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MAKERSPACE CLASSROOMS: WHERE TECHNOLOGY INTERSECTS WITH PROBLEM, PROJECT, AND PLACE-BASED DESIGN IN CLASSROOM CURRICULUM

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In considering the integration of technology in the classroom it is necessary to factor in the ways in which teachers design for their use. Makerspaces 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. This paper explores the design of curricular and instructional activities by two teachers who have been re-designing their class into a makerspace-oriented classroom.

Christian McKay is a digital fabrication labs and makerspaces coordinator in the School of Informatics and Computing, and also a fourth year PhD student in Inquiry Methodology in the School of Education, both at Indiana University. This experience, coupled with his MFA in sculpture, informs his educational research at the intersections of art, design, craft, and technology. Being a former public school teacher has shaped Christian's framework of collaborative research with teachers as they work toward integrating makerspace technologies and processes into their classrooms.

Tarrence D. Banks (Tarrey) was born and raised in Indiana, and is a graduate of Butler University with a B.S. in elementary education. He received his MA in school administration from Indiana University and is currently a PhD student at Prescott College focusing on project-based learning and sustainability education. Tarrey is a founding teacher at the Bloomington Project School, a k-8 project-based charter school in Bloomington, Indiana, where he team-teaches in the middle school.

Scott Wallace has his MAT in chemistry from Indiana University, and has been a teacher of science for eight years at the secondary and higher education levels. He is currently teaching all subjects to a 7/8 mixed-grade classroom in Bloomington, Indiana, and team-teaches in collaboration with Tarrey.

INTRODUCTION

There is a recent move toward understanding the educational affordances of the tools used in makerspaces, such as 3D printers and laser cutters (see Figures 1 and 2). While the research interest in the tools and their use also extends to the design processes associated with them, a significant portion of the research is based in the makerspaces that are found in informal learning spaces such as community-based hacker spaces, libraries, and museums (Honey & Kanter, 2013; Sheridan et al., 2014).

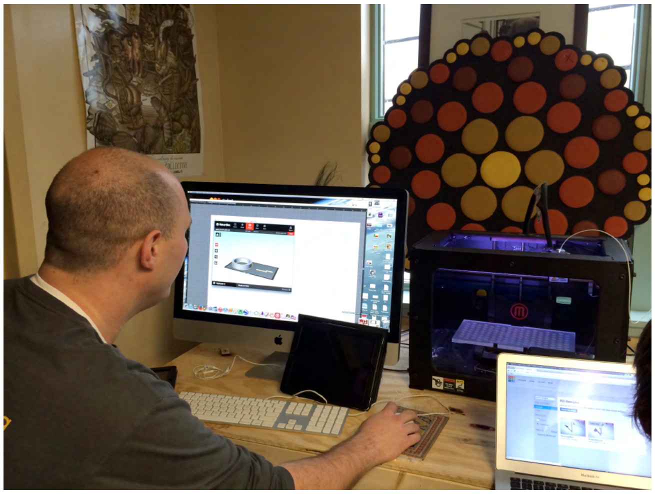

FIGURE 1. 3D printer.

FIGURE 2. Laser cutter.

FIGURE 3. Makerspace classroom.

While there is also a movement toward researching the affordances of makerspaces and the technology associated with them in schools (Blikstein, 2013), less is known about the ways in which teachers are integrating maker technologies into their classroom curriculum and what design processes are being utilized as they do so.

This paper explicates, in their own words, the design decisions of two teachers, Tarrey and Scott, team-teaching a multi-age 6th, 7th and 8th grade class as they have been integrating maker technologies into their classroom curriculum, and shifting their classroom architecture (both physical and instructional) toward designing a fully dedicated makerspace classroom (see Figure 3). The maker technologies are being used to support the students' learning in project, problem, and place-based (P3) curriculum.

DESIGN + P3 CURRICULUM + DIGITAL FABRICATION

May 2015: Full Circle

As I rolled through downtown Bloomington, Indiana at 5:00 in the afternoon, people stared, laughed, and even spontaneously cursed! Rightfully so I suppose, as I was towing a 24' × 16' tiny house with a rented U-Haul truck!

I was en route to City Hall, house in tow, to our middle school students' final exhibition after a year's worth of project-based work. At our school we call this work the *P3 framework*, which stands for problem, project, and place-based learning. We try our best as teachers to engage our students in big 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. This particular project started when my teaching partner, Scott, texted me a link to a documentary called Tiny, where a man took a year of his life to build a tiny house and ultimately downsized his life. I think the text was something like: "could be a cool project." That's really all it took.

I watched the movie and my mind started reeling with the kind of work we could do. In our P3 model, all we really needed to do was think through some initial connections and potential questions we might tackle. That, along with a strong rationale for how it satisfies the 3 P's, and how we could build curriculum that addresses state content standards is more than enough to get started.

August 2014: Planning and Student Co-Construction

At the staff retreat in August, after a pitch from us, our middle school team began to think through what the project might look like. At that time we saw the tiny house project being *a semester-long project that would culminate sometime in January,* and we would spend the rest of the year working on a documentary film project.

Initially we pitched it to the 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. Through multiple conversations, brainstorming sessions, and Google surveys, we constructed 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 (see Figure 4). Each student was required to write an extensive cover letter and fill out a "real life" job application.

As the applications came in students were assigned jobs and teams were assembled. 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 (see Figure 5).

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, as teachers, we 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, professional architects, and even a man we met in our town who was building his very own tiny house.

FIGURE 4. Student design teams.

FIGURE 5. Case study development.

FIGURE 6. Maker cart.

October 2014: A Continuation

Around the end of October, as we were wrapping up our first quarter and heading into fall break, it was clear that we had a project on our hands that could consume our entire year. As teachers, after a pitch to students, *we decided to forego the documentary project and stick with Tiny Houses for the entire year.*

At the Bloomington Project School, students and teachers were immersed in a technology-rich environment that supported the design and execution of a project on this scale. In fact, the Tiny House project even inspired the students and teachers to turn their classroom into a complete makerspace to facilitate the incredible amount of design and building that was occurring on a daily basis. 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 work cart housing a 3D printer, and a laser cutter (see Figure 6).

The requirements that were developed collaboratively 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 (see Figure 7). Teams were drawn to a variety of methods of making the scale models that involved learning software to create them.

We teachers found ourselves spending countless hours learning how to use programs like Adobe Illustrator, Pixler, Tinkercad, and Blender in order to support the students using the programs. Teams were drawn to laser cutting or 3D printing and became proficient and even advanced at using professional design software and 3D modeling programs like Blender and SketchUp (see Figure 8). The interests of the students had us spending lunch, recess, and before and after school helping students print and laser cut their display pieces.

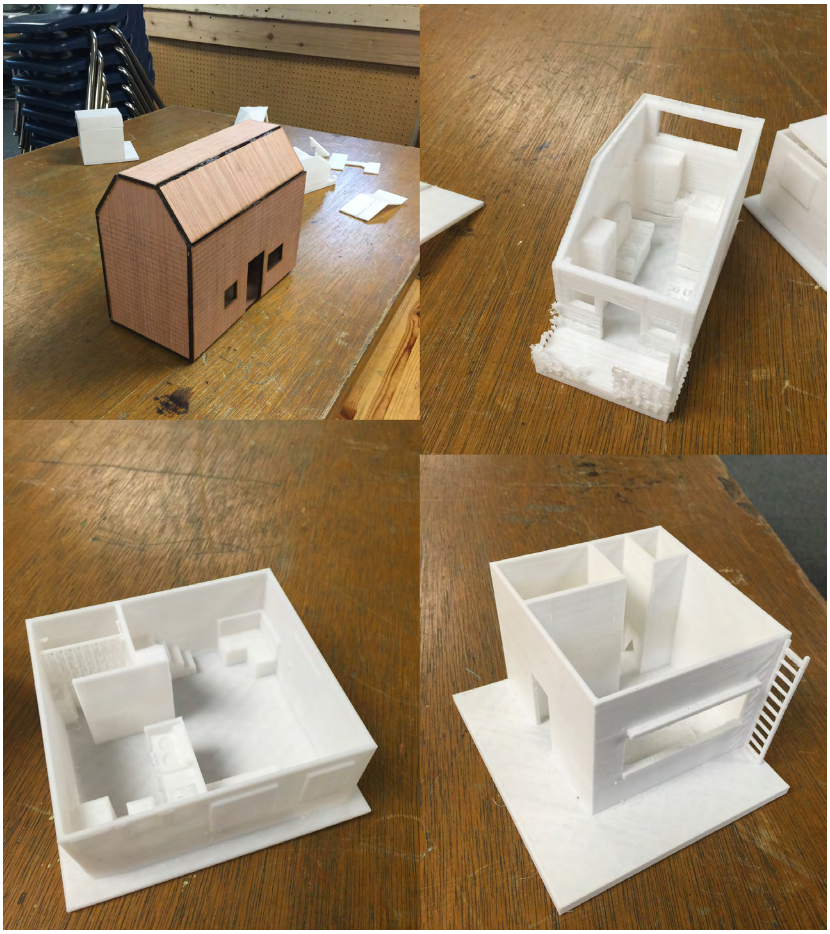

FIGURE 7. Tiny house models.

FIGURE 8. Design modeling programs.

Without fail, each group's models needed troubleshooting, modification, and on occasion even complete redesign as they encountered real life struggles in bringing their ideas to life. Some of these redesigns were related to how designing in the virtual space of 3D modeling programs did not always carry over well into fabricating those designs with laser cutters and 3D printers. Other design issues for the students came to light through human-centered design processes, where they came to understand the shortfalls of their specific designs as they might relate to actually living in their designed spaces. These design and fabrication issues were addressed and refined through the students' iterative design processes throughout the model prototyping stages.

Keeping the work of 90 students safe and secure presented its own challenges as well. We provided group folders through the Google Suite where students could "drop" files that were completed in preparation for presenting the work. Teaching students to be technologically literate and savvy was a big part of our work for this project, and not surprisingly, this process of developing technology literacy for the students expanded our own literacy.

When the project began, we had no clue we'd be so lucky as to find a Tiny Home being built in our very own community. Through a parent's networking, the classroom was introduced to a local builder who was building his own Tiny Home at the very same time the project was happening. This builder, Don (a pseudonym) came to the classroom weekly to help teams answer questions that could only be known by someone who was doing the work himself.

Don was an incredible resource for the students' questions about building methods, reclaiming materials, and city codes and ordinances. On multiple occasions, we took the class on field trips to Don's Tiny Home to see his progress and inspire the students' own work. It was this Tiny House that accompanied the students' work that was presented to the City of Bloomington (see Figure 9).

FIGURE 9. Tiny house.

FIGURE 10. Student showcase.

May 2015: Closing the Circle

As the year drew to a close, the work was scheduled for showing in the Atrium of City Hall. By this point, students felt like real "makers" and even built their own display boards to showcase the work. Teams had been dropping their files into their shared folders and we partnered with the local university to print large panels that would be mounted onto the boards students built.

Aligned with their panels, students showcased their laser-cut or 3D printed home models (see Figure 10). Turnout was incredible. Hundreds of visitors streamed through the atrium, including the Mayor Elect of the City. The work was actually on display for two days before the event, and many passers-by wondered if local college students had completed the work. Most people could not believe that it was the work of 12-14 years old children.

The students' projects 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. The boards included not merely architectural considerations, but also local codes and regulations to the impetus behind the students' specific designs, and on to how the final implementation of their house designs might be incorporated into tiny house communities.

CODA

There is an aspect of Tarrey's and Scott's 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 both, Scott and Tarrey, often referenced themselves specifically as not being designers and as being unknowledgeable about how designers function.

Jonassen (2010) indicates design problems as being among the most complex and ill-structured, but that most designers engage in a typical cycle. 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.

Tarrey and Scott designed, through an iterative and self-reflexive practice, a P3 project that was implemented first and foremost through 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 iterative design process the teachers engaged in began with Scott and Tarrey's defining the problem space of what project to engage the students in and ended with the final tiny house designs showcased by the students. 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 is constructed by teachers with their students in attempting to solve real world problems that are made relevant to the contexts of learning. This P3 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. Through Tarrey's and Scott's intimate knowledge of the contexts of their classrooms, students, and the technologies available to them, these teachers are engaged in the continual process of becoming and being the designers of rich learning experiences for their students.

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