

9. Challenges in Facilitating Computational Experiences in Informal Learning Environments

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Abstract: There is growing interest in implementing computational resources, technologies, and experiences in informal learning environments like museums, makerspaces, libraries, and community centers. In this paper, we highlight six shared challenges facilitators in three different informal learning contexts encountered in designing and implementing computational activities for their participants. These challenges touch on facilitators' identities, the relevance of existing materials, infrastructural constraints, visitors' perceptions of computational tools, issues of equity, and technical challenges.

Introduction

Informal education spaces are uniquely positioned to support learners, especially those historically and currently marginalized in STEM (science, technology, engineering, and mathematics) spaces, in developing confidence and interest in STEM and computing (Horn, 2018; Rahm, 2008; Roque, 2016). Carefully designed STEM activities center creativity, expression, and personal meaning-making, leading to STEM identity development and consequential learning for learners of all ages (Archer et al., 2022; Barton et al., 2017). We refer to the informal educators within these spaces as *facilitators* to reflect their roles in sparking, sustaining, and deepening learners' STEM experiences (Gutwill et al., 2015). Challenges arise as informal learning environments include making and tinkering spaces for creative interactions with new tools, technologies, and knowledge. At the institutional level, they may face budget constraints, copyright issues, and challenges in creating connections with their communities (Abbas & Koh, 2015; Slatter & Howard, 2013). Facilitators in these spaces also face challenges, such as not having enough staff to provide learners with one-on-one support (Abbas & Koh, 2015; Moorefield-Lang, 2015) or feeling that a wide range of disciplinary expertise is needed to support their learners' diverse interests (Bers et al., 2015).

Beyond this broad look at challenges informal making and tinkering spaces face, few articles have focused on challenges specific to implementing computing-based activities in these spaces. Braun and Visse (2017) and Martin (2017) highlight how librarians face challenges as they implement new coding initiatives, and note that librarians need resources such as high-quality professional development experiences to feel comfortable facilitating computational experiences. Riedy et al. (2019) found that computational materials in informal making and tinkering spaces can introduce tensions for facilitators, particularly when their goals as educators diverge from their learners' goals. Roque and Jain (2018) emphasize that adopting a "tinkering mindset" can help facilitators address some of the tensions and challenges that emerge when engaging learners in computing-based activities.

In conversation with existing literature, we ask: *what challenges do facilitators face in implementing computational activities in their spaces?* We are particularly interested in how challenges in informal STEM education spaces intersect with the tools, knowledge, and perspectives on computing held by facilitators and learners. To that end, this study aims to broaden the understanding of computing-specific challenges in informal STEM learning spaces by drawing on interviews with facilitators across various sites, including library makerspaces, a science center, and community technology centers. Making these shared challenges visible can support practitioners, designers, and researchers in grounding the design of computational activities and tools in the experiences of educators who engage their learners in these topics.

Method

Interviews

A pair of researchers conducted 90-minute semi-structured interviews with 16 interviewees from Fall 2020 to Spring 2022 with three organizations distributed across the United States: a network of makerspaces situated within public libraries (six interviewees) in the Mountain West, a making and tinkering space within a science center (five interviewees) in the West, and a network of community technology centers (five interviewees) throughout the US. These sites are part of an ongoing research project called “Facilitating Computational Tinkering” – a collaboration between university researchers and informal education spaces to design more equitable, social, and interdisciplinary ways of engaging with computing.

Leadership from each of the partner sites nominated a group of facilitators within their networks or institutions and we contacted each facilitator to invite them to participate in the interview study. Participants had a variety of backgrounds and roles in their organizations. The duration of facilitators’ experiences in their current roles varied from less than a year to more than ten years. Except for one participant, none of the participants had formal educational or professional backgrounds in computing. The interviews took place over the video conferencing platform Zoom due to COVID-19 impacts. The main goal of the interviews was to uncover participants’ goals, facilitation, and challenges of incorporating computing into their spaces. We grounded the interview by asking participants to share a computing or design-based activity. We also asked questions about their personal and professional goals, backgrounds, impacts of the COVID-19 pandemic on their practice, and how they think about equity in their spaces.

During their interviews, facilitators shared diverse examples of computational and design-based activities in their spaces. As a research team that believes in expanding notions of what “computing” can look like in informal spaces, we did not explicitly define computing in our interviews. Therefore, facilitators’ explanations of computational activities varied widely. These activities included topics such as using computer software to create files for digital fabrication tools (e.g., laser cutters and 3D printers), engaging in video production, programming electronic tools like the raspberry pi, exploring coding platforms like Scratch, and combining programming tools with physical materials (e.g., programmable motors and instruments).

Analysis

Recordings of the interviews were professionally transcribed. A team of three researchers then engaged in an iterative cycle of analysis. We recorded initial impressions of the data by open-coding a subset of the transcripts and used memo-writing to keep track of emerging themes. These themes were brought together into an initial codebook. Broadly, this codebook captured themes of participant backgrounds, challenges, computing (including tools and materials, activities, and perspectives), goals, COVID-19 impacts, facilitation practices, and equity. We iterated on this codebook by coding interviews together, clarifying, and adding definitions as needed. After researchers reached a shared understanding of the codebook, they divided transcripts among team members and coded each transcript using the codebook.

For this paper’s analysis, we looked at intersections between two codes, “challenges” and “computing,” in the facilitator interviews. Challenges included moments where participants expressed feeling unsure what to do, encountering something they did not expect, encountering a dilemma, identifying a barrier, or any other unexpected or challenging issue – as explicitly specified by the participant and interpreted by our research team. Computing had three subcodes: tools and materials (materials for computing activity, technology-based tools, computationally produced artifacts, and other resources to support computing), activity (description of computational activity design, assessment, goals, and

outcomes), and perspectives on computing (what facilitators believe counts as a computing activity). Segments in which these codes intersected were analyzed thematically, resulting in six themes, which we will explore next.

Findings

In our analysis, we identified six themes related to facilitators' challenges in incorporating computing into informal STEM learning spaces, which we illustrate in the following sections. We describe common challenges shared by *at least one facilitator at each site* (a total of at least three facilitators) to ensure that the challenges described are cross-cutting and not specific to a single site.

Facilitator's discomfort with computing

Facilitators reported varying levels of comfort, familiarity, and confidence with computation. Several facilitators described themselves as being less comfortable with computing saying things like, "I'm no expert at coding or Scratch or anything like that" and "[coding]'s not my strong suit." Brad, a community tech facilitator, described how this challenge intersected with the material and technology richness of his space:

It's hard to meet the demands of every kid every day... I can't go from not knowing coding this week to... Yeah, I can teach someone next week about [coding]. So just trying to be an expert in several different areas can be a challenge..." (February 2021 interview)

Amy, a facilitator in a library makerspace, shared a similar discomfort. Amy positioned herself as a co-learner whose role is to help learners become experts, but noted that this strategy was not always well-received by some of the visitors in her space:

I will say like, "I'm here to help you become an expert. I don't know everything, and there's probably gonna be things that we'll have to learn together, and that's totally fine." Which some people very much do not like. There are some adults who want me to say, "You're right, I do in fact know everything about computers and how they work"... (November 2020 interview)

Amy noted that some learners expected her to deeply understand computing. Brad described why that could be challenging in informal STEM spaces that are material and technology-rich – facilitators might be expected to have expertise with many different tools, machines, and materials in addition to computing.

Lack of accessible, adaptable, and relevant computational resources

According to facilitators, learners come to their spaces with diverse personal interests, varying technical and computational experiences, and different cultural and linguistic backgrounds. Facilitators valued this diversity and described the need to be prepared to adapt activities and to provide well-translated culturally relevant resources to support their visitors. For example, Cate, a community tech facilitator, explained how the language and reading skills embedded in some computational tools could create barriers for some learners:

It's funny because I think coding is supposed to be like a universal language, but there's a lot of language involved with learning it, I would say. And so he [a participant in the space] was trying it and he was really engaged and

bought in like, “Yeah, this is something I should learn,” but there was just paragraphs of reading for him [to do with the activity], and that was difficult... (February 2021 interview)

In addition to literacy-related challenges, Jenna, a science center facilitator, described the challenge of facilitating coding activities for families in her space, stating, “It’s harder with different activities, especially with coding one sometimes.” Finally, Anna, a library makerspace facilitator, mentioned that it could be challenging to make connections between learners’ interests and computing when other tools or activities in the space might better facilitate this connection:

If people come in and wanna use the embroidery machine... it’d be pretty hard to be like, “Oh yeah, you could do this coding thing and make some weird designs,” but they also see that it can make Pikachu so it’s a hard sell... (February 2022 interview)

In this case, the goals of a coding activity may not align with visitors’ goals, which in this context was wanting to recreate popular images on a fabrication machine. In short, the facilitators we interviewed were interested in and saw value in providing their visitors with opportunities to engage in computation. However, facilitators emphasized the importance of resources that are accessible, easy to adapt to different learners, and relevant to learners’ goals.

Lack of one-on-one support in busy, “drop-in” spaces

Facilitators’ workspaces are typically structured as drop-in spaces where visitors choose how long they stay in the space and how often they return. While many sites also offer workshop-style programming, facilitators spend much of their time with learners facilitating drop-in interactions. During drop-in time, facilitator-to-participant ratios can vary widely from one facilitator and a few participants to one facilitator and 20 or more participants. Typically, the facilitators we interviewed worked in pairs within their spaces.

Many facilitators, like Diego, a community tech facilitator, emphasized the challenge of trying to support many participants during drop-in times. Diego said, “Honestly anything over 20 students, it’s just overwhelming, it’s just really hard to pay attention to kids.” Facilitators like Anna, a library makerspace facilitator, noted that facilitating computational activities during drop-in time can be particularly difficult because these activities are conceptualized as requiring more one-on-one facilitation. Reflecting on introducing a robot-building activity during their drop-in time, Anna described the challenge of supporting and sustaining kids’ participation towards meaningful progress:

It’s hard finding that balance where if we’re just busy helping other folks, how quickly can we get them the assistance they need and how much help can we give before they kinda lose interest... I definitely know that one-on-one [interaction] makes such a difference. (February 2022 interview)

Anna identified one-on-one support from a facilitator as helpful in guiding learners as they explored the kit, but noted that offering this support is challenging when the space is busy. This challenge was echoed by several facilitators, highlighting the importance of attending to facilitator and participant interaction structures, particularly when computational tools and materials are involved.

Visitors’ associations of computational tools with school learning

Providing a space that feels complementary to but distinct from school was a goal that several facilitators shared. Traci, a community tech facilitator, described this goal by saying, “we’re just there to allow them to find what they love and give them freedom....” Some computational materials, like certain coding environments, were described by facilitators as

being in tension with this goal because their visitors perceived them as “too much like school.” Cate, a community tech facilitator, shared that some of their learners viewed Scratch as a classroom tool:

Sometimes kids just don't like it, especially because they think Scratch is used in the classroom a lot, and so they're like, “Oh, we do this in school, so I don't know if [we] wanna do this here”... [I] definitely sometimes have to convince the kids to use Scratch, 'cause they're not super into it right away.” (February 2021 interview)

That said, learners' familiarity with Scratch from school can lead to additional challenges when facilitators attempt to use Scratch to engage learners in computing. Cate went on to describe how some of her learners are very familiar with Scratch and are looking for opportunities to learn different computational skills:

And so, I think when kids think about doing Scratch outside of school they're like, “I already know it all. I just, I've already learned it, I don't need to do it again.” [...] for the kids who really start to learn coding, like who've done Scratch and really understand coding, they wanna do something that's more real, like something that they're gonna do, and especially those older teenagers, something that they're gonna use in a job... (February 2021 interview)

Beyond Scratch, Amy, a library makerspace facilitator, shared how teaching programming languages at her site can become a challenge for younger learners because teaching languages such as Python or JavaScript can feel too much like formal instruction:

We absolutely have taught classes, especially for adults that are more of like, here is how to use Python, here is how to do JavaScript. But I feel like for kids and teens, it's a snooze fest. It's too much like school. (November 2020 interview)

In this way, supporting learners' computational interests can be a balancing act for facilitators who want to engage participants in expressive and open-ended computational experiences that children do not typically experience in school while still supporting skill development in new programming languages and other forms of computation.

Inaccessibility of computational tools and materials

Facilitators often spoke about the importance of providing their learners with access to computational materials and tools. However, facilitators noted that neither they nor visitors always had access to computers that could run the various software they wanted to promote in their spaces. For example, the library makerspaces included access to Chromebooks, which were not always compatible with the computational tools they wanted to use in activities. Anna, a library makerspace facilitator, noted that “we only have Chromebooks in our space aside from the free-standing computers... Chromebooks don't run anything.” The Chromebooks limited the activities and workshops the facilitators could design and run.

Additionally, even if the spaces had access to appropriate technology, it did not mean that visitors had access to such technology outside of their visits. This disparity was viewed as an equity issue, as voiced by Leonardo, a science center facilitator:

I mean, the big issue in question that is unresolved for me is access to materials and tools for computational stuff. And a lot of times there is just that hard limit of like kids don't have computers. And what's the answer to that. And how does that not propagate existing inequities that kids with access, they get even more access, and kids without access get left out. And as we think about how to work with populations of and collaborators... can we build in access to these tools, but in a way that... builds towards this becoming a permanent thing, that it's

not just like, oh, you have access to this for the duration of this project, but then we take it away. (October 2021 interview)

Leonardo described a tension that several facilitators shared: they wanted to provide access to high-tech tools that are not typically accessible to visitors outside of their spaces due to the cost of the tool, but they also wanted visitors to be able to continue explorations they started in these spaces, at home. They worried that access to their spaces might become a form of gatekeeping, where some learners only have access to computational tools and materials at specific times.

Uninteresting technical challenges

Because technologies like computers and microcontrollers are often part of computational activities, facilitators and their visitors may encounter various technical challenges when engaging in computational activities. These challenges are sometimes described by facilitators as “uninteresting” or “unproductive” because, in the context of the activity, the challenges are unnecessarily frustrating and misaligned with many facilitators’ goals for their visitors to engage with computing in fun and open-ended ways. Jenna, a science center facilitator, described an activity where learners got stuck during the setup of the activity instead of focusing on the actions that could be carried out through the code:

I think of them as the sticking points, the points where it’s actually really easy to lose people if it’s not a smooth process. So if it’s too hard to scan a Sprite into a digital project, that seems like a little moment, but actually it’s a really important moment. (March 2021 interview)

Jenna worried that learners might lose interest and miss an opportunity to fully engage in the experience because of these uninteresting technical challenges. Leonardo, a science center facilitator, echoed this worry, stating:

They were frustrated by the fact that in order to just turn on a light, you have to use a [programming environment on the iPad], like it was the most impractical switch I’ve ever devised. I just want this thing to be on, and now I have to go through this complicated [process]. (February 2021 interview)

In these cases, facilitators recognized the importance of paying attention to learners’ frustrations during computational activities. When the challenges that learners encountered crossed a line into “unnecessary” or “uninteresting” rather than an important part of the learning, debugging, and problem-solving skills in computing, facilitators became concerned that these challenges might discourage learners from engaging in computation.

Discussion

To design high-quality computational learning opportunities for informal education settings, we must understand facilitators’ barriers to incorporating and implementing computing. Informal learning spaces have the potential to meaningfully engage historically marginalized communities as facilitators craft learning experiences that are relevant and expand notions of what topics like STEM and computing can look like. However, striving towards these ends requires deep and critical thought about the challenges facilitators face, and potential solutions. Our results highlight six challenges that align with previous research on the challenges that facilitators navigate, e.g., facilitators’ perceptions of their expertise impacting their comfort with facilitating certain activities (Litts, 2015) and informal learning spaces requiring a high level of adaptability and flexibility in facilitation (Koh & Abbas, 2015). However, our results dig deeper into how these challenges manifest in computing activities specifically.

Although the challenges we described were shared between sites, their details and level of impact varied. For example,

facilitators in library makerspaces with limited funding found access to technology more challenging than facilitators in the science center, which had different sources of funding and visitor demographics. The community tech center had a free membership model, and facilitators anticipated that members would regularly visit. However, facilitators in the libraries and science center noted that while some visitors returned regularly, most were one-time visitors. Many of these challenges are complex and do not necessarily have simple solutions, as they are intertwined. For example, uninteresting technical challenges can intersect with a lack of one-on-one support for participants; a participant encountering a frustrating technical issue could experience even more frustration without one-on-one support from a facilitator. For these reasons, we believe that an in-depth understanding of these challenges requires attention to the complexity of practice within each institutional context.

The heterogeneity of the challenges also leads to variations in how facilitators at each institution may respond to them. The facilitators we interviewed are already exploring ways to address the challenges we raise here, such as leveraging networks of peers and mentors with computational expertise and limiting participant capacity during new computational activities to provide more one-on-one support. Prior literature may also offer suggestions for how to address some of these challenges, such as creating opportunities for computing-specific professional development opportunities (Braun & Visse, 2017) for and with facilitators, or designing and creating activities and materials that are culturally relevant for learners (Scott et al., 2010). Of particular interest to our research team is the goal of broadening what counts as computing in terms of materials, activities, practices, and knowledge that builds on the histories and everyday experiences of youth, families, and other community members such as facilitators. Computing does not require microcontrollers or text-based coding exclusively but can also involve everyday materials and personally relevant storytelling and activities (Tzou et al., 2019). We note that these solutions cannot be transplanted from one context to another. Researchers and practitioners must take the time to deeply understand the context, its limitations, and its affordances so that solutions can connect with existing practices and routines. Additionally, practitioners must play an active role in this solution-building process rather than it being driven solely by researchers (Hladik et al., 2021).

In our future work, we aim to collaboratively address these challenges with facilitators across these spaces by engaging them in the co-design of computational activities and making the solutions they have already designed visible. We hope the co-design process can support the development of facilitators' identities as designers, creators, and facilitators of computational learning experiences.

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