# Scaling Informal Technology Education through Makerspaces

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## 1. Introduction

Making refers to hands-on design, prototyping and fabrication activities conducted by amateur technologists, designers, and artists using consumer-grade technologies, such as 3D printers and low-cost microcomputers and microcontrollers [1, 2]. Maker education models provide multiple points of entry for youth to gain exposure, interest, and skill-building in high-growth technology skills [1, 2, 3, 4]. Research has shown that maker-based programs can engage underrepresented audiences, including minorities and females, in technology career pathways [5, 6, 7]. Maker education principles and approaches have transformative potential across both *formal learning environments* (i.e., in the classroom [1]), and *informal learning environments* (i.e., designed settings and experiences outside of the classroom [2, 3]). The flexibility of informal learning environments like afterschool programs, make them especially amenable to the iterative, experimental, ethos of making and provide the needed flexibility to experiment with systemic changes to youth-centered learning approaches. Previous research has shown that technical professional development for educators working in informal learning settings leads to early-stage, positive impact on educator skill development [8, 9, 10], as well as, youth outcomes [10, 11]. Despite these outcomes, current maker afterschool content is often delivered by staff with limited subject expertise or confidence [12, 13]. Resources and guides on how to establish and run a makerspace are becoming increasingly available; however, research is needed to understand the most effective ways to create these resources and support educators seeking to create and run maker learning programs for the first time.

In this NSF-funded project (Division of Research on Learning in Formal and Informal Settings), we are studying how to expand maker-based educational programs across three different sites. We used three professional development models, comprising of (1) satellite-site engagement, (2) home-site engagement, and (3) remote engagement. During the trainings, we worked with educators who had not delivered a maker-based program to design their space, familiarize them with maker concepts and technologies, and train them in an established maker curriculum. Results to date show that a hybrid online and face-to-face training offers the most promising approach to training educators and helping them setup their own maker programs, and that building in flexibility and customizability in the curriculum may increase educator and youth engagement.

In the next section, we briefly describe the project and the developed maker educator training approaches, as well as, our data collection and analysis methods. Finally, we present preliminary results and conclude with lessons learned from the project.

## 2. The Rec2Tech Project: Developing Educator Training Programs to Expand Maker Learning Experiences for Youth

The Rec2Tech project is a holistic, scaffolded approach for supporting the expansion of maker learning programs in informal afterschool settings. It is developed by the Digital Harbor Foundation (DHF), a non-profit organization that has been providing out-of-school-time learning programs to youth in an American urban setting for the past 7 years. Building on experience serving more than 5000 youth, DHF has developed an educator training program and an introductory youth maker curriculum that covers key topics such as digital fabrication, programming and web development. In addition to providing learning experiences for youth, DHF also operates a youth-staffed 3D print shop that offers technical employment training opportunities for youth [14, 15].The print shop employs youth who are eligible to work through a state government minor work permit and have completed a 14-week introductory course. The print shop offers 3D printing, 3D scanning, and 3D modeling services to community clients, as well as several national clients such as Nation of Makers [16] and CSforAll [17]. Former projects include developing assistive devices for older adults, printing art assignments from younger youth, printing chess sets for local parks, and designing a case for scientific sensing equipment that will go in a volcano.

DHF was founded through transforming an underused recreational center in downtown Baltimore into a dynamic and accessible maker learning hub where diverse youth could participate in hands-on, technology-enhanced courses. The Rec2Tech project was developed by DHF in response to demand by community partners for a structured and scaffolded way to replicate this model of transformation in new sites and with educators who might not have prior experience in delivering maker content. The Rec2Tech program comprised of three stages: 1) space design, 2) curriculum training, and 3) ongoing skills development and curricular supports for educators. Three variations of the program were developed, each being deployed at one site:

- **Home-site engagement:** The participating site sent at least 2 educators for 3 days of intensive training (8 hours per day) at DHF. The educators received instruction on how to work with the tools in their makerspaces and deliver maker content based on the provided curriculum. Afterwards, the educators delivered the program with online support and monthly phone meetings form DHF staff.

- **Satellite-site engagement:** DHF deployed a mentor to work side-by-side with at least two educators in their afterschool space for intensive in-person curriculum training over three days (8 hours per day).

- **Remote engagement:** In this model, all training and support took place remotely. Participating educators received asynchronous, step-by-step training in space design and the maker curriculum. The online training included text- and photo-based task descriptions and session outcomes, with supplementary video demonstrations and talks of complex tasks and course subjects. Educators could request support from DHF staff via email, phone or video chat.

In all variations, space design and physical setup was conducted by in person DHF staff at the sites (over a period of 8-12 hours). Additionally, following training educators from all sites could join in monthly phone meetings with DHF staff to discuss any questions or challenges. The main focus of this research project was to study the possibilities and limitations of each training model with a view of refining the Rec2Tech training approach and informing future plans for expanding maker learning programs.

### 2.1.Program Setup and Educator Training

Three sites participated in the program; each going through three stages of preparation including the application of one of the three training models described above. During the first stage, DHF consulted with participating sites to identify a space suitable for the delivery of the program. The sites then received equipment, including 3D printers, laptop and desktop computers, and digital prototyping materials. DHF staff installed and tested the equipment at each site. Next, educators were trained using one of three training models. Finally, the sites recruited 10-12 youth and conducted the maker training program for them with continued support and supervision by DHF trainers.

Site 1 is situated in a local high school which transformed one of its underused classrooms into a maker space. Staff at site 1 were trained using the home-site engagement model. Site 2 is an organization that provides art-focused classes to youth and adult community members. Staff at site 2 were trained using the satellite-site engagement model. Finally, site 3 is an organization that provides drop-in afterschool programs to underserved youth in an urban setting. Staff at site 3 were trained using the remote engagement model.

### 2.2.Data Collection and Analysis

We conducted pre- and post- interviews with all educators and administrators (n = 9) at the participating sites. Additionally, we conducted two focus groups where participants met and discussed their experiences with DHF staff and each other. Finally, for the duration of the program setup and administration (roughly 9 months), we organized monthly group phone calls in which participants raised any questions they had about the program and commented on their experience. All interviews, focus group discussions and check-in calls were audio recorded, transcribed and analyzed using an inductive thematic analysis method where main themes and subthemes were systematically identified, compared and contrasted and synthesized.

## 3. Lessons Learned

Our analysis to date has resulted in several preliminary findings that we will share in this section. These include the effectiveness of hybrid training approaches that provide diverse resources to multiple educators, the importance of customization and flexibility in curriculum design, and support for youth entrepreneurial interests.

### 3.1.Effective Hybrid Training Models

Our findings so far indicate that the educators and administrators who participated in the program preferred a hybrid training model, similar to the home-site and satellite-site engagements, that included both in-person visits and training as well as online resources accessible throughout the administration of the program. Participants commented that having DHF staff install and demonstrate the equipment and going through learning modules was helpful and increased their capacity to deliver the programs effectively.

Participating sites 2 and 3 experienced challenges with staff turnover. This meant several educators who had undergone training at DHF left the organizations before the completion of the programs. The administrators used online resources, their own knowledge from DHF trainings and the experience of other educators who had participated in the training to train incoming staff in the remaining program materials. This result highlights the importance of training multiple staff at each site to increase its resilience and organizational capacity to manage changes in staffing.

### 3.2.Curriculum and Program Customization

Participating educators and administrators found DHF's curriculum allowed them to support and scaffold their delivery of maker content for the first time. They described how the curriculum provided a structured way of delivering content to youth, as well as, a way to break down and categorize technical skills needed for implementing youth's final self-directed projects. The educators and administrators also observed that youth with diverse sets of technical and design skills had joined the program, which made it difficult to keep the more technically savvy youth engaged in the modules they already were knowledgeable in. Additionally, participating educators noted that youth found certain parts of the module (e.g., 3D modeling and 3D printing) more interesting than others (e.g., web development).

These observations point to an opportunity to create a customizable curriculum that can include optional advanced modules for youth who want to further develop their skills and also provides suggestions and structure for educators and youth at each site to incorporate unique activities and content that is of particular interest to their community.

### 3.3.Supporting Youth's Entrepreneurial Aspirations

Educators at sites 1 and 2 observed that youth in their programs wanted to apply their learning to future jobs and entrepreneurial endeavors. For example, a youth at site 1 had suggested designing and 3D printing keychains. Another youth at the same site expressed a desire to setup a 3D printing business. These ideas point to youth interest in strengthening their job and entrepreneurial skills through maker learning experiences. As previously mentioned, DHF has been operating a youth-staffed 3D print shop for the past two years, which may have inspired some of these entrepreneurial ambitions. Given previous research that has shown maker activities can lead to innovation, entrepreneurial aspirations, and as an entry point into technical jobs, in the future maker curriculums can include modules or case studies that support such outcomes.

## 4. Conclusion and Future Work

As the demand for after-school informal learning programs that engage diverse youth with digital technology grows, so does the need to study different approaches for supporting educators and administrators who lack experience delivering maker programs. In the current project, we developed three variations of a maker educator training program based on a successful maker curriculum that has been developed and refined over 5 years. We deployed the program in three participating sites where educators and administrators learned to set up a maker learning space and deliver the curriculum to youth. Through interviews, program observations and call-in focus groups with the educators and administrators, we found participants preferred hybrid training models that combined in-person training and space setup with online resources that could be accessed any time. The participants also enjoyed having a curriculum to start with and expressed interest in customizing it to reflect specific youth interests and motivations in the future.

Moving forward, we plan to develop the hybrid training model described in this poster and deploy it in new sites to compare outcomes with the current project. We will also invite local educators to extend and customize the existing curriculum to reflect the cultural and community perspectives of the youth populations they serve. We will then study the differences in youth and educator engagement and learning using the new training model and curriculum design practice.

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