Iteration in STEAM: Moving Beyond Failure

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Abstract: Iteration is a central practice in art and science; however, it has yet to be deeply explored in STEAM learning environments. This study adopts a sociomaterial orientation (Fenwick and Edwards, 2013) to characterize the nature of iteration in one STEAM activity, an Optics Design Challenge, with informal educators. We found that iteration emerged as "microcycles" of interactions, specifically as adjustments, additions, and negotiations in both material artifacts and the narrative.

Keywords: Iteration, STEAM, informal education, design challenge, sociomaterial

Iteration

Designing STEAM programs has been a promising approach to both removing systemic barriers to participation for those who have been historically marginalized from STEM fields, as well as to reimagine expansive notions of STEM learning (Vossoughi and Bevan, 2014). However, while STEAM programs have been gaining traction, STEAM as an integrated construct could benefit from a more detailed articulation of the practices involved. We have been working to address this gap by identifying a set of core STEAM practices that draw on art and science disciplines (Carsten Conner et al., 2017). Iteration is a key practice in this model and is the focus of this paper. Iteration can broadly be defined as a successive and repetitive process that builds from previous outcomes, whether in design or experimentation (Bevan, 2017; Elliott, 2012). It is foundational in both science and art as a way of understanding phenomena through testing and improving a particular design (NRC, 2012; NCCAS, 2014). In tinkering, making, and science education, iteration has sometimes been considered as a response to correcting failures or mistakes (Bevan, 2017; Vossoughi, Escudé, and Kong, 2013). In arts integration literature iteration has been explained as a process of refinement (Halverson and Sheridan, 2014). To explore this more deeply, we ask the following research questions: What does the practice of iteration mean in STEAM? More specifically, what are the forms that iteration takes in an art-science design challenge?

Theoretical framework and methods

In order to characterize the nature of iteration, we adopt a sociomaterial orientation to foreground subject-subject relationships between humans and materials (Fenwick and Edwards, 2013). We draw on Goodwin's (2017) notion of accumulation in co-operative action as a theoretical framework to explore the material and narrative transformations in interactions during an Optics Design Challenge. This design challenge explored the scientific concepts of light absorption and reflection, and was one of five art-science activities that were part of a two-day STEAM professional development workshop. In this activity, participants were asked to design a "set" of their choosing for a hypothetical theatrical production using construction paper, glue, and scissors. Each set was designed under three different colored lights to provide opportunities for iteration. More specifically, the groups began their design under a green light, and continued that design as the light switched to red, and then blue. Part of the task was to consider what elements would appear and disappear under the different lights, and to think about how that would contribute to the story narrative.

Participants in this study were children's librarians from one library system in the Northwest. They worked in small groups of three or four, and each group collaboratively designed a set. The duration of the activity was approximately 30 minutes, and we analyzed a total of two hours of video data from four of these groups. We utilized interaction analysis (Jordan and Henderson, 1995) and grounded theory (Glaser and Strauss, 1967) to explore how learning unfolded in collaborative discussion and material manipulation in the design of each set. Videos were transcribed and coded for utterances and interactions along two dimensions: 1) manipulations of the materials (physical tools), and 2) manipulation of the story (narrative tools) (e.g. Cole, 1996; Elliott, 2012). We note that one methodological shortcoming of this analysis is that it focuses on one design challenge, and in coming work we are expanding the focus to consider other activities.

Major findings

In this STEAM activity, iteration was an accumulative (Goodwin, 2017) and generative process, or what Elliott (2012) calls a process of "progressive alterations". This manifested in three interrelated interactional forms: *additions*, *adjustments*, and *negotiations*. We provide exemplars of each form through the following example. One group designed a set for a story that unfolded as the participants assembled materials under different lights. In the beginning of the design process, under the green light, one participant proposed that they add trees to the set because it "would look different under different light". Chelsea, another participant, suggested that they add a house instead because it would be easier to cut out than a tree with many leaves, and they could "put different things on the house". We coded this interaction as an example of a *negotiation*: although a full draft of the design did not yet exist (e.g. Vossoughi et al., 2013), the affordances and constraints of the physical materials altered the course of both the material and narrative design. When there was agreement, Chelsea cut out a house and added it to the set background, a move we coded as *addition*. The house became the focus of the story, and Chelsea then cut out a long curved shape and placed it down (*addition*) as a river. Another participant repositioned (*adjustment*) the river to be near the house, and to line up with the edges of the paper. The narrative then focused on a house by the river, and this led to two of the participants collaboratively cutting out raindrops and gluing them to the set (*addition*). When the light switched from green to red, the participants noted how the light shift gave the set an "ominous" feel, and the rain became "driving rain". In the end, the scene told the story of a rising river that flooded a house. Through the transformation of materials – negotiations, additions, and adjustments – the participants engaged in what we call "microcycles" of material and narrative iterations that transformed the story.

Conclusion and implications

Iteration has sometimes been considered as a way to refine or correct failed attempts at designing something, with the implication that a there needs to be a draft of the design for it to occur (Vossoughi et al., 2013; Bevan, 2017). While this may be the case in science and engineering learning environments, the findings in this study point to another manifestation of iteration within a STEAM context: namely that iteration was a generative process that occurred in microcycles of adjustments, additions, and negotiations. Furthermore, we find that the materials themselves had agency within these design challenges. We argue that while iteration is a shared practice between science and art, STEAM learning environments provide opportunities for co-creation between people and materials in ways that are unique to this integrated field.

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