1998) and building on the framework of "identity resources" by Nasir and Cooks (2009), we especially explored the role and qualities of identity resources within a computing environment designed to engage youth and families who may not see themselves in the world of computing. These frameworks enabled us to concretely examine what features of the learning environment allowed youth and families to access resources that supported their learning and identity. We discuss and highlight some of these features in this section.

First, facilitation played important roles in helping families to access the material, relational, and ideational resources and engage in the practice of creating and expressing themselves with computing. Facilitators helped families get started and overcome technical issues so that they could engage with the technologies and materials. They actively asked families about their interests and backgrounds and connected these interests to the activities. Facilitators also helped to frame what mattered in the experience such as learning together, celebrating work in progress, and sharing ideas. Researchers have highlighted the kinds of practices and roles that facilitators play in welcoming and engaging non-dominant groups in STEM-rich learning experiences (Gutwill et al., 2015). We see opportunities to continue studying how facilitators take up these practices and roles, particularly in how they support positive identity development (Roque & Jain, 2018; Roque & Stamatis, 2019).

Second, qualities of the material resources were important in helping families meaningfully engage in the practice of creating with computing. The tools and materials were malleable, or easy to create with and personalize. As they started working with Makey Makey, the ability to tinker with physical and familiar materials such as aluminum foil and Play Doh created opportunities for families to create new meanings as they engaged with familiar materials in new ways. As they progressed through the workshops, Julia and Eric were able to create a project for the final showcase that reflected their stories and ideas. When designing personally meaningful artifacts, Papert (1980) argued that learners created "objects-to-think-with" which could help them reflect concretely on ideas in the process of making. In using these tools to express their ideas and "funds of knowledge," these projects also became "objects-to-be-with" as it began to shift in how they saw themselves and each other as creators with technology.

Finally, inviting families into the learning environment and hosting it in a community-based organization created opportunities for figured worlds to overlap and open new opportunities for family members to see themselves, each other, and computing in new ways. While not all computing environments are like FCL, it was still a valuable context to highlight the kinds of opportunities that can open up when creative computing environments include the different people, activities, and settings in a young person's life. Computing outreach programs often serve children, without integrating other people in the larger learning ecology (Barron, 2004). Children are left to explain and advocate for their interests to their peers, parents, and teachers (DiSalvo et al., 2014). FCL centers families as well as their relationships, goals, and values in the learning experience rather than centering the learning around the technologies and its related materials. Engaging family members as co-learners and co-creators can have the potential to expand who participates, how they participate, and why they participate in STEM and computing (Tzou et al., 2019; Suárez et al., 2018). For Julia and Jorge, participating in FCL allowed them to strengthen their relationships as well as enrich their abilities with technology. Building relationships was as instrumental as building projects in their learning and identity development — or as Julia put it in her final reflections, "When you make something together with your kids... you become a little bit more close."

References

Barron, B., Gomez, K., Martin, C. K., & Pinkard, N. (2014). *The digital youth network: Cultivating digital media citizenship in urban communities*. MIT Press.

Barron, B., Martin, C. K., Takeuchi, L., & Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media*, 1(2), 55–77.
Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal*, 50(1), 37-75.
DiSalvo, B., Guzdial, M., Bruckman, A., & McKlin, T. (2014). Saving face while geeking out: Video game testing as a justification for learning computer science. Journal of the Learning Sciences.
Gutiérrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher*, 32(5), 19–25.
Gutwill, J. Hido, N., & Sindorf, L. (2015) Research to practice: Observing learning in tinkering activities. Curator: The Museum Journal, 58(2), 151-168.
Holland, D., Lachicotte, W., & Skinner, D. D., & Cain, C. (2008). Identity and agency in cultural worlds.
Kafai, Y. (2006) Constructionism. In Sawyer, K. (Ed.) *The Cambridge Handbook of the Learning Sciences*. Cambridge, U.K.: Cambridge University Press.
Kelleher, C., & Pausch, R. (2005). Lowering the barriers to programming: A taxonomy of programming environments and languages for novice programmers. *ACM Computing Surveys* (CSUR), 37(2), 83-137.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2008). *Stuck in the shallow end: Education, race, and computing.* MIT Press.
Margolis, J., & Fisher, A. (2003). *Unlocking the clubhouse: Women in computing*. MIT press.
Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. Theory into Practice, 31(2), 132–141.
Nasir, N. & Cooks, J. (2009). Becoming a hurdler: How learning settings afford identities. *Anthropology & Education Quarterly*, 40(1), 41-61.
Nasir, N. I. S., & Hand, V. (2008). From the court to the classroom: Opportunities for engagement, learning, and identity in basketball and classroom mathematics. *Journal of the Learning Sciences*, 17(2), 143-179.
Papert, S. (1980). *Mindstorms: children, computers, and powerful ideas*. New York, NY, USA: Basic Books.
Pinkard, N., Erete, S., Martin, C. K., & McKinney de Royston, M. (2017). Digital Youth Divas: Exploring narrative-driven curriculum to spark middle school girls' interest in computational activities. *Journal of the Learning Sciences*, 26(3), 477-516.
Resnick, M., & Rosenbaum, E. (2013). Designing for tinkerability. *Design, make, play: Growing the next generation of STEM innovators*, 163-181.
Resnick, M., Maloney, J., Monroy-Hernandez, A, et al. (2009). Scratch: Programming for all. *CACM*, 52, 60-67.
Roque, R. (2013). *Collateral benefits: Focus groups as social support groups* [blog]. Retrieved from http://ethnographymatters.net/ blog/2013/07/15/collateral-benefits/
Roque, R. (2016) Family Creative Learning. In Peppler, K., Kafai, Y., & Halverson, E. (Eds.) *Makeology in K-12, Higher, and Informal Education*. New York, NY: Routeledge.
Roque, R. & Jain, R. (2018) Becoming facilitators of creative computing in informal learning contexts. In Kay, J & Luckin, R., *Rethinking learning in the digital age: Making the learning sciences count: The International Conference of the Learning Sciences (ICLS) 2018, Volume 1* (pp. 592-599). London: International Society of the Learning Sciences.
Roque, R. & Stamatis, K. (2019, Accepted) It's about relationships: Examining facilitation as a relational practice. In *Proceedings of the 2019 Connected Learning Summit*. Irvine, CA.
Rusk, N., Resnick, M., & Cooke, S. (2009). Origins and guiding principles of the computer clubhouse. *The computer clubhouse: Constructionism and creativity in youth communities*, 17–25.
Silver, J., Rosenbaum, E., & Shaw, D. (2012). Makey Makey: Improvising tangible and nature based user interfaces. *Proceedings of the International Conference on TEEI*. New York: ACM.
Suárez, E., Tzou, C., Bang, M., Meixi, Roque, R., Pinkard, N., ... Martin, C. K. (2018). Designing for Axiological Innovation Within Family-Centered Learning Environments. In Rethinking Learning in the Digital Age: Making the Learning Sciences Count (Vol. II, pp. 1187–1194). London, UK: ISLS.
Tzou, C., Meixi, Suárez, E., Bell, P., LaBonte, D., Starks, E., & Bang, M. (2019). Storywork in STEM-Art: Making, Materiality and Robotics within Everyday Acts of Indigenous Presence and Resurgence. *Cognition and Instruction*, 37(3), 306-326.
Yu, J., & Roque, R. (2018). A survey of computational kits for young children. In *Proceedings of the 17th ACM Conference on Interaction Design and Children* (pp. 289-299). ACM.