Interactive tools for distributed community building and collaboration in maker education

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Abstract: The COVID-19 pandemic raised awareness of the need for expanding the vision of how we can support collaboration across distributed communities of making educators and learners. However, this raises critical questions surrounding how we support these learners to authentically engage with the practices, mentorship, skill acquisition, and social interactions that sit at the heart of effective maker education initiatives. To this end, this symposium brings together experts in collaborative making at a distance to highlight the many innovations being developed to support making when co-location may not be an option. Participants in this symposium will get a chance to engage with presenters around their designs, with several of the approaches being available for use with remote participants to better explore their potential.

Introduction

The COVID-19 pandemic closed schools and educational infrastructure across the world forcing even those most innovative learning systems to adapt to new modes of learning. These experiences over the past two years have highlighted the need for an expanded vision of learning and making. Effective and reliable learning environments are those that help learners connect, collaborate, and build communities in both co-located and distributed systems. In this symposium we bring together educators and designers that have experimented with a diverse range of innovative digital and physical tools aimed at supporting collaborative making, troubleshooting, mentoring, etc. These tools can provide ways for people from different backgrounds to find maker communities where they belong and connect with peers and mentors both synchronously and asynchronously, providing new ways to explore their own identities within them.

Makerspaces are highly dynamic social learning contexts. In a makerspace, learners may use diverse tools that range from screwdrivers to lasercutters, dig through drawers of sensors and actuators to spark ideas, explore shelves of scrap materials, observe others building their own projects, see examples of completed and in-process projects, etc. A project doesn't exist in the head pre-formed and planned, it emerges in interaction from these many moments. Consequently, thinking and learning in makerspaces cannot be located as a mental representation in the head of one learner or defined by a completed project. Rather, making is an assemblage of people, tools, and materials that dynamically form, evolve, dissolve, and reform.

Much has been written on the many design decisions that go into creating effective makerspaces. Research suggests that the materials (Kafai et al., 2014), the arrangement of the physical space itself (Sheridan et al., 2014), the available tools (Blikstein, 2013; Kumar & Tissenbaum, 2022), facilitation (Litts, 2015), the framing of maker activities (Holbert, 2016), and the social possibilities (Ryan et al., 2016; Vossoughi et al., 2016) all impact how learners explore ideas and practices, as well as how they experiment and embrace new identities. When making occurs outside of carefully structured community spaces, a number of new challenges emerge such as information sharing, access to appropriate tools and technologies, and supporting social interactions among makers and facilitators. While maker educators went to great lengths to address many of these roadblocks during the pandemic–for example many educational maker experiences made due with using recyclables and home items as well as intentionally designed maker "kits" that could be shipped directly to learners–the social dynamic of the makerspace has been elusive, difficult to recreate for geographically distributed learners.

This gap was filled mostly with existing commercial communication software. However, these tools tend to be designed to replicate the superficial features of in-person interactions, rather than to consider new modes of interaction or to leverage the affordances of the digital medium. For example, YouTube can be great for sharing videos of projects or to share information with participants but there is no opportunity for dialogue or discussion. Tools like Zoom, Microsoft Teams, and Google Meet, are designed around a meeting model where a few people take turns talking or a presentation model where one speaker talks to many others–audio ensures only one speaker at a time, and video tends to focus only on the face of connected individuals. Tools such as Slack that focus on text allow for a greater degree of synchronous and asynchronous communication, but the kinds of media that can be easily shared and discussed is limited by the threaded conversation model. The thoughtful educator can cobble together a mix of these various technologies to create something resembling a learning community (and many did!), but all have been quickly abandoned once face-to-face interactions resumed.

Objective

The challenges faced by maker educators during the COVID-19 pandemic leaves us with the open question, can we create meaningful and social maker experiences for learners that are geographically distributed? To answer this question we have gathered together learning scientists, educators, and designers that have explored new technologies, procedures, and systems for supporting learners and teachers to make together, when they can't physically be together. These projects in this symposium explore both the use of existing tools, as well as emerging technologies to support new modes of interaction, making, and sharing. They also highlight the value of "low-tech" solutions that leverage the expertise of educators that have honed their craft.

Session Format

The symposium will leverage the 75-min face-to-face format for the initial sharing and discussing of each project, with short lighting talks from each presenting group. However, as part of this symposium, attendees will have the opportunity to explore these different tools, hands on, in a structured poster format, as a way to understand the particular affordances of each, and how they can be implemented across a range of maker spaces. Likewise, leveraging some of the technologies described in the project, we will also create opportunities for remote participants to explore the described tools and engage in conversations with designers and present participants. For these tools we will have Zoom rooms set up at each station to engage in discussion with the remote participants. The session will conclude with our discussant, Erica Halverson, facilitating conversations with the presenters and the present and remote attendees on the opportunities and challenges shown during the session, along with possible synergies and future directions for the field.

Implications

This session will provide an opportunity for a growing, but still relatively new field of maker education and computer supported collaborative learning. By providing a wide array of approaches to collaborative making at a distance, we believe this symposium will help researchers in designing their own approaches to supporting learners who may not have the opportunities to engage in colocated making. Through this, we anticipate the symposium will help scale up this area of collaborative maker education research and build a stronger network of researchers conducting similar work.

CoBuild19 - An attempt to get kids making during the pandemic

Adam Maltese

Our project sought to address the shift to at-home learning during COVID-19 by creating maker/STEM activities for families. Our CoBuild19 project team developed approximately 60 STEM activities (see cobuildathome.com) for children in grades K-6 using items readily available in most households and delivered fully online. The activities were designed through collaborations with museums, maker education groups, teachers from K-12 and education researchers. Our research focus was to see how families engaged in these activities.

Most activities we created involved a video and/or a user sheet. These resources were meant to be used more toward the end of an activity starter than a recipe that produced exact replicates across all families that completed it. In the beginning, the activities consisted of whatever team members could pull together, including From Junk to Journal, DIY Slide Whistle, Leprechaun Traps and DIY Puzzles. As things progressed, we tried to create themes for the weeks and associated activities, including Design and Prototype Week, Textiles Week, Social and Emotional Learning Week, and Kids Cooking Week. Engineering activities included: Heat Shield Design Challenge, Wind-powered delivery devices, Build your own grabbers, and others.

Throughout the initial phase of the project we were experimenting with ways to create and share activities to increase participation. Although we could point to evidence of success - we had a few thousand members in the Facebook group and our videos got many views, with the highest garnering 23K - we got very few submissions, including text, videos or images of what families created. Without this, we had no real data to work with. We polled members of the Facebook group about the activities. The responses (n = 101) were dominated by the option "We are glad to know the ideas are available, but we are not using much" (49%), followed by "We occasionally do activities" (35%). These responses were consistent with the lack of project submissions, so we decided to experiment with different approaches.

Through the rest of the summer and into fall, we experimented with other strategies that we thought would meet our goal of providing activities while also producing more substantive data on youth and family participation. We ran multiple rounds of summer camps where we combined daily online Zoom sessions that were filled with an hour of activities and making led by facilitators. Based on engagement in the sessions and the Padlet videos youth recorded afterwards, we decided these were more successful at generating rich data on kids making.

Our initial activities involved little inclusion of technology since we did not want lack of access to technology to be a barrier to participation. After the success of summer camps we decided to create an online club to try out engaging kids in Grades 5-8 in engineering, design and computer coding, using the micro:bit microcontroller. We structured the Design with Code Club to be different from other common coding offerings in that we wanted the main focus to be on kids designing solutions to problems that might include the use of technology and coding. The first four weeks included COVID-related design challenges and bits of coding instruction. The last two weeks focused on kids solving a problem they selected to address.

ScratchJr Connect: Sharing resources for digital making around the world

Marina Bers & Jess Blake-West

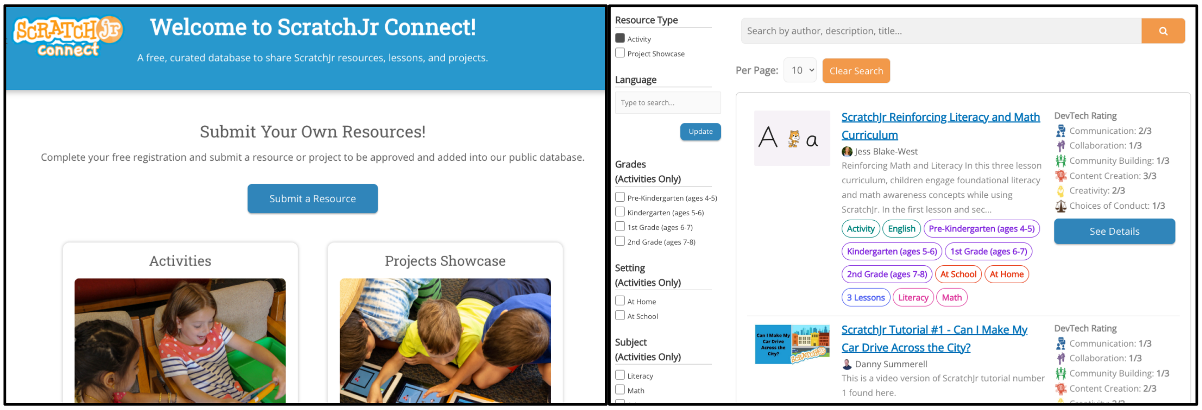
ScratchJr is a free introductory programming app for young children (5-7) that promotes playful, expressive creation and introduces foundational concepts of computer science in a developmentally appropriate way (Flannery et al., 2013). While ScratchJr supports creative coding by design, it is crucial to have appropriate scaffolding in the form of activities, lesson plans, and examples to provide an engaged, meaningful experience. The DevTech Research Group at Boston College and educators around the world have worked to create these resources to support the millions of ScratchJr users, however until recently there has not been a way for these resources to be shared. This need is met with ScratchJr Connect (Figure 1a) - a curated database of ScratchJr educators and family members to share ScratchJr activities, lesson plans, and project showcases.

ScratchJr Connect provides an online community for innovative adults looking to encourage young children in digital making with ScratchJr in novel and exciting ways. Teachers, parents, and any other person involved in teaching and learning with ScratchJr can create free accounts on ScratchJr Connect, and then choose to either browse hundreds of ScratchJr resources, in 64 languages, or submit their own resource (Figure 1b). Resources include both

Activities (lesson plans, story starters, game ideas) and Project Showcases, which are examples of projects and creations already made on ScratchJr, which serve as inspiration to other users.

Figure 1

a) ScratchJr Connect online portal b) Examples of ScratchJr resources



All submissions are approved by a DevTech researcher, who rates each activity submission along the scale of Positive Technological Development (Bers, 2012) which includes 6 metrics designed to promote positive behaviors: Communication, Collaboration, Creativity, Community Building, Content Creation and Choice of Conduct. This ensures that ScratchJr Connect remains pedagogically grounded on our approach to learning and that the resources and examples being promoted cultivate creative making with a coding playground approach (Bers, 2020).

In this presentation, Marina Bers, Augustus Long Professor at the Lynch School of Education and Human Development and director of the DevTech Research Group, along with Jessica Blake-West, ScratchJr Learning Experience Designer at the DevTech Research Group will present on the design process, early success, and future applications of ScratchJr Connect.

Connecting CS Teachers through E-Textiles Virtual Professional Development

Deborah Fields, Yasmin Kafai, Helen Butapetch, John Ottina, & Gail Chapman

In this paper we share the seemingly ordinary community-building digital technologies that helped facilitate nine days of virtual professional development (PD) on the Electronic Textiles (hereafter e-textiles) unit for Exploring Computer Science (ECS). The e-textiles unit challenges teachers to learn new content about computing by designing functional circuitry in hands-on, personalized crafts, in ways that stimulate inclusive pedagogy and asset-based perspectives of students (Fields et al, 2018). ECS is a program that includes both the teacher curricular materials for a one-year introductory high school computer science (CS) course and a robust, two-year model of professional learning that includes nine days per year (Goode, et al., 2014). Our goal as a team of experienced Exploring Computer Science (ECS) facilitators, e-textiles teachers, and researchers was to develop a fully online PD model that could handle the challenges of preparing teachers to teach physical computing while providing a supportive, community context for discussing content, pedagogy, and equity issues in CS teaching.

Finding the right combination of supportive technologies spanned two years, including planning and two rounds of implementation (2020-2022), with careful reflection for re-design. We decided on a few seemingly basic digital technologies that supported the following design goals: 1) *transparency* of in-progress crafts, 2) *community-building*, and 3) *connection* to teachers' everyday classroom practice. Below we share three technology choices that orient our revised PD model with explanations for those choices rooted in theory and practice.

Virtual Sewing Circles for Making Connections. Research has shown that making e-textiles together generates community through commiseration over shared mistakes, providing just-in-time peer help and simply visiting during the crafting time (e.g., Jayathirtha et al., 2020). Without a shared physical table for making, we utilized Zoom breakout rooms with 5-8 people each for multiple hours at a time, encouraging teachers to leave videos and audio on, even while children, pets, and partners interrupted. Observations demonstrated that in these smaller groups, conversations ranged from e-textiles-specific problem solving, to family or hobbies, to school challenges (including equity, pedagogy, administration).

Playlists for Building Community. Day-long meetings in Zoom can become exhausting, and during our first PD, teachers requested a playlist to fill whole group time during reflections, crafting, and breaks. We created an open, collaborative playlist on Spotify where all members could choose songs. The playlist became an artifact of the community, providing an underlying rhythm to the PD that also helped us get to know each other through music tastes and head bopping.

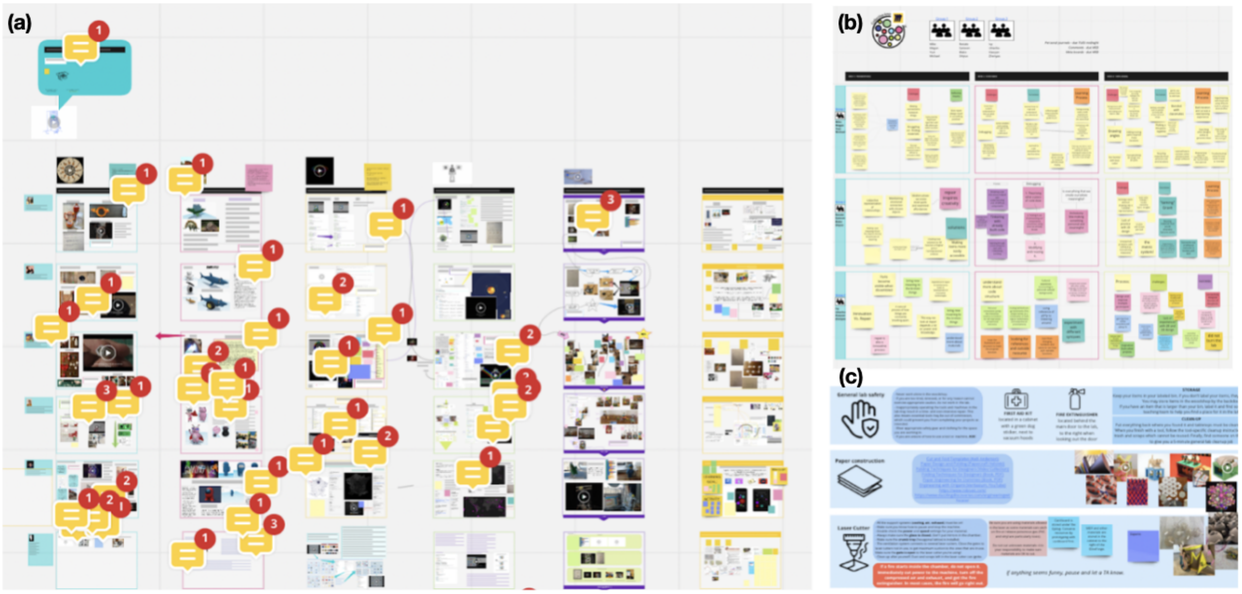
Collaboratories for Reflections on Crafting and Coding. One of the most important needs that emerged was a direct connection to teacher practice, especially since e-textiles introduced a plethora of new tools and materials (from Arduino software to sewing scissors). We chose to use Google Suites because most teachers use it already as school-supported technology. Slides documented in-progress crafts through pictures, videos, and reflections; Docs stored code that was easily visible to facilitators for virtual review; Jamboard provided for think-share reflections on teacher practice, allowing 25 participants to "see" each others' voices. A single "Slide of All Slides" per day stored every link to sample codes, curriculum pages, Jamboard reflections, and each others' projects-in-progress slides.

Designing Digital Collective Knowledge Spaces for Virtual Making

Yipu Zheng & Paulo Blikstein

When the COVID-19 pandemic shut down access to physical makerspaces and removed the layers of face-to-face interactions and support, students faced many challenges when navigating virtual maker activities (Jayathirtha et al., 2020; Benabdallah et al., 2021). Given such a context, our team conducted a 3-year design-based research (2020-2022) to examine students' needs in virtual making and to design a digital collective knowledge space (Hong & Scardamalia, 2014) to better support both individual learning and community knowledge building.

Figure 2
(a) The collective board in the 1st design, (b) the meta board added in the 2nd design to create a multi-layer structure and to integrate small-group collaborations with class-level discussions , and (c) the class resource board in the 3rd design for recognizing distributed expertise in the class



Iterative prototypes of the digital collective knowledge space were implemented using the Miro collaboration platform and tested with 35 adult students enrolled in a graduate-level 15-week-long project-based design class in 2020, 2021, and 2022. In the first design iteration, we created a collective board and each student had one rectangle area per week for sharing their in-process artifacts and reflection from their projects (Figure 1a). The board enabled students to easily share multimedia artifacts (e.g., text, photos, drawings, video, audio), and links among relevant content can be drawn using lines and arrows among different posts. Even though students and instructors asked questions or gave feedback directly on the board, and the collective board was used to support class discussions, peer interaction was still infrequent and brief. Based on this data, in our second DBR iteration, a *multi-layer structure* was added to the collective board to support interactions both at a small-group level and at the whole class level (Figure 2b). Individual boards were used for reflection and sharing mainly within groups, while meta boards were designed for reporting the collective group findings to the class. In the third DBR iteration, some of these features were refined and the class resource board was made available for everyone to share their expertise and find helpful links to different tutorials (Figure 2c). Additionally, the data suggested that some students needed more structure to document their work, so specific board templates were provided to guide students through different phases of the final project (e.g., a template designed for the brainstorming phase).

Based on the design iterations, we summarize three design guidelines to consider when constructing a digital collective knowledge space for virtual making. First, it is necessary to create a dedicated space *and time* for sharing knowledge. Due to the lack of a physical boundary created by the makerspace, we found students were more likely to be distracted when making at home--so creating collective *time* was crucial. Second, the design of the digital collective knowledge space needs to foster a creative and supportive culture where the achievements of each individual and the community are celebrated, and the ideas and interests of all members are valued. Third, increasing the visibility of others' processes (e.g. making, thinking, debugging, testing, and interacting with different technologies) is important in virtual making and should be encouraged in the knowledge space. Meanwhile, the avoidance of information overload, the management of peer pressure, and the balance between publicity and privacy need to be carefully considered when encouraging the sharing of in-process ideas and artifacts.

Using Assessment to Support Connection and Collaboration in Public Library Makerspaces

Kailea Saplan & Rebecca Millerjohn

Defined first and foremost as communities of practice (Halverson & Sheridan, 2014), makerspaces are valued just as much for the social connection and collaboration they afford as the access to materials and making they provide (Chang et al., 2019; Lakind et al., 2019; Teasdale, 2020). The importance of connection and collaboration is especially pronounced in public library makerspaces, which are often guided by an institutional mission to support and sustain the community they exist for and within (e.g., Lakind et al., 2019).

But opportunities for connection and collaboration do not always occur organically. It can be difficult for an inclusive community to emerge when makerspaces continue to grapple with a culture of exclusion that privileges expensive technology and reinforces gendered and racialized notions of making and makers (Melo, 2020; Vossoughi et al., 2016). For that reason, pedagogical tools and instructional practices that are designed to support opportunities for connection and collaboration are integral to community-focused makerspaces, including assessment tools that allow maker educators to document, analyze, evaluate, and expand those opportunities (Cun et al., 2019; Wardrip et al., 2019). In this presentation, we share a digital assessment tool that enables library maker educators to study and expand the connection-building they facilitate in their makerspace.

It was our intention to design an assessment tool for and with library maker educators who best understand the affordances and challenges of their learning environment. Ideation for the assessment tool began by conducting surveys and interviews with educators across four public libraries in the United States. Data collection revealed a vast array of learning outcomes favored by the educators, including "self-directed learning" and "building relationships" which emerged as their top priorities. The assessment tool is meant to help educators better understand the learning outcomes their programs afford so they can make informed decisions about their offerings and facilitation. In this presentation, we focus on how the tool helps educators support relationship and community building in their maker programs.

The tool has been designed to capture evidence *in situ;* like a second pair of eyes with a more reliable memory, it allows educators to collect data and take note of their interpretation of that data as it unfolds. Educators engage with the tool in three phases: (1) they set up the tool by inputting descriptive information about the upcoming activity, (2) they capture evidence of connection and collaboration during the activity, and (3) they close out the tool by adding construct tags and reflection notes that represent their sensemaking of the evidence. The third phase represents a crucial opportunity for educators to impact their future practice by linking assessment with action, but it is also a challenging phase for some educators for which we are still developing scaffolding frameworks and procedures. The development of the tool is still in progress, as our design plan calls for multiple iterations of testing and revising the tool. During this symposium, we will present the latest version of the tool. In-person and remote attendees will have an opportunity to practice using the tool in a synchronous, mini-workshop facilitated by the authors.

In addition to sharing the tool itself, we will present a summary of the tool development process, which includes the data collection and analysis that informed the tool's creation, and discuss what we have learned about the benefits, challenges, and limitations of the tool while testing and revising it. We will share how educators experienced the tool while using it in-person with learners and remotely, reflecting on the different ways connection and collaboration were visible and tangible for each. Lastly, we will discuss how this assessment tool ultimately provided a distant and asynchronous platform for maker educators across different libraries to build community and shared understanding of assessing library makerspaces.

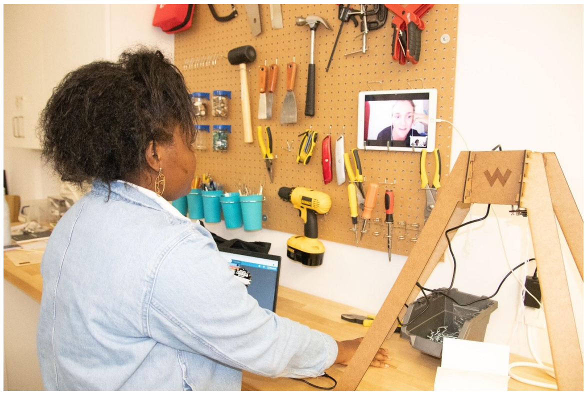
Connected Spaces: Supporting collaboration and mentorship between physically distributed makers

Mike Tissenbaum, Casey Smith, Nathan Holbert, Isabel Correa, Kevin Hall, Ashita Bawankule, & Blake Danzig

The Connected Spaces (C/S) project is a technological toolkit and design framework to connect geographically distributed middle and high school learners interested in fabrication and making to like-minded colleagues. We anticipate that these connections can benefit students traditionally underrepresented in STEM+C career pathways by providing opportunities to develop their identity as makers and sense of belonging to a larger community invested in peer mentoring, collaborating around problems, and growing together in the field.

The C/S technology framework is composed of two primary technologies shown in Figure 3: a digital dashboard for providing connection and knowledge awareness, and the REACH (Remote Embodiment for Augmented Collaborative Help) projector for supporting distributed embodied collaboration and debugging.

Figure 3
C/S Technology Framework: Always on video connection (a), and REACH Projector (b)



(a)

(b)

The dashboard (see Figure 3a) aims to support community building, collaboration, and help seeking in communities distributed across makerspaces or working individually. The expectation is that productive collaboration within distributed communities can emerge by building awareness of other makers' skills, affinities, and ways of navigating similar challenges.

The REACH projector (see Figure 3b) is a two-way communication device that allows users to talk and share gestures around a common physical artifact while in separate locations (Smith & Tissenbaum, 2022). A user places an artifact on the work surface beneath the projector and an audiovisual link projects the artifact onto a second user's setup. The embedded cameras in each REACH system capture everything in both spaces, creating duplicate images of hand gestures and interactions with the artifact while the users collaboratively discuss it. By using projections to augment the physical space, the projector aims to preserve the embodied affordances of in-person exchange around a physical artifact.

Through the development of these technologies and their implementation in community and university makerspaces across Illinois and New York we are studying and supporting unique forms of collaborative engagement. To this end, in the summer of 2022 we implemented the Connected Spaces system across simultaneous workshops in both Champaign, IL and New York, NY, which focused on personally-relevant computing and user driven making activities. Twenty-four middle school students from two local after-school programs that work primarily with Black and Hispanic/Latinx youth participated in making activities centered around building personally-relevant projects with microcontrollers, block- based programming, and simple circuits. During the camp, we tested both the dashboard and REACH's efficacy to support synchronous and asynchronous collaboration across and within the respective camps.

First, we implemented the dashboard across camps through low-fidelity prototypes that used pre-existent tools – such as Miro Board, Rocket Chat, and Zoom – to test two mechanisms that we believe might enable collaboration. The first key feature involved an always-on video connection with a remote mentor. To prototype this we used an iPad hosting the video connection directly to specific students that were working on projects where we felt the mentor may be helpful. We also joined the video conference with a phone so that we could point the phone's camera at the object to be debugged. The second key feature consisted of a shared digital board for students to showcase their expertise and have a space for asking and answering questions about specific maker projects. Every student was displayed on the board, and each student indicated their affinities - maker skills (soldering, LEDs, coding, etc) they felt they personally embodied) - with icons representing these skills. When a student ran into a technical problem or had a question, with the help of a facilitator, they recorded a brief video (less than 30s) explaining the problem and asking for help. This video was posted to a specific students' board based on their affinity, for them to watch and record a response video back to the question asker. Together, both mechanisms allowed us to test differences between synchronous and asynchronous interactions and with different levels of expertise.

Second, we examined the use of REACH during day 4 of the camp, where new circuit building elements were introduced to allow students to expand on the functionality of their projects. Students were divided into groups and provided flashcards describing one of two simple electrical circuits. Once students had completed their first circuit, the flashcards were removed and students were asked to help each other build a circuit that they had not seen in the first round. Eight students helped each other build their new circuits via remote links established by REACH stations positioned at opposite ends of the room, while the remaining students collaborated while co-located around a table.

In this session we will present excerpts from the Summer 2022 pilot data consisting of multi-modal video, audio, and coded gesture data from the circuit building activity. The discussion around the dashboard will focus on the challenges of integrating technologies for collaboration into the flow of making. Although students found remote interactions with both mentors and peers to be helpful, these interactions didn't happen spontaneously but were usually mediated by a facilitator. REACH discussions will focus on how it supported students to engage in distributed collaboration during making activities as well as the particular affordances and constraints of this tool in comparison to co-located collaboration with a lens towards the ways in which REACH can extend, but also fall short of, in-person collaboration.

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