Lessons Learned Creating Youth Jobs in an Afterschool Maker Space

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As an engineer at heart, I love to assist in the research on 3D printing and education in any way that I can.

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NSF GRANTEE PRESENTATION: Lessons Learned Creating Youth Jobs in an Afterschool Maker Space

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Introduction

Real-world problem solving through "Making" is becoming a popular way to engage youth in STEM (Science, Technology, Engineering and Math) education. Making promotes valuable skills including exploration, investigation, and discovery, which engages children in the classroom and may encourage them to pursue STEM fields [4, 17]. Since it is often difficult to infuse Making into students' schedules, this frequently occurs in after-school programs. Unfortunately, not all youth are able to participate in after-school activities due to financial pressures and may instead take jobs in non-technical fields such as food service or retail [15]. These non-technical jobs take time away from making, designing, and tinkering, which can leave them behind their peers who are honing skills for technical career paths.

We are working to create a living laboratory "print shop" at the Digital Harbor Foundation (DHF) Tech Center in downtown Baltimore to study the impact of Maker employment with inner city youth. The print shop opened in late January 2017, and is currently available to the local community for 3D printing and scanning services. Youth who work in the print shop have the opportunity to 1) develop and maintain technical skills; 2) hone "design thinking" skills through real-world problem solving; and 3) develop important soft skills (including working with a client, creating and sticking to a project timeline, and professionalism).

Our research is investigating many areas of maker and design thinking, the impact of maker jobs, and how to establish and maintain a community 3D print shop. This print shop has been designed to be a living laboratory to evaluate commercial and research software for 3D modeling, scanning, and fabrication software with youth performing real-world tasks.

Related Work

3D Printing and Modeling Education in High Schools and After-school Programs.

To better understand trends and obstacles in mainstream classrooms we interviewed 15 high school students who had taken 3D printing classes in school or after-school programs, and 7 instructors who had taught these classes [2]. These interviews highlighted the significant challenges balancing time and technological resources. We identified shortcomings with existing software including the need to support student success, design tools with meaningful metaphors, and ease the transition from novice to expert user.

Making and 3D Printing in Formal Education

While past work has studied the looked at the impact STEM and STEAM (Science, Technology, Engineering, Art and Math) in learning environments, understanding the impact of digital fabrication on youth is a developing field. Notable examples of this research include studying 3D printing as a means of learning and producing creative artifacts [1, 13], understanding accessibility challenges with youth [3,14], the benefits, implementation strategies, and technical challenges for integrating 3D printing in education [5, 7, 10, 12, 16]. Through engagement in these technical topics, Making can become a pathway to Engineering for youth [11].

Impact and Trends for Youth Employment

There are many organizations working to preserve the middle class and combat poverty and high unemployment rates [6] in Baltimore. One strategy is to provide meaningful job training in growing areas including biotechnology, health care, construction, and food service[1]. While these programs are successful, we believe there is an opportunity to expand these offerings to include making and digital fabrication with youth. Youth job choices can have a direct positive impact on their long term careers [8] and provide many positive benefits including employable skills, independence, leadership, communication skills, and help youth stay "out of trouble" [8, 9].

Despite these benefits of youth employment, it is difficult for many youth, particularly those from low-income families, to find jobs [15, 18]. Of the limited youth jobs in Baltimore, most are in areas that require and utilize few technology skills such as foodservice or retail [15]. One of our goals in this work is to help youth see how the skills they learn in maker spaces can translate into careers. We believe that showing youth that these skills have real-world value and applications will encourage them to hone these technical skills and increase the likelihood that they will identify as "Makers" and "Engineers" in early-adulthood. By targeting youth that would otherwise be pulled out of after-school programs to work, we hope to help diversify the pipeline of future makers and engineers.

Motivation for Youth-Run Print Shops

3D printing physical objects is becoming popular and we believe "making" with the help of 3D printers will become a common everyday activity [19]. Along with the popularity of 3D printing, 3D printers are becoming an affordable and mainstream technology. Individuals interested in having 3D printed parts without making the commitment to buy or operate their own printer are starting to have options to outsource fabrication services locally (e.g. 3D Hubs or the UPS Store[2]) or through services that print and mail objects (e.g. Shapeways or iMaterialise[3]).

Fused deposition modeling (FDM) is currently the most popular consumer 3D printing technique. FDM printer costs range from hundreds to thousands of dollars and these machines can create plastic models by layering small strands of heated material, which harden and bond together, solidifying into a 3D object. To create these models, users must either have access to an existing 3D model or use computer-aided drafting (CAD) tools to build such a model and then process this file for printing on their specific brand of printer.

Current 3D printing technology is slow, and successfully printing a 3D model is not trivial. In addition to learning the technical skills to operate a 3D printer, an operator must be able to troubleshoot the machine and monitor it to successfully print. Most operators have experienced the frustrating experience of running a 3D printer for several hours only to return to a nest of wasted filament and a failed part (Figure 1). Given the current state of 3D printing technology, these machines require supervision and trained technicians to keep them running efficiently. We believe that as 3D printing continues to become popular, demand will grow and create a new career path for professional 3D printer operators and modelers.

[1] http://www.abagrantmakers.org/?page=BWFC

[2] http://3dhubs.com/, https://mountainview-ca-1847.theupsstorelocal.com/products--services/3d-print

[3] http://www.shapeways.com/, https://i.materialise.com/

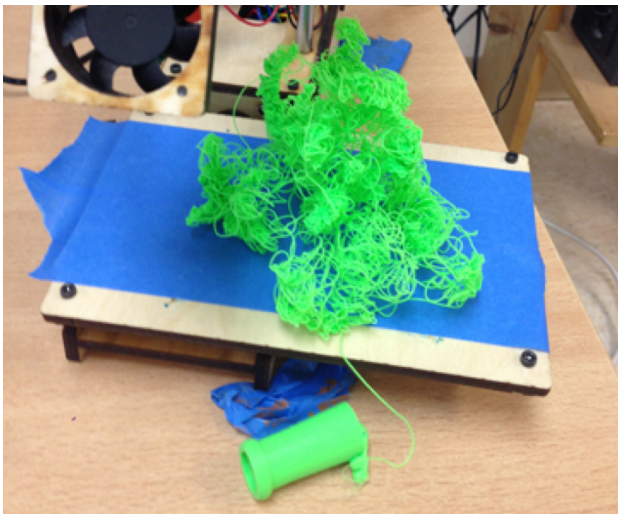

Figure 1. Common printer failure where the model came loose from the print bed during the print resulting in wasted filament. This error can be avoided by observing the print.

We have observed the need for outsourcing fabrication in our prior work interviewing educators who teach 3D printing [2] and have access to 3D printers. These educators discussed many difficulties balancing their time and resources with a high demand for 3D printed objects. Instructors offered 3D printing as part of an extra-curricular club or activity, since they were unable to make time in their regular school curriculum for 3D printing. Since 3D printed objects can take minutes, hours, or even a day to print, educators had to strategically choose printing priorities. While balancing their time, they received numerous requests for 3D printing projects from staff members and instructors wanting to incorporate 3D design into their curricula, create tactile learning aids, and personal gifts. These resource concerns are multiplied when educators need to produce large numbers of 3D printed objects. These educational settings would benefit from a centralized fabrication center to serve their diverse 3D modeling and printing needs.

Lessons Learning Opening a Print Shop in a Youth Maker Space

In this section we summarize our current progress designing a print shop that is integrated into the Digital Harbor Foundation's existing youth programs and culture.

Youth Employees and Digital Harbor Foundation

Our print shop engages youth who are eligible to work through our state's Minor Work Permit and have completed the 14-week *Maker Foundations* program at DHF. This program attracts a diverse group of youth in grades 6-12 who show sustained, independent motivation toward tech learning. This after-school course (with 56+ contact hours per student) provides students with many skills. Students who complete Maker Foundations become *DHF Members*, and receive access to advanced tech programming, individual mentoring and open after-school access to the DHF Tech Center.

Topics covered in the Maker Foundations program include:

- *Digital Literacy: B*est practices for Internet searches, app navigation, and computer use.
- *Digital Fabrication:* Create digital designs for 3D printing, and learn about the hardware components of 3D printers; students develop their own 3D-printed designs and prototypes.
- *Graphic Design:* Principles of graphic design, and design their own logo and illustration.
- *Game Development*: Learn Scratch to create a simple game, and develop coding fundamentals.
- *Web Development:* Basics of Wordpress, CSS, and HTML coding languages.
- *Electronics:* Introduction to circuits, soldering, Arduino, Raspberry Pi, and Makey Makey[4].

In order to motivate students to continue to develop their technical skills, DHF requires students to obtain digital badges to represent technical skill mastery. They are active participants and advisors in the Mozilla Open Badges Initiative[5], a national working group that is developing best practices to award mastery-based badges, and are helping expand this program.

Interviewing Youth to Work in the Print Shop

We recruited our first cohort of youth employees through email, word-of-mouth to current and former DHF Members and fliers that were hung in the DHF Tech Center in Fall 2016. We then interviewed all youth interested in working in the print shop. The goal of these interviews was not to "weed out" interested youth, but to provide youth with the interviewing experience and learn more about their personalities. Interviews lasted about one hour and youth answered open-ended questions about their interests, hobbies, and self-perceived skills. During the interview youth were asked how they would clean up or reorganize the physical space, and were invited to take a break to walk around the current space for inspiration. This question was asked to get a sense of youth's ability to independently identify work tasks.

We interviewed eight youth participants (4 female) who had completed the Maker Foundations program and were eligible to be employed under a work permit. The main eligibility requirement to receive a position was the ability to work a two-hour shift in the print shop at least once a week. All eight youth participants were offered paid positions in the print shop, and started working at least once a week (depending on their schedule) in December 2016.

Helping Youth Transition From Learning in a Maker Space to Working in a Maker Space

Since all print shop employees were familiar with the DHF Tech Center we wanted to ensure they saw working in the print shop as a job, and not a class or club. We felt this was important since many of them still participate in regular activities within the DHF Tech Center, and we wanted to send clear signals for when they are "employees" and when they are "members." To this end, we made physical changes to the space that would signal to them (and their friends) when they are working. Changes include requiring print shop employees to wear a uniform that has a name tag and Print Shop T-shirt that says "Staff." Print shop employees are required to use special laptops that are unique color from the laptops youth use when they are taking a class or working on personal projects. Finally, each employee uses a special tablet to "punch" in and out of work which is tied to their timesheets.

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[4] https://www.arduino.cc/, https://www.raspberrypi.org/, http://www.makeymakey.com/

[5] https://wiki.mozilla.org/Badges

Creating a Youth-Run Business within a Youth Maker Space

The print shop is located in the DHF Tech Center, in a corner of a large room that also houses other youth programs. The print shop is separated from the rest of space by a counter for customers and employees to discuss potential jobs. This counter has samples of 3D printer filament, and examples of infill and perimeters (or walls) for prints (Figure 2). These samples can be used by employees to help customers decide on the settings for their job. The walls behind the counter are filled with diverse 3D printers that are unique from the 3D printers that are available to DHF members. These printers are much more advanced than what is used in Maker Foundations and able to print objects in diverse sizes, resolution, and sizes. The 3D printers, tools, and supplies in the print shop are only available to print shop employees and staff.

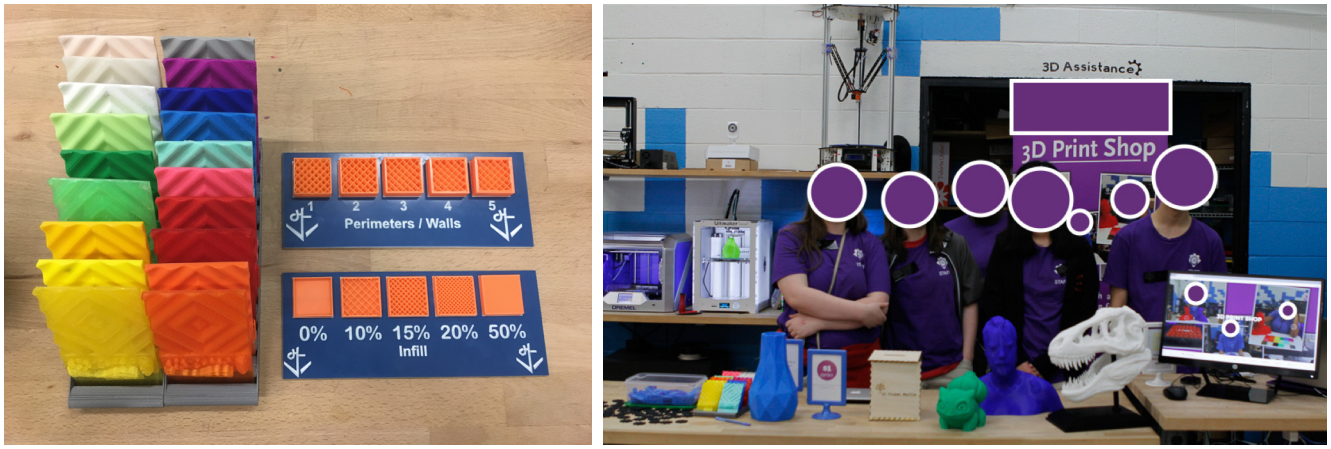

Figure 2. Samples available for customers in the print shop to see available filament colors, and understand the Infill and Perimeters / Walls settings on prints. (Left).
Photo of some print shop employees wearing their uniforms in the print shop space. (Right).

Supporting Communication Between Youth Employees

Print shop shifts currently consist of two youth working in the print shop. During a shift staff from DHF are available to answer employee questions and help them learn new skills. To help ensure large jobs are completed in a timely manner, print shop employees must communicate with each other across shifts and accurately track the status of jobs. We are currently exploring which tools are best for our employees to communicate, but are having success with them using Slack (a collaboration tool frequently used by development teams) and Google Spreadsheets to track job status. Every month we organize a monthly "all-hands" meeting for all employees, staff, and researchers involved in the print shop.

Expected Outcomes for Youth Working in the Print Shop

Youth working in the print shop learn advanced technical skills and develop professional soft skills. We will measure how these experiences impact interest in engineering and making.

Advanced Technical Skills Youth Employees Learn in the Print Shop

Working in the print shop provides youth the opportunity to hone the technical skills they learned in Maker Foundations and learn advanced concepts related to 3D printing. Specifically, print shop employees learn more about the "slicing" process, where data from a 3D model is converted into instructions for a 3D printer to build a physical object. This task is mostly handled by staff in Maker Foundations, but crucial when determining the resolution, density, and cost when printing models for clients.

The print shop is stocked with a diverse set of 3D printers that can accommodate print jobs with a range of resolution, filament, and size. These printers are more advanced than the ones youth use in Maker Foundations and each has unique capabilities. Youth working in the print shop learn how to operate these machines, understand their differences, and perform simple maintenance tasks to keep them running. In the future, print shop employees will learn more advanced 3D modeling skills including creating objects with professional modeling tools, and learning how to prepare data from 3D scans for printing.

Professional Development Opportunities for Youth Employees

Youth working in the print shop receive professional development and financial literacy training to help them manage their income from working in the print shop and learn how to manage and count income and costs from the print shop. Youth develop soft skills required to work with clients, email etiquette, following design requirements, and time management. These skills are taught by DHF staff helping run the print shop. Working in the print shop provides employees experience developing important skills one typically learns during their first job including punctuality, tracking work time, responsibility, and professionalism with colleagues.

Impact on Identity and Future Career and Engineering Opportunities

We believe that youth who see the connection between the skills they are learning in maker spaces and careers will be more likely to pursue additional engineering training. Specifically, working for real clients who are paying for their services will change the way they value maker activities from a "hobby" to a "career." We have begun to see some of this transformation as print shop employees have been very motivated to be work on projects for real-world clients and excited see their work be used by others.

Conclusion and Future Work

This research is enabling youth with the opportunity to deeply engage in making and gain technical work experience. We have summarized strategies we are using to select youth and help them transition into these jobs. We plan to add more services and recruit customers to provide more real-world clients. We are measuring the impact of these jobs on the youth's technical skill development and identity as an engineer. The strategies employed in this research to create a successful print shop can be replicated in many other formal and informal making programs (including high schools, libraries, and other maker spaces).

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