MINI LABS: BUILDING CAPACITY FOR INNOVATION THROUGH A LOCAL COMMUNITY FAB LAB NETWORK

By Jeff Ginger, Robert McGrath, Betty Barrett and Virginia McCreary

ABSTRACT

The "Fab Lab to Lab Fab" project aims to create a network of small workspaces in school classrooms, public or school libraries, and other community-based anchor institutions (such as a church basement or the Boys and Girls Club) that will enable a diverse range of students to experience the exhilaration of designing and making what they have envisioned. This network of small labs will be one attempt to create compact, less expensive, and less equipped labs much like those envisioned at the less expensive end of the Fab Lab "powers of 10" spectrum. The talents and capabilities of the Champaign Urbana Community Fab Lab (CUCFL) on the University of Illinois Urbana campus will be deployed to create and support these mini labs. As of August 2012, three different organizations, a public library, an elementary school and an after school teen mentoring and leadership program have agreed to partner with the CUCFL. One of the goals of the project is to link each mini lab to the main community Fab Lab to in order to help community site users to expand their skills and opportunities beyond the capabilities of the mini lab. In this way, the CUCFL serves as the "hub" for these "spokes" out in the community to connect to the larger Fab Lab mission.

This paper reviews the process and progress of establishing mini lab sites in cooperation with chosen community organizations and goes further to explain some of the challenges, learning outcomes and likely impacts encountered along the way.

BACKGROUND

Founded in 2008, the CUCFL is a rapid prototyping and production facility housed at the University of Illinois at Urbana-Champaign (Watson 2011). Though it is located on the University of Illinois campus, the lab is a community resource open to anyone. Volunteers have run the lab from its inception and collaboratively developed the following mission:

> *The Champaign-Urbana Community Fab Lab (CUCFL) promotes ingenuity, invention and inspiration by introducing learners of any age to modern*

prototyping and fabrication equipment. Our goal is to encourage creativity as well as an interest in architecture, art, computing, engineering, mathematics, science, and technical trades. We believe community access, provided at a reasonable cost and in cooperation with the global Fab Lab network, builds local capacities by enabling personal growth, economic development and cross-cultural understanding. We encourage people to build virtually anything they can imagine!

This mission statement represents a localized vision of the values laid out in the international fab lab charter, most notably in the way that it emphasizes strengthening the local community through promoting open community access to, and education in using, techniques and equipment of digital fabrication.

The CUCFL is affiliated with the International Fab Lab Network that originated at MIT. One of the primary goals of the Fab Lab movement is to develop the skills needed across a community or society to use digital tools and related concepts creatively to facilitate innovation and entrepreneurship. Periodically, the global Fab Lab initiative develops and issues technical challenges to all the labs in the network. In 2011, the most recent challenge was to see if labs could be created using the power of ten. This problem challenged people in the labs to think through, if and how, labs might be created at a series of cash outlay levels: $100, $1000, $10,000, etc. At the CUCFL, this challenge was appealing because it seemed to offer an opportunity to fulfill the lab mission and use a mini lab to attract young people who might later connect to and experiment with the capabilities of the larger lab.

The CUCFL is now in the process of creating mini labs in a variety of venues, including school classrooms, public libraries and dedicated clubhouse/community centers. These sites are constructed as collaborative sites at which both the CUCFL and the site have a mutual set of responsibilities. The mini lab sites need to meet certain criteria: ability to provide a computer, Internet connection and TV or other monitor for the communication network, a dedicated space or container for the equipment and materials. They have also agreed to assist or cooperate with on-going project assessment and have committed to use their materials in the promotion and development of skills and capabilities that match those laid down in the Fab Lab mission: personal growth, economic development and cross-cultural understanding.

In return, each local mini lab will receive a set of essential equipment and supplies that will enable the people at that site to create a variety of objects of their own design. In most cases, sites are provided a small vinyl cutter with related tools and materials. In

addition, the CUCFL is designing and constructing a series of kits (e.g., templates and tutorials for simple projects) that would be used to integrate the capabilities and materials at these small sites with the greater capabilities of the main CUCFL. Connection to the main CU Fab Lab is essential because it will provide training, assistance and materials to the mini labs. Communication could be face-to-face, via local telephone calls or over the Internet. Each site will have access to basic web conferencing hardware and software to enable teleconferencing. The ultimate goal is to create an interconnected web of communication and interaction that would support fabrication and learning in several contexts. The main lab will be able to develop greater proficiencies in the people working there to support the mini labs and acquire additional equipment to facilitate the completion of the kits and the learning associated with this work. We believe that learning and teaching are connected, so by teaching students we expect to also learn ourselves. Knowledge gained could include more intricate understandings of our own equipment, a better grasp of the various contexts and ways in which students learn, and greater knowledge of the ways that technical and creative education can be integrated into both formal curriculum and informal learning programs. The labs are targeted at students from 8 to 18 years of age.

Fab Labs aim to develop greater innovation and creativity in the people who work in or in cooperation with the labs. At first glance, this could seem to contradict the notion of using kits. We see the kits as links to standard curricular requirements as well as launching pads for further discovery on the part of the students. Curiosity, innovation and creativity are in large part learned behaviors that are socialized in individuals. Following steps and copying help learners to establish foundations and an intuitive sense of design and process, necessary traits before they can embark on self-driven exploration and craft. We hope to stimulate students to come to the main lab to find inspiration and opportunity for more creative or involved projects.

This system is loosely modeled on the Global Fab Lab Network that exists on a much bigger scale through the initiative of the Center for Bits and Atoms at MIT. This is a rapidly growing global network of Fab Labs that currently interacts through a conferencing system and periodic regional and international meetings [1]. The minilabs would also have access to the resources of this larger network through their interaction with CUCFL. By setting the labs up with the standardized software and communications equipment used in the MIT Network, students at these sites would also be able to engage the members of this broader global network. In 2011, the CUCFL submitted a

[1] http://fablabinternational.org/

grant proposal to the Community Informatics Initiative (CII), a research and teaching center in the Graduate School of Library and Information Science at the University of Illinois.[2] The Community Informatics Initiative worked with local organizations to help people understand, develop and employ information and communication technologies to achieve their goals. CII helped numerous groups around CU and broader Illinois to create community networks, establish computing centers, build software systems and provide information services.

ENGAGEMENT, TO DATE

To review, the mini fab lab project has the following stages:

- 1st stage – identifying and establishing partner sites, training people, designing kits and tutorials
- 2nd stage – initial programs and relationship building
- 3rd stage – mini lab deployment and continued collaborations

As of yet we have completed a great deal of the first and second stages but not the third.

The first serious dilemma was how to successfully identify community sites that would support a mini lab enthusiastically and effectively. This task was far more difficult than we ever imagined. Some sites were recommended by the Community Informatics Initiative while others were recruited by volunteers or people who had worked in the CUCFL and endorsed an organization with which they had a preexisting connection. After a number of months and a selection of activities, three sites were confirmed; the Tap In Leadership Academy in Champaign, the Urbana Free Library, and the Stratton Elementary School in Champaign.

All located within 5 KM of the CUCFL, each site offers a different mission and approach in what they do, and a correspondingly a different group of student participants. This relatively diverse sample will provide an opportunity to learn about the common and unique aspects of collaborating with different partners in different contexts.

[2] http://www.cii.illinois.edu/

Community Partner Overview

Tap In Leadership Academy (http://www.tapinacademy.org/home.php)

Tap In Academy is a 501(c)(3) dedicated to providing one-on-one mentor-tutoring and scholar-centered enrichment activities that encourage academic achievement, leadership skills and cultural awareness. By providing scholars (ages 12-16) with equitable opportunities for intellectual, social and emotional growth, Tap In fosters the kinds of competencies and lifestyles that land students in to four year universities. Tap In is located in a community center nearby the University of Illinois campus, a facility that has a flexible computer lab, recording area, student lounge and good potential for a miniature fab lab installation.

Urbana Free Library (http://www.urbanafreelibrary.org/)

The Urbana Free Library has earned a reputation for the quality of its collections and for outstanding service to patrons of all ages. The library is at the very heart of community life in Urbana and continues a longstanding tradition of provision of public computing and digital information access. They are in the midst of redesigning their computer lab and finding a good way to provide a dedicated teen space, which makes it a good time for integration of a mini Fab Lab.

Stratton Elementary School (http://www.champaignschools.org/schools/home/?id=12)

Stratton Elementary is a progressive learning environment that recognizes, respects, and supports the gifts, talents and diversity of students and community. They value and promote genuine collaborative relationships, social justice, and life-long learning for the success and enrichment of all. The Stratton Leadership Magnet School has a unique MicroSociety® curriculum that includes six strands: (1) Technology, (2) Academy, (3) Humanities & Art, (4) Citizenship & Government, (5) Economy and (6) HEART (giving back to society). The school has a variety of classrooms and a computer lab where a small fabrication equipment set might fit.

Collaborations

Following is a brief review of our collaborations with each community group.

Tap In Leadership Academy

Tap In came as a recommended group from the Community Informatics Initiative, as the two entities have worked successfully both in the past and presently on a variety of projects. A recent Fab Lab volunteer had personally run several workshops with the

group and was able to aid in setting up a timetable to integrate effectively with their summer enrichment program.

Tap In relies on mentors to help provide instruction for the younger participants and so our first collaboration involved preliminary training in a group. While generally successful this was widely-regarded as a mistake, because we did not spend substantial time instructing this group on how to use the Silhouette Cameo electronic cutters, the machine they would eventually be taking home. Instead, we dazzled them by creating name tags and even a preliminary iPhone case with the Epilog laser engraver. This seemed just fine right up until the middle of the workshop series that followed, when the laser engraver broke down.

As indicated, the preliminary training was followed by a six week workshop series that involved over 40 learners in junior high and early high school. The large group was split up into subsections and most scholars were able to visit the lab for at least two days. They were given a tour, taught the Fab Lab Process, learned how to implement ideas and convert pictures in Inkscape and Silhouette Studio and, ultimately, to make a sticker or paper cutting as well as an object on the laser engraver. The curriculum, tutorials and guide materials for this series were all developed in an open and collaborative fashion through the use of Google Docs.

As we finish up the summer Tap In will quite likely be the first site to receive its mini fab lab installation.

URBANA FREE LIBRARY

Recently public libraries have begun to venture into the world of information and materials production (OCLC 2012) and the Urbana Free Library (UFL) plans to add a mobile miniature Fab Lab as an extension of their youth programming and volunteer tech services in the fall of 2012.

Since Urbana is in the process of remodeling their computer lab and adding programs to address teen space needs they have not yet been able to deploy a permanent mini fab lab. Instead, we ran a short series of exploration days at the library by bringing over several Silhouette cutters and inviting youth to create stickers and see the kinds of things they could do at the main Fab Lab. Around sixty kids visited the event at one point or another and many of them went home with some kind of creation to call their own. This began the initial relationship with one of the UFL youth librarians, who later came out to visit the main fab lab with another librarian to create materials for their summer reading series.

Moving forward, as the school year begins, the Fab Lab will be working with the UFL tech volunteers to better ensure an ongoing relationship between the library and the fab lab as well as properly supported and utilized equipment.

Stratton Elementary School

A Fab Lab volunteer and parent to a child at Stratton school has acted as the point person for our development so far. Our first visit to the school occurred early in the summer, where we reviewed some of the places where a lab might be set up as well as consulted with some key administrators about how the mini lab might be best used. A small group of teachers then later visited us at the main fab lab and were given a tour and a chance to experiment making small projects of their own. We spoke more specifically about some of the ways they might integrate concepts like fab lab experimentation into their course plans. Work with Stratton will likely resume in the fall, we hope that the lab capabilities will be leveraged by both teachers and students.

Outcomes

One of our main goals in providing mini labs is to understand the elements that make them successful and replicable across the Champaign Urbana area. We believe that a network of relationships will allow for the existence of many small labs that can offer on site, hands on activities for young people that will encourage them to pursue STEM related studies and enhance the efforts of their schools and clubs. In addition, this plan will enable the main lab, the CUCFL, to develop and strengthen the potential support and response it can provide to the minilabs and the community. This is a mutually responsible relationship that can continue beyond the life of this grant into the future. In addition this network can evolve since it has the ability to replicate itself as well as explore new options as they arise.

Discussion

It is worth noting several factors that have set the stage for our community engagement with each of these groups. It is difficult to claim just how much these factors matter, but they are certainly worth recognizing, as we've bumped into them, often the hard way, along the way.

Dedicated Community Partner Representatives

All three groups have had a single person from their site shoulder a great deal of responsibility in managing collaborations. In the case of Stratton, a particularly active parent who is also involved in volunteering at the school has assumed this role. At

Urbana Free Library one of the new Youth Librarians has stepped up to make frequent use of the lab. He has even brought in his own family in addition to making way for the integration of the mini lab into both the library infrastructure and programming. One of the authors of this paper, Jeff Ginger, functioned as the dedicated community partner representative for Tap In, though he plans to replace himself with another GSLIS student who will be working under an assistantship with Tap In in the fall. None of our collaborations would be possible without these preexisting connections and relationships as well as dedicated individuals. This won't come as news to most people who have done community engagement for, but know that it is imperative to have someone on the community group side devoted to cooperation.

Fab Lab Volunteers

Our Fab Lab is entirely volunteer run and located within the University of Illinois campus. Our open hours take place at night and on weekends, which often does not intersect with the times community groups are available for programs or visits. In any case, group activities require scheduling space, equipment, and people. We have had to draw considerably on our volunteers who have flexible daytime hours, consisting of just a few individuals who are academics or retired. We were lucky enough to have a couple of part-time student workers to assist us as well. These individuals have not only had to be proficient with use of Fab Lab equipment, but in order to run workshops for large groups of learners they had to have teaching and presentation skills as well. This was an unforeseen requirement during our initial envisioning of community collaboration.

The Balancing Act

Our Fab Lab is a run-by-consensus organization, which makes allocating time for organizing people, promoting events and performing tasks challenging. Just as in the case of the collaborating groups, the collaboration has been possible mainly through the effort of a handful of interested volunteers.

These volunteers have continued to confront long-standing questions, such as how participants in these community groups might seek information about us, or what the best way to solicit feedback from they might entail. As a result we have needed to work hard to find an adequate balance between the wisdom of our small crowd (organization) and quickly doing what needs to be done, all the while remaining attentive to community partner agendas.

Wider Implications

This work gives rise to a number of research and impact questions.

How does learning happen with the Fab Lab?

Learning can happen in a variety of contexts. In most developed countries a substantial portion of everyone's childhood is spent within the walls of academic institutions learning in a formalized, curriculum-based environment, but this is by no means the limit of where and how learning might occur. In fact, there is considerably concern that our academic system may be failing to adequately prepare children for competitive and meaningful participation in an ever-increasingly global world. This topic relies mostly outside of the scope of this paper, but readers should know it often revolves around issues of interdisciplinarity as well as creativity (or innovation) and critical pedagogy (Robinson 2011). Improvement or modification of the often overly-bureaucratic systems behind and within the formalized education structures is sometimes not possible, and alternative learning settings offer one possible solution.

Learning that takes place within the Fab Lab is often of two alternative varieties, non-formal, and informal (Schugurensky 2000, Livingstone 2001). These forms are notably distinguished in that they are less hierarchical, less propaedeutic in nature (reliant on former schooling) and are typically voluntary. Non-formal learning characteristically takes the shape of workshops and short classes, appearing as tennis lessons, painting courses and programs like Sunday school in a church. Informal learning arises apart from these two, and can be conceptualized in three ways: self-directed, incidental, and socialization (Schugurensky 2000).

The mini Fab Lab project aspires to engage with learners on all three levels and in all arrangements of informal learning.

First, one of our labs will be integrated with Stratton Elementary School, a certified member of the basic education system in the US. Though it will not comprise the subject of a class it will likely see integration into the arts, sciences and engineering.

Second, our series of workshops with Tap In Academy and training mentors, teachers and librarians easily fit into the realm of non-formal learning: short one or two day sessions with flexible objectives and few assumptions of prior knowledge. Much of the learning that happens in libraries and after-school programs like Tap In also fits within this non-formal dimension: loosely guided and short-term programs without strict participant requirements.

Third, learners in open-shop settings like Fab Labs and libraries must drive their own experience, learning from mistakes without tests or perfectly correct answers. Self-directed learning often is encompassed by projects undertaken by individuals with general assistance from facilitators or fellow practitioners. It is intentional because the individual is consciously setting forth with the intention to learn (as well as create or critique or whatever else). A typical beginner prompt for the mini fab lab installations goes something like "try making a sticker with your name on it using Silhouette Studio and the Cameo Electronic Cutter." Participants are given general boundaries and must experiment and ask questions as they go along.

Fourth, even though learners may set out with the specific objective of learning how to, say, build a box with a laser engraver, they necessarily develop other seemingly unrelated skills simultaneously. For instance, the person interested in creating a star-shaped box may have to struggle to learn how to properly describe what they wish to do, practicing verbal communication skills, and later, if they decide to draw it, visual expression and projection as well. This learning is incidental and unintentional, but is consciously absorbed.

Fifth, and finally, attitudes and behaviors are crucial to successful scholarly learning experiences. These are 'learned' through the life-long process of socialization, as people perform their identities in everyday life. The Fab Lab has the potential to elate and incite curiosity, drum up motivation, encourage divergent thinking through experimentation, and require patience and persistence. For many of the young participants these last two categories have been the hardest. Kids growing up today learn they can find the 'answer' on the internet within minutes and many copy information as if it were their own with striking ease. Many of them have trouble spending time building a unique or remixed design and have little tolerance for recovering and trying again after failure. This is ironic, in a sense, because the Fab Lab is a fast-paced prototyping environment that makes production faster than ever previously considered possible. Determining what attitudes to foster in young learners, such as a sense of duty to give attribution or an impression that ownership is powerful, is among the emerging challenges for Fab Lab operators and educators.

How does learning in the Fab Lab relate to literacy?

The concept of literacy finds many different definitions in varying contexts, but one of the most globally conscious, as well as universally adopted, is that put forth by the United Nations Educational, Scientific and Cultural Organization (UNESCO 2004):

> *Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential and to participate fully in their community and wider society.*

In presenting this definition UNESCO (2004, 2005) thoughtfully positions literacy as a set of social practices rather than a singular skill, and elevates it to the level of a human right (the right to education, UNESCO 2005). It suggests that meaningful acquisition and application of literacy provides the basis for positive social transformation, justice, as well as personal and collective freedom. However, as astute readers will note, this characterization purposely restricts focus to text and written materials.

More recent conceptualizations of literacy, including media literacy, information literacy, digital literacy and more, extend this definition to include dealing with information using technologies, formats and conventions of a given time and culture (Lankshear and Knobel 2008). In these adaptions literacy is fundamentally about being an active player: necessarily involved and directed activities that are about interacting with, sharing and producing information. Typically, however, studies and measures of digital literacy and the like focus on creation of purely digital products that are viewed on screens. They do not usually capture the application of digital, information and media tools in the creation of expressions that take the form of physical objects.

The Fab Lab enables literacies that build upon creative engagement with information. Several of the perspectives and competencies often associated with digital literacy (Jenkins et al. 2006) are easily recognizable:

- **Play** - The capacity to experiment with one's surroundings as a form of problem-solving. Participants are directly encouraged to *safely* investigate combinations of materials, tools and techniques in the lab.
- **Appropriation**— The ability to meaningfully sample and remix media content. Creators in the lab often borrow and convert from one artistic medium to another, altering appearances and messages as they do so. They must respond interactively to the various requirements for machines and materials as they do so.
- **Multitasking**— The ability to scan one's environment and shift focus as needed to salient details. This happens in the Fab Lab not only in the form of working with dual-display computers, but as participants operate computers in unison with the interfaces of milling machines, laser engravers and electronic cutters.

- **Distributed Cognition**— The ability to interact meaningfully with tools that expand mental capacities. The Fab Lab relies on a network of knowledge, both within the locality of the lab, but also within the various people and locations involved. The international Fab Lab network extends the knowledge of the main fab lab, which broadens the knowledge of the mini fab labs. Learners aspire to leverage this potential as they problem-solve and share.
- **Visualization** - The ability to translate information into visual models and understand the information visual models are communicating. The process of digitization present in the initial stages of design is quite visual, especially in the case of rendering models for 3D printing, where learners tinker with numbers that drive graphical representations of what will become real world objects.

Physical creation in the lab is a potential metric of applied digital literacy. Throughout the processes of making in the Fab Lab individuals identify, access, manage, integrate, evaluate and analyze tools and information to construct new knowledge in creating expressions and communicating with others. The mini labs project has enabled us to implement, revise and share teaching techniques. It has also shown many young learners that computers are relevant to them in new ways; very few had ever designed and engraved their own door tag or name sticker before.

SO WHY DOES THIS MATTER, ON A SOCIAL SCALE?

As mentioned earlier, the development and deployment of mini labs and all of the associated workshops and exchanges with the main fab lab impacts the perspectives of involved parties.

First, youth learn a fundamentally empowering lesson: they too can be a creator of things. Not just information, not just ideas, but the combination of the two applied to real world physical objects that they can hold. Implicit to this notion is that they are able to influence the world around them. Everyone involved may experience this empowerment: students, teachers, and volunteers.

Second, they work towards demystifying the black boxes so rampant in our world today. Many people grow up without learning how the inside of a computer works or what takes places behind the scenes as a graphic is created. The Fab Lab encourages digging beneath the surface (seeing inside of the open-face 3D printer) to discover cause and effect processes. Even just opening the lid of the Silhouette Cameo cutter and trading out the blade and loading the cutting mat helps to dismantle small fears that could eventually accumulate to the debilitating levels often seen in older people when they try to learn how to use computers. Rejecting the surface world and peering beneath the

surface of technologies is key to critiquing them and mastering them to make them their own (Illich 1973).

Third, the Fab Lab is representative of the democratization of production and know-how. The mini fab lab project especially embodies this principle, as it is at its core about distributing productive capabilities in places where all kids can reach them: schools, libraries and community centers. Just as youth may grow up today learning they can become broadcasters on YouTube, they can ascertain the interpretation of active production through contribution to the Fab Lab.

Fourth, the mini fab lab project entails what David Gauntlet (2011) casts as "Making is Connecting." The effort represents a kind of *true* community engagement in that it breaks us out of the walls of the Fab Lab and into often underserved or underrepresented sections of the community. The diversity and access provided through these organizational partnerships sets the CU Fab Lab far apart from the often lofty and privileged settings that occur in other labs run by a majority of rich, white male constituents in engineering. The relationships built through shared collaborations and sites may positively influence social capital, an accepted measure of community. Beyond this the Fab Lab operations group is a kind of community of practice unto itself, where meaningful participation may lead to life satisfaction and wellbeing. We can already see some evidence of developing community ties as several Tap In scholars as well as one librarian have brought their families in to visit the lab after our initial programs.

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