# Centering and Decentering Participation in Public Computing Through Co-operative Action

Basak Helvaci Ozacar, Stephanie Hladik, Marie-Claire Shanahan, and Pratim Sengupta
basak.helvaciozacar@ucalgary.ca; skhladik@ucalgary.ca; mcshanah@ucalgary.ca;
pratim.sengupta@ucalgary.ca
University of Calgary - Werklund School of Education

**Abstract:** In this study, we focus on how different kinds of participation negotiation play out in public computing exhibits among family members. We examine how children's ideas, knowledge and desires are centered (or not) in public computing and how that influences the types of engagements that families have in a public computing environment. We present an analysis of three cases, each showcasing different patterns of interaction. In one case, a preverbal child is centered in their interaction through the actions and utterances of her parents. In another case, a father provides translation support such that his daughter can make her desired code changes a reality. Finally, we present a case in which the father's actions and words strongly guide the interaction, decentering the goals of the child. Our study has implications for future research regarding family interactions in museums, as well as the design of informal learning environments.

## Introduction

Family behavior and learning in informal science settings have been studied for a long time (Dierking & Falk, 1994; Zimmerman and McClain, 2014) and recently computational programming and simulation exhibits in science museums have received considerable attention (Hsi & Eisenberg, 2012; Horn et al., 2009; Lyons et al., 2015; Horn, 2018). These studies show the possibility for young learners and their families to engage meaningfully in practices of computational modeling and scientific reasoning within and across STEM disciplines. We believe that designing public computing (Sengupta & Shanahan, 2017) environments in science museums further deepens the emphasis on supporting authenticity in visitors' engagement in informal science spaces (Evans, Mull, & Poling, 2002; Dillon et al., 2016; van Gerven et al., 2018). Sengupta and Shanahan (2017) introduced public computing "as a new form of open-ended, public learning environments, in which visitors can directly access, modify and create complex and authentic scientific work through interacting with open source computing platforms" (p. 1124).

In their influential review of family behavior and learning in informal science settings, Dierking and Falk (1994) conclude that family interactions cannot be ignored as learning experiences and that interactions between parents and children are complex and multifactorial. They argue that researchers must be open to considering many different experiences as learning. Kisiel et al. (2012), for example, ground their work in mediated action, examining how scientific reasoning in informal science learning environments can include cultural tools (exhibits, signs) and interaction between individuals. They illustrate that various types of scientific claims-evidence reasoning can be observed in exhibit spaces and that these activities are distributed among the multiple people at the exhibit and the exhibit itself. Kopczak et al (2015) investigate the nature of family talk at touch tanks, focusing specifically on talk related to ecological concepts. They found that exhibit facilitators play an important role in supporting and scaffolding parent-child talk.

In examining the literature on family interactions, however, it is important to note that Kisiel et al. argue that family interactions are highly contextual to the setting and the scientific context of the exhibits. We cannot necessarily generalize how families will learn and interact in exhibits of different types. Within computing learning experiences, opportunities for agency, for having one's ideas and knowledge valued in group activities is a very important influence on future participation in computing activities (e.g., Hodari et al., 2016). In another context, Zimmerman & McClain (2014), focusing on intergenerational learning at a nature center, reported that many families created participation frameworks to organize their activities. Some of those frameworks aimed to solve family disagreements and some were created so that all family members' prior knowledge and contributions were valued. The authors also concluded that families built ideas together, and sometimes sacrificed scientific accuracy to ensure that a child's idea could be included (Zimmerman & McClain, 2014). Here we focus on how these kinds of participation negotiation play out in public computing exhibits. We examine how children's ideas, knowledge and desires are centered (or not) in public computing and how that influences the types of engagements that families have with them.

## Theoretical framework

Our work is grounded in a *phenomenological* approach to computing (Sengupta, Dickes, and Farris, 2018; in press), that stands in contrast to a *technocentric* approach (Papert, 1987). The phenomenological approach focuses on the *sense experiences* (Merleau-Ponty, 1962) of the learners and participants, and arises from the concern that much of computing education research remains grounded in technocentrism, i.e., the fallacy of referring all questions about technology to the technology itself. In technocentric approaches to learning computing, the focus remains on the "charisma" (Ames, 2019) of the computing infrastructure (hardware, software) as the driver or the seat of learning (Sengupta, Dickes, and Farris, 2018; in press). A phenomenological perspective, in contrast, orients our attention to how the learners and participants are *experiencing* computing *in context*, and also calls for explicit attention to multi-modality of their experiences (Sengupta, Dickes, and Farris, 2018; in press). A particular danger of technocentric approaches is that we might not recognize the value of assistance provided by adults during young learners' experiences of computing and making (Vossoughi et al., 2017). This is particularly important for our study, because of the central role of adult-led facilitation plays in the specific context of our work, as well as in science museums.

We adopted Goodwin's (2013) notion of *co-operative action* as a *phenomenological* (Sengupta, Dickes & Farris, 2018) lens for analyzing family interactions with public computing. This perspective sees all human action as a continually unfolding process, where actors use, adapt and transform available semiotic resources both from the immediate contributions of those around them and the accumulated meanings available in tools, languages and surroundings. Each action or conversational turn of using, adapting and transforming creates a new present with new resources available to the next contributor. In a simple example that happens outside numerous schools each morning, a parent might say "Here, you take the backpack" and the child responds "No, *you* take the backpack". Most of the words might first appear to be straightforward repetition, but repurposing them in this way creates new and cumulative meanings that might invoke frustration or defiance and may even be drawing on resources created through the same disagreement over and over each morning. Goodwin labels these accumulating resources as a public substrate from which further action emerges and is built. These actions are built by performing systematic and selective operations, such as reuse, decomposition and transformation on the public substrate. For example, Jornet and Roth (2015) examine how students' prior shared experiences create a substrate from which they can make meaning of various scientific models and representations together. Goodwin (2013) examines the concept by illustrating how a man whose words were limited to combinations of Yes, No, And uses the resources available from the contributions of others and spatial relationships in the environment to communicate complex ideas. This framework provides a valuable way of making sense of how ideas, desires and agency are taken up as families work together in public computing.

Access to meaningful opportunities to modify, explore and play with simulations and their open-source code for all potential visitors, including children, is one of the key goals of public computing spaces (Sengupta & Shanahan, 2017). In this paper, we ask: When families interact in a public computing exhibit, who are the actors who contribute to the co-operative action of the family group? Are children's contributions centered and taken up as meaningful elements of that action?

## Methods

### Setting

The setting of this study is an open source, public computing exhibit called Hack the Flock in Telus SPARK science museum in Calgary, Canada, pictured in Figure 1. The exhibit is located in the Open Studio gallery, an area of the science museum in which visitors are encouraged to tinker, play, and explore with professional tools. The Hack the Flock exhibit consists of a large screen and a table which has a computer monitor, mouse, and keyboard attached to it. On the large screen behind the table is the boid (bird-droid) flocking simulation. The exhibit is designed to allow visitors to alter various aspects of the boids, including their group flocking parameters (alignment, cohesion, and separation), as well as their individual physical properties such as shape, colour, and size. The computer code for this exhibit, all of which is accessible to visitors, is written in the "Processing" programming language which enables developers to create visuals and simulate the interactions between them more easily than in many other languages. Most basic changes in the code can be done in one of two ways: changing a number in the code or commenting/uncommenting (turning on/off) lines of code.

### Data collection

Over a period of four months, we video and audio recorded interactions between the facilitators and the visitors at the exhibit. The video recordings captured discourse, physical movement, gestures, interactions with the simulation, and changes made to the code. A total of 84 videos were recorded, ranging in length from 50 seconds to one hour (median length of 13:46). Of those 84 videos, 10 videos involved family interactions, which we defined as visitor groups that involved at least one child and adult interacting at the exhibit and with each other.


Figure 1. Hack the Flock exhibit.

## Analysis

Our initial analysis consisted of re-watching each of the 10 family interaction videos and choosing three that represented potentially distinct types of child-centered action based on differences in age and language that would likely influence the co-operative action. Case 1 involved two parents and pre-verbal child. Case 2 involved a father-daughter dyad where the school age daughter's first and most comfortable language was not the language of the exhibit. Case 3 involved a father-son dyad with an adolescent son.

These videos were transcribed and divided into several action sets (Goodwin, 2013), where each action set was determined to center around a particular code fragment or a change that the group made in the code. Then, from the transcripts and videos, we created diagrams of the actions in each action set. The diagrams identified the participants (e.g., Mother, Father, Child, Facilitator) and illustrated the ways in which each participant, in turn, engaged in transformation of the substrate that the group had created. We focused on how all actions could be examined as examples of co-operative transformation zones "that decompose and reuse current resources to create something else." (Goodwin, 2013, p. 17). Each action set illustrates a complex set of interactions between the participants, the facilitator, and/or the physical exhibit that unfold around or result in an alteration in the code by one of the participants. The diagrams highlight who engaged in contributions and transformations of the substrate, who was centered in those transformations and how those became part of the emergent action of the group.

In each of the action set diagrams in the following section, colored circles denote particular actors. The circled labeled "E" represents the exhibit. The numbers before the texts on each arrow indicate the order of the actions within the action set. Some action sets were quite large, and therefore required multiple diagrams. The solid lines indicate verbal actions whereas the dashed lines indicate nonverbal communications (including gaze, pointing, sounds, other actions like changing code, etc.).

For the purposes of this study, we interpreted action sets as "centering" when the child's *sense experience* (Merleau-Ponty, 1962) is driving the interactions both with the physical exhibit and with the other people present at the exhibit. In such interactions, for example, even when changes to the exhibit are made by the parents or facilitators, they directly represent the child's interpretations and/or intentions. This is aligned with a phenomenological approach to computing (Sengupta, Dickes & Farris, 2018; in press), as we are attending to the ways in which the child interacts with computing at the exhibit through a rich array of interactions, both direct and indirect. This provides a deeper understanding of their lived experience with computing at Hack the Flock than simply focusing on what technical computing concepts they are using or learning.

To summarize: A child may be centered at Hack the Flock if all of the people present (child, facilitator, parent) are working together to make the child's goals a reality, or by turning over physical control of the exhibit's hardware to the child. On the contrary, "decentering" a child at the exhibit means that their sense experience of computing is not driving the interactions; instead, interactions at the exhibit may be driven by the parent (e.g., the parent telling the child what to do), or by others physically dominating the control of the exhibit hardware.

## Findings

In each of the three cases, the position of the child as an actor was different. In case 1, the child interacts with the exhibit through the parent. That is, the child may not be directly typing on the keyboard, but the parents are making changes to the code in accordance with the wishes of the child and centered the child as a participant in the co-operative action. In the Case 2, the child is working with the code and the parent supports the child's desired changes by offering suggestions, stimulating discussion, pointing out mistakes and also acting as a translator and intermediary for the child's contributions. In Case 3, even though the child is the one actually changing the code, the parent is dominating the interaction with their wishes, which may be different than those of the child or facilitator. These interaction styles are not static, however, and families in each video may shift fluidly between these interaction styles throughout the course of their engagement at the exhibit.

### Case 1: Centering through nonverbal communication

The main participants in this video (duration: 4 minutes) are a facilitator (F), a father (D), a mother (M) and their child (C) (who is preverbal). The overall interaction was comprised of a total of 5 action sets, in which a preverbal child is progressively re-positioned more and more centrally as the key participant in coding.  As the family was walking near the Hack the Flock exhibit, the facilitator greeted them and attempted to guide them towards the exhibit and explain that a research study was taking place to investigate how individuals and families interact with the exhibit. However, the parents voiced their concerns that the pre-verbal child was "too young" to meaningfully work with the coding exhibit. The facilitator went on to explain that younger children had previously interacted in meaningful ways with Hack the Flock. At that point, the family sat down and began to work with the facilitator at Hack the Flock. The dad and child were seated on the stools in front of the screen with the mom standing next to them, and the facilitator was standing on their other side next to the computer.

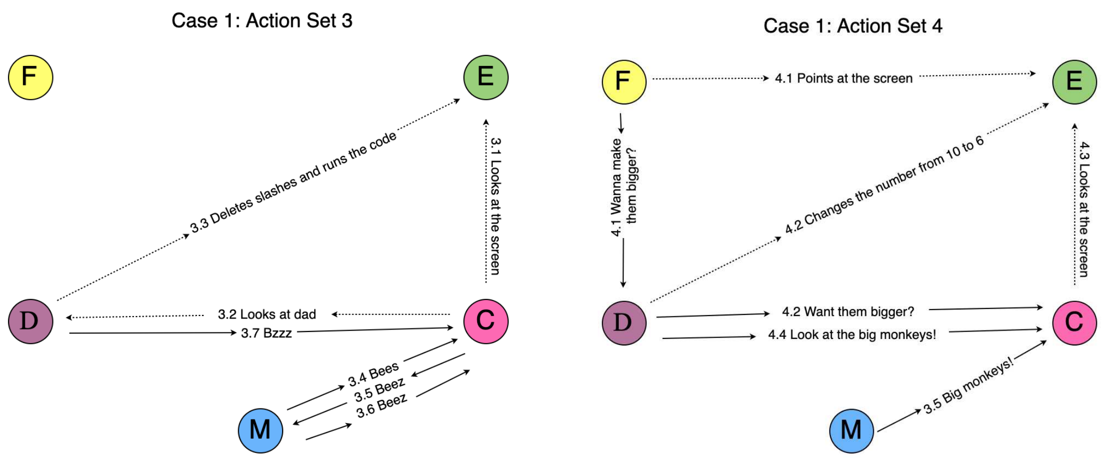


Figure 3. Case 1 - Action Sets 3 & 4 : Child makes verbal contributions to the coding.

Prior to action set 3, the father had made a couple of small changes at the exhibit (including changing the color of the boids), to which the child had reacted with happy gestures and sounds. At the beginning of action set 3 (Figure 3), upon mom's insistence, the child looks at the screen, watching it for a while. After some time, the child does not see new changes on the screen, and she looks directly at her dad (Action 3.1). As a response to the child, dad adds double slashes in front of the line for birds (to remove them) and deletes double slashes in front of the line which creates bee images (to add images of bees to the screen). Then he runs the code (Action 3.2). Mom sees the bee images appear on the screen and says "Bees" (Action 3.3), engaging her daughter verbally in the results of the code change. The child mimics her mom and says "Beezz" (Action 3.4). Mom laughs and repeats the word, imitating the child's pronunciation (Action 3.5) while pointing to the images on the screen (Action 3.6). Here, the parents are trying to teach the baby what the word "bee" sounds like and connect it to the image of a bee on the screen. In the action 3.7. by sounding like a bee, Dad accentuates this interpretation. In this action set, the mutual interactions between the child and dad and the child and mom increases compared to the first two action sets (not included in this paper) while the interactions with the facilitator decreased, and the child also makes a verbal contribution for the first time.

In this action set 4, Dad alters and runs the code one more time to make the images appear bigger on the screen (Action 4.1) and he asks a question directly to the child (Action 4.2). He comes to a conclusion that the child wants the images to be even bigger and makes the necessary changes in the code (Action 4.3), based on the child's "ga ga" sounds (Action 4.4). The father chooses to interpret the child's verbal utterances in relation to the possible code changes, thereby centering the child as making valuable contributions to the coding itself.

## Case 2: Centering through translation

The main participants in this video (duration: 17 minutes) are a museum facilitator (F), a father (D), and his daughter (G) (approx. 9-11 years old). Overall, the image of centering that emerges in this video involves the father positioning the daughter in a progressively more central role through acting as the translator. A researcher, who is mainly silent behind the video camera, plays a brief role in the video. Additionally, another adult family member who did not consent to be part of the research occasionally interacts with the exhibit. During the consent process, the father mentioned to the facilitator and researcher that his daughter mainly speaks and understands French rather than English. As will be shown in the following action set, the father acts as a translator for his daughter at the exhibit, both in terms of the spoken and written languages (English and French), as well as translating and supporting his daughter's understanding of computing. Neither the facilitator nor the researcher present in the video have more than a very basic understanding of French, making the father's role even more critical to his daughter's participation in public computing. The overall interaction was comprised of a total of 19 action sets.

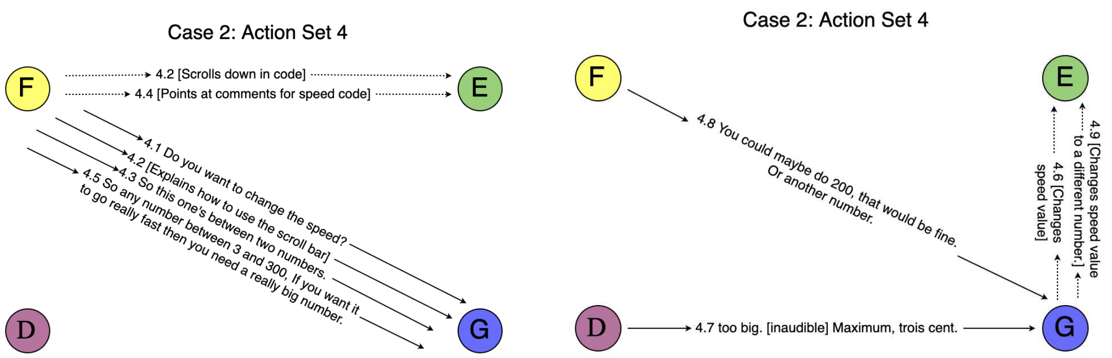


Figure 4. Case 2 - Action Set 4: Preparing to make a speed change.

In action set 4, the facilitator asks the girl if she wants to make a new change to the code: changing the speed (Action 4.1). In order to get to the speed variable in the code, the facilitator explains and demonstrates to the girl how to use the scroll bar (which can be confusing to visitors) (Action 4.2). In this action, the facilitator provides the girl with a skill in how to navigate the code, which she can use later in the interaction. Drawing from the group's previous experience with limits (not shown here), the facilitator explains that there is both an upper and lower limit for speed (Action 4.3) and points at the relevant comment (explanation) in the code (Action 4.4), directing the attention of both the dad and the daughter. Explaining the comment to the girl, she says that the number has to be between 3 and 300, and in order to make the boids move quickly, the number needs to be bigger (Action 4.5). Following that explanation, the girl types a number in for speed (Action 4.6). Watching his daughter, the father explains that her choice is too big (Action 4.7) and repeats, in French, that there is a *maximum, trois cent* [Maximum, three hundred]. He translates both the facilitator's explanation as well as the comment in the code to a language that the girl can understand, in order for her to make a code change that will work. The facilitator tries to offer a suggestion of 200 to the girl (Action 4.8), but also makes space for another number if the girl wants, still centring the girl's desired change. The girl then changes the speed to a different number (Action 4.9) but hasn't restarted the code yet.

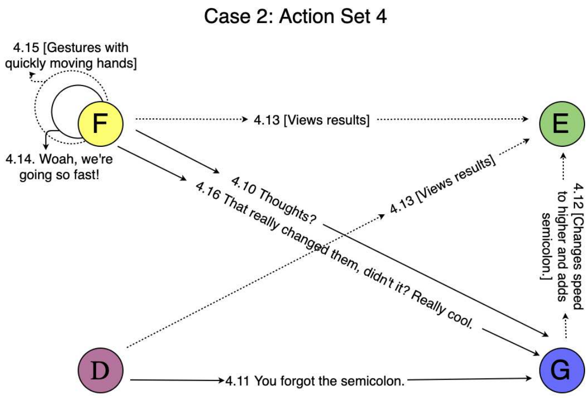


Figure 5. Case 2 - Action Set 4 cont'd.

In the continuation of action set 4, the actions center around syntax rather than the limits of the speed value. The facilitator prompts the girl about her choice (Action 4.10). The father points out that the daughter has made a syntax error in her code by forgetting the semicolon (Action 4.11). Similar to his comment previously, he is translating his knowledge of code (that all lines must end with a semicolon) and re-explaining it to his daughter so that she can make the appropriate fix, without doing it for her. With that in mind, the girl changes the speed number again and adds the semicolon (Action 4.12). All parties view the result of the change (Action 4.13) and the facilitator remarks that "Woah, [the boids] are going so fast!" (4.14) with an accompanying gesture of quickly moving her hands (4.15), showcasing her reaction to the girl's goal of changing the boids' speed.

## Case 3: Decentering through imposition

The main participants in this video are a museum facilitator (F), a father (D), and his son (B) (approx. 12-14 years old). The duration of the interaction is 15 minutes (14 actions sets), and the overall image that emerges is one in which the son is decentered through intentionalities imposed by the father. During the interaction, the dad is physically standing over his son at the computer (due to there only being one stool present at the exhibit) and they are working together. The dad is often telling the son what to do, such as exactly which numbers to type in, and telling the son "don't change that part". The father has previous programming experience, evidenced through the technical terminology he uses to interpret the programming commands, as well as his fluency in navigating and understanding the code on the screen.

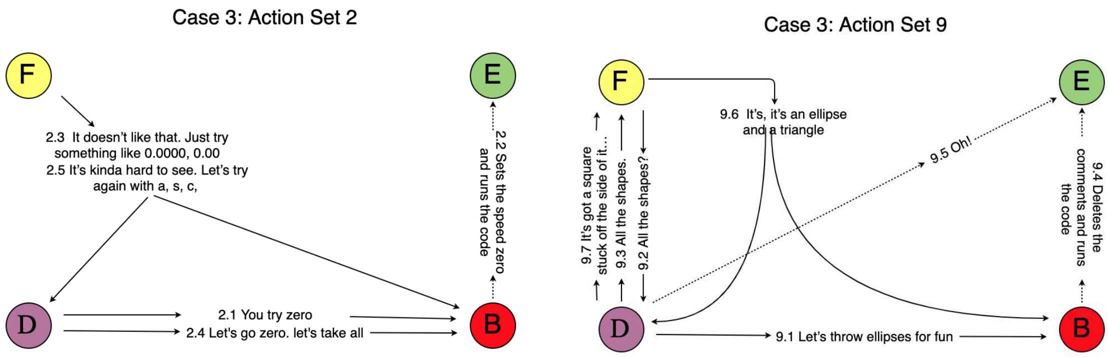


Figure 6. Case 3 - Action Set 2& 9: Dad insists on setting speed to zero and dad wants ellipses.

Throughout action set 2, the dad suggests what to try, the boy makes changes aligned with his dad's suggestions and the facilitator informs them about the speed parameter. The dad insists on seeing a particular change. In the beginning the dad wants the boy to set the speed zero and run the code (Action 2.1). The boy does as his father tells and runs the code (Action 2.2). They all see that there are no boids moving on the screen. Then the facilitator suggests a number close to zero but not zero like 0.0001 (Action 2.3). However, the dad ignores the suggestion by the facilitator and indicates that he wants the boy to put zero into all other parameters by saying "let's go zero, let's take all" (Action 2.4). The facilitator further explains the separation, cohesion and alignment, and their effects on each other (Action 2.5). Despite the explanations by the facilitator, the dad again says "zero" and wants the boy to try zero (Action 2.6). In response to this situation, the facilitator tells them that they might not see much of a difference (Action 2.7).

In action set 9: the dad wants to add ellipses (Action 9.1). And the facilitator remarks "all the shapes" (Action 9.2), the dad confirms by repeating the facilitator's comment "all the shapes" (Action 9.3). The boy deletes the slashes which comment out the rest of the shapes (which include triangles, squares, and rectangles) and runs the code (Action 9.4). There are many shapes on the screen now and the dad says "oh" in surprise (Action 9.5). The facilitator starts pointing out the different shapes (Action 9.6) and the dad describes the chunk of shapes by saying "It's got a square stuck off the side of it." (Action 9.7), however it seems like the shapes don't look like what the dad expected.

## Discussion

Family interactions at museums can take many forms, and though we often consider these family interactions to be positive experiences for children, our three cases showcase the ways in which cooperative action at a public computing exhibit can work to either center or decenter a child. In case 1, even though the toddler is too young to actually press the keys on the keyboard, or verbally voice their intentions and desired changes, the parents still position the toddler centrally in the interaction at Hack the Flock. In case 2, the father plays an important supporting role in the interaction - he translates, literally, English verbal explanations and written code comments to French so that his daughter can understand them. He also translates aspects of the code, such as syntax, to help his daughter make a code change without causing an error.

Across both these cases, what emerges is an image of cooperative action in which parents can help reframe their children's participation in coding science through supporting their actions. This is vividly portrayed in case 1, we saw how parents encouraged engaged their pre-verbal child through repeating the sounds of bees, or by making the monkeys bigger to amuse the child. These interpretive actions of the parents are forms of translations (quite literally in case 2) that serve as Goodwin's (2018) public substrate, upon which children's agentive participation develops and deepens progressively. But the point of our analysis is not to suggest that all forms of public substrates are potentially productive; intentionality of parents, as we saw in Case 3, also plays a crucial role. Rather than creating room for the child's interpretive actions, such public substrates inhibit new interpretive actions of the child, and thus may not be aligned with a phenomenological approach (Sengupta, Dickes & Farris, 2018) for engaging children in coding and/or science, as it limits scope for their own sense-making. Our analysis therefore suggests that the relationship between cooperative action (Goodwin, 2018) and positioning of learners (Shanahan, 2009) needs to be foregrounded in order to help us better understand how cooperative action can support or hinder disciplinary engagement.

## Implications and significance

Our study has implications for future educational research investigating family interactions in informal computing learning spaces such as museums. Our cooperative action analysis brings to light different patterns of social behaviour taken up by families as they interact with a public computing exhibit. Our phenomenological analysis illustrates that facilitating agency for children in public computing experiences must go beyond attending to who is sitting at the keyboard or screen making changes to the code or who is speaking in the interactions. Parents can play many different roles at an exhibit, and their actions and words can work to either center or decenter their child in the exhibit learning experience.

From a design perspective, designers of informal computing learning environments should consider the different affordances of their learning environments and which patterns of cooperative action are encouraged by the design. How might signage, facilitator interactions, and physical space be designed such that the child can be centered at the exhibit, whether acting through parents or being supported by parents? Staff members in informal learning environments can also gain insight into how each of their questions and actions act to bring the child to the center of the interaction with the museum while still engaging parents in the learning activity.

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