Forms of Emergent Collaboration in Maker-Based Learning

Erica Halverson, University of Wisconsin-Madison, erica.halverson@wisc.edu
Breanne Litts, Utah State University, breanne.litts@usu.edu
Brian Gravel Tufts University, Brian.Gravel@Tufts.edu

Abstract: This paper is a work-in-progress where we discuss the ways in which collaboration can be identified and understood in the context of maker-based activities. While the importance of collaboration is often identified as crucial to successful project-based learning activities, there is not much empirical work that describes: a) what these collaborations look like and b) what happens for learners as they engage in collaborative activities. Here, we draw on data from three different studies of maker-based activities to explore the following question: *What forms of collaboration are made possible in maker activities?* In asking how collaboration develops through making we shift from collaboration as a design feature of learning environments to both a process and an outcome of learning. We take up an emergent perspective on collaboration focusing on the collaborative interactions that occur naturalistically in maker activities.

Major issue(s) addressed

Learning environments where groups of people are engaged in creative production require collaborative engagement, people and tools working together to produce a piece of work. Creative production affords what Sawyer and DeZutter (2009) call "collaborative emergence," an activity that has an unpredictable outcome with moment-to-moment contingency, where subsequent actions can change the effect of prior actions, and the process is fundamentally collaborative. Collaborative emergence is distributed across people, tools, and time (Halverson et al., 2015) and can therefore be understood as both a process of making work and an outcome of a work process. We are curious about what happens if we center collaboration as the subject of our empirical inquiry into how learners engage in making activities not as a design feature to "produce learning," but as a core component of the learning process.

We are interested in collaboration as both a process and an outcome. Typically, in educational settings collaboration as seen as *in service of* a learning goal whether individualistic or collectivistic, serving as a design feature of learning activities. In maker contexts, scholars have taken up the collaboration-as-design-feature notion whether pairs of people work together to produce individual artifacts, or whether individuals work together to produce a collaborative artifact (Litts, 2017). In the data we analyze for this paper, though, we see that maker activities and spaces afford new forms of collaboration that are not explicitly designed-for. From this perspective, collaboration is not only a method for achieving a goal, but also an end in and of itself.

We characterize this orientation toward collaboration as "collaboration through the air" (Kafai & Harel, 1991), where makers "pick up" an innovative idea by being in the same physical space, working with the same tools, materials, and processes but without explicitly coordinated goals. Kafai and Harel first noticed this phenomenon in their studies of instructional software design projects; they describe a collaborative production style where learners construct their own individual products, yet are working together under the same "umbrella goal" permitting learners to move between individual and collaborative styles as they desire/need. Hall (2015) also documented this phenomenon in studies of a writing lab where participants' writing was visible through ambient display. Through this display, they co-created an "aesthetic of cohesion" across their writing. Working with what Hall calls an "ambient audience," he argues that visual representations were passed from screen to screen without explicit conversation or designed collaborative action. In our analysis, we ask what collaboration looks like in maker activities where the learning outcomes for participants are not set a priori and therefore more flexible in terms of the role collaboration can play in the learning process.

Significance of the work

Schoenfeld describes the importance of "ideas in the air" as a mechanism for seeing and solving problems in the scientific community (cited in Kafai & Harel, 1991). When learners are working in the same physical space together, knowledge floats around waiting to be "picked up." In cases like those described in Hall (2015) and Kafai and Harel (1991), learners need space and time to pick up ideas when they are ready and to drop ideas when/if they need to. This vision for the role of collaboration in learning stands in sharp contrast with the designed-for way we typically incorporate collaboration into a learning environment. We often imagine that in order to collaborate learners need to be told when and how to do so. When we study collaboration in learning environments, we often look at purposeful collaboration such as the impact of role assignment on individual

learning outcomes (De Wever et al., 2008). The significance of this work is to reclassify collaboration as an emergent process and outcome of creative, constructionist learning environments, rather than as a designed-for feature that is built in when the instructor or designer finds it necessary or important.

Theoretical and methodological approach(es) pursued

Data for this paper is drawn from our collective research projects that sought to study what people learn through making, how makerspaces function as learning environments, and the design of a school-based makerspace to afford productive learning outcomes for a range of students. Across this work, we attend to the theoretical framings of research in the Maker Movement as described in Halverson and Sheridan (2014): *Makerspaces* as communities of practice, *makers* as identities of participation, and *making* as a set of activities. Our research on makerspaces has described the learning arrangements that characterize makerspaces, highlighted individual features of makerspaces and explored how makerspaces foster youth growing and developing their own personal networks of expertise and practice. Our research on makers has demonstrated the habits of mind young makers develop through their participation in makerspaces and in maker activities including agency and resourcefulness. We have also examined the disciplinary outcomes associated with making activities, such as young childrens' acquisition of knowledge about circuitry. (For citation list of project findings, please see: https://tinyurl.com/references-collaborativemaking.) The focus on disciplinary knowledge outcomes through participation in maker activities is consistent with other research in the field that occupies the "activities" portion of the Maker Movement research agenda (e.g. Peppler & Glosson, 2013).

We first noticed the importance of collaboration in a pilot test of maker activities that could be used to look at learning processes. We tested an activity where we asked groups of makers to "make flow" as an open-ended making activity. As we watched adults and young people take on this task, we noticed that people were collaborating in a range of ways, though they were not given explicit instructions to do so. For example, when young makers were told to make flow, one participant used a glass jar, cardboard rolls, sugar, tape, and scissors to make a modified hourglass. Another maker, seeing what the first participant had done, took up the same set of materials and created a charming-but frail sugar mill that fit into the city she was already building. In our observations, we were struck by how similar the use of tools and materials was between these two makers who did not know each other and were not working together. Examples such as this motivated us to take a more purposeful look at how collaboration happens across maker activities.

For our analyses, we use data collected (fieldnotes, interviews, and photographs) across three studies: design experiments conducted at three different youth makerspaces, and ethnographic data collected during open-ended making time in a high school-based makerspace. Across cases, makers worked side-by-side and could work together, but were not explicitly instructed to do so. All makers had access to shared tools and materials available in their respective spaces. In some of the design experiments, makers were told what to make (e.g. "Make something that lights up"), while in the open-ended maker experiences they had freedom to make what they wanted. Taken together, these data represent 110 young makers over 16 making episodes. We are currently working through a constructivist grounded theory axial coding process (Charmaz, 2000) through which we identify episodes of collaboration that include "helping" (either peer-to-peer or adult-to-youth), "working together", and "through the air." Our goal is to complete an exhaustive analysis of our projects' making episodes in order to build a theory of collaboration in making. In this paper, we share three paradigmatic examples of collaboration through the air that help to ground our thinking.

Major findings, conclusions, and implications

Collaboration as helping

Helping is predominant form of collaboration that we see across our data. We noted that collaboration-as-helping took shape in at least two different forms: helping expertise and helping hands. First, in one of our "make flow" design experiments in a library pop-up youth makerspace, Jackson and Shawn teamed up to work with the circuit blocks, which are wooden blocks with motors, lights, switches, and other components with which learners connect using alligator clips to build circuits. Even though they did not previously know each other, Jackson welcomed this collaboration, since it was natural for how he works in the space and because Shawn had circuitry knowledge and expertise that Jackson needed. The two worked closely together to build a large, complex circuit with the blocks, yet in the process they realize the space could use more circuit blocks. So, their task morphed from making a circuit with the blocks to making new circuit blocks for the community space. As a woodworker, Jackson was able to contribute his expertise to building the new circuit blocks. Thus, over the course of this making episode, Jackson and Shawn collaborated through an ongoing exchange of expertise between circuitry knowledge and

woodworking.

In another "make flow" design experiment (part of the same series) that took place at a museum youth makerspace, Charlie and Sarah collaborated toward the end of their making episodes, primarily because they were friends. They both explained that the collaboration was rooted in the fact that Charlie "needed an extra pair of hands" installing the support beam for her racecar track. Over several minutes, Sarah transitioned from her paperclip circuitry experiment to fully helping Charlie: moving her materials to the same table as Charlie, but still working on her experiment; helping Charlie, then returning to her experiment; and finally, solely helping Charlie. Over this episode, Charlie and Sarah's collaboration emerged from a distant, to side-by-side, to direct collaboration. Charlie reflected on this transition explaining: "I was struggling, I needed extra hands, and then she just came in and she helped like hold things together and gave me suggestions" (Interview, 07/30/2014). Sarah elaborated that "it looked like [Charlie] needed an extra pair of hands, and like she's my friend," so abandoned her experiment to help keep Charlie's racecar "steady and stable…helping her through the process of making it" (Interview, 07/30/2014). This making episode emerged as a case of collaboration as helping primarily to give an "extra pair of hands" to a friend, however, over the course of the episode Sarah joined Charlie's making process more fully.

Inventing technological possibilities

In Nedlam's Workshop, a 3,500 sq ft. woodshop turned makerspace in a large urban high school in the Northeast, 20-30 students came to the space each day from about 2:30 PM - 4:30 PM (attendance logs) to socialize with friends, to make pancakes and hot chocolate, and to tinker with the digital tools; but, a group of students came specifically seeking opportunities to work with and shape wood. *"A group of five Haitian-American girls, three of whom had been in before set about working on mostly wood stuff- with one making a sword, the other making a box..."* (Fieldnotes, 10/20/14). Around this time, the extruder for the 3D printer, which had consumed much of the youth's attention to date, began malfunctioning, and the machine went offline for about a week. This coincided with a what the lead facilitator called a "turning point" (Fieldnotes, 10/27/14) in the youth's work, where a noticeable interest in making things with wood emerged. Painting, carving, cutting, and gluing or nailing together wood occupied the youth's attention, where they mostly focused on how they could personalize and/or make something that reflected their interests in the material: "Someone showed Angeline how to use the soldering iron to burn into wood. She made a "P+A" in a heart on a scrap piece. She said that her uncle does a lot of work with wood." (Fieldnotes, 11/6/14).

This episode marked the emergence of a popular trend of burning designs into pieces of wood with the soldering irons, which is not precisely the intended use for that tool, but a reasonable extension of the tool's functionality. Within the trend that emerged, some students, Angeline included, began creating religiously-affiliated messages in wood (see Figure 1). Students burned biblical passages, and references to God and their faith. Judeline, a Haitian girl, worked alongside her two sisters and a cousin, borrowing techniques from each other including how to burn certain shapes or how to stain the wood different colors, to create their religious wood burnings. The forms of undirected collaboration that took hold illuminate a complicated intersection of tools, materials, and representations. Initially drawn into the space by the digital tools, youths' attention shifted to a more familiar medium, wood. They repurposed a maker tool—the soldering iron—to express their own identities and interests in wood. Youth sat and worked together, and these "collaborations through the air" supported how they were able to make their way in a relatively unfamiliar place.

Judeline and her sisters became frequent participants in Nedlam's over the following 2 years, where their collaborating took the form of seeking guidance from a community volunteer to learn woodworking techniques. Their collaborations evolved from working alongside others, to inventing possibilities for the tools available, to exploring ways of expressing identities, to ultimately seeking help for more complex projects, all of which built the foundation for her sustained participation.

How did you make that flashlight?

During a design experiment at a museum-based makerspace where groups of fifth grade makers were told to "make something that lights up", a group of 12 students worked at two tables. Makers had access to cardboard, wires, batteries, brads, paper clips, small LED lights, and colored tape. Because this was part of a larger experiment, in this particular group students were taken through the steps of how to connect the parts of their circuit together. Halfway through the making session, DiVonte figured out how to make an on/off button by introducing a brad into the circuit that could be used to break and connect the circuit. As he was working on this, the boys on either side of him noticed what he was doing and asked him how they could do this too. They also used the brad innovation to add buttons to their circuits. When we asked these makers, "What would you want

[people] to know about what you made?", DiVonte wrote: "that I made it light up. I made a swich [sic] go on and off." Cameron wrote, "That it is a buttin [sic]. There is tape on the wires so it cannot harm you." Several others in the room referred to their projects as "flashlights". In an unrelated making episode with blocks later in the session, which was designed for collaboration, these makers "incorporated the flashlights into their blocks" (Fieldnotes, 03/03/15) but did very little collaborating with the blocks themselves. While our prompt for them was "make something that lights up" the addition of the on/off button seems to have floated the concept of a flashlight and gotten picked up by most of the makers in the room without explicit directions or decisions.

At a different table, a group of three other makers were more focused on the aesthetics of their "flashlights" than their functionality. While tape was initially made available for functional purposes (one way to attach pieces together), there were at least six different colors of tape available. Khaliyah starting using the tape to decorate her flashlight. When I asked her about it after the making episode, she said, "I thought it would be pretty cool to decorate it a little bit, to show some color and stuff. And make the colors pop, and make it more interesting" (Interview, 03/03/15). She never articulated this interest during the maker activity, rather she just started using the tape in this way. Emma and Lily followed suit, and each ended up with differently decorated flashlights, all using the colored tape, the only colored material available. Khaliyah put the concept of decorating into the air, Emma and Lily took it up, and it became a collective activity. Interestingly, Khaliyah was also able to help the other two with technical questions, having explicitly connected a prior activity on making robots from her classroom to this activity. Perhaps the informal mentorship role she was playing with the other two makers made the taking up of her ideas more likely.

Forging ahead with collaboration

As designers, our instinct is often to create explicit opportunities for collaboration. If we want learners to collaborate, we have to tell them to, even going as far as assigning roles within the collaboration (De Wever et al., 2008). But this form of collaboration, what we call "designed-for" is in-service of other goals, usually the acquisition of disciplinary knowledge. In this paper, we present an alternative and more emergent perspective on collaboration in making activities. An inherent characteristic of makerspaces is that makers are making together in some fashion. Such spatial designs distribute knowledge throughout the space itself and through proximal interactions with other makers, available to be "picked up" and used when a maker is ready for it. This has clear implications for how we design maker and other project-based activities; rather than using collaboration as a method for acquiring disciplinary content, perhaps we should design for emergent collaboration-through-the air. This may lead to more productive processes and products that are at the center of constructionist learning.

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