Board 335: Material Agency with Summer STEM Youth Designing with Micro:bits

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Introduction and Research Purpose

In this poster, we report results related to an NSF EEC CAREER project that characterizes framing agency, defined as making decisions and learning in the process of framing design problems. Our past studies of framing agency have relied on discourse analysis to characterize agency in talk [1-3]. However, this analytical approach, with its focus on talk, misses much about the materials in the design process, and given that design is commonly cast as a conversation *with* materials [4], a fuller understanding of framing agency could come from attention to material interactions. This study aimed to investigate a design setting in which materials played a consequential role, and to incorporate another analytic method to attend to the roles of materials in framing agency. Specifically, we examined ways learners negotiated their agency *with* materials in the context of an informal STEM camp focused on learning about the past, present, and future of radio frequency communications.

Theoretical Framework

While researchers commonly treat humans as having agency—and even define agency as a human property [5-7]—research on design has long troubled this notion by treating designing as a conversation *with* materials [4, 8]. In this way, the materials designers work with—as well as those we offer learners—might be (a) unalterable; (b) used functionally but unchanged; or (c) modified dramatically in use [9]. This post-humanist stance brings attentions to the *relationships* between humans and non-human artifacts [10]. This approach decenters humans in foregrounding the agency imbued in materials by their creation and form [11, 12]. Decentering humans may seem a strange approach to take, especially in a study that aims to understand human learning. This decentering is intentional and in service of developing keener focus on interactional relationships themselves, not just between humans as is common in such studies, but also between materials (or other nonhumans) and humans.

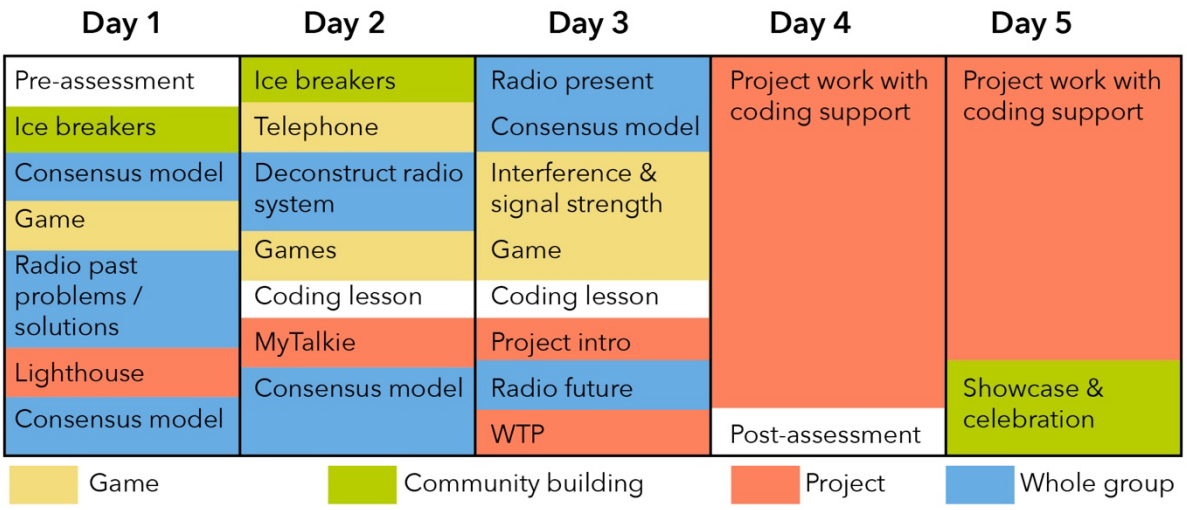
Designers interact with physical materials (in this study, papercrafts, micro:bits), nonphysical materials (in this study, computer code) [13], ideas (in this study, radio communications, human needs), contexts, and specter-like versions of stakeholders conjured for the purpose of arguing for a preferred idea (in this study, invoked community members, such as “sad people” who want “to feed the ducks”) [14]. Decentering the human across such interactions allows us to focus on relationality of interactions—and especially how nonhuman agents contribute to framing a design problem and learning in the process.

Methods

The current study reports data collected at a camp (Figure 1), supported by an NSF AISL project, that aimed to develop participants’ understanding of wireless radio communication through making and designing [15]. Over five days, participants (N = 4, ages 11 to 15) were guided by camp facilitators to frame problems and prototype solutions that can be solved via radio communications (such as connecting people and resources). Facilitators (a researcher and two graduate students, one with experience teaching engineering, the other with experience designing

the my:Talkies) scaffolded participants to work with micro:bits, the small, BBC-developed microcontroller along with its block-based programming interface [16] and my:Talkies (a pair of paper templates a micro:bit is mounted into and then folded into a box [17]). We posed a broad design scenario of a local community in need of radio communication systems [18], but asked students to develop their own framing. Students completed the Wrong Theory Protocol (WTP), an ideation activity in which designers first propose harmful and humiliating ideas, before generating beneficial ideas, a method that jointly supports creativity and empathy [19] before individually planning their design solution [20].

Figure 1. Design of the Radio Crafters Camp



We collected video recordings, interviews, and artifacts of participants in a week-long camp. For the current study, we selected focal students as a way to highlight variability (N=4).

In order to bring together inferences about how agency is displayed in discourse with human-material agency relationships, we used two forms of qualitative analysis. Interaction analysis (IA) [21] provided a way into the data to make sense of the arc of framing *with* materials. IA is an extension of conversation analysis that makes use of video data and guides researchers through repeated viewings, in which they make small conjectures that are testable within the dataset. The tools of IA include analytic foci:

- *The structure of events*. Sometimes referred to as chunks, events are recognizable and small
- *Turn-taking*. In both speech and with materials, turn taking can reveal power imbalances as well as interaction patterns:
    - *Talk-driven interaction*: talk is the primary purpose and means of interacting
    - *Instrumental interaction*: talk is driven by a physical task
- *Participation structures*. How do participants and materials make their engagement visible? Who/what participates/is excluded, and how?

Aligning with a posthumanist stance, we merged the IA focus on *artifacts and documents* which poses questions like *who controls materials?* into other foci, and we reframed these to also draw attention to material-as-actor. The insights related to other foci—beginnings and endings, routines and their variations, and segmentation, trouble & repair, spatial organization—overlapped entirely with the foci listed above.

We used discourse analysis [22] to characterize students' framing agency. Past research employed discourse analysis to characterize agency in how adults talk about their decisions to leave and reenter formal educational pathways, resulting in a toolkit—specific ways verbs, hedge words, and subjects (e.g., "I" versus "you") communicate who has agency [23]. In our prior work, we adapted this toolkit to focus on the context of design problem framing and developed a procedure for analyzing data that attends to the subjects and verbs (Table 1) [1]. For instance, when Olivia (a pseudonym) explained, "I did the sensor programming" she shows high individual agency by using a first person singular subject and by not using modal verbs. Had she instead said, "The sensor programming is done," we would wonder whether she had help, or if someone else did it. Likewise, if she had said "I had to do the programming," we would notice that she offloaded her agency onto an unnamed entity—a display of low agency. This example also draws attention to the temporal quality of framing agency, in that an account of a completed task is less likely to be described in tentative terms. If she was talking about ongoing work, and said "I could do the programming" to a collaborator, this would be indicative of framing agency.

Table 1. Discourse analysis toolkit with examples of markers—subjects and verbs—for framing agency

Discourse	***Inferences***
Subject of verbal clause	
First person singular "I"	High individual agency
First person plural "we"	High shared agency
Second person, specific "you"	Directing or attributing
Second person, generic "you"	Mitigation of agency, placing self among others
Third person "it," "they," "the micro:bit"	Attributed agency
Verb modality	
Full control "do it," "did it"	High agency
Potential control "could do it," "might be"	Framing agency
No control "have to do it," "must be"	Offloading agency to others

Results and Discussion

All participants received the same initial problem setting, technology, craft materials, and base papercraft templates (my:Talkies). In their work with the my:Talkies, participants left the paper largely unaltered. They did not cut or modify the template itself, even though they had access to

scissors, which participants used to cut out the template before assembly, and other craft supplies. Instead, they created wraps and callouts for the templates, working in construction paper, and added other objects (Figure 2).

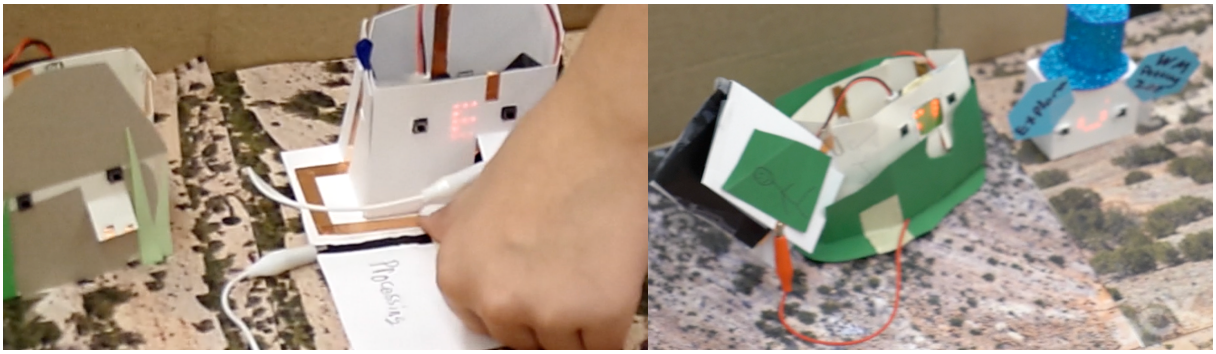


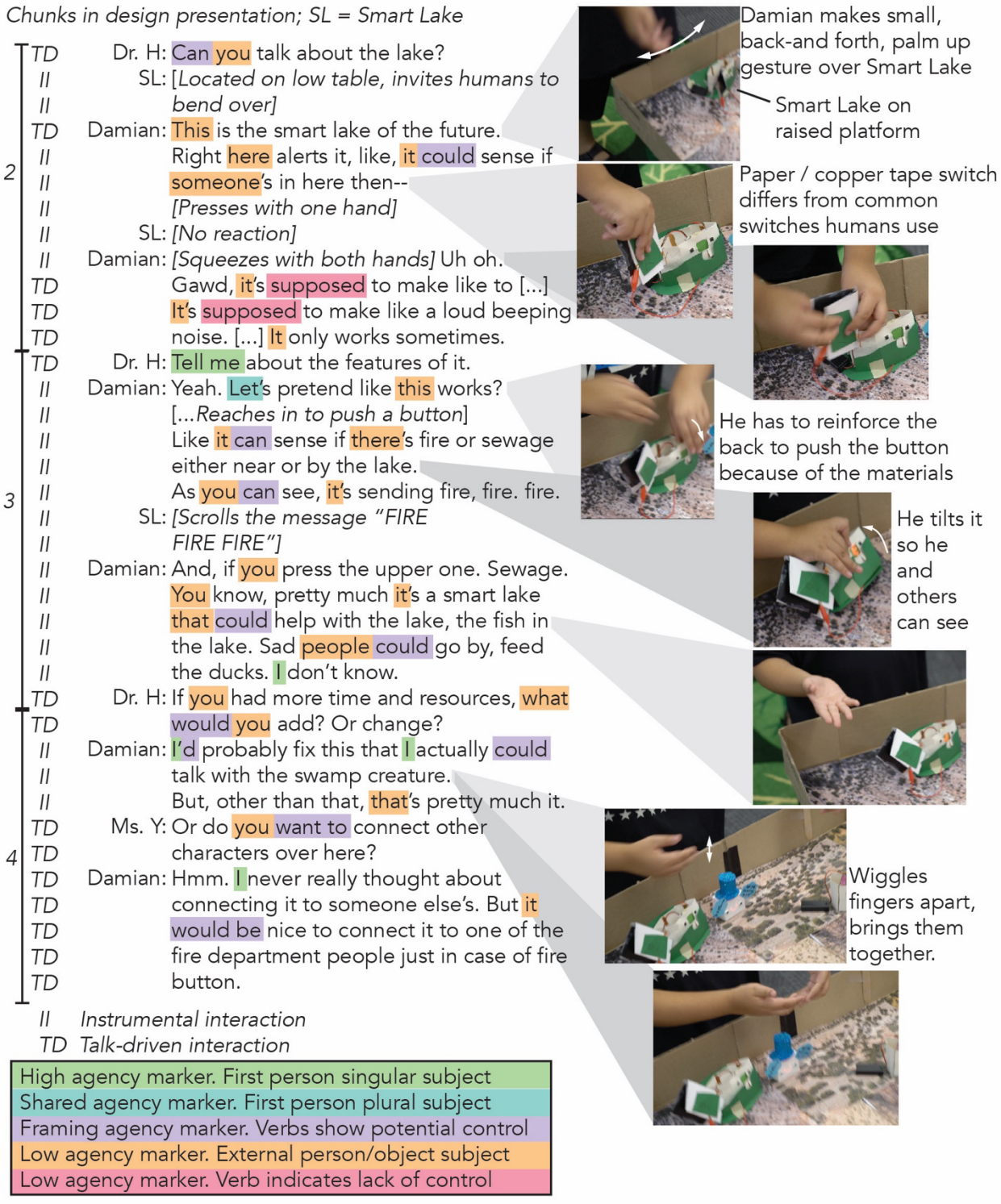
Figure 2. Examples of construction paper wraps and labels: on the left, stone-colored and green paper offer the viewer a sense of masking the my:Talkie as a rock, sitting next to another that has functional labels added to a separate piece added to the template base; on the right, a my:Talkie is wrapped in green paper to represent its placement at the edge of the lake, and a separate piece of paper with a green construction paper label reading "off" is next to it.

At the end of the camp, participants gave an informal design presentation to the camp facilitators, demonstrating their solutions and explaining design features. Unsurprisingly, these presentations were facilitator-led, with facilitators structuring the flow of events (Figure 3). The facilitators tended to shape talk-driven interactions, but when materials did not cooperate, attendees shifted to instrumental interaction as they tried to convince the materials to perform as requested (Figure 3, chunk 2), as they demonstrated it behaving as expected (Figure 3, chunk 3), or as they considered other possible designs (Figure 3, chunk 4).

Across these interactions, only the participants interacted directly with the materials. In reviewing the data corpus, we noted that facilitators did not touch the participants' creations, and likewise, participants did not touch one another's creations. This could be because the copper tape and paper circuits were somewhat temperamental. In contrast to observations from our related studies of collaborative making where multiple hands are needed and group ownership develops, here, there was a clear relationship between each participant and their creation.

We share additional vignettes in the poster and discuss implications for supporting students to frame design problems *with* materials. We also discuss implications for analytic methods that foreground agency relationships with materials in designing [24]—a task that was notably foreign for us.

Figure 3. Bringing discourse and interaction analysis together, the vignette above illustrates how Damian attributes agency to the materials and displays framing agency in considering possibilities.



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