Making Together: Cultivating community of practice in an all-girl constructionist learning environment

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Abstract

This practice paper investigates instructional practices that support relationships among young female makers. This paper summarizes a design-based research study where a group of all-female makers constructed toys for younger students in their immediate school community. Makers supported one another through contributing ideas, building together, sharing expertise, and providing helpful encouragement. Through the process of making, they developed individual expertise that contributed to the sharing of knowledge within their classroom community. Drawing on literature from constructionist design paradigms and community of practices, data from this Making and Engineering class describes an emergent community of makers. Additionally, this paper highlights the value of makers creating personally and socially meaningful projects in collaboration with others. Finally, we describe the flexible and playful environment of the Making and Engineering classroom that contributed to how makers shape their shared practices.

Keywords (style: Keywords)

Constructionism; Community of practice; maker education; girls in making

Introduction

Makerspaces are venues where individuals gather around a shared interest in making to learn, create, and share expertise. Sharing of expertise has been identified as a key feature of these spaces that helps to induct new members and expand the making community (Halverson & Sheridan, 2014). This practice paper aims to illustrate the importance of near-peer communities of practice (Lave, 1991) within an all-female makerspace as research on collaboration in makerspaces has thus far focused on inter-generational or adult learners who develop their expertise to teach or mentor younger makers (Blikstein, 2013; Halverson & Sheridan, 2014; Resnick & Rusk, 1999; Holbert, 2016). Our study investigates the collaboration between elementary-aged makers in a Making and Engineering class. This paper examines how young makers who are newly introduced to Making and Engineering, support one another during the making process and gain individual expertise through their collaborations. In examining this community of young makers our paper aims to answer the following questions:

- How does working alongside peers influence the process of making?
- How do young female makers adopt and develop specialties when assisting one another during making activities?
- How did the Making and Engineering classroom structure influence the practices developed by a community of young female makers?

In making artifacts alongside their peers, an emergent set of practices developed among the makers. Several cases will be analyzed to examine evidence of peer-support indicative of a community of practice within the constructionist classroom project. The values of this community of practice uniquely supported the peer-to-peer and peers-to-client relationships of this instructional design. Sharing newly formed expertise, collaborating, and providing supportive feedback were facets of their making practice. Through assisting others, makers reinforced their learning of essential engineering and design skills.

This paper presents cases of students that exemplify the community of practice formed within the all-girl maker classroom. These cases emerged from field note data analysis and one-on-one interviews.

Literature Review

Constructionism: “In the world” tangible and sharable knowledge

The activities employed in the Making and Engineering class draw on the constructionist design paradigm. Papert’s constructionism extends Piaget’s constructivism by proposing that the construction of knowledge “in your head” happens best when constructing tangible and shareable objects “in the world” (Papert & Harel, 1991; Papert, 1993). Constructionism is a “framework for action” (DiSessa & Cobb, 2004,) situated and pragmatic (Ackermann, 2001; Noss, 2010). In constructionist design learners build public artifacts that are personally and socially meaningful. This construction process leverages diverse ways of thinking, knowing, and practicing (Turkle & Papert, 1990) and situated learning so it is about developing concrete relationships with objects and ideas (Ackermann, 2001; Wilensky, 1991).

The creation of an artifact, which could be either physical or virtual, allows learners to externalize their mental models and iterate on their thinking throughout the making process. Additionally, it enables learners to see and critique one another’s work (Papert & Harel, 1991). Resnick (2004) highlights the value of learners playfully creating personally-meaningful projects in collaboration with their peers. He believes that learning should be a social activity where learners share ideas, collaborate on projects, and build on others’ work. In their “Instructional Software Design Project” research, Kafai and Harel (1991) found that by ensuring all students in a class worked towards the same goal, in this case creating math games to teach younger students about fractions, the students were able to support each other as they faced similar problems, shared ideas, helped others and discussed technical problems. Some students in this study choose to work together by

discussing problems with a partner or working together as a team. Even those who chose to work alone, sought help or inspiration from others' for their work. Working on the same project goal is an engine to drive constructionism and communities of practice. However, the environment needs to be designed to encourage and support learners' collaboration and sharing. Learners learn better when they are immersed in an environment and community that supports their interests (Papert, 1980). Access to other creators can be especially important for deepening learner's expertise through receiving feedback, brainstorming ideas, working on projects together, and finding encouragement (Ito et al., 2009).

Community of practice

Learning in a community of practice is inherently social (Lave & Wenger, 1991). "Communities of practice sprout everywhere, in the classroom as well as on the playground, officially or in the cracks" (Wenger, 1998, p.6). Instead of didactic instruction from a teacher to a learner, this viewpoint describes a diverse set of essential actors and forms of participation. Lave (1991) explains that structure and experience reinforce each other such that they shape the relations among persons acting, settings, situations, and systems of activity. Near-peers, members of a community matched in ability, are identified by Lave and Wenger (1991) as important in the circulation of knowledgeable skill.

Just as there is a rich field of actors, there may be many different ways of participating in a community of practice. As members develop mastery through peripheral participation, they move into more central modes of participation within the community. However, there may be no such thing as a central role. The notion of legitimate peripheral participation outlined by Lave and Wenger (1991) is used to suggest that there are "multiple, varied, more- or less-engaged and inclusive ways of being located in the fields of participation" defined by a community (p. 36). Developing an identity gives meaning to shared skills which, are then incorporated into identities. Forming an identity as a member of a community and developing skills are mutually reinforcing.

Participation is central to learning in a community of practice. Learners absorb and become absorbed in the culture of practice, which increasingly provides them with occasions to make the culture of practice their own (Lave & Wenger, 1991). As described by Halverson and Sheridan, "communities of practice emerge around makerspaces as members co-participate in a range of activities" that go beyond making to unrelated socializing (Halverson & Sheridan, 2014, p. 502). Makerspaces can be understood as communities of practice where making activities are a part of a larger in-person, or online, community.

Methodology

Population and Site

This practice paper is part of a larger design-based research project called "Bots for Tots" which aims to increase diversity in maker and engineering design activities (Holbert, 2016). In investigating girls' participation in maker activities, we draw on data from the second iteration of the project, where the population is solely female participants. This iteration of Bots for Tots took place at an all-girls private school in a suburban area in the North-Eastern United States. 41 fourth-grade makers (aged 9-11) from two classes (20-21 students per class) participated in the study as a part of their Making and Engineering class, a bi-weekly class which ran 45-minutes per session. Throughout the academic year, students participated in 17 sessions in total as described in Table 1.

The school has a long tradition of pairing fourth grade "Big Sisters" with first grade "Little Sisters" under its Big Sister/Little Sister mentorship program. For the first time, as part of the Bots for Tots project, the fourth grade Making and Engineering class had the explicit goal of designing and building "dream toys" for their first grade Little Sisters. The class began with two sessions of making with a 2D- to 3D-objects with cardboard in order to familiarize them with tools and materials

in the lab as well as preparing them up for creative activities ahead. After the two cardboard sessions, the fourth-grade makers interviewed their Little Sisters using the "My Client Profile" worksheet. During this interview makers questioned their Little Sisters about toys by asking: What kind of toys do you like? If you could imagine any toy, what would it look like and how would you play with it? Makers then used the completed My Client Profile to discuss and brainstorm toy ideas with their classmates. After three sessions of prototyping, makers met their Little Sisters again to receive initial feedback on their prototypes before they began working on their final toy construction. The makers then spent seven sessions building and completing their final designs. Finally, the makers delivered their newly constructed toys to their Little Sisters and had a playdate where the girls discussed the toy's design and construction while playing together.

Name of activity	**# of sessions the activity occurs**	**Major activities**
Make 2D to 3D cardboard animals	3	Makers drew animals they selected on a piece of paper and used cardboard to make it 3-D.
Interview with Little Sister	1	Interviewed first-graders about their dream toys
Brainstorm with small group	2	Shared information. Each maker gained from their Little Sister and asked for classmates' input about their design ideas.
Prototype	2	Made prototypes
Meet Little Sister for prototype feedback	1	Showed Little Sister their prototype and asked for feedback
Complete final toy design	7	Revisited the feedback from Little Sister and planned for improvements. Finalized toy construction
Toy delivery and play date	1	Met Little Sister for toy delivery, explained the design of the toy, and played together.

Table 1: Structure of the Making and Engineering class.

Data Collection

All names used in this paper are pseudonyms chosen by the makers.

Interview: While all 41 makers participated in the study, 12 were randomly selected for one-on-one interviews. We interviewed the makers at the beginning of the year, before the Making and Engineering class had begun to determine makers' experience with technology, construction, and crafts as well as knowledge of relevant Making and Engineering concepts or skills. Interviews lasted approximately 40 minutes per participant. We interviewed the same makers again at the end of the year after the class had concluded. In the post interview, makers were asked about their experience working with their friends and making toys for their Little Sister. Our goal was to understand how making with others influenced the overall making process and how makers may have developed and adopted specialties when collaborating. All interviews were initially video-recorded then, transcribed first by both the authors and then by an independent service.

Field notes: Detailed field notes were taken during observations of the Making and Engineering class. These observations focused on how the fourth-grade girls interacted with their classmates in the Making and Engineering learning environment (offering help, sharing materials, developing the sense of expertise, providing each other feedback and support).

Artifacts: A variety of maker artifacts were produced throughout this project. These include worksheets (My Client Profile worksheet, a worksheet to record feedback from their Little Sisters,

and others), photographs of participants working on their projects, as well as photographs of their toy designs throughout the construction process. These artifacts provided a broad picture of each participant's work, such as whether they worked independently or alone, as well as their level of expertise both in technique and constructed toy. All artifacts were de-identified.

Results

Idea Generation

Idea Sharing

After conducting the initial client interviews with their Little Sisters, the teacher had makers gather in small groups to brainstorm ideas. Linda noted under "Concerns" on her "My Client Profile" worksheet that her Little Sister was, "hesitant about answering making me think that toys are not her favorite and she said that she likes toys that draw." Three of her peers provided suggestions about how to design a toy that would address these concerns. One girl tried to convince Linda to make a huge stuffed crayon so it would be, "soft like a fuzz ball." Another, added it could be a double-sided marker. Building on this idea, another maker told Linda the marker should have four colors. While Linda wasn't initially interested in a multi-sided marker, at the end of the class session on her post-it note summary she wrote, "Double sided marker. Put a squishy thing on top. Four sided marker/crayon and put squishy things on the handle."

Co-constructing

As there were more fourth-grade Big Sisters than first-grade Little Sisters, four makers had to share a Little Sister with another maker. Fourth-grade makers Susie and Paula decided to make a toy together for their Little Sister, while Betty and Chloe made two separate toys.

Susie and Paula interviewed their Little Sister together and wrote similar findings on both of their "My Client Profile" worksheets. For example, under the heading "Likes" they wrote, "yellow, blue, medium, real animals, panda, cheetah, hard" and under "Concerns," they wrote, "don't break, no spider, and colorful". She also made the observation that their Little Sister "likes dolls with clothes." In order to assist the makers with planning their projects, the instructor made a "Brainstorming" worksheet as a helpful guide. The makers were asked to answer the following questions: "I want to explore:" and "My sketch for (Little Sister's name)" Susie and Paula both crossed out the word "my" and "I" on their worksheets and changed those words to read, "we" and, "our" as shown in Figure 1. They summarized their shared design plan as making a "wooden or plastic doll with movable parts and brown hair." They worked together for the duration of the school year and consistently divided their making efforts.

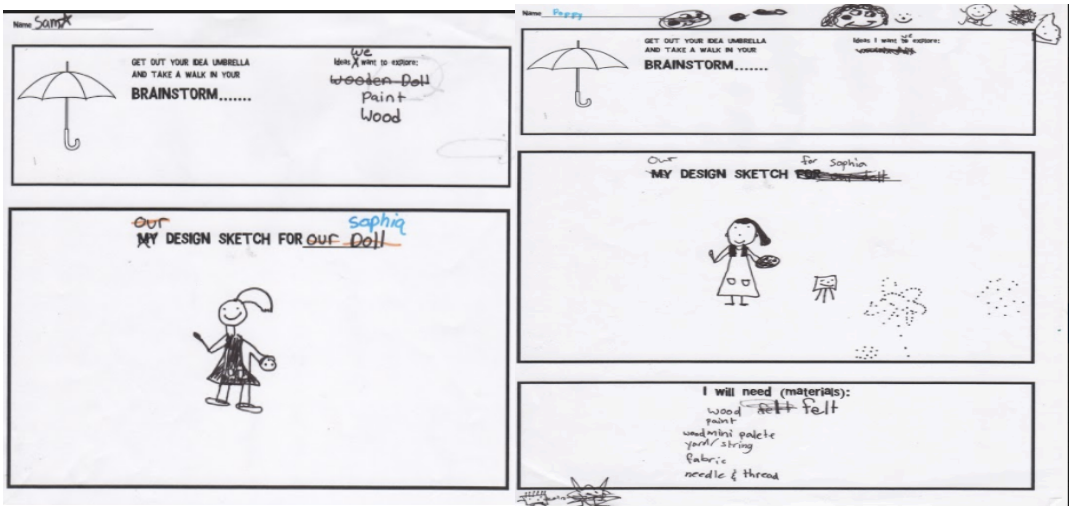

Figure 1: Susie and Paula's Brainstorming worksheet.

In contrast, Betty and Chloe did not work together. In the post-interview Betty reflected back on her making process. She described how she didn't make the toy her Little Sister asked for. Betty said, "I shared my Little Sister with my friend Chloe. I was trying to make her a stuffed bunny…I feel like we should have worked together. It would have turned out a lot better...yeah." Betty described that as the making process progressed she realized, "that it was kinda dumb," not working together.

Making Process

Overcoming challenges

Betty intended her dollhouse to have two levels. But, she cut one piece of wood slightly smaller than the others so when she glued her house together it was slanted. She looked unhappy with her design so her classmate provided encouragement by saying that it looked "like a cool modern loft house!" Another agreed and said, Betty could decorate her dollhouse as a fun, whimsical witch house. However, Betty still appeared unsatisfied. She decided to take the second floor out and redesign her roof. Though this process delayed her work, Betty offered continued help to her friend Maya.

Maya's project was a stuffed animal and Betty said she "helped Maya a couple of times because [Maya] just didn't know how to sew." Betty taught Maya to hand sew because there was a queue to use the sewing machine. Betty humorously talked about her experience supporting Maya, "I just kind of showed her how to like sew, and she's like, 'Oh.' And then she tried to use the sewing machine and it just got all bunched up. I'm like, 'Okay Maya, you go hot glue this onto my house and I will cut all this off." Maya and Betty worked on each other's projects to finish their toys in time.

Sharing expertise

In the post-interview Hailey said, "I asked my mom to teach me the sewing machine at my house so that helped me a bit when I sat down at the sewing machine there [referring to the one in the classroom], I certainly know how to use it, to thread it and stuff so that's a big help." Hailey described the best part of the class as helping others saying, "you got to help other people….like...oh can you help me thread the needle?," referring back to the sewing machine needle. She added that "[helping others] felt really good." Hailey helped others sew by providing procedural cues such as, "you gotta pin it. You're going to start here...leave a place open to stuff," and to another maker, "pick the guide up. Pick the needle up. Rotate." In one instance, Madison wanted to begin sewing her project. She asked Hailey, "can I sew it now?" Hailey responded, "can I just get you started?" Madison replied, "can I do it? I'm kind of a control freak." Hailey then said, "trust me, I do it too." After more prompting, Hailey stepped back from the machine. For Hailey's own project she sewed a pillow for her Little Sister. To test it, Hailey placed the pillow on the ground and rested her head on it. She then solicited feedback on her pillow design by inviting a friend over to also rest their head.

Wrapping up

Facing time constraints

Towards the end of the school year, Margie had finished her toy early, a purple stuffed tennis ball. In the post-interview Margie said that her friend, Cathy suggested that she make a tennis court to go with the tennis ball. While Margie used her extra time to supplement her toy, Ellie walked around the class and shouted, "who needs help?". LillyJane mentioned Ellie in her interview. She said that she received help from Ellie and that if she had extra time, she would have offered similar assistance to her peers, "If I was finished with mine, people were coming around and helping people like Ellie. She helped me. But like I didn't get, because I was doing my stuff, and I didn't have enough time to help other people." Hailey also mentioned Ellie as a person she went to get confirmation from on her ideas.

Erica had her friends help her by finding materials and painting her doll house because it "was

pretty big". Similarly, Betty was making a dollhouse and needed help making items to furnish it. She told us during the interview that she saw Chloe "just wandering around doing nothing, so it was like, 'Can you help me make the chairs?'" Holly was also behind in finishing her toy doll during the final class period and enlisted her classmate Anna to help her make a skirt and hair for the doll. When the instructor told the class to clean up, Holly asked Anna if she could visit her house over the weekend to help her with the project.

Discussion

Making with others

Working with others influenced the makers process of constructing toys for their Little Sisters. The Making and Engineering class created a community that involved making, brainstorming, designing, helping, valuing others' ideas, and sharing their projects. When Linda was struggling to generate an idea that responded to her Little Sister's toy preferences, she asked for input from her peers. Linda incorporated all of their ideas to create her soft three-sided marker project. Valuing the ideas of others emerged as a characteristic of this community. Makers reified their practices through the toys they created for their Little Sisters (Wenger, 1998). Though Linda was responsible for her own project, her work reflects the contributions of her four fellow makers.

Making tangible objects acted as a medium for the makers to communicate their abstract ideas to each other. It became an external representation of the makers' ideas that enabled them to play and to gain a better understanding of possibilities and limitations (Resnick, 2013). Sharing the same Little Sister, Susie and Paula needed a common vision to construct together effectively. From the beginning of the process, they compared their "My Client Profile" worksheets to generate toy ideas. On their "Brainstorming" worksheet, they both sketched out a picture of a girl wearing an apron with a paint palette as shown in Figure 2. This sketch can be understood as a mutual concrete representation of their project. While they individually sawed each wooden piece, they would frequently piece them together to align their designs. The artifact they shared allowed Susie and Paula to communicate more clearly about their progress towards their shared vision.

Figure 2: Susie and Paula were sawing wood together to make different parts of their doll.

Creating an object allowed learners to explore and expand their ideas but also to see their thinking and provide feedback on a visible artifact (Peppler & Hall, 2016). When Betty was disappointed by her slanted two-level dollhouse and wanted to quickly make a pillow instead. She received feedback and encouragement from her peers, that the house looked "cool" and "whimsical," after this reassurance she decided not to start a new project, but figured out a way to improve her existing one. Just as "having a tool to perform an activity changes the nature of the activity," so did having objects to share their ideas around change the makers' process of making and helping one another (Wenger, 1998, p. 59). Betty was able to refer to her project and how it differed from

her intended design. But also, her classmates supported her by reframing her project, providing encouragement, and easing her disappointment so that she was able to progress past this mistake her project.

Developing expertise

As the makers progressed in their projects they began to develop specialized areas of expertise. In doing so, some members such as Hailey can be understood as moving into more central roles within their community of practice (Lave & Wenger, 1991). Though makers were not assigned stations to oversee, Hailey took it upon herself to improve her sewing skills by asking her mother to teach her at home. She used her expertise to provide support to her peers and assist them in developing their own abilities. Hailey is shown assisting her peers in Figure 3. The makers can be understood as displaying different learning trajectories or modes of participation, as not all makers developed expertise in one domain. Hailey's proficiency was developed to support a core practice that emerged within this community, supporting others. As expressed by Hailey, "[helping others] felt really good." Her knowledge of sewing allowed her to support others and made her feel proud.

Figure 3: Hailey (first from the left) helping her friends at the sewing machine station.

Similarly, Ellie positioned herself as a creative contributor to the classroom community by walking around the room and providing suggestions to her classmates. Ellie's project, a giant stuffed purple snake, was highly praised by her friends and teachers. Ellie's skills at making mutually reinforced her identity as a proficient maker that she adopted within the Making and Engineering classroom (Lave & Wenger, 1991). She expressed her expertise, by going around the classroom and providing help to her friends who were struggling with their own projects. For Ellie, being an expert wasn't simply about having specific skill, soft toys, but being able to be a generalist who could assist anyone in the classroom.

Making and Engineering classroom

Though the makers were designing for others, by working alongside each other their construction became more personally meaningful. An important instructional decision within the Making and Engineering class was to allow makers the freedom to move around and express themselves. The program also ran throughout the academic year. This allowed makers to have enough time to experiment and tinker with multiple new ideas and iterate on their designs (Resnick, 2013). The makers practice within this space involved activities that extended beyond making. Halverson and Sheridan (2014) described communities of practice in makerspaces as involving activities that moved beyond making to include playing board games, caring for resident pets, and taking walks together. Similarly, the much younger all-female makers in this Making and Engineering school-based class were able (and allowed) to talk, sing, and move around the classroom as they worked. The makers expressed their enjoyment of making together. When Hailey wanted to test the pillow she had created she lied down on the floor and invited a friend to rest their head next to her to try out the pillow as well. The classroom environment allowed makers to more freely interact with their peers, whether it was inviting a friend to rest their head on your pillow or by singing a song together.

Despite the open-ended instructional approach, many students experienced time constraints that impacted their making. As Lave (1991) explains structures and practices reinforce each other to shape the relations among actors, settings, and systems of activity. Structures contributing to the formation of this community can be understood as the single gender school, the "Little Sister" program, and the tight time restrictions of each classroom period. When Maya couldn't complete her stuffed animal because she didn't know how to use the sewing machine she sought help from a friend. Her friend, Betty tried to teach her but she still had difficulties operating the machine in Figure 4. Betty hadn't finished her own project yet despite wanting to assist her friend. They switched their projects so their abilities could match the remaining tasks and they both could work more efficiently. Another set of makers, Anna and Holly, indicated that they would continue working together outside the classroom. Holly invited Anna to her house on the weekend to help her finish her toy. Despite time-constraints, the flexible working environment allowed these makers to creatively address their problems whether by continuing to work together outside of class or by dividing up tasks across projects.

Figure 4: Betty teaching Maya how to use the sewing machine.

Conclusion

Through our analysis of young female makers who formed an informal community of practice, we provide insights into what learning looks like in a school-based constructionist learning environment. Working with others influenced the makers processes of constructing toys for their Little Sisters. As clearly demonstrated in the collaborative efforts of Susie and Paula, making changed from being an "I" and "my" process to a "we" and an "our" one. As the makers created their projects, they developed different areas of expertise. Whether specific knowledge or general making skills, makers used their abilities to complete their own projects as well as assist others. The classroom practices extended beyond physical construction to include playful interactions amongst makers such as: singing, resting on the floor, switching projects, working together outside class time, and a myriad of other activities both related and unrelated to making. By looking into how young girls make and interact in a constructionist learning environment, we can better facilitate and cultivate the learning community where learners help one another, share their knowledge, and create meaningful projects together.

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