Revealing the Hidden Processes of Making - A Case Study in a Pop-Up Makerspace STEAM Studio

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This study examines making and learning processes in Pop-Up STEAM Studios often overshadowed by the final product. Through a community-based STEAM solar lantern challenge, researchers revealed valuable and hidden processes of making through dynamic interaction between "episodes" (planning, making, redesigning, and testing), Learning Practices of Making, and timestamp moments of creating solar lantern using a convergent parallel mixed methods design and data from the digital story.

Introduction

Making refers to the active construction to create something shareable (Martinez & Stager, 2019). Our NSF-funded pop-up makerspaces focused on exploring community-based STEAM (Science, Technology, Engineering, Arts, and mathematics) challenges in a high-poverty rural county in the U.S. Midwest. Unlike permanent makerspaces that are restricted to a stationary location and limited audience, pop-ups are inexpensive and temporary setups open for wider participation (Pandey & Srivastava, 2016). In this case, residents engaged in a community-wide STEAM-making challenge of designing an artistic working solar lantern. This case study explored and showcased the making process, which is often overshadowed by the focus on presenting the final product (Alter et al., 2009). There is value in uncovering the learning that occurs in the messy and iterative processes of making (Blikstein, 2013; Garcia & Coneway, 2019; Maltese et al., 2018). This process-focused approach reflects design thinking and the development of learning processes happening in different "episodes" of our design framework: planning, making, redesigning, and testing. Design thinking is a crucial component in a makerspace setting, offering opportunities to uncover dynamic interactions between the episodes of the design framework and Wardrip and Brahms' (2015) Learning Practices of Making (LPM): Tinker, Inquire, Seek & Share Resources, Hack & Repurpose, Express Intention, Develop Fluency, and Simplify to Complexify within a pop-up STEAM studio. The research question guiding this study is: How did the deconstruction of a digital story reveal the design thinking process in a pop-up STEAM studio design challenge?

Papert's (1993) Theory of Constructionism and the practices of Reggio Emilia, Italy, frame this study and are often cited as influential to the maker movement (Martinez & Stager, 2019). Papert believed the learner keeps on constructing new knowledge internally based on prior experiences and that constructing shareable tangible artifacts supports the learner's conceptual understanding, facilitating knowledge development in a more concrete way (Papert, 1993). In Reggio's preschools, teachers practice a pedagogy of negotiated learning (Forman & Fyfe, 2012), carefully crafting provocations that captivate children's curiosity, stimulate their interests, ignite their imaginations, and foster inventiveness through the mediums of construction, exploration, and art, often sparked from questions and wonders of children as they explore the environment, engage in conversations, and express intentions. Students persist in exploring and testing theories of interest and record their process of learning in the form of diagrams and drawings. Teachers document the explorations and understandings using photos, observational notes, and video transcripts, creating visual displays, like digital stories, that document students' work-in-progress. These displays and artifacts provided students with additional opportunities for "reflecting on their design process and thinking process" (Resnick, 2007, p. 5). We deconstructed this method by taking apart the visual displays to reveal the making process.

Methods

Cross (2007) identifies design as an application of "the arts of planning, inventing, making, and doing" (p. 1). The deconstruction of the digital story revealed the "iterative and non-linear" design thinking process of this maker (Brown, 2009, p. 5). In our larger study, we found that participants engaged in iterative and non-linear episodes of planning, making, redesigning, and testing (Panwar & Vasinda, 2023). This study was conducted in six community-based Solar Lantern Making Challenge Popups, including three rural libraries, a county family resource center, a university-sponsored botanical garden, and a public park in a high-poverty rural county in the U.S. Midwest. Multigenerational community members engaged in making solar lanterns with materials provided in the pop-up studio, including solar path lights, various art supplies, and upcycled containers. Researchers observed, photographed, videotaped, questioned, and interviewed the participants about their processes, looking specifically for the LPM and in which episode of the design framework they were engaged. In this

case study, we purposefully selected a female participant (age 5-12 years) as an information-rich case because of her continuous engagement in designing and making the solar lantern (Wan, 2019). This allowed us to gain an in-depth understanding of the design thinking process in a pop-up makerspace and helped to uncover the hidden processes of making explicitly.

We used an episode-based design framework (Figure 1) for the units of analysis to analyze the LPM. Planning describes the decision-making involved in an intention or goal. Observations of planning episodes included participants' engagement as they entered the space and contemplated the challenge. They looked at the materials available and made decisions often while verbalizing their intentions (plan) and how they wanted to go about their making. Making episodes was their initial construction process, but it also overlapped with the redesign. The redesign might occur at any point in planning or making as changes were articulated or observed when participants made adjustments or changes to their project. Redesign often came as a result of testing. Testing involves evaluating the performance or quality of the creation. It might occur during the making episode after completion of the product, or at any stage of development along the way. The LPM communicates the making process and progress through seven actions: Inquire, Tinker, Seek & Share Resources, Hack & Repurpose, Express Intention, Develop Fluency, and Simplify to Complexify (Table 1).

Figure 1

Iterative Episodes of Design Framework

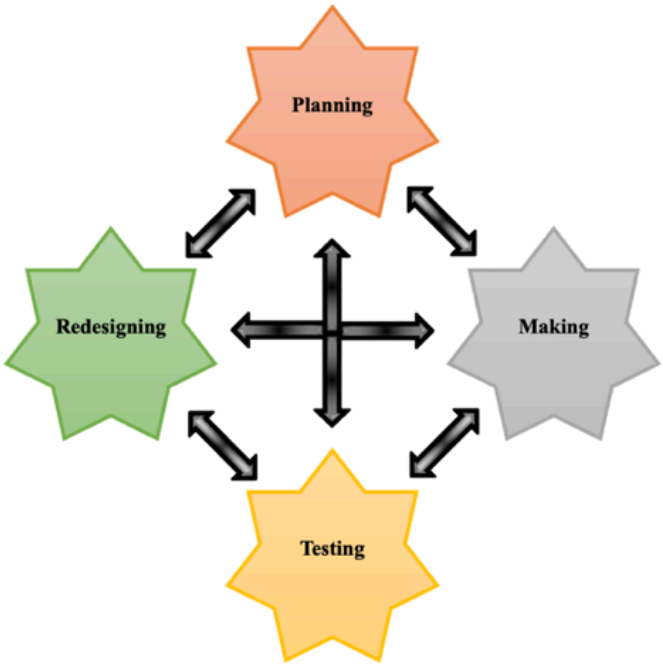


Table 1

Learning Practices of Making (Brahms & Wardrip, 2015, p. 376)

Learning Practice	Practice Description
Inquire	Openness and curious approach to possibilities of the context through exploration and questioning of its materials properties.
Tinker	Purposeful play, testing, risk-taking, and evaluation of properties of materials, tools, and processes.
Seek & Share Resources	Identification, pursuit/recruitment, and sharing of expertise with others; include collaboration and recognition of one's unfamiliarity and desire to learn.
Hack & Repurpose	Harnessing and salvaging of materials, tools, and processes to modify, enhance or create a new product or process; includes the dissociation of object property from familiar use.
Express Intention	Discovery, evolution, and refinement of personal identity and interest areas through the determination of short and long-term goals; includes responsive choice, negotiation, and pursuit of goals alone and with others.
Develop Fluency	Development of comfort and competence with diverse tools, materials, and processes; developing craft.
Simplify to Complexify	Demonstration of understanding of materials and processes by connecting and combining component elements to make new meanings.

Using a convergent parallel mixed methods design, data were collected simultaneously from survey and visuals, analyzed separately, then merged to support the study's findings (Creswell, 2017). We arranged the gathered visual data based on the video time stamps to showcase the development of the making process through digital stories. The analysis took place in two stages. First, we deconstructed the digital story into visuals and transcripts. Second, we uploaded each visual piece according to the time it occurred, along with the transcript, into QSR NVivo (Release 1.0) for coding. Time stamps of the visuals were crucial in the coding process. Two parent codes were generated:

2. LPM along with the child codes of Inquire, Tinker, Seek & Share Resources, Hack & Repurpose, Express Intention, Develop Fluency, and Simplify to Complexify.
3. Episodes of design framework with the child codes of planning, making, redesigning, and testing.

A sequential connection between the LPM and the episodes of the design framework was established as we moved from one timestamp visual to another. The resulting coded data from NVivo was transported to R studio to generate a graphical representation communicating the iterative nature of the design thinking process (Figure 3). We analyzed the digital story, graphical representation of the digital story and questionnaire data of the pilot case to establish the findings.

Findings

The deconstruction of the digital story and timestamp visuals revealed the dynamic iterative interaction between observable episodes of the design framework and the LPMs through the timestamp scatter plot (Figure 3). Learning practices such as Tinker and Hack & Repurpose were most evident, followed by Inquire and Develop Fluency. Next evident were Express Intention, then Seek & Share Resources, and finally, Simplify to Complexify. When the timestamp scatter plot of the deconstructed digital story and questionnaire data (Figure 4) were compared, interestingly, the participant didn't report on the LPM Simplify to Complexify, but the scatter plot (Figure 3) depicts acquiring a complex design during the end of the process, enacting Simplify to Complexify. We found a non-linear transition within different episodes of the design framework (Figure 5) from making (timestamp visuals numbering from 1-5) to testing (timestamp visual number 6), back to making (timestamp visual numbering from 7-9), then to redesigning (timestamp visual number 10), returning again to making and testing (timestamp visual numbering from 11-13), then redesigning (timestamp visual number 14), making again (timestamp visual number 15), redesigning again (timestamp visual numbers 16, 17), then redesigning and making (timestamp visual number 18). We were unable to observe episodes of planning, but making, redesigning, and testing were observable (Figure 5), but the participant reported episodes of planning were imperceptible to us.

Figure 3

Timestamp Scatter Plot of the Deconstructed Digital Story After Analysis

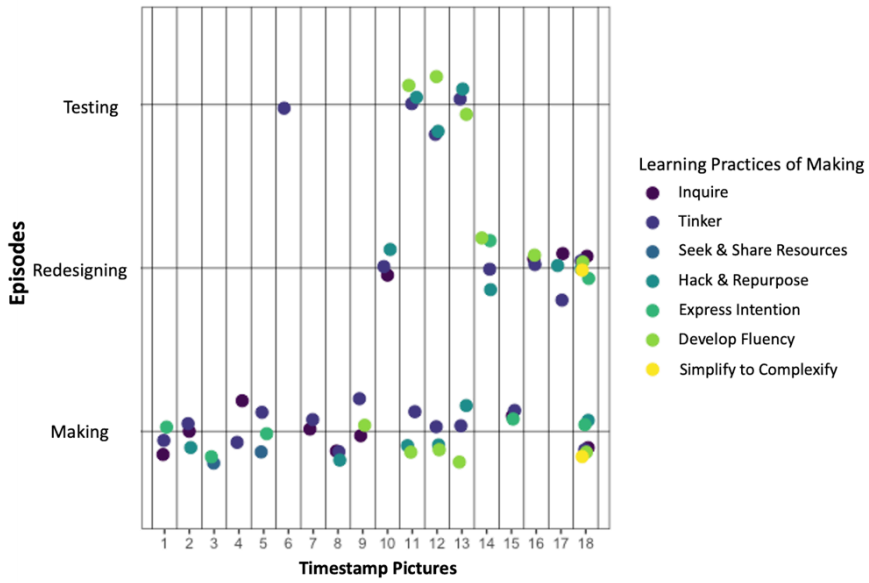


Figure 3. Timestamp Scatter Plot of the Deconstructed Digital Story After Analysis

Figure 4.

Questionnaire Data of the Participant

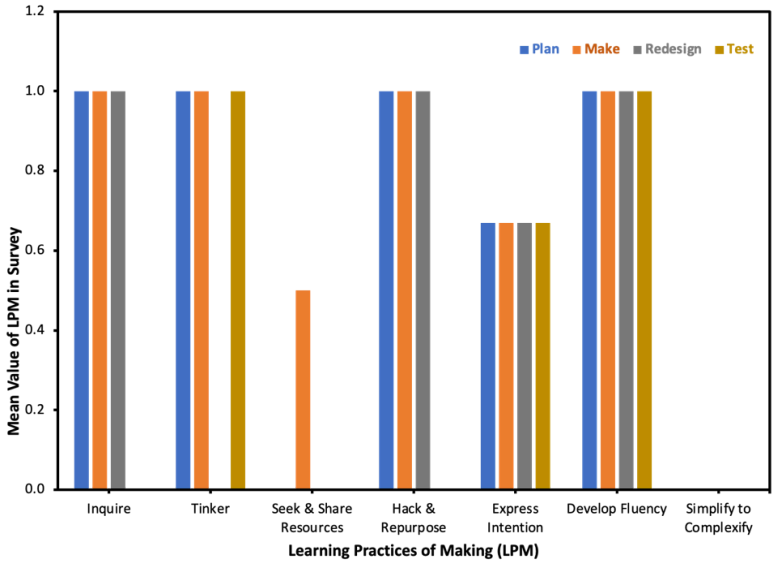
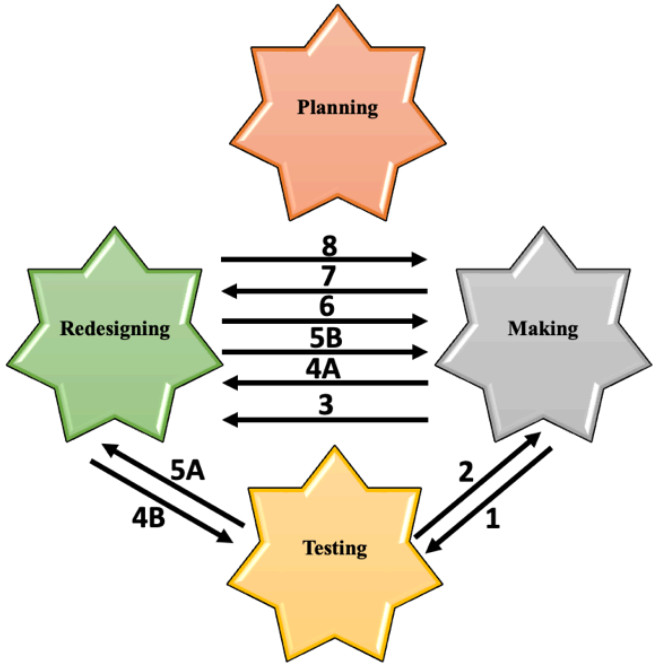


Figure 4. Questionnaire Data of the Participant

Figure 5

Iterative Episodes from the Scatter Plot



Conclusions

Representing the interactions between episodes of making and LPM reveals much more than the back-and-forth interactions. When the often invisible process of making is made visible, there are still hidden aspects that only the maker knows (planning and intent). Conversely, there may be some processes hidden to the maker (Simplify to Complexify) because they may be unaware of their growing expertise. Therefore, additional research is needed to understand the planning processes in making and helping makers understand the practice of Simplify to Complexify as part of their growing expertise.

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