Surfacing the complex conceptions of equity across making and tinkering spaces

Ricarose Roque

Department of Information Science, University of Colorado Boulder, Boulder, Colorado, USA

Stephanie Hladik

Centre for Engineering Professional Practice and Engineering Education, Price Faculty of Engineering, University of Manitoba, Winnipeg, Canada, and

Celeste Moreno and Ronni Hayden

Department of ATLAS Institute, University of Colorado Boulder, Boulder, Colorado, USA

Abstract

Purpose – Relatively few studies have examined the perspectives of informal learning facilitators who play key roles in cultivating an equitable learning environment for nondominant youth and families in making and tinkering spaces. This study aims to foreground the perspectives of facilitators and highlight the complexities and tensions that influence their equity work.

Design/methodology/approach – Interviews were conducted with facilitators of making and tinkering spaces across three informal learning organizations: a museum, a public library system and a network of community technology centers. This study then used a framework that examined equity along dimensions of access to what, for whom, based on whose values and toward what ends to analyze both the explicit and implicit conceptions of equity that surfaced in these interviews.

Findings – Across organizations, this study identified similarities and differences in facilitators' conceptualizations of equity that were influenced by their different contexts and had implications for practice at each organization. Highlighting the complexity of enacting equity in practice, this study found moments when dimensions of equity came together in resonant ways, while other moments showed how dimensions can be in tension with each other.

Practical implications – The complexity that facilitators must navigate to enact equity in their practice emphasizes the need for professional development and support for facilitators to deepen their conceptions and practices around equity beyond access – not just skill building in making and tinkering.

Originality/value – This study recognizes the important role that facilitators play in enabling equity-oriented participation in making and tinkering spaces and contributes the "on the ground" perspectives of facilitators to highlight the complexity and tensions of enacting equity in practice.

Keywords Equity, Informal learning organizations, Facilitators, Making and tinkering, Makerspaces, Out-of-school

Paper type Research paper

1. Introduction

Making and tinkering spaces [1], such as those in museums, libraries and community centers, are informal learning spaces which have the potential to invite children and families into learning experiences that build on their interests, recognize their family and community knowledge and engage them socially supported environments (Bevan *et al.*, 2015; Roque, 2020; Tzou *et al.*, 2019; Vossoughi and Bevan, 2014). Informal learning educators, or facilitators, play important roles in enabling participation in making and tinkering spaces, as well as ensuring spaces are welcoming learners from nondominant groups (Calabrese Barton *et al.*, 2017; Vossoughi *et al.*, 2013). Studies of facilitators reveal the depth of their practices to spark and support youth interests, sustain engagement and deepen learning trajectories (Gutwill *et al.*, 2015). Like participants, facilitators themselves have a wealth of knowledge and history of practices that they bring into their role and spaces. They have varying interests, backgrounds and teaching experiences. They may also have varying experiences engaging youth and families, especially from communities who have been historically marginalized. These backgrounds and experiences go on to influence the kinds of learning experiences they may create for participants. In other words, facilitators' varied experiences influence how they may interpret and enact broad organizational goals for equitable participation. These enactments include the design of spaces and programs as well as moment-to-moment interactions with youth and families from nondominant communities. While recent research has highlighted vignettes of equitable learning in making and tinkering environments (Calabrese Barton *et al.*, 2017; Vossoughi *et al.*, 2020), there have been few investigations into exactly how facilitators conceptualize equity in their spaces and communities and how those conceptualizations impact their professional practice (Hladik, 2022).

In this paper, we present a study of how facilitators conceptualize equity in their work. We examined facilitator perspectives across makerspaces within a public library system, a museum making and tinkering space (MMTS) and a network of community technology centers (CTC) as they participated in a multi-institutional collaboration to co-design computing activities that met the needs, interests and strengths of their communities. We analyzed 16 interviews with facilitators by adapting a framework from Vossoughi (2017) that expands conceptions of equity beyond access to consider who participates, whose values are embedded in these experiences and what outcomes are prioritized. We found a variety of conceptions of equity that tended to align with their organizational commitments and ranged from a focus on access to materials, people and opportunities to cultivating connections between youth interests and future possibilities with college and careers. We also examined facilitators' reflections on their actions and noted the significant complexity and tensions in the ways facilitators tried to align their commitments to equity in practice.

As Philip and Azevedo (2017) argue, "comparing and contrasting across [informal learning] settings offer the potential to understand the nuances and span of various meanings of equity in everyday science learning" and to reveal "what other lenses would elucidate these settings as sites of contestation" (p. 530). Along those lines, this paper contributes to ongoing conversations on how informal learning settings can be spaces that provide youth and families from nondominant groups more expansive and equitable engagement in making and tinkering spaces. In particular, we highlight the complexity which facilitators need to navigate to meet this potential for equitable learning opportunities. We also argue that equity-oriented researchers need to pay attention to facilitators' conceptions of equity – how these conceptions occur, what supports them and its implications for enabling equitable participation in informal learning environments. This work has implications for what kinds of professional development opportunities are needed to help facilitators reflect on and

untangle this complexity of conceptualizing and enacting equity in practice, as well as what steps informal learning organizations can take to support facilitators in their joint missions to provide equitable learning environments for making and tinkering.

2. Background: equity in making and tinkering spaces

Philip and Azevedo (2017) argued that educational researchers should be clear about the definitions of equity and theories of change that drive those definitions in their work, as these definitions and theories have implications for how societal structures and epistemological perspectives are addressed in the work. The goal of our paper is to elucidate the definitions and experiences of equity held by the facilitators in these making and tinkering spaces, and therefore we wish to avoid providing a strict definition of equity that constrains our understandings of the facilitators' perspectives. However, we draw upon Teeters and Jurow (2018) to frame our understandings of equity and equity-oriented work in the context of this research (pp. 27–28):

> Equity is historically situated, culturally shaped, and always politicized. There is no predetermined endpoint for equity; rather, it is a fluid and shifting aim. Given that perspective, community-engaged partnerships that strive for equity need to be responsive and alert to the dynamics of equity and inequity when they emerge. Our view on equity is founded upon a commitment to the organization of greater opportunities for people from non-dominant backgrounds to determine their own social futures. Importantly, work for greater equity is not only about gaining access to current structures of power, it also involves transforming those structures to facilitate more liberatory and just goals (Philip and Azevedo, 2017). We thus refer to the process of pursuing greater equity as equity-oriented work, acknowledging that this work is ongoing.

These ideas of history, culture, power structures and liberation have been explored by researchers in making and tinkering environments. Vossoughi *et al.* (2016) conducted a literature review to examine the maker movement through the lens of culture and power. They argued that a dominant view of making that focuses on making as "a uniquely American activity focused on technological forms of innovation that advance hands-on learning and contribute to the growth of the economy" (p. 207) is rooted in gendered, white, middle-class values and cultural practices which ignore the practices and values of learners of color and working-class learners in making. Making and tinkering spaces must intentionally take a historized approach to making as a cross-cultural activity and pay explicit attention to pedagogy, in addition to other things such as materials and space, to challenge hegemony in making and tinkering spaces. For example, Calabrese Barton *et al.* (2017) studied how a community makerspace became a place for youth from minoritized communities to engage in Science Technology Engineering and Mathematics (STEM) in ways that were consequential. Youth looked for ways to transform themselves and their communities through making projects that centered on issues that were important to them, such as an alarmed jacket, and had agency to choose different forms of participation and activity in their projects (Calabrese Barton *et al.*, 2017).

Other researchers have advanced equity work in making and tinkering spaces by paying careful attention to the creation of distributed learning systems in which skills, knowledges and material resources are shared amongst family members and makerspace facilitators (Brahms and Crowley, 2016). Sheridan and Konopasky (2016) highlighted how the value of resourcefulness can be embedded in the design of a physical space and the tools within it in ways that promote individual and community development. Finally, building a culture that prioritizes learning, literacy, deep projects and process can ensure that these learning opportunities are available and meaningful to all students (Blikstein and Worsley, 2016). However, despite the increasing focus on equity in these spaces, challenges still persist

including gender imbalances in makerspace leadership and participation, gendered imagery on recruitment materials and language uses that celebrates particular identities and experiences (e.g. being a geeky, smart tinkerer) that can be exclusionary (Kim *et al.*, 2019; Kye, 2020).

Studies that focus specifically on the facilitation of making and tinkering spaces are incredibly rare (for exception, see Vossoughi *et al.*, 2021a). Several researchers have acknowledged the importance of facilitators in informal STEM learning spaces more broadly, especially those who work with minoritized communities (Booker and Goldman, 2016; Dawson, 2019; Roque, 2020; Roque and Jain, 2018). However, there is a dearth of literature that specifically examines how these facilitators conceptualize equity in their spaces. In a notable exception, Villanosa (2021) investigated museum practitioners' beliefs and assumptions about racial, ethnic and cultural diversity within their institutions in her doctoral thesis. Drawing from interview data from 26 museum practitioners, she noted that they tend to avoid explicitly mentioning race and ethnicity, instead relying on class or linguistic descriptions. Their positionings of these ethnic and racial groups were often dehistoricized, depoliticized and monolithic. While some museum practitioners were able to identify barriers in engagement for minoritized learners (such as the centering of whiteness in museums) as well as some culturally-based interventions at their institutions, Villanosa (2021) noted that they generally lacked the tools to interrogate and change their viewpoints which work against their personal and institutional equity goals.

Our paper aims to expand on past work on equity in making and tinkering spaces to focus on the perspectives of facilitators as they navigate equity across activities and organizations. In surfacing facilitators' conceptions of equity and the complexities in which they enact their commitments, we can better identify and advocate for the kinds of support needed by facilitators and highlight important questions for equity-oriented researchers in informal learning environments.

3. Theoretical framework

Our work with facilitators in informal making and tinkering spaces requires a concrete framework, grounded deeply in issues of practice (i.e. the day-to-day decisions of facilitators and their organizations). Additionally, we wanted to be able to tease apart the ways in which different values and discourses emerged and shifted across different activities. We drew upon Vossoughi's (2017) equity framework for out-of-school learning as the starting point for our analysis.

Vossoughi (2017) argued that research into equity in informal settings "treats all learning as a cultural sociopolitical process and foregrounds questions of epistemology, power, and justice" (p. 1). She noted that many equity-oriented researchers may rely (implicitly or explicitly) on an "access" frame for equity which she argues "is a necessary but insufficient approach to studying and working to transform educational equities" (p. 1). To expand beyond this frame, she posed four questions for researchers and practitioners to consider when engaging in equity-oriented work:

(1) Access to what?
(2) For whom?
(3) Based on whose values?
(4) Toward what ends?

Vossoughi emphasized that these questions allow researchers and practitioners to "problematize narrow, ethnocentric measures of learning and argue for ecologically valid

approaches to research" (Vossoughi, 2017, p. 1). That is, these questions can allow us to break down ideas of equity, as they pertain to physical space, people (including both learners and educators), values and goals – as well as connections between these components as they influence teaching and learning. Finally, and most importantly for us, these questions challenge educators to think beyond the issue of access to new technologies or learning opportunities, a viewpoint that is prevalent in making and tinkering spaces, as well as informal spaces more broadly, which can result in surface-level solutions that do not address systemic issues in informal settings.

In the next sections, we detail how these four questions inspired the codebook used to analyze facilitator interviews and understand their multiple, overlapping ideas of equity.

4. Methods

4.1 Overview of research partnership

This paper reports on data collected from a research–practice partnership (RPP) between multiple US-based universities and informal STEM education organizations. The partnership centers around the collaborative design, implementation and evaluation of computational making and tinkering activities. Our three partner organizations include six makerspaces in a public library system, a making and tinkering space within a science museum and an international network of CTC. This paper reports on interviews conducted with staff members in all three partner organizations in the first year (from Fall 2020 to Spring 2021), in which we aimed to examine challenges that educators faced in incorporating computing experiences within their spaces, especially goals and issues of enacting equity in these experiences. For this paper, we focused on answering this question: How do informal educators across different organizations talk about their conceptions of and actions toward equity? Pseudonyms are used for each of the spaces and interviewees.

The six Library Makerspaces (LM) are located within public libraries in a city in the Mountain Region of the USA. Each makerspace promotes free access to tools, materials and technologies, and the locations of each library makerspace were specifically chosen to meet the needs of communities who may not otherwise have access to these technologies in their schools, homes or other community centers. The LM offer both drop-in hours as well as specific workshops and programs. Each library makerspace uses two full-time staff who facilitate open hours and programs and may also have other facilitators on a part-time basis.

The MMTS is located within a science museum in a city on the West Coast of the USA. Visitors must pay the museum's admission fees but the museum also partners with local schools to host free field trips. This space is explicit about using constructivist theories of learning in which visitors construct their own knowledge and personally meaningful creations through collaborative interactions with materials, tools, technologies and people in the space. Facilitators are full-time paid staff and have diverse backgrounds from film and anthropology to physics and biology.

The CTC are part of an international network of more than 100 centers across 21 countries. These centers are located within various community-based organizations which influence the population of youth that they target as well as the types of programs they provide. Each center aims to provide a creative, safe and free out-of-school learning environment where young people from underserved communities work with adult mentors. Youth sign up as members and can access the space as well as programming grounded in youth interests and facilitated by staff or local organizations. Full-time staff are paid and have a variety of educational and professional backgrounds. We interviewed staff members from centers across the USA.

We use these three contexts to examine our question: How do informal educators across different organizations talk about their conceptions of and actions toward equity?

4.2 Research participants

Leadership from each of the organizations nominated a group of facilitators within their network of sites or organizations, and we invited each facilitator to participate in the interview study. A total of 16 staff members were interviewed in total: 6 from the LMs, 5 from the MMTS and 5 from the CTCs. Research participants [2] had a variety of backgrounds and roles in the organization, and none of the research participants had formal educational or professional backgrounds in computing. All research participants were paid staff members. Demographic information for each facilitator and their site's intended community is included in Table 1.

4.3 Data collection

We conducted 90-min semi-structured virtual interviews with each facilitator via the video-conferencing software Zoom. Prior to the interview, we asked facilitators to identify a computing-based activity that they had implemented in their space to share with us. To allow a broad interpretation of what a "computing-based activity" could involve, we did not explicitly define computing before or during the interview. Activities ranged across many different tools, technologies and projects. Examples included geometric artwork with programming environment TurtleArt, making zines with the Adobe Creative Suite, creating a game using Scratch programming and robotics activities with Arduino microcontroller kits. Specific questions related to the activity included goals, how it was designed, facilitation practices and challenges. We also asked questions about facilitators' academic and professional backgrounds, goals (both personally and related to their position in their institution), how their work has been impacted by COVID-19 and how they think about equity in their role and their space. While this final set of questions was able to explicitly get at facilitators' notions of equity, ideas about equity were also implicit in their discussions of activities and challenges in their spaces. For that reason, the entire interview was considered as data for our analysis.

4.4 Analysis

All interviews were professionally transcribed. A team of three researchers (authors Roque, Hayden, Moreno) began by iteratively open coding a subset (3) of whole transcripts, each writing memos to keep track of emerging themes. During the interviews, when we asked facilitators explicitly about how they considered equity in their work, facilitators tended to make broad statements about what it meant to them. For example, LM facilitator Daniel shared:

> I always thought of it [equity] and still think of it as leveling the playing field, thinking about their future and thinking about what they might want to do in the future, providing them an opportunity to develop the skills or at least be introduced to these ideas before they get to that point where they might already be behind.

In conversations about their activities and facilitation practices, we noticed more implicit talk about equity in their spaces. An initial codebook was developed based on emerging themes such as challenges experienced by facilitators to incorporate computing. This initial codebook also included codes for the four questions posed by Vossoughi (2017). For the sake of clarity, we will refer to these four questions as "dimensions of equity" to distinguish the questions posed by Vossoughi (2017) and the interview questions we asked facilitators. The analysis team then iterated on this codebook by coding interviews together, clarifying and adding definitions as

Site	Pseudonym	Race/Ethnicity (as identified by participants)	Community demographics (as identified by each participant)
Library Makerspace (LM) 1	Daniel	Chicano	Asian, Black or African American, White, Hispanic or Latino
LM 2	Emilia	Hispanic	Hispanic or Latino
	Anna	Caucasian	Black or African American, Native Hawaiian or Other Pacific Islander, Hispanic or Latino
LM 3	Eric	Black and African	Black or African American, White, Hispanic or Latino
LM 4	Amy	White, Latino	American Indian or Pacific Islander, Black or African American, White, Hispanic or Latino
LM 5	Katie	Chinese-American	Black or African American, White, Hispanic or Latino
Museum Making and Tinkering Space (MMTS)	Sara	White	American Indian or Alaska Native, Asian, Black or African American, White, Hispanic or Latino
	Naomi	Asian, Japanese	Asian, Black or African American, White, Hispanic or Latino
	Leonardo	Caucasian	Asian, Black or African American, White, Hispanic or Latino
	Primo	Asian-American, Filipino-American	Asian, Black or African American, White, Hispanic or Latino
	Jenna	White	American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Hispanic or Latino
Community Technology Center (CTC) 1	Diego	Latinx	Hispanic or Latino
CTC 2	Traci	African American	Black or African American, Hispanic or Latino
CTC 3	Cate	White	Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Hispanic or Latino
CTC 4	Brad	Caucasian	Black or African American, White
	Benton	Black	Black or African American, White
10 total sites across 3 organizations	16 total participants		

Source: Authors' own work

needed. Table 2 summarizes our interpretations of these four dimensions that we used in our codebook. These four dimensions represent just a subset of the overall codebook, however the additional sections of the codebook were not relevant to the analysis reported here.

In our interviews, facilitators were concretely reflecting on their practices (e.g. how they welcomed people, how they curated materials, how they set up a space, how they designed and implemented an activity, how they iterated, how they supported youth, etc.), and therefore we added a question of "how" into our analysis.

Dimensions of equity	Description	Examples
Access to what	What participants have access to, discussions around access and barriers	Diego: Adobe provided a full year Adobe [Creative Suite] license... But then the other challenge came that not everyone had the device to download the applications, or their phones didn't support it Daniel: I think the reason that computing and ultimately programming and coding are in these spaces is so that we can bridge that gap in even access to just learning these things
For whom	Descriptions of participants' demographics and backgrounds	Eric: We have a big Somali population that comes to attend with us, which is pretty awesome, and it's just a big mix of individuals [that] actually come to our space, Black, Hispanic, Latino, white Emilia: We see some [participants from other neighborhoods] and they're just coming to [this library] to do that one program... We're trying to target a certain area and they're not coming in
Based on whose values	Values, goals, philosophy or background that are motivating the opportunity	Sara: The hardest challenge I remember was not the tools, not the digital fabrication tools... but it was like, "How do we help support people learning about making designs that they're excited about? And is that even something that everybody's excited about?" Primo: We [the making and tinkering space team members] try to focus on process and sometimes it's just the case, especially with digital tools, that you don't end up with anything that you get to take home, especially if you're using a borrowed laptop. And that's feedback that we've gotten from families, from [afterschool] staff, and from kids, like, "So we don't get to take anything home? That sucks! I don't like this."
Toward what ends	Outcomes/visions for short term, medium term and long term	Brad: That class is designed to... teach them soft skills, work readiness training, like how to make a resume or mock interviews, or goal setting Jenna: The best-case scenario is when I see that shift in action and people get this new sense of possibility and identity, but I don't think that is always what happens

Source: Authors' own work

Table 2.
Dimensions of equity with descriptions and examples from data

Once all team members had a shared understanding of the codebook, the remaining interviews (13) were split up and coded individually. While we initially intended to study individual facilitators' conceptions, we found strong alignment in facilitators' conceptions of equity according to their organizational affiliation. In Section 5.1 of the findings, we present the equity dimensions across each organization.

As we were conducting this analysis, we found excerpts where the equity dimension codes were overlapping (e.g. talking about both "for whom" and "access to what" at the same time) and our team further examined these excerpts. In these excerpts, individual facilitators were reflecting in further depth about a specific activity or experience in their space. For example, a facilitator might discuss who they were trying to engage (for whom) and how they were designing or redesigning an activity to encourage their participation (access to what). At times, the equity dimensions were in alignment as facilitators brought their commitments together to make progress in their equity-oriented work. Other times, the equity dimensions were in tension, where a facilitator was fulfilling a commitment to one dimension but at the cost of another dimension. These tensions were either mentioned by the facilitator or our research team interpreted them as tensions because the facilitator had to make a decision that contradicted their earlier statements on their equity work. In both cases, facilitators were trying to balance their commitments along with the affordances of their spaces and organizational goals. We discussed these examples in our weekly meetings as a team to develop a shared understanding of our interpretations of alignment and tensions. In these discussions, we selected a subset of examples from different facilitators to describe a range of these alignments and tensions which we describe in Section 5.2 of our findings.

Finally, once a draft of the findings were completed, we conducted virtual "share-back" sessions with members of each organization to present our findings from all three settings. We then invited the facilitators to comment on the results, ask questions and provide insights. We aimed for these share-backs to go beyond traditional "member checks" where researchers report on and discuss findings but to also engage facilitators in reflective activities about their practice, their motivations and their next steps.

5. Results
We present our findings in two parts. The first part (5.1) describes our categorization of facilitators' reflections and commitments in practice along the four dimensions of equity across each organization. The second part (5.2) presents a range of examples across organizations that dives further into facilitators' reflections on their experiences and describes more of the complexity of facilitators' practices in acting along these dimensions of equity – sometimes in resonant ways that furthered their commitments to equity and other times in ways that complicated those commitments.

5.1 Unpacking what facilitators are saying about equity
One question in our interview protocol asked facilitators, "How do you think about equity in your role and in your space?" From facilitators' responses, we found patterns across each organization. In Table 3, we highlight general themes in each organization's responses that align with the four dimensions posed by Vossoughi (2017).

LM facilitators emphasized providing free and open access to tools, staff and spaces for all ages and backgrounds. MMTS staff discussed their views on how tinkering as a pedagogy "at its best" is inherently equity-oriented. The CTC facilitators' considerations varied by site such as engaging youth in culturally responsive activities, but many discussed equal access for all to opportunities to pursue youth interests and career development. These explicit discussions around equity tended to focus on what participants would have access to in these spaces, which ranged from access to materials, pedagogical experiences or career opportunities.

Alongside these explicit answers, we used the dimensions of equity adapted from questions posed by Vossoughi (2017) to identify other ways that equity emerged implicitly

Dimensions of equity	Library Makerspaces	Museum Making and Tinkering Space	Community Technology Centers
Access to what	Free and open access to tools, staff, spaces	Experiences designed with constructivist pedagogy	Free and open access to tools, staff, and space along with local and national network of resources
For whom	Open to anyone: all ages and all backgrounds	Museum visitors Formal and informal educators and local organizations	Focused on upper elementary to high school youth within the target population of the community-based organization
Based on whose values	Negotiating community and participant interests within facilitated activities and setting	Incorporating facilitators' perspectives and participants experiences into activity design over time	Varying perspectives from within and outside CTC but balanced with youth interests
Toward what ends	Participant achieves personal outcome Creative confidence, new ways of looking at tools and materials	Sense of wonder, agency, joy and new ways of looking at the world	Youth development and career readiness

Table 3.
Dimensions of equity across the three organizations based on interview analysis

Source: Authors' own work

in their responses to other questions in the interview, which are also included in Table 3. For example, LM facilitators responded to the explicit equity question by reflecting on providing access, but elsewhere in their interviews when they discussed their facilitation strategies, they talked about the importance of supporting participants' goals (toward what ends). As another example, when discussing goals for the kinds of experiences or activities they have designed, MMTS facilitators shared that while part of the goal is engaging learners in new possibilities with coding (e.g. mixing art and code through physical and digital mediums) they also wanted to support joyful learning experiences that cultivate a sense of wonder about themselves and the world. Facilitator Jenna shared:

> In a learning context, [joy is] like those moments with learners where you can see they are making discoveries and it's coming from a place of [. . .] That they're just bubbling up with excitement and wanting to express it in different ways. And I think a lot of it has to do with the fact that it's coming from their own motivation and their own questions that they've answered or something that they're surprised by.

The dimension of "toward what ends" allowed our team to surface goals and possibilities for participants that facilitators had in mind when designing their learning experiences. Looking at both how facilitators directly addressed the question of equity in their spaces, as well as considering the ways in which decisions that we interpreted as having equitable aims emerged, allowed us to see a fuller picture of facilitators' conceptions around equity.

This breakdown has been helpful in noting similarities and differences across the organizations. For example, LM and MMTS facilitators tried to engage a wide variety of participants, whereas the CTC facilitators focused on upper elementary students and teens. All facilitators negotiated varying values in their spaces from different groups (e.g. facilitators, external organizations) but tried to balance them with their participants' interests. At times, their conceptions were related to the constraints and affordances of each space. Unlike LM and MMTS sites which had more drop-in style engagements with

participants, the CTCs were embedded in organizations that cultivate longer term relationships with community members – an affordance that can support their goal of cultivating youth development and career readiness (toward what ends). These different conceptions of equity would then impact what they did in practice and vice versa (e.g. because they saw participants over time, they could commit to a more youth development perspective).

While Table 3 provides general themes for these dimensions, we want to note that facilitators responses' often cut across multiple dimensions, and that this complexity is obscured within this representation. In the next findings section, we dive into this complexity that emerges from looking across these dimensions.

5.2 Cross-cutting questions and tensions in practice
While these dimensions gave us a starting point to unpack what facilitators were saying implicitly and explicitly about equity, facilitators also shared the kinds of activities and challenges they experienced when trying to engage their youth in computing activities. In sharing more about *how* they were enacting their facilitation, facilitators revealed more of the complexity and tensions around enacting equity in their spaces while navigating their organizational values and goals around equity. In reflecting on these complexities and negotiations, facilitators shared the kinds of pedagogical decisions they made (e.g. what was readily available in the space, how they welcomed newcomers) that were informed by their conceptions of equity. For these reasons, our second extended findings section dives deep into some of the tensions and questions that arose for facilitators as they discussed equity in their spaces.

5.2.1 Aligning their commitments to expand possibilities and opportunities. When sharing experiences about incorporating activities or reflecting on their facilitation, we used the four dimensions from Vossoughi (2017) to note the ways they were enacting equity in practice. At times, their actions or reflections on their actions showed the ways in which their commitments across some or all of the four dimensions overlapped and aligned – reinforcing or expanding their work toward equity.

5.2.1.1 Expanding "for whom" by modifying "access to what": making the sewing machine accessible to young children. Not all tools and equipment may be accessible to young children in a makerspace such as a 3D printer or a laser cutter. For that reason, meeting their commitment of accessibility for visitors of all ages and backgrounds (for whom; as noted in Table 3) meant that LM facilitator Emilia also had to take into account different visitors' needs in terms of accessing tools and resources (access to what). Emilia described how some adults might think that young children cannot use a sewing machine:

> A lot of people think that kids, young kids, should not be using a sewing machine. Which they totally can. They're very careful [...] But they're little kids, they can't reach the floor, they can't reach the pedal, right? So we do adapt it, so we put maybe like a box underneath so that it reaches [...] The pedal reaches higher so they can still use it on their own.

By raising the pedal with a box, Emilia adapted her practice so that young children, who are not viewed as typical users of the sewing machines, were able to work with them, the same as adult participants in the space. In this example, Emilia was able to meet her commitments to "for whom" by making adjustments to the affordances of what people had access to (access to what) and expanding who might be able to access the tool. This is an example of a pedagogical decision that was directly informed by Emilia's conceptions of equity in the library makerspace.

5.2.1.2 *Considering "by whom" to connect to "for whom": facilitator positionality and participant interactions.* CTC facilitators Brad, Diego and Cate, and MMTS facilitator Sara highlighted different times when they reflected on their own social positions and goals (based on whose values) to consider how it impacts their interactions with their youth participants (for whom). For Brad, he shared his positionality as a white man in a predominantly African-American community and reflected on what role he could play to support his youth, especially when the George Floyd protests occurred. He emphasized his role in listening to youth and offering them a space to connect with other youth and facilitators. Similarly, Diego reflected on the work he and his organization, which primarily served a Latino community, needed to do to support youth after the George Floyd protests, specifically around issues of colorism.

CTC facilitator Cate and MMTS facilitator Sara discussed their positionality in terms of their professional and academic backgrounds in the context of their spaces. Cate shared that because she does not have a technology background, she positions herself as a learner with the youth members of her organization instead of being an expert. Like Cate, Sara also did not have a technology background. She shared hopes of designing computing activities that would appeal to someone like her, as she felt that an activity that felt welcoming to her would also be welcoming for the museum visitors and educators that visit her space (for whom):

> The diverse or divergent ways of engaging in [computing] is something that I would hope for because I would also hope I could see myself in that activity just like I would hope somebody else could see themselves there.

Reflecting on their social positions and values (based on whose values) in relation to the participants that they served (for whom) had implications for professional practice in terms of activity design and relationship building with youth.

5.2.1.3 *Resonance across dimensions in culturally sustaining practices: remixing Lotería.* We found one example in particular in which a facilitator's commitments across all four dimensions resonated to create possibilities beyond what he explicitly stated as outcomes of his spaces. CTC facilitator Diego worked in an organization that served the Latino community (for whom). Across the organization, staff had a shared commitment to culturally relevant engagement by grounding their approaches and activities within their Latino community (based on whose values). Diego shared an activity that remixed the traditional Mexican card game Lotería by producing new graphics with creative technologies:

> Mexican families basically play [Lotería], so we're designing, for example, all those icons, we're redesigning them in a more contemporary way. So we do graphic design and we're gonna do a new way of seeing the Lotería [. . .] I decided to bring [technology] here and use it as a tool of connecting with the culture and also engaging them and just learning, you know, how to do stuff, basically. Because that's basically what we do, we kinda get them started and get their interest going in different ways; by creativity, they'll be learning other things.

By engaging in these culturally relevant activities, Diego is able to introduce youth to new technologies and cultivate their creativity – and such activities can also be onramps to more opportunities in the space and beyond (toward what ends). In reflecting on why he takes a culturally relevant approach, Diego shared aspirations that went beyond engaging youth in learning how to use the technologies:

> [This is] a space where our youth can actually find a culturally relevant space to gather and to create ideas and to really know [. . .] that the space is their space [. . .] We are just there to kind of provide the support, but I really want to achieve that awareness in the community that this space is for the youth, for our community, that they can come and they can guide it in many ways.

While Diego shared this activity to describe an example of how he incorporates technology into his space, we found implicit equity work to engage Latino youth and community members. Diego wanted youth to see the CTC space as a space to share their ideas and connect with others who recognize their cultural heritage (access to what). Beyond access to the "stuff" in the space, Diego was also trying to provide access to a "safe" space for youth where they could feel welcome and have a place of belonging. Eventually, Diego hoped that youth and community members would develop a sense of ownership over the space and help shape what happens within it (based on whose values, toward what ends).

5.2.2 Tensions in aligning commitments and uneven outcomes in practice. Not all activities or facilitation practices aligned so neatly across the dimensions for facilitators, which posed different challenges and questions.

5.2.2.1 "For whom?" changing community demographics and who shapes a space over time. For some sites or facilitators, commitments were put in action at the start of an initiative but changing conditions complicated what occurred over time. In the following example, we share how early attempts by library staff to reflect the interests and needs of community members in their makerspace became challenged over time as community demographics changed. To select the location of any makerspace, library staff engaged in a process that assessed community assets and needs to ensure that a makerspace would serve especially high need areas. Once a location was chosen, the library staff involved community members in determining what to include in the makerspace rather than what is "Silicon Valley trendy" as one facilitator noted. This engagement included interviews and surveys with questions thoughtfully constructed to make them accessible to community members. Participants included a combination of people who regularly came to the library as well as those that did not. For example, based on community interests and feedback, one LM was designed to focus heavily on textiles and included sewing machines, embroidery and other textile-related crafts.

However, after the makerspace opened and time passed, facilitators became concerned about who actually took up these opportunities. Some LMs were in or near neighborhoods that were rapidly gentrifying, changing the demographics of the neighborhood and displacing former community members. Additionally, with a library-wide commitment to engage any visitors, some open and widely publicized opportunities sometimes reached families outside of their immediate communities. As a result, despite being offered in high-needs communities, these opportunities were being taken up by families who already had considerable access to technology learning opportunities in their own communities. In addition, an inability to anticipate who might attend, staffing levels and capacity limits, meant that facilitators were sometimes unable to welcome and adequately support all visitors in the space. At times Eric and his colleague were so occupied that they were unable to help others, especially first time users. Eric shared some of the consequences of when their two full-time staff members were overwhelmed by too many participants:

> That can cause someone to have a bad experience [. . .] then sometimes they'll just get up and walk out and you're like, "Oh, I don't [. . .] I wish I would have noticed that a little bit sooner to actually help them 'cause that would have helped improve their experience in what they wanted to learn or do."

Eric worried about who the spaces lost or failed to engage because they were unable to support them at the right time. These experiences shared by facilitators posed new questions to consider around equity that build on the four posed by Vossoughi (2017). While there might be initial commitments to whom a space serves, time and changes within a community's demographics or participation patterns can raise a new question of "Who

takes up the benefits of these opportunities?" Who participates in the space can also create tensions between commitments and reality in "based on whose values?" and "toward what ends?" as those who actually participate in the space can shape and influence what occurs and what is valued leading to another question: "How do the space and opportunities evolve based on who participates?"

5.2.2.2 *"Based on whose values?" balancing youth interests and facilitators' goals to bridge to new possibilities.* While all facilitators described a *commitment* to youth interests (for whom, based on whose values), how facilitators and spaces *perceive* youth interests can influence what happens in the spaces (access to what) and for what purposes (toward what ends). CTC spaces in particular aimed to connect youth to college and career trajectories by building on and expanding youth interests toward new possibilities (toward what ends) which, in turn, impacted the kinds of experiences CTC facilitators provided (access to what). For example, CTC facilitator Brad shared job training programs with youth, encouraged youth to explore popular STEM careers in the area and partnered with a local university to connect youth to relevant programs (access to what). At the same time, Brad tried to be sensitive to how youth responded to these opportunities, which sometimes led him to throw out opportunities he had developed. Facilitators must engage in a balancing act as they navigate youth interests as well as their goals for expanding and bridging youth interests.

This balancing act can be tricky as facilitators curate tools, activities and opportunities from external partners or organizations, as these external resources can be embedded with differing values. CTC facilitator Cate shared how she engaged youth in engineering activities through Meta's "Engineer for the Week," a program where educators can sign up and receive resources to engage their students in a week-long "sprint" around a challenge designed by Meta. She used the resource because it provided some instruction around STEM activities she wanted to promote (access to what). However, Cate had to tweak the provided curriculum because at times the activity was too directed and went against CTC values to support exploration and the development of youth interests (based on whose values).

5.2.2.3 *"Based on whose values?" negotiating differing values across organizational relationships.* MMTS facilitators often worked with other community organizations and provided making and tinkering activities onsite to expand who they might engage with their activities (for whom). Once at the organization, however, facilitators encountered different norms and values around participation that sometimes contradicted facilitators' commitments to equity. Facilitator Primo shared a tension around who the organization allowed to participate in their activities:

> I wanna say day one even, of my work with [community organization], was the idea of tinkering and enrichment [. . .] as icing to a cake of behavior. And that there is, "So-and-so, sorry, you're not invited to tinker [. . .] You spoke up. You said a bad word. You punched somebody. You did this, you did that. You disobeyed some kind of rule. You're not invited here."

Staff at the hosting community organization would remove students from making and tinkering activities provided by Primo if they deemed their behavior inappropriate. Primo recognized the problematic practices of discipline in out-of-school spaces, but they struggled with how to navigate this norm, especially since they were "visitors" at the site (based on whose values). As Primo continued to regularly work with the organization through an afterschool program and build relationships with staff and students over a period of years, Primo tried to shift staff members' perspectives on how tinkering spaces can enable working out challenges with students:

The phrasing that I've used with the [community organization] and staff is to say, these are the spaces where we can work stuff like that out because it's built on collaboration, and it's built on elegant adoption of another person's idea or elegantly exerting your own idea in a space that is by nature populated with other people.

Primo tried to emphasize to staff at the community organization that he was ultimately trying to cultivate a collaborative space that respects multiple perspectives and ideas. Rather than removing students, Primo wanted to better understand the interests and ideas of all students so that they can design the learning environment to invite them rather than exclude them (based on whose values, toward what ends). The kinds of negotiations that facilitators must engage in pose new questions of whose values are prioritized, how and when? Primo negotiated and worked to shift those norms toward more equitable participation.

6. Discussion
Using this adapted framework allowed us to distill facilitators' conceptions of equity along other dimensions beyond access to also consider questions of for whom, based on whose values and toward what ends. We found strong alignment of facilitators' conceptions of equity along their different informal learning organizations and distilling their conceptions into these dimensions also allowed us to compare across these organizations (Table 3). We saw how each organization was committed to values of community development and engagement in ways that led to more equitable outcomes in making and tinkering (Sheridan and Konopasky, 2016; Vossoughi *et al.*, 2016). At times, their conceptions of equity were enabled or constrained by their community and organizational contexts, such as CTC facilitators being able to have repeated engagements with youth compared to LM facilitators who had more drop-in and ephemeral engagements with participants.

It was not enough to unpack their conceptions into neat categories, and instead we also focused on the ways that these dimensions overlapped or were in tension with each other in practice. This work highlighted the versatility of the theoretical framework in how it guided our understanding of the complexity of facilitators' equity work in their making and tinkering spaces. When dimensions overlapped, we saw resonance in their practices to achieve new possibilities, such as how Diego leveraged the game of Lotería to both engage youth with technology and to cultivate a space that valued their cultural backgrounds. These examples add to existing research that shows how minoritized communities can engage in making and tinkering in meaningful ways (Calabrese Barton *et al.*, 2017) while also challenging the white and middle class values that have been historically common in the maker movement (Vossoughi *et al.*, 2016). In contrast, facilitators' experiences illustrated how challenging it can be to achieve exact alignment along dimensions of equity, such as how they negotiated differing values in organizational relationships or external resources. Additionally, tensions emerged because of forces out of their control such as a changing demographics in a gentrifying neighborhood. Many of these tensions have not been adequately explored in the making and tinkering literature and provide useful starting points for future research.

As we examined the tensions and challenges that facilitators shared, new questions and dimensions emerged for us that complemented and complexified the original four questions that Vossoughi posed to push equity-oriented researchers and educators beyond considering access. For example, after initially assessing communities' needs and interests to design what opportunities are available in their spaces (access to what), how do making and tinkering spaces meet the changing social, economic and political contexts of their communities and how does it influence their initial commitments to equity? Who takes up

the benefits and who participates in a space's evolution (for whom)? Some facilitators were reflective of their own positionality and how it impacted their practice. In considering for whom, how do facilitators consider "by whom," or the role that they play as facilitators in shaping how they develop relationships with participants? And how do facilitators conceptualize participants (for whom)? Additionally, as facilitators balanced the varying values that were showing up in their spaces from different groups and organizations, how were values also showing up in external materials, technologies and resources (based on whose values)? How do facilitators interpret, interrupt or reify the values in these objects, which were developed by external actors, and how do these values impact what outcomes facilitators aim to support (toward what ends)? These emergent questions highlight how much facilitators must navigate, and must be part of ongoing conversations between facilitators, researchers and designers as they work toward equitable futures in making and tinkering. There is always an opportunity to delve more deeply into issues of equity in making and tinkering spaces, and for many of the facilitators who took part in this research, orienting their work toward equity felt like a moving target, requiring ongoing reflection and practice.

Our work builds on existing research into equitable pedagogies (Vossoughi *et al.*, 2021a, 2021b) and project/activity design for nondominant youth in making and tinkering (Calabrese Barton *et al.*, 2017; Kafai *et al.*, 2009) to focus on the people who bring those pedagogies and activities to life: the facilitators. While this analysis helped us to surface facilitators' negotiations to enact these conceptions, future work will focus on data collection that captures facilitation in action to determine how these conceptions shape facilitators' daily practice. We continue to conduct "share-backs" with facilitators who participated in the interviews as well as their colleagues – which have become valuable sessions for facilitators to reflect on their individual and collective journeys developing their capacities to support equitable learning spaces. As LM facilitator Amy shared:

> There's never going to be a like, we designed the perfect mission statement, and now we're done. Equity accomplished. You just have to check in with people all the time and have a lot of really honest conversations.

In these share-backs, reflecting back their conceptions and engaging in the dimensions of equity have helped to surface facilitators' conceptions. However, we have learned in our share-backs that surfacing conceptions and assumptions are just initial steps and educators seek more resources to challenge and push themselves further.

We want to emphasize the essential investment in facilitators' ongoing professional development. Informal learning organizations can engage communities that have been traditionally marginalized in STEM by supporting academic outcomes as well as imagining new futures that are grounded in the values of youth and their communities. However, to realize this potential, facilitators need support and resources both within and beyond their organizations. In addition, the voices and experiences of facilitators must be central within these resources and learning opportunities, such that they are responsive to their day-to-day opportunities and challenges. While there are many resources developed for facilitators to support making and tinkering in their spaces, there are relatively few resources that support facilitators in negotiating their equity-oriented work within the differing affordances of their spaces and commitments to equity (e.g. see pedagogical "zines" from Blue Dandelion: www. bluedandelion.org/zines). Resources developed in collaboration between facilitators and equity-oriented researchers are especially needed to more specifically address the persistent issues of practice and power within these spaces (Vossoughi *et al.*, 2020).

Additionally, building these systems of support cannot solely be the responsibility of the facilitators; the development of policies, practices and resources must be a collective responsibility of all members of the organization to facilitate alignment at all levels, from the youth up to organization leaders. Leadership in informal learning organizations need to recognize that facilitators need time and space to reflect on their ideas of equity on their own and with their colleagues as well as thoughtfully designed professional development opportunities that can deepen facilitators' reflective capacities as equity-oriented educators (Ash *et al.*, 2012; Tran *et al.*, 2019). On a regular basis, informal learning organizations should work collaboratively with staff and participants in their space, including youth and families, to co-construct and revisit their conceptions and commitments to equity as their communities' social, cultural and political context shifts over time – and what these shifting contexts and commitments mean for the structures and policies within their organization.

Our study is embedded in a larger collaborative effort across informal learning and academic institutions with a commitment to orienting our shared work toward equity. Our share-backs have been an effort to also align commitments across institutions and organizations but, as we surfaced conceptions of equity, we realized that aligning our commitments also felt like a moving target. Differences are necessary, especially as organizations work with different communities and have varying affordances and constraints. While aligning commitments might be an initial and core step in collaborative initiatives such as research–practice partnerships or participatory design work across organizations, we have learned that it requires ongoing discussion, reflection and action throughout the life of the collaborative work. This work is necessarily messy and complex, and if it is only undertaken at a surface level (or skipped entirely), it can impact the success of educational innovations. We hope that this work has highlighted both the frameworks and processes that can be valuable for researchers and educators to collaboratively surface and navigate their work toward more equitable futures in making and tinkering.

Notes

1. We use the phrase "making and tinkering space" rather than "makerspace" as not all spaces that leverage making and tinkering approaches to learning self-identify as "makerspaces." Additionally, (Calabrese Barton and Tan 2018) note that the phrase "making and tinkering" can help "call attention to the manner in which making takes shape (and the learning and trajectories of makers) is always in dialectic with the dynamic culture that surrounds it, rather than only the physical space itself" (p. 764). And so, for the remainder of this paper we use the phrase "making and tinkering" to refer to spaces that engage in these practices and include settings such as makerspaces, media and technology centres and emergent tinkering spaces.

2. To avoid confusion, outside of this section we use "facilitators" to refer to the facilitators who participated in our research and "participants" to refer to the children/youth/adults who participate in the various making and tinkering settings.

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Corresponding author

Ricarose Roque can be contacted at: ricarose@colorado.edu