# Design Moves of “Maker” Teachers: Design and Fabrication Culture in the Classroom

**Christian McKay**
Indiana University
Bloomington, IN 47404, USA
mckayc@indiana.edu

## Abstract
In considering the integration of technology in the classroom it is necessary to factor in the ways in which teachers design for their use. Maker spaces and their use of digitally-based rapid prototyping tools such as laser cutters and 3D printers are serving as new models for technology integration in learning environments. While there has been some research on the educational affordances of such technologies little research has been done to understand their use in the traditional classroom environment by teachers. Here I explore the design of curricular and instructional activities by two teachers who have been re-designing their class into a maker space oriented classroom.

## Author Keywords
Maker space; problem-based learning; instructional design; curriculum design; fabrication cultures; classroom cultures; teacher identity



## ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

## Introduction
With their fluid use of digital fabrication tools and processes, maker spaces are burgeoning technology-rich learning environments. While there has been a growth in research conducted on maker spaces the studies have been conducted primarily in the informal learning environments of spaces such as science museums, libraries, after school drop-in spaces, and community-based hacker/maker spaces [5, 13, 14]. Much of the research conducted in both, informal, and formal learning spaces is focused on studying the efficacy of various learning interventions as they are connected to materials and tool use, such as learning circuitry through e-textiles [8, 12]. Additionally, there has been research on the impacts of engaging in craft-based work in maker spaces to encourage computational thinking, and other STEM-based practices in marginalized communities of learners [2]. Although there is literature concerning the ways in which teachers move as designers of curriculum and instruction in maker classrooms [7, 9], most of the research that includes teachers in maker spaces focuses on the affordances of integrating the

technologies of maker spaces in the formal learning environments of classrooms [4,10], and more broadly in schools [1] in context to constructionist principles of learning [11].

Many of these studies do provide valuable information on variables that affect learning in informal and formal educational maker spaces. However, through their focus on technology-oriented interventions the incomplete knowledge they provide paradoxically also serves to support the continued cyclical patterns of well-intentioned, reform-minded policies that fail in their attempts to successfully integrate new technologies into the classroom [3]. While Cuban calls for "describing and analysing (sic) the past, particularly the nexus between new technologies and schooling… to inform policymakers, practitioners, and researchers" [3], I argue for the need to look at and analyze the ways in which teachers' and students' in-the-moment practices are enacted in the construction and transmission of knowledge within the network of a maker space. This seems particularly needed because less is known about how the enacted practices of various stakeholders in their network shape the culture of use of the technological tools and design processes of maker spaces, both more broadly, and more specifically in context to those found in "traditional" classroom environments.

This position paper touches on some of the enacted practices regarding design decisions of two teachers team-teaching a multiage 6th, 7th and 8th grade class in a community-based charter school. As the teachers have been integrating maker technologies into their classroom curriculum and shifting their classroom architecture (both physical, and instructional) toward designing a fully dedicated maker-space classroom, the maker technologies are being used to support the students' learning in project, problem, and place-based curriculum (P3).

The classroom environment has students and teachers immersed in a technology-rich environment that supports the design and execution of complex projects. As a recipient of an innovation grant, the school purchased 1:1 iPads for teachers and students, a cart of MacBook Air laptop computers, and a mobile "makercart" housing a 3D printer, and a laser cutter. The tiny-house project highlighted below even inspired the students and teachers to demobilize the "makercart" and turn their classroom into a complete maker space to facilitate the incredible amount of design and building that was occurring on a daily basis.

## P3 Curriculum + Design + Digital Fabrication

The school engages students in curricular activities that follow a P3 model; P3 stands for *problem, project, and place-based* learning. Through this curricular framework the students are engaged in work that is connected to the local community and the issues facing it. These projects can start in a multitude of ways: student generated, co-constructed, negotiated between students and teachers, etc.

The project used here to highlight the teachers' design moves as "maker teachers" was developed around the concept of tiny-houses. This project had the students engage in inquiry into the tiny-house movement, local building codes, and architectural design processes. The project then moved the students toward designing and fabricating scale models of their designs, and eventually showcasing their work publically at the end of the school year at city hall.

Of note with how this project was developed is that while the teachers initially conceived the curricular activity as being about the design of "tiny houses," they held a public forum with their students to gauge interest-level and get some ideas around curricular entry points, activities, connections, and some potential products or artifacts that could come out of this work. Multiple conversations, brainstorming sessions, and Google Surveys helped the teachers construct the basic architecture of the project. Students would work in teams of 8-10 with each student playing a specific role, or holding a specific job. Jobs consisted of: team leader, house designer, sustainability coordinator, neighborhood and community developer, and technology specialist.

As the project began, students conducted multiple case studies of various tiny-house projects from around the world, critiquing and uncovering the various mission statements, concept plans, and house designs. This work helped students build some context around why individuals and communities were turning to tiny houses and the concept of downsizing.

Alongside this research and exploration, teams began to construct their team agreements, and were introduced to a set of consensus building and decision making protocols. They used these processes to begin creating their own mission and vision statements for their tiny home communities. At this point the teachers were beginning to construct what the requirements for the final project would be. These requirements evolved over the course of the year with feedback from university level architecture students, and professional architects.

The collaboratively developed requirements specified that students understand scale and be able to create a ¼ scale model of their tiny-home. It quickly became apparent to the students that the technology they had available would make much more professional results than a strictly handcrafted model. Teams were drawn to a variety of methods of making the scale models that involved learning software to create them.

To facilitate this the teachers found themselves spending countless hours learning how to use programs like Adobe Illustrator, Pixler, TinkerCad, and Blender in order to support the students using the programs. Through this teacher led support the student teams that were drawn to laser cutting or 3D printing became proficient and even advanced at design software and 3D modeling programs like Blender, and SketchUp. The interests of the students had the teachers spending lunch, recess, and before and after school helping students print and laser-cut their display pieces.

The yearlong project culminated in the students displaying their projects at the city hall. They displayed their models as interactive objects for visitors to engage with. Some of these models could be opened up to view the interior space, and all were of a scale to pick up and rotate by hand for closer viewing. Accompanying these models were large boards, which both, visually, and textually told the teams' design stories from their initial research, which included not merely architectural considerations, but also local codes and regulations, to the impetus behind their specific designs, and on to how the final implementation of their house designs might be incorporated into tiny house communities.

## Conclusion

There is an aspect of the teachers' movements as teachers-as-designers (both becoming and being) that is well worth noting. As these two teachers engaged in their everyday practices in designing this tiny house project, they were involved in the very cycles and processes they worked to make explicit to their students. What is interesting is not simply that they were doing this, but that they did not appear to be aware of the parallels between their own design practices as teachers and those they were explicitly encouraging the students to engage. This observation stems from the ways in which they both often referenced themselves specifically as not being designers and as being unknowledgeable about how designers function.

Design problems are among the most complex and ill structured, but most designers engage in a typical cycle [6]. That cycle may take the form of defining the problem, locating one's interests in relation to that definition, developing ideas toward a preliminary design, which in turn lead to a detailed design, and subsequent artifact that is shared out in the world.

These two teachers designed, through an iterative and self-reflexive practice, a P3 project that was implemented through a process of co-designing by way of engaging their students' impulses and interests. These interests in turn lead to an inquiry into and subsequent design of tiny houses. The project was meaningful in that it engaged students in an authentic process of designing something fundamental to how we live by engaging them in a process of shaping spaces we commonly live in.

The project these teachers co-designed illustrates how it is possible to move toward an understanding that innovative instructional design in the traditional classroom is constructed by teachers with their students in attempting to solve real world problems that are made relevant to the contexts of learning. This framework is valuable in helping move away from the technology- and tool-centric view of innovation in the design of classroom instruction and curricular activities as rooted in the use of technology, tools and materials. This is particularly true in context to the burgeoning discourse surrounding maker culture. It is rather through these teachers' intimate knowledge of the contexts of their classrooms, students, and the technologies available to them, that they are engaged in the continual process of becoming and being the designers of rich learning experiences for their students.

## References


1. Blikstein, P. (2013). Digital fabrication and 'making' in education: The democratization of invention. *FabLabs: Of Machines, Makers and Inventors*, 1-21.
2. Buchholz, B., Shively, K., Peppler, K., & Wohlwend, K. (2014). Hands on, hands off: Gendered access in crafting and electronics practices. *Mind, Culture, and Activity*, *21*(4), 278-297.
3. Cuban, L., & Jandrić, P. (2015). The dubious promise of educational technologies: Historical patterns and future challenges. *E-Learning and Digital Media*, *12*(3-4), 425-439.
4. Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard* Educational Review, 84(4), 495-504.
5. Honey, M., & Kanter, D. E. (Eds.). (2013). Design, make, play: Growing the next generation of STEM innovators. Routledge.
6. Jonassen, D. H. (2010). Learning to solve problems: A handbook for designing problem-

solving learning environments. New York, NY: Routledge.

7. Justice, S. & Markus, S. (2015). Educators, Gender Equity and Making: Opportunities and Obstacles. FabLearn15: Digital Fabrication in Education, Stanford University, Palo Alto, CA.
8. Kafai, Y., Fields, D., & Searle, K. (2014). Electronic textiles as disruptive designs: Supporting and challenging maker activities in schools. *Harvard Educational Review*, *84*(4), 532-556.
9. McKay, C., Glazewski, K. (In Press) Maker Technology: Understanding and Designing the World. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. 4). Routledge.
10. McKay, C., & Peppler, K. (2013). MakerCart: A Mobile Fab Lab for the Classroom. Position Paper at the Interaction Design for Children Conference (IDC), New York, NY.
11. Papert S., & Harel, I. (1991). Situating constructionism. *Constructionism*. *36.* 1-11.
12. Peppler, K., & Glosson, D. (2013). Stitching circuits: Learning about circuitry through e-textile materials. Journal of Science Education and Technology, 22(5), 751-763.
13. Sheridan, K. M., Halverson, E. R., Litts, B. K., Brahms, L., Jacobs-Priebe, L., & Owens,T. (2014). Learning in the making: A comparative case study of three makerspaces. *Harvard Educational Review*, *84*(4), 505-531.
14. Toombs, A. L., Bardzell, S., & Bardzell, J. (2015, April). The Proper Care and Feeding of Hackerspaces: Care Ethics and Cultures of Making. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems(pp. 629-638). ACM.