Exploring Teachers' Approaches to Standards-Based Making in Elementary Classrooms

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Abstract: In this paper, we explore how standards-based Making activities offer opportunities for teachers to address interdisciplinary concepts and encourage students to tinker, collaborate, create, and design. This qualitative study draws on results from a two-year, NSF-funded research project that involved the integration of standards-based Mobile Maker Kits into 15 elementary schools within a suburban-rural Southern school district. Specifically, we examine teachers' goals for using Mobile Maker Kits, as well as how the hook, brainstorm, prototype, share, synthesize framework supported them in integrating Making into their existing standards and curricula.

Context for the Study

Human beings have been makers for nearly all of our history--designing, planning, and crafting with our hands and with tools to solve problems. In recent years, hobbyists and tinkerers connected by a passion for creation, technology, and innovation, have developed an interconnected Maker community that aims to explore, discover, and create solutions to 21st century conundrums (Dougherty, 2012). While there has been an explosion of interest in Makerspace installation across both in and out of school contexts over the past 10 years, Making practices and pedagogies draw on constructivist and active learning approaches that educators have been using for decades to put students at the center of their own educational processes (Litts, 2015; Martinez & Stager, 2013; Papavlasopoulou, Giannakos, & Jaccheri, 2017). Papert (1980), for example, suggested that asking students to tinker, make, and redesign shapes using computer programming could enable them to critically engage with complex mathematical concepts.

Advocates for Making argue that these practices can spark interaction, innovation, fabrication, and design thinking, all key skills for a 21st century world (McKay, Banks, & Wallace, 2016). Recent studies have even suggested that infusing inquiry-based Maker activities into classrooms for academic purposes can potentially change conceptualizations of how we teach and how students learn (Buchholz, Shively, Peppler, & Wohlwend, 2014; Oliver, 2016; Stornaiuolo, Nichols, & Vasudevan, 2018). Although much of the previous work on Making has focused on informal and out-of-school settings (e.g., libraries, museums, and community centers), researchers have begun to identify several common pedagogical practices that can support active, interdisciplinary learning while Making. Examples of these practices include: the collaborative construction of ideas, artifacts, strategies, and purposes for Making (Hackett, 2014; Sheridan et al., 2014); supports for empowering makers to exert control over their choices (Cohen, Jones, Smith & Calandra, 2017); the use of transdisciplinary approaches to problem-solving and creation (Halverson & Sheridan, 2014); and engagement in cycles of iterative design that involve failure, rethinking, and reconstruction (Kurti, Kurti, & Fleming, 2013).

The goal of the Mobile Maker Kits project is to explore alternatives to more traditional Makerspaces and to examine how standards-based Making activities can be fully integrated with classroom activities, interdisciplinary content, and existing classroom curricula. This paper draws on data from the Mobile Maker Kits project, in which we collaborated with P-5 students and teachers in 15 schools across a suburban-rural school district to design and integrate Making activities into elementary classrooms. Specifically, in the following sections, we describe teachers' pedagogical goals for integrating Making into their classrooms, as well as how teachers utilized the hook, brainstorm, prototype, share, synthesize framework to integrate Making into their standards and curricula.

Method

This study addresses the following research questions:

- What pedagogical goals do teachers identify?
- How do teachers utilize the hook, brainstorm, prototype, share, and synthesize framework to support students in standards-based Making activities?

Mobile Maker Kits

Mobile Maker Kits is a three-year (2017-2020), NSF-funded research project that aims to integrate standards-based Maker materials into 15 elementary schools within a suburban-rural Southern school district serving nearly 27,000 students (55% White, 30% Black, 7% Hispanic, 8% Multiracial), 41% of whom receive free or reduced lunch. Over the course of the project, we have designed 20 unique Mobile Maker Kits, which have been used by more than 75 teachers and 5,000 students.

In order to ensure that all objectives are met within a given lesson, to provide a structure to support student learning, and to facilitate teacher use of the Mobile Maker Kits, we designed each Making lesson around five pedagogical elements (hook, brainstorm, prototype, share, and synthesize). Each kit includes a guided read-aloud, supports for key vocabulary, formative and summative assessments, discussion guides, and all needed materials (e.g., picture books, craft materials, tablets, 3D printer pens, circuits and other electronics). Lesson plans, assessments, and other resources for implementation are freely available to all teachers on our website (removed for the purposes of manuscript blinding). Throughout the design and implementation process, we've worked with our partner teachers to create, revise, and refine Mobile Maker Kits that bring together literacy-centered activities, interdisciplinary standards, creative responses to practical problems, and design-based thinking. This collaborative work played a critical role in supporting the design of activities that account for both the benefits and challenges of classroom Making.

Data Collection and Analysis

In order to provide an in-depth analysis of teachers' use of the Mobile Maker Kits, this study analyzes data from a purposive sample of 28 teachers who used kits during the first three months of the Y2 implementation. Primary sources of data included: teacher surveys measuring beliefs, self-efficacy, and pedagogical approaches connected to Making; teacher journal entries; pedagogical artifacts from the implementation of Mobile Maker Kit activities; and video recordings of classroom interactions. In the first phase of analysis, using qualitative coding procedures informed by grounded theory (Patton, 2002), we analyzed 28 survey responses, journal responses, and pedagogical artifacts using constant comparative cycles of open and axial coding to identify themes and then to integrate and organize categories (Lincoln & Guba, 1985).

Then, in order to triangulate findings of the initial analysis, we conducted a microanalysis of three purposively selected classroom videos using the multimodal discourse analysis (MMDA) approach, which assumes that social interactions necessarily rely on forms of communication beyond language (Kress & van Leeuwen, 2001; Norris, 2004). Videos were chosen to ensure diversity in grade levels (1st, 3rd, 4th), types of Mobile Maker Kits used, and teacher self-efficacy in using the kits. The focus of analysis was on the pedagogical approaches used by the three teachers to enact the kits, as well as teacher and student interactions.

Findings: Teachers' Pedagogical Goals for Using Mobile Maker Kits

Teacher surveys revealed several primary pedagogical goals for using the Mobile Maker Kits, including supporting interdisciplinary pedagogies (36%), encouraging student collaboration (15%), and increasing access to technology (11%). Several teachers noted that the Mobile Maker Kits offered opportunities for elementary students to tinker, create, and engage with key concepts across disciplines. For example, as Renee, a first grade teacher, reflected, "Using the book *Moosletoe* by Margie Pallatini, the students watched a read-aloud and worked independently to sequence/retell events in the story...After they were done retelling, they created a course that the Ozobot would follow to help with their retell. My aha moment was their conversation and discussion as we reflected on each lesson--they were able to overcome any of the obstacles that they came across." Findings from video analysis of Renee's implementation of the kit indicated that students were utilizing vocabulary, discursive structures, and patterns of collaboration that brought together disciplinary practices encompassing English language arts, mathematics, and computer science.

Several teachers referenced the necessity of specifically encouraging students to change, adjust, and even discard their plans; as Claire, a 3rd grade teacher, said, "Many of my students did not stick to their original plans, but they worked well together to come up with additional ideas...I had to tell them that it was ok to do a different idea." Teachers also noted that they used particular strategies, including collaboration, differentiation, and incremental Making and reflection, to support students' developing abilities to challenge, negotiate, and discard ideas. For instance, Juliet's fourth grade students were required "to work with their partner to come up with creative solutions to any problems they encountered." Likewise, after creating purposively selected groups, Renee found that "all groups were able to create a working path. Some groups were able to create more intricate paths than others, but all groups were successful in making their Ozobot travel and meeting the requirements of the challenge." These findings suggest that in order to support students to challenge, negotiate, and discard ideas in the process of Making, pedagogical and interactional models need to account for the value of failure and discord over efficiency and ease.

Findings: Teachers' Use of the Hook, Brainstorm, Prototype, Share, Synthesize Framework

The Hook, Brainstorm, Prototype, Share, and Synthesize framework is designed to scaffold students through the Making process by encouraging design thinking, revision, and collaboration. First, the Hook phase utilizes three different components--an anticipation guide, a read-aloud, and an interactive activity. While the anticipation guide piques students' interest and generates reflection about the larger concepts of the lesson, the read-aloud and interactive activities play a key role in anchoring Making to literacy practices, content understandings, and expectations for student learning. Next, during the Brainstorm phase, students draw on prior knowledge developed and activated during the Hook to generate ideas using discussion, sketching, organizing materials, creating graphic organizers, and making lists. During the Prototype phase, students use craft materials and technologies to make, revise, rethink, and sometimes discard their products. Then, the Share phase offers opportunities for students to present their creations to their peers, get feedback for future iterations of their designs, and to ask each other questions about how their designs address the disciplinary content. In the final phase, Synthesize, students engage in metacognitive reflection about content learning outcomes and other skills targeted in Making activities, such as design thinking processes and collaborative creation.

Several teachers noted that the framework was useful in supporting students' mastery of standards addressed in the Mobile Maker Kits. As Ellen explained, the Hook and Brainstorm phases played a key role in framing the activities for her students: "I like to use the mentor texts and allow them to have time to generate ideas days before they started Making. That way, they really understand the standards and story elements and they don't get lost while Making." Others noted that the framework helped them to reinforce both discipline-specific vocabulary terms like “plot” and “climax,” as well as computer science terminology like “algorithm” and “code.” Teachers specifically noted that the Synthesize phase was critical in reinforcing new knowledge, such as when Renee’s students used textual evidence to explain how their Ozobot tracks supported their retellings.

Other teachers referenced the role of the framework in supporting transdisciplinary practices focused on problem-solving, design thinking, and collaboration. Eve, a 3rd grade teacher, said that the Brainstorm phase allowed her students to reflect on a variety of things that they had built to solve a problem: “another room in my house with my dad because there wasn’t enough space”; “my dad’s truck so that he could go to work”; “a marshmellow house to see if it could stand up to an earthquake”; and “a cake because I was hungry.” Teachers specifically noted that the Prototype and Share phases supported oral communication, discussion, and collaboration skills. For instance, in Ava’s fourth-grade class, students used a Mobile Maker Kit that addressed math, art, ELA, and science standards and tasked students with creating fraction bead art using abstract patterns. Ava decided to use a two-part Share phase that also provided enrichment tasks for students who finished their creations early. In the first phase, as students finished their designs, they were asked to leave them on a table in the center of the room so that other students could try to decipher the patterns their peers used to create their abstract pattern bead designs.
In the second share phase, students engaged in an inner circle, outer circle activity to practice using computer science vocabulary and ways of communicating to share their work. Ava noted that this activity provided students with opportunities to practice using disciplinary vocabulary and communication practices and helps to reinforce key speaking and listening skills.

Conclusion

Our findings demonstrate that teachers were able to leverage standards-based Maker kits to create new opportunities for student participation in transdisciplinary design thinking and to scaffold students into classroom-based Making practices. For teachers and teacher educators interested in Making in academic settings, this study suggests ways to scaffold and support students as they engage in new forms of collaborative creation and interaction (Author, 2017; Buchholz, Shovely, Peppler, & Wohlwend, 2014). Further, we hope that the hook, brainstorm, prototype, share, synthesize structure for designing similar lessons can help teachers create interactive lessons that bridge disciplinary boundaries, foster a spirit of innovation, and spark joy in the learning process.

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