



MAKING + LEARNING

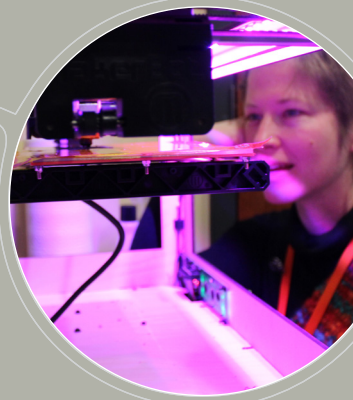
in Museums and Libraries

A PRACTITIONER'S GUIDE AND FRAMEWORK



INSTITUTE of
Museum and Library
SERVICES

children's
museum
PITTSBURGH



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MAKING+LEARNING

is a cooperative

agreement between the

CHILDREN'S MUSEUM OF PITTSBURGH *and*

the **INSTITUTE OF**

MUSEUM AND LIBRARY

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is supported by

thought partners **MIKE**

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Chicago Public Library,

ADAM ROGERS *from*

North Carolina State

University Libraries *and*

LISA REGALLA *from*

the **Maker Education**

Initiative. *Learn more at*

makingandlearning.org

Executive Summary

The framework can help guide museum and library professionals who are new to makerspaces in the development of a space, and help seasoned veterans reflect on their maker work thus far.

Many libraries and museums have made a commitment to support the establishment of maker programs or makerspaces. Despite the recent growth of these investments, the field knows surprisingly little about how to support learning within these spaces.

This report introduces a framework to support learning in library and museum makerspaces. The framework demonstrates how we can create the conditions for ambitious learning experiences to unfold within the making experience.

The project has been carried out through a cooperative agreement between the Institute of Museum and Library Services and Children's Museum of Pittsburgh. Several thought partners have also been critical to this work and have provided expert support: Exploratorium, Chicago Public Library, North Carolina State University Libraries and Maker Education Initiative.

After conducting more than 50 interviews and site visits to library and museum makerspaces across the country, as well as convening a national group of library and museum professionals, the project leaders identified three key elements that create the conditions to support learning in makerspaces.

Element 1: Purpose

Libraries and museums implement making programs for myriad reasons. Why and how do

making experiences, activities and/or spaces align with and further the goals of a making program and connect to the organization's overall mission?

Element 2: People

People play an important role for learning through making in museums and libraries. Educators, librarians, volunteers and guest makers are used in a variety of ways based on a program's goals. Constraints such as funding and capacity to manage staff are also a factor. What role do people play in managing, monitoring and facilitating learning in a makerspace or program?

Element 3: Pieces And Parts

Making is a "hands-on" approach to learning and the tools and materials selected should dovetail with the program's goals and the capacity of the staff. What tools, materials and architecture are central to supporting learning through making in a program and space?

Our Ambitious Goal: Make Every Makerspace Better.

Ultimately, this framework can help guide museum and library professionals who are new to makerspaces or who are just beginning to develop a space. It can help seasoned veterans evaluate their current maker work, too.



Tulsa Children's Museum

SECTION ONE

INTRODUCTION

The goal of Making+Learning is to build the capacity of libraries and museums to create and sustain effective makerspaces and related programs for learning.

Many libraries and museums have recently invested resources to implement maker programs or makerspaces. This project defines “making” as building or adapting objects using real tools and real materials and engaging learners in the process of using these tools and materials.

While these programs and spaces serve a variety of goals, they overwhelmingly serve as sites of ambitious learning. As the maker movement grows by leaps and bounds, the field itself knows relatively little about how to support learning within these spaces.

This report introduces a framework to support learning in library and museum makerspaces. There are three elements to the framework: purpose; people; and pieces and parts. Through a description of the framework, as well as case studies on how making and makerspaces are being implemented around the country, this document aims to share ways that we can nurture and grow conditions for learning within making experiences.

Why a Framework?

A framework is, in many ways, simply a metaphor. It focuses our attention on important elements of a setting, activity or idea. In this case, the focus is on supporting

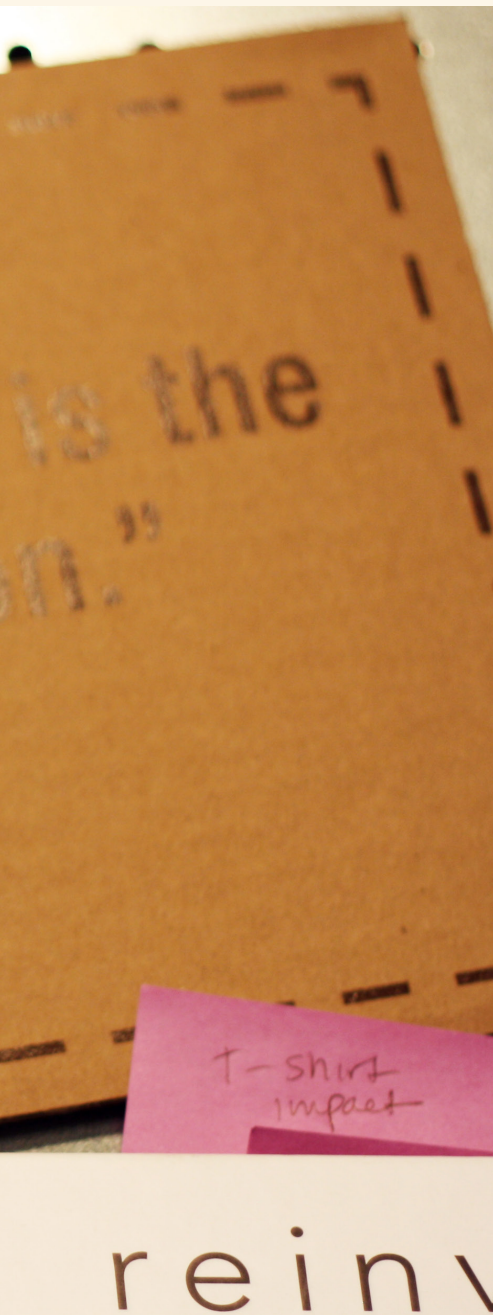
learning through making. Building a framework serves several goals:

Design: The framework provides design considerations for practitioners who seek to develop a new maker program or makerspace. Each of the framework’s three broad categories provides guideposts that can steer the intentional design of the program or space for an organization’s audience.

Reflection & Professional

Development: The framework’s three categories serve as reflective points for practitioners currently engaged in this work. In this way, the elements of the framework serve as points to elicit formative feedback, and to create points for conversation amongst stakeholders.

Evaluation: The framework can offer a structure for considering the evaluation of maker programs and makerspaces. The framework’s three categories may steer the development of summative measures to evaluate a program or space’s impact.



The elements of the framework are intended to guide practitioners' planning and implementation of maker-based learning experiences. The framework is not intended to prescribe how to develop and implement those learning experiences. From visiting makerspaces and exploring maker programs across the country, we know that there are many different ways to offer productive maker-based learning experiences. Instead of prescribing a fixed methodology, the goal of the framework is to encourage critical discussions and encourage practitioners to consider critical aspects of design for their individual maker experiences.

In the spirit of making, this framework is meant to be flexible and adaptable. It is designed to support the local concerns, priorities and conditions of any museum or library.

Purpose. What's Yours?

Libraries and museums implement makerspaces and maker programs for many different reasons. Similarly, libraries and museums can choose from an array of innovative approaches when designing learning experiences. Why and how do making experiences, activities or the space align with and further the goals of a making program? How do they connect to the organization's overall mission?

Ask yourself:

- What are the goals of your program and makerspace?
- How do you define and measure success?
- In what ways does the program or space align with your organization's mission?
- What audience does your program or space serve?
- Who are the stakeholders of your program or space?
- What are the underlying values of your program or space?

People Matter Most

Makerspaces and maker programs often garner attention for their expensive tools or unusual materials. But what is the real secret of makerspace success? People. People create the conditions for learning through making in museums and libraries. Museum educators, librarians, volunteers, and guest makers are used in a variety of ways based on a program's goals and constraints such as funding and staff management. What roles do people play in the management, monitoring and facilitation of learning in a makerspace or program?

Ask yourself:

- What roles do people play in supporting your program or space?
- What staffing structure exists or needs to be developed to support your program or space?
- What is your approach to facilitating making learning experiences? Why?
- Can you assess your staff's capacity to support making?
- What strategies can you employ to ensure that your staff's capacity develops over time?

The Right Pieces And Parts

We're often asked by makerspace novices, "What equipment should we buy?" and "How many 3D printers do we need?" While the tools and materials are an important component of making, they should align with a program's goals, the capacity of the staff, and your organization's visitors. What are the tools, materials and architecture that are central to supporting learning through making in a program and space?

Ask yourself:

- What tools are important in terms of the purpose of your maker experiences? Why?
- What materials are important in terms of the purpose of your maker experiences? Why?
- What physical architecture is conducive for the purpose of your maker experiences? Why?

- What role does digital technology play in the selection of tools and materials by your audience? Why?
- What processes (i.e., design process) are important to integrate in your maker experiences? Why?

By addressing these elements, we can foster the conditions for learning in library and museum makerspaces.

The next sections of this report will:

- Further explain the elements
- Provide brief descriptions of different makerspaces and maker programs
- Explain how they address elements of the framework

Depending on an organization's experience and capacity, engaging in the framework may reveal meaningful gaps that cannot be instantly rectified. However, ongoing engagement in these elements can support the intentional design and implementation of a makerspace. This includes identifying meaningful intersections across the elements.



Framework Development

We developed the framework in several phases. First, our project team members reviewed the relevant literature about making as it relates to museums, libraries and learning. This included policy reports, evaluation reports, conference proceedings, blog posts, research articles and books related to the intersection of making and learning. The effort informed the project's understanding of the current landscape of making and learning within museums and libraries, and it guided the subsequent activities of phase one and phase two.

The Landscape of Making

During the first phase of the project, our team visited libraries and museums across the country with active maker programs and/or makerspaces. Several strategies guided our selection process. Based on conference presentations we'd attended and publications we'd read, we were able to generate a list of institutions recognized as leaders and early adopters.

After consulting with our collaborators at IMLS and project thought partners, we included additional museums and libraries to the list of prospective sites. We took this comprehensive list, and then refined it to reflect a diverse range of museums and libraries with respect to region of the country, institution type and type of geographic municipality (urban, suburban or rural). In all, we visited 30 sites across the United States.

Proof Positive

For each site visit, we visually documented the library and museum makerspaces with photographs. We interviewed at least one staff member and, in many cases, interviewed multiple members of the makerspace team. These interviews were digitally recorded and later transcribed verbatim. Additionally, we collected collateral materials that communicated programs offered and other (outward-facing) aspects of the makerspaces. When we couldn't physically visit a space, we conducted the interview remotely.

SITE VISIT AND CONVENING PARTICIPANTS

Ann Arbor District Library,
Ann Arbor, MI

Anythink Libraries,
Adams County, CO

Arkansas Discovery Network,
Little Rock, AR

Benedum Foundation,
Pittsburgh, PA

Betty Brinn Children's Museum,
Milwaukee, WI

Carnegie Library of Pittsburgh,
Pittsburgh, PA

Carnegie Museum of Art,
Pittsburgh, PA

Chattanooga Public Library,
Chattanooga, TN

Chicago Public Library,
Chicago, IL

Children's Museum of Houston,
Houston, TX

Cleveland Public Library,
Cleveland, OH

Creative Discovery Museum,
Chattanooga, TN

Explora
Santa Fe, NM

Free Library of Philadelphia,
Philadelphia, PA

Grable Foundation,
Pittsburgh, PA

Great Lakes Science Center,
Cleveland, OH

Idaho Commission for Libraries,
Boise, ID

Iowa Library Services - North Central
District, Des Moines, IA

Kentucky Science Center,
Louisville, KY

Kidzu,
Chapel Hill, NC

Lawrence Hall of Science,
Berkeley, CA

MacArthur Foundation,
Chicago, IL

Madison Public Library,
Madison, WI

Meridian Library District,
Meridian, ID

The interview transcripts were analyzed for reoccurring themes related to supporting learning, the steps taken to implement their program and then the general effectiveness of the space and/or program. The initial framework emerged from this analysis. This framework was discussed with the thought partners, the IMLS collaborators and local colleagues, and was revised based on their feedback. These revisions included both the elements of the framework, as well as the specific language used to describe the elements.

A Meeting Of Maker Minds

In January 2015, our project team hosted a convening of library and museum makerspace practitioners, as well as relevant policymakers and funders. The primary purpose was to examine and evaluate the framework as a usable and relevant tool for supporting learning through making. Through structured discussions that were grounded in maker-based activities, participants discussed how the elements of the framework resonated, or conflicted, with their own experience as designers and facilitators of making. Additionally, participants identified missing pieces and perspectives, and noted language choices

that may have presented barriers to practitioners working in institutions like their own.

The Framework Refined

Following the convening, the framework was revised once more. Case studies, which illustrated the elements of the framework, were developed for this publication.

The framework consists of three elements that we believe create the conditions for learning in makerspaces and programs in museums and libraries. These elements are: Purpose; People; and Pieces and Parts. In the upcoming sections, we'll describe these elements and provide case descriptions to illuminate the variety and interrelationship within and among these elements.

Curious about what happened at the convening? For a description of the convening, see a summary on the IMLS blog: <https://www.imls.gov/news-events/upnext-blog/2015/02/maker-movement-takes-over-pittsburgh>

Museum of Discovery,
Little Rock, AR

Museum of Life and Science,
Durham, NC

Museum of Science,
Boston, MA

National Museum of American History:
Lemelson Center for the Study of
Invention and Innovation,
Washington, DC

National Science Foundation,
Washington, DC

New York Hall of Science,
New York, NY

Orange County Library System,
Orlando, FL

Phoenix Public Library,
Phoenix, AZ

Science Museum of Minnesota,
St. Paul, MN

Science Museum of Oklahoma,
Oklahoma City, OK

ScienceWorks Hands On Museum,
Ashland, OR

Scott Family Amazeum,
Bentonville, AR

Sprout Fund,
Pittsburgh, PA

Tech Museum of Innovation,
San Jose, CA

Tulsa Children's Museum,
Tulsa, OK

Tulsa City-County Library,
Tulsa, OK

University of Nevada Reno,
Reno, NV

University of North Carolina at Chapel
Hill, Chapel Hill, NC

University of Pittsburgh,
Pittsburgh, PA

Vermont Department of Libraries,
Montpelier, VT

Westport Library
Westport, CT

Winchester Thurston School,
Pittsburgh, PA

Young Adult Library Services
Association, Chicago, IL

A Note on Language

This report is peppered with the terms “makerspaces” and “maker programs.” Maker-based learning experiences take place in a wide variety of settings in museums and libraries. Therefore, “maker programs” is used to acknowledge that making can take place with or without a dedicated space. A maker program can encompass the maker activities that are carried out in the conference room of the library, using a mobile cart, working out of a closet or acting as a “pop up” in any corner of a museum or library.

The term “maker” or “making” can be inclusive or exclusive, depending on your perspective. Here, “making” is viewed as an umbrella term that

may include programs that refer to themselves as tinkering rather than making, or spaces that refer to themselves as Fab Labs, rather than makerspaces. While some will argue that there are meaningful differences between those terms, we’ve chosen to group these terms together for the purpose of creating the most broadly applicable framework. The field continues to learn a great deal from a variety of hands-on, participatory learning experiences. Our project team asserts that all programs may gain value from embracing the elements of our framework.

SO THAT WE’RE ALL SPEAKING THE SAME LANGUAGE

The following symbols represent a variety of components that makerspaces and maker programs utilize in order to provide a robust learning experience. We use these symbols to draw the reader’s attention to certain makerspace components that are addressed in the text. We do not claim that these components are comprehensive and include every single important variable in the implementation of a making educational program. However, these symbols do make note of the complexity that exists as we put together makerspaces and maker programs to support learning.

VISION



The organization's ideal future state, based on its values.

GOALS



End states the organization hopes to reach.

MISSION



An important goal or purpose that aligns with values.

VALUES



The organization's core morals and belief system.

EXPERTISE



Expert-level skills that the organization can leverage.

KNOWLEDGE



Information and facts gained through experience.

TECHNIQUE



A particularly skillful way of completing a task.

SUCCESS METRICS



The criteria by which success can be measured.

LEARNERS



The users of a makerspace or program.

FACILITATORS



The people who teach, advise, scaffold, and plan a program.

INTERACTION



Shared activity between two or more people.

APPROACH TO LEARNING



The framework through which learning is defined.

ACTIVITIES



Structured or unstructured interactions within a program.

TECHNOLOGY



The technologically-enabled tools and resources.

TOOLS



The instruments available for conducting a maker activity.

MATERIALS



Raw or unformed items available for tinkering/making.

SUPPORTING STAFF



Any person who provides support to a maker program.

FUNDERS



People or organizations who provide financial assistance.

PARTNERS



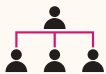
People or organizations who take a vested interest in the organization or program.

VOLUNTEERS



People who support the program without compensation.

STAFFING STRUCTURE



The arrangement of staff reporting and management.

STAFFING CAPACITY



The availability and capability of staff members.

SPACE



The environment in which the maker program is situated.

SAFETY



The precautions taken to ensure safety for all.



VISION



MISSION



VALUES



GOALS



APPROACH TO
LEARNING



SUCCESS METRICS



LEARNERS



Museum of Discovery

SECTION TWO

PURPOSE

The success of a learning experience is incumbent upon identifying its purpose with respect to its goals, mission and affiliations, programmatic strengths and values.

Why making? When libraries and museums can choose from a wide variety of traditional, innovative and potentially effective learning experiences to implement, what is it about making that helps achieve their intentions and goals? This is the overarching question of the purpose element of the framework.

What Are Your Challenges?

Today's library and museum makerspaces seek to achieve a variety of goals, including:

- Cultivating 21st century skills such as critical thinking, creativity, communication and collaboration
- Supporting workforce development and economic vitality
- Assisting with college and career readiness and awareness
- Supporting Science, Technology, Engineering and Mathematics (STEM) or Science, Technology, Engineering, Art and Mathematics (STEAM) learning
- Seeding entrepreneurship
- Nurturing dispositional shifts like persistence, resilience, interest, self-efficacy, etc.
- Engaging visitors in a positive, social and creative atmosphere

What Audience Are You Trying To Reach?

The purpose element of the framework also addresses the extent to which a program

or space targets a specific audience. For certain institutions this might be easy to answer. For instance, for typical children's museums, the dominant audience is families with young children. But for many museums and libraries, the audience may be a point of explicit consideration.

The values and/or goals addressed in maker-based learning experiences may align better to certain audience segments. For example, equipment safety might be an issue for young children, whereas workforce development might be more appropriate for teens or adults.

What's Your Intended Impact?

Identifying the metrics of success for a maker experience is vital to assessing the extent to which the program is having an impact on participants. However, identifying success can be challenging since traditional metrics of success may be inadequate to capture the richness of maker-based learning experiences. For example, counting the number of participants in a program may not make sense since many maker programs place a greater emphasis on depth of experience. Also, the more participants there are in a program, the more pressure that's put on the facilitator. This ultimately can translate into a less enriching learning experience.



CASE STUDY: PURPOSE

Connecting Making to the Heritage of a City

Betty Brinn Children's Museum: www.bbcmkids.org Be A Maker Space: www.makermke.org



The Be A Maker Space (BAM) is the makerspace of the Betty Brinn Children's Museum of Milwaukee, Wisconsin. As a children's museum, **Betty Brinn seeks to provide interactive experiences and educational resources primarily for newborns to 10-year-olds.**

Started in 2014, BAM is a raw space within the children's museum with a big wooden table at its center. Temporary wooden walls define the space. A large metallic clock stands at one end of the space. More than 100 years old, the clock is a remnant of the museum building's previous use as a train depot. On a busy day in December, visitors who entered the space were greeted by a mixture of old and new technologies spread out for observation and use: a hacked Roomba vacuum robot playing "Jingle Bells," and an 8-foot cardboard "robot."



BAM has several overarching goals for the experiences that it provides. One goal is **to help learners understand the made world and develop skills to build and take apart objects they come across in their daily lives.** Additionally, the BAM staff works to facilitate learning experiences that emphasize the process of making as opposed to just valuing the final products. They encourage visitors to work collaboratively rather than individually.

With these broad goals and values in mind, BAM seeks to establish and uphold a

connection to the city in which it's located through the activities of the makerspace. Mike Cook, BAM's Director of Maker Experiences, talked about how these experiences connect to Milwaukee's industrial heritage. Cook explained that making resonates with the city's blue-collar character. Many children's parents work in industrial jobs.



While the connection to Milwaukee's industrial past does not actually manifest itself in every program, **BAM believes that there is a real value to putting authentic tools in the hands of learners.** Cook said an amazing spark occurs when a child is empowered with a tool. He said that they never received that sort of reaction from glue sticks and scissors.

A by-product of BAM's connection to the city and its industrial past has been **the recognition by children, parents and even**





brian radmond



staff as seeing themselves as makers. When Joe Dorn, Maker Educational Program Manager, learned that the museum had plans for a makerspace, he thought, “Okay cool, but am I a maker?” Dorn felt that many people wondered if they had what it took to be a maker, too.

While the arguments for making and makerspaces often focus on the immediate content and skills derived from the experience, Be A Maker Space is fostering a cultural connection, and by situating their programs within the context of Milwaukee’s heritage, **BAM is hoping to change how children and families see themselves and their city in the context of making.**



brian radmond



brian radmond

CASE STUDY: PURPOSE

Aligning Making to a Larger Campus Vision

Makerspace @ Kenan Science Library, UNC-Chapel Hill: library.unc.edu/makerspace



LEARNERS

The makerspace at the Kenan Science Library at the University of North Carolina-Chapel Hill was originally designed to meet the needs of science students. Over time, **its role on campus has evolved beyond exclusively serving the needs of science students to exemplifying the evolving interplay between the goals of makerspaces and the programs and activities they provide.**



GOALS

The initial goal of the makerspace was intimately tied to the library's larger mission: **to provide innovative services and a robust collection for the science students.**



The library's services and collection connect students and faculty to meaningful resources. As this work evolved, the library has become a catalyst for maker-related activities across the university.

David Romito, a science librarian, described the makerspace program's beginnings. He said that microbiology instructors wanted to demonstrate how molecules fit together. They printed out 3D models of the proteins. Soon, a chemistry professor challenged students to design their own molecules using a 3D modeling program called SketchUp, which required more support from the makerspace.

Before long, the Kenan Science Library makerspace faced a scale issue. As its reputation grew with faculty and students across campus, it became difficult to maintain the same level of service with increased demand. Dorianne Mizzy, Head of Kenan Science Information Services, explained that technology limitations were resulting in a bottleneck. At that time, there were approximately 125 students minoring in Entrepreneurship, and it would take them several weeks to 3D print 125 projects – that is, if everything went well. Thus, to meet the goals of the makerspace, the staff needed to re-think how it served the campus community. This was partly an equipment issue – one that called for a different level of machinery. **It was also a social and organizational issue in needing to think about the way that they connect the patrons to resources.**

As the makerspace scaled up, the staff looked outside the library to see if anyone else on campus was doing similar work or providing



LEARNERS

CASE STUDY: PURPOSE

Defining Success in the Process of Making

Lawrence Hall of Science: www.lawrencehallofscience.org

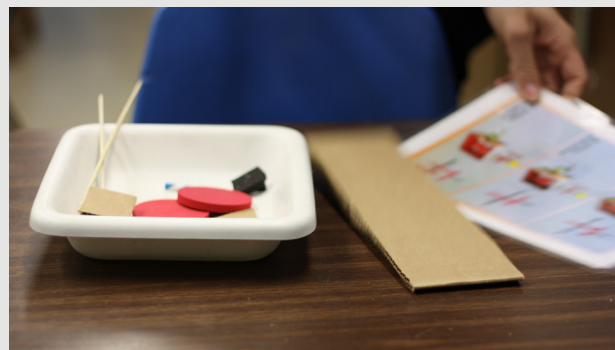
Shifting notions of success in makerspaces and maker programs is forcing many educators to look beyond the traditional metrics of number of learners served.

The Ingenuity Lab – a program and exhibit at the Lawrence Hall of Science, University of California-Berkeley’s Public Science Center – is at the forefront of the conversation about **addressing this challenge of measuring success**. The Ingenuity Lab focuses on fun ways that human ingenuity can be leveraged to solve problems. Program activities revolve around themes such as hydraulics, structures, linkages and water-powered machines. By approaching challenges in creative ways, the program believes that people may find solutions that are unique to their own interests and perspectives.

In some ways, as a program and exhibit, the Ingenuity Lab defines success in a similar way as other comparable endeavors. Monika Mayer, Director of Ingenuity Programs, said that **success is partially based on visitor and participant feedback**. In addition, engagement time with activities has been high. Typical exhibit engagement time is about two minutes, but in the Ingenuity Lab exhibit, it averages just under 40 minutes.

Mayer and her team look for evidence of success through participant engagement in Ingenuity Lab activities. For instance, Mayer

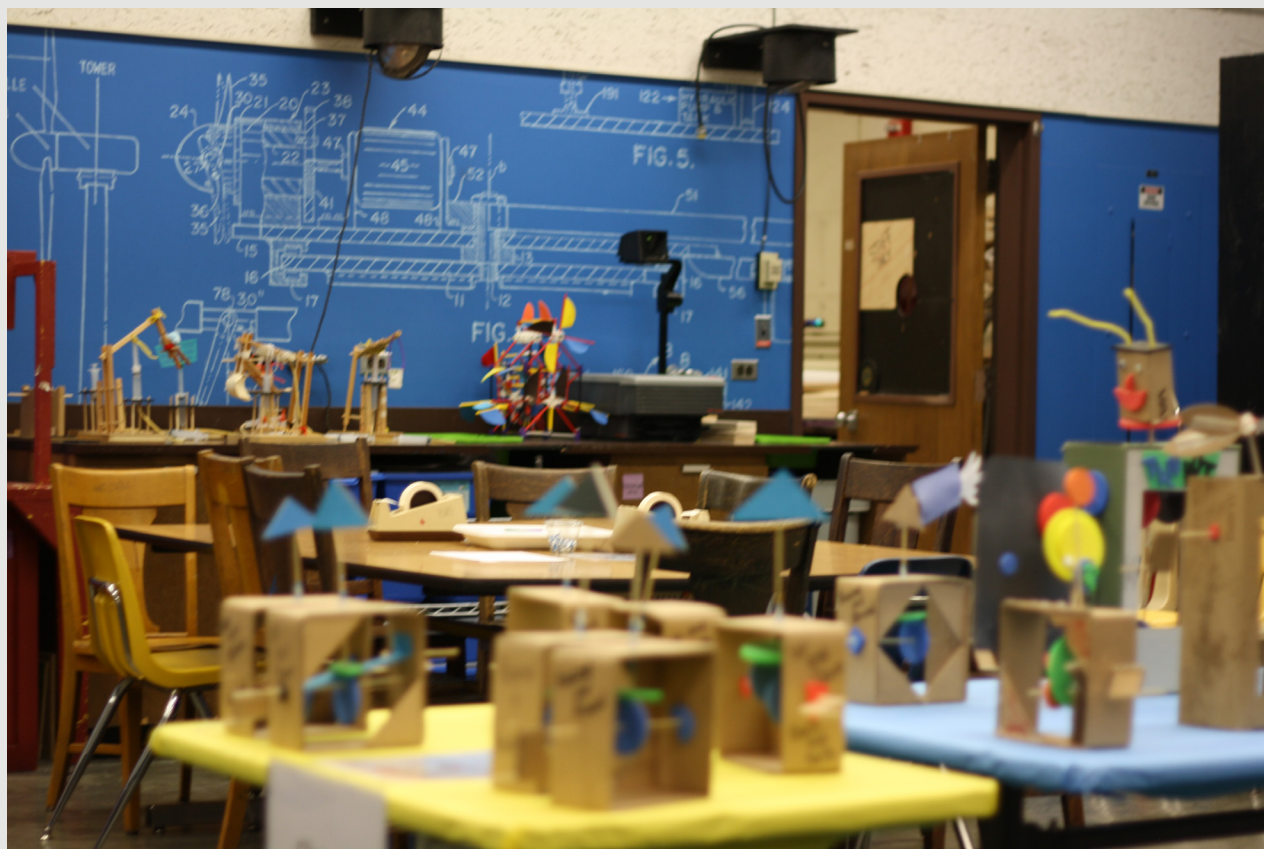
says that the program emphasizes “working like an engineer.” This means that learners engage in a series of phases. They often brainstorm an idea in a team, decide on an idea or a set of ideas and design, build and test their prototype.



Since the program focuses more on process than the final product, **evidence of success is found in the extent to which the learners engage in various phases of the process**. This might include the extent to which the learners seek to incorporate a particular mechanism that is tied to the overall theme.

However, success with making activities does not only rest in the program itself. Mayer says that they receive and collect photographs of projects that visitors and participants work on outside of the program. Recently, the father of a seven-year-old visitor emailed to thank Mayer. His son had exhibited at a Mini Maker Faire – a showcase of maker projects within community – namely because of the unique





opportunity to explore at The Ingenuity Lab.

In general, the Ingenuity Lab's work to monitor success represents a common tension among museum and library makerspace practitioners. On the one hand, there are established methods for monitoring success, such as tracking the number of participants engaging in an exhibit or program or the duration of the engagement. At the same time, these do not fully capture the richness and uniqueness of the programs themselves, nor the innovation and creativity of the learners' constructive activities.





Partner Perspective: “Purpose at the Chicago Public Library”

Chicago Public Library Maker Lab // On-Ramp to Digital Design and Multiple Forms of Making

Andrea Saenz
First Deputy Commissioner
Chicago Public Library

The patrons represent a wide swath of the populace across all demographic measures, suggesting that the Maker Lab has achieved the goal of broad access and inclusivity.

Chicago Public Library's Maker Lab was established in 2013 to serve as an access point for adult patrons to learn how to use emerging digital design and production tools in a collaborative and exceedingly democratic setting. The Maker Lab supports CPL's larger goal of making science concepts and complex problem-solving skills broadly accessible.

In preparing to launch the Maker Lab, we organized our programming to support the following objectives:

1. Serve as an access point for fostering an interest in Science, Technology,

Engineering, Art and Math for all patrons.

2. Offer a hands-on experience with digital fabrication technology that can be translated into real world job skills.
3. Serve as a bridge to other maker organizations that will allow patrons to expand their skills and offer deeper opportunities for their application.
4. Create an opportunity for Chicago Public Library to further investigate and implement strategies and skills for 21st Century learning, finding methods that best support its mission and incorporating them into regular programming.

5. Create a model space that can be replicated by public libraries and other institutions, and share project outcomes with the library and maker communities.

Today, the Maker Lab provides access for any Chicagoan to learn about and use cutting-edge tools in design and fabrication in a collaborative and welcoming setting. As Chicago's only free makerspace, the Lab serves as a gateway to exploring the growing maker ecosystem. The Maker Lab team coordinates workshops that focus on everything from origami to Arduino-powered robotic knitting, thus inviting learners to explore new technologies.

The space allows the Library to introduce adults to digital design and fabrication and explore STEM concepts. It also offers mentor-led workshops and hosts daily open shop hours where participants can work alone or collaboratively, as well as interactive workshops where users work together to design and solve problems. The Lab serves as a bridge into digital fabrication for over 4,000 visitors each month – and includes students, entrepreneurs, retirees, inventors, designers, hobbyists and those who are simply curious.

CPL complements services offered by local, fee-based makerspaces, universities, museums and others by leveraging community members' expertise as instructors and building relationships among Maker Lab participants that reach beyond the walls of the library. Maker Lab programming includes visits to explore other spaces in Chicago's maker ecosystem and "pop up" Maker Labs in neighborhood libraries, parks and schools. Maker Lab participants are deciding to join these or pursue new career and educational opportunities as a result of the networks and insights gained at CPL's Maker Lab.

Maker Lab program offerings are organized into two main categories: Instructor-led Digital Toolbox classes and Open Shop. Instructor-led classes focus on specific tools and skills to create a product and provide opportunities for beginners to easily engage with basic design concepts. Open Lab caters to participants with some level

of experience with the Maker Lab equipment for self-directed creation.

We've seen a remarkable response from community members of all ages and walks of life. We've also been surprised by the extent to which our making activities have engaged women. In contrast with other tech and hacker spaces, where it's often hard to break into the group where people speak in the same terms and know how to use most of the tools, our Maker Lab serves as an "on ramp" to the maker community. That is one of the things a good library does well. It lets a person ask a question in a non-judgmental place where they are not graded on the result. This helps people feel safe coming to the library to learn something new. The Chicagoans who have participated represent a wide swath of the populace across all demographic measures, suggesting that the opportunities presented by the Maker Lab have achieved the goal of inclusivity established by the program design team.

Through regular surveys, Maker Lab participants have reported:

- Improved ability to use digital design software, such as Inkscape and Sketchup.
 - Improved ability to use digital fabrication technology, such as 3D printers and vinyl cutters.
 - They made something while in the Lab, thereby boosting their creative confidence.
 - They worked collaboratively in the Lab, thereby creating a greater sense of belonging.
- Increased understanding of the maker movement, the technologies they employ and improved connection to the Chicagoland hacker/maker community and spaces.
 - Plans to pursue the creative and career interests fostered by the Maker Lab through enrollment in classes, membership in makerspaces or self-directed study.



LEARNERS



FACILITATORS



SUPPORTING
STAFF



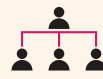
VOLUNTEERS



PARTNERS



FUNDERS



STAFFING
STRUCTURE



STAFFING
CAPACITY



INTERACTIONS



Museum of Art and Design



SECTION THREE

PEOPLE

The importance of people in a maker-based learning experience begins with defining the role people play in supporting the mission of the program or space.

Even though colorful walls or fancy equipment are what people equate with makerspaces, we'd like to let you in on a hard-earned secret. People have the potential to make or break a makerspace program. The importance of people in the facilitation of maker-based learning experiences cannot be underestimated.

Ideally, it is people who facilitate the maker-based learning experience. This includes the planning, designing or adapting of activities before the experience. During the maker-based experience, facilitators demonstrate, ask and answer questions, provide feedback and encouragement and connect learners to resources to further their projects. After the activity, the facilitators reflect on the activity, document the artifacts of the activity, then clean up and organize the space for the next learning experience.

It Takes A Committed Staff

Related to the role of people is the staffing structure. For some sites, this includes creating new positions such as a program manager who has ownership over the space and accompanying activities. For other sites, this means reallocating

responsibilities so that existing staff members can facilitate maker experiences in addition to their ongoing responsibilities. Of course, many institutions are unable to hire new people or reallocate time. Instead, some libraries and museums have had success by utilizing volunteers, college work-study students, interns and even children to support maker-based experiences.

Facilitation 101

Finally, what is the model of facilitation for your makerspace or program? Facilitation might mean hands on co-learning between a staff member and participants. It might mean an interactive discussion with participants while they are engaged. It might even mean inserting signs or resources into the space to further their creative process. Ultimately, facilitation means using an awareness of the maker-program's goal so that the people are facilitating toward a particular end.



CASE STUDY: PEOPLE

Thinking Differently About Staffing Structure

Westport Library: westportlibrary.org

MakerSpace: westportlibrary.org/services/maker-space

The Westport Library's makerspace opened in 2012. Situated in the center of the main floor of the library amid stacks of books, **the makerspace serves as a place for creation, collaboration, innovation and entrepreneurship.**



While economic development and workforce development have come to be a goal for many libraries, Bill Dery, former director of innovation, described Westport's goals in different terms. He noted that, while economic development is important, they are more focused on building community.

Westport's makerspace serves learners of all ages. In order to meet the needs of those who

visit the makerspace and provide innovative programs, the Westport Library has had to think differently about its staffing structure. In other words, **in order to get the expertise needed to work, manage and facilitate their maker-based learning experiences, they've had to reach out to a diverse set of people—even some of their youngest patrons.**



Sam is one of the makerspace facilitators at Westport. He is an engineer who was looking for work and wanted to diversify his skills. Sam knew that the makerspace didn't have a teacher for Solid Works, a software package used in 3D design. Bill understood that Sam had a background in CAD, but did not know Solid Works. So Bill told him that if he taught himself, the library would compensate him to teach other patrons. The makerspace provided professional development experience for Sam to learn Solid Works and, through a grant, Bill was able to hire Sam to work up to 10 hours a week to extend the library's programs.

Jacob, another trainer, came to the makerspace as an 11-year-old who needed to do community service for his Bar Mitzvah. Once Jacob started volunteering, he poured his energies into all aspects of the makerspace, experimenting and mastering new tools and activities. He is now a trainer, which means the library considers him qualified to teach specific skills to other patrons, such as how to work with certain



software or tools. However, that does not quite capture the extent of his role. Bill said that Jacob is more than a trainer for them. He can come whenever he wants. He has access to every adult staff room. He has all the codes.

Westport also brings local teachers into the space. A local middle school teacher is serving as a volunteer facilitator. She recently volunteered to become an Imagination Foundation leader. She and Bill identified a natural overlap and are taking advantage of it.

Imagination Foundation is a national non-profit organization that has the mission of finding, funding and fostering creativity for children around the world. <http://imagination.is>

The Westport Library relies on diverse stakeholders to fulfill roles in its makerspace, who work together to offer community building maker-based learning experiences.

This demonstrates that the work of a makerspace does not solely need to be carried out by dedicated staff. While paid staff are certainly important, Bill and his colleagues are resourceful about meeting the growing needs of the community through volunteers, part-time staff and outside partnerships.



CASE STUDY: PEOPLE

Facilitating Creatively Without Staff or Space

Science Museum of Minnesota: www.smm.org Learning Technologies Center: shimmrglitr.tumblr.com



The Learning Technologies Center at the Science Museum of Minnesota (SMM) has been designing and supporting innovative learning experiences since 2010. It creates and encourages informal science learning through creative and meaningful applications of classic and emerging technologies. **To guide the design of its learning experiences, the Center has developed an engineering design continuum that consists of: Play – Tinker – Make – Engineer.** This continuum is supported by a pedagogical approach that is guided by: Inquiry – Design – Engineering Design.



Keith Braafladt and his colleagues recognized that **these thoughtful approaches depend on facilitation to carry out their vision for visitor learning experiences.** So, based on need and circumstances, Braafladt built up a cadre of volunteers to help facilitate them. Developing **the capacity for and approach to volunteer facilitation to support learning through making** at SMM went through several phases.



Braafladt and his team did a test with 30 volunteers who were already active museum volunteers. He and the volunteers set up stations around the museum with maker activities from previous workshops. Braafladt quickly trained the volunteers on facilitating the activities, and then opened what became the first of many pop-up maker activities that now take place every Saturday and on other high attendance days.

This tremendous effort of activating volunteers has grown the initial volunteer cohort of 30 to 44, which Braafladt divides into two crews. He schedules one crew on one week, and one crew the next. With at least 20 per crew, Braafladt can count on a regular attendance of 10 to 15 volunteer facilitators. To manage the demand that the volunteers experience during their facilitation time on the museum floor, Braafladt has developed an ever-growing menu of maker activities. When a learner signs up for a particular activity, the volunteer rolls out the cart of supplies and sets up. About four hours later, the volunteer takes everything down and cleans up.

As the program has matured, it's evolved to better support the volunteers, who range in age from teens to seniors. To develop the capacity of these volunteers, Braafladt and team try to be responsive to each volunteer's needs, while understanding that they learn best by doing, over and over again. Each





volunteer gets a two-hour training that informs them about the program, introduces some of the activities, and then gives them an opportunity to play. **Braafladt focuses the training on developing relationships and fostering conversation, since it is fundamental to their work with learners.**



There are at least two key aspects of Keith's work that are relevant to the role people play in supporting maker-based learning experiences in the museum. First, **the number of volunteers and the assigning of volunteers to activities underscores the important role that people, facilitation and interactions have on supporting learning through making.**

Second, a lack of full-time staff and dedicated space are not insurmountable barriers to integrating making into an organization's programming and learning experiences. Braafladt and team are able to galvanize enough participation from volunteers to carry

out learning experiences on a regular basis. Whether they're demonstrating an activity, explaining, troubleshooting or providing encouragement, the volunteers provide the backbone of SMM's maker-based learning experiences.



CASE STUDY: PEOPLE

Networking Organizations to Facilitate Making

Arkansas Discovery Network: www.museumofdiscovery.org/about/arkansas-discovery-network
 Oklahoma Museum Network: <http://omn.sciencemuseumok.com>

Sometimes building the capacity of educators goes beyond a single organization. The Donald W. Reynolds Foundation has supported two statewide networks of museums engaged in making: the Oklahoma Museum Network and the Arkansas Discovery Network. Each network supports a variety of methods for engaging museum staff and visitors in making experiences and, when possible, the two networks work together to share resources. One notable focus of this work has been **building the capacity of museum staff as facilitators of making experiences through professional development.**



While there is active communication and collaboration between the two networks, each one has taken a slightly different approach to building their member museums' capacity for the facilitation of making. In Arkansas, the network regularly hosts a series of network-wide professional development sessions. Kathleen Lawson, Network Director of the Arkansas Discovery Network, underlines the importance of bringing in experts from other museums to facilitate workshops around specific activities or mediums of making. Importantly, the professional development that the educators receive through these workshops is focused on **the facilitation of the particular activities and the pedagogy which guides this practice.** For example, if the activity is centered on automata, the educators do not simply learn how to build automata in their spaces – they learn how to support their visitors in the process of building their own automata, which is notably a different skill.

In Oklahoma, the network has established a different strategy for building the capacity of the museum-based makerspaces. In addition to regional workshops, **the professional learning of the network museums is supported by a staff member who plays a role similar to an instructional coach in a school.** Trevor Taylor has played this role at the Oklahoma Science Museum's Tinkering Garage, where he worked with museum





educators to prototype new activities and actively support learners in the space. While traveling across the state, Taylor worked with local museum educators and staff to share prototyped activities, co-plan new activities, co-facilitate activities and debrief about the pedagogy, design and practice of facilitating rich experiences for learning. He played the role of a critical friend to network museum educators as well as a guide for those educators who desired to improve their facilitation strategies.

In viewing the learning experiences in makerspaces and maker programs as facilitated endeavors, the work of the Arkansas Discovery Network and the Oklahoma Museum Network provide useful examples of how each educator or museum is not alone in developing their own or their staff's facilitation capacities. By leveraging the resources of

a network, whether it be in-state or across a more remote community of practice, it's possible to **provide learning opportunities for educators to improve and deepen what it means to support learners of making in museums and libraries.**





Partner Perspective: “Makerspaces as Social Endeavors”

Karen Wilkinson and Mike Petrich

Exploratorium Tinkering Studio

The collaborations, friendships and relationships that develop in makerspaces can be life changing for all involved, young and old, novice and expert.

The growth of makerspaces in museums and libraries comes with an increased awareness of maker-centered learning and the importance it plays in the overall educational landscape. This movement offers an opportunity for institutions to embody their educational stance, putting the person and his or her learning at the center of the process, focusing on their development over time and making these educational possibilities more accessible, more personalized and more widespread than ever before.

Makerspaces first emerged as grassroots spaces for people to make things, to think with their hands and develop new ideas and fluencies through explorations involving tools and materials. Developing this type of fluency (and disposition) is important, especially in the makerspaces

focused on supporting social learning. Social spaces like these support makers to work alongside other makers, seeing themselves as increasingly competent and contributing to the collective and independent work people are engaging in. The collaborations, friendships and relationships that develop can be life changing for all involved – young and old, novice and expert.

It’s important to note that making and tinkering dispositions are developed one learner at a time. They take time to nurture and require a deliberate effort to support. Spaces and programs that support this type of development in people are carefully designed, well facilitated and based on an educational plan of action core to the organizational mission.

Designing Makerspaces for People

The Tinkering Studio is an immersive, active, creative place at the Exploratorium, where museum visitors can slow down, become deeply engaged in an investigation of scientific phenomena, and make something with their hands. While creating the Tinkering Studio, we developed a few guiding principles for the space.

As we were developing the space, we asked a few key questions, including: What does an ideal makerspace look like when it is designed to support thinking and learning? What kinds of activities or experiences are people engaged in? What sets of tools, materials, and supplies are available for them to use? What is the educational philosophy embodied by the design of the space and programs offered there?

In the Tinkering Studio, visitors are invited to explore a curiosity-driven exhibit, chat with a featured artist, or investigate a range of phenomena with staff artists, scientists, educators and others by participating in a collaborative activity. This is often accompanied by an eclectic assortment of materials, tools and technologies, provided for people to use as they explore and create.

Spaces and tools are cool and innovation and new inventions may be inspiring, but it's the community of learners inhabiting these spaces that are its greatest assets. People bring projects and purpose together, giving life to the things that are made and ultimately bringing life to the space itself. Because of this, educational makerspaces designed for people don't always start with a checklist of equipment and tools. Designs that support engaged exploration, personal expression and the development of understanding over time include the following decisions that need to be considered in order to design spaces for people to engage in meaningful making. Designs of these sorts necessarily encourage us to consider how we might support the educators and activity designers who are supporting the learners. In our space, the notion of a community of practice has emerged as important.

Developing a Community of Practice

The people of makerspaces – the facilitators, mentors, visitors and caretakers – all play an important role in helping convey the values and goals of the program. Developing ways of making those ideas visible and tangible to everyone involved helps foster a sense of community of practice, an idea that can be embodied by all who enter the space as it becomes more established.

Many programs approach making spaces as teaching spaces, teaching how to use a fabrication tool, or offering a class to learn how to program microcomputers, etc. These types of programs have their place, but makerspaces that support learning in museums and libraries need to be clear about the difference between a maker teaching space and a maker learning environment. This distinction shifts the focus from the tool (as in a training program), to the person (as in a learning environment). These distinctions impact learner expectations and, by extension, facilitator roles.

Makerspaces become communities of practice when people begin shifting roles and seamlessly move between learner, teacher, mentor and facilitator. Working with learners over time in a makerspace supports facilitators to consider new areas for development, and new possible outcomes for the program activities themselves. If facilitators are encouraged to engage in the explorations and activities as co-learners, distributed learning occurs and everyone involved in the space benefits.

New ideas formed this way push the predicted activity outcomes into new territory and potentially lead to tangents beyond the current program expectations. Supporting facilitators to be actively assessing the pedagogy and purpose throughout the programs will help ensure the evolution of the makerspace, pedagogically and programmatically.

When facilitators and activity developers are actively and collaboratively engaged in revising the maker programs through regular debrief sessions, peer-to-peer mentoring and dedicated time to

revise the toolset, activity structure and expected outcomes, a shared understanding and ownership emerges. Old ideas are reviewed and reconsidered, new ideas emerge and purposeful refinements made to programs and experiences are the ultimate signs of success. A general openness towards constant refinement and seeking out opportunities to learn at every step is fundamental to creating an active community of practice.

Conclusion

While entrepreneurial advancements in makerspaces are exciting, the more interesting outcome for us has been the evolution of an individual's thinking, learning and personal stance toward their own making abilities. The capacity for the people who use these spaces to arrive at the edge of their understanding and push through to new ideas is worthy of supporting. Telling the stories of the processes that lead to these innovations is worth spending time on.

The wonderful thing about making is that it's a deeply human endeavor. It is firmly in the hands of the people and communities we are interested in working with in the first place. People are the reason that we're engaged in these spaces. Supporting learners to grow and change, to see themselves as makers who can make a difference as they develop new dispositions, attitudes and expertise is the reason to pay attention to our skills as facilitators, designers and stakeholders of these programs. It's an investment that reaps rewards far beyond a physical space or set of programs, it pays dividends in people as doers, enabled and empowered to advocate for a different approach to learning in and out of schools.



TOOLS



TECHNOLOGY



MATERIALS



FUNCTIONS



ACTIVITIES



SPACE



Scott Family Amazeum

SECTION FOUR

PIECES & PARTS

If explicitly aligned with the purpose and people, the pieces and parts of a makerspace or program will help the learning experience develop an identity of its own.

Many people think about maker experiences as the tools and materials that enable staff, visitors or patrons to create a variety of artifacts. We refer to these tools and materials as pieces and parts.

Know Your Goals

Once a museum or library has identified its overarching programmatic goals for its makerspace, then it should consider the tools, materials and equipment that best facilitate those goals. For example, if fostering creative expression is the overall goal of a makerspace, this goal may be reached by means of materials like cardboard, wires, wood, and textiles. If supporting workforce development is a goal, then pieces and parts should be chosen that engender specific skills and mindsets valued by the workforce area of interest. This could include skills like persistence, collaboration and goal setting, as well as tool and/or equipment proficiency within the focus workforce area.

Know Your People

Ideally, the pieces and parts should also align with the skills, capacity and interests of the people who manage the space. For example, if the facilitators of a program are skilled programmers, then activities could make use of tools and materials that enable those facilitators to develop those skills in learners. A goal of this program

or space might be related to developing the technological fluency of the learners or cultivating those skills with respect to a particular end in mind, as a means to support creative problem solving.

Know Your Physical Space

Another important component of pieces and parts is the architecture of the physical space in which programming occurs. Learning happens in a designed context, whether it is a permanent, dedicated space, or a temporary space that is transformed as needed. How the physical context for making is defined and designed is important for communicating to learners the intentions of the program as a learning experience. For example, does the arrangement of furniture suggest collaboration or service? Are materials and tools visible and within reach? How does the location of a maker activity align with a display of books/media or an adjacent exhibit? These questions address the architecture of making as it relates to the purpose and people of the program, space, and organization as a whole.

Ultimately, when there is intentional alignment between the three elements of the framework –the purpose, the people and the pieces and parts – a space may develop a cohesive identity about what it is and what kinds of learning experiences the program is working to support.



CASE STUDY: PIECES & PARTS

Viewing Tools in Service of Program Goals

New York Hall of Science: nysci.org



MISSION

The New York Hall of Science (NYSCI) has been a leader in maker programs in museums for several years. **They have produced a popular book about the topic, *Design, Make, Play*, which is the same phrase that guides and shapes the ethos of the museum.** One important aspect of the work that has shaped the programs, the tools and materials involved in the program is their focus on design.



LEARNERS

In particular, the Little Makers Program, Design Lab and the Makerspace have been innovative spaces for design with youth of various ages.



APPROACH TO LEARNING

David Wells, Director of Maker Programming at NYSCI, explains that the overall focus is not just on building, but also on designing, especially with youth visitors. In the case of building a roller coaster, this means that the youth participants will spend time generating ideas, sketching out some of their better ideas and getting materials together to help them realize their design. Only then will they begin building. **In this design-focused approach, it is the design that determines the materials more than the materials determining the design.**

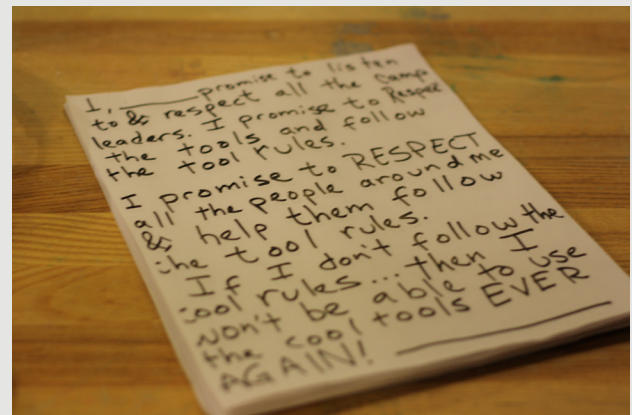
Engaging youth in the design process isn't always easy. Sometimes they are reluctant to engage. Sometimes they need help coming up with ideas. And sometimes they need a friendly reminder that their first attempt at making may leave something to be desired.





TOOLS

This focus on design is also captured in how young people think about tools. The learners often focus on 3D design. This does not mean 3D printing – there are more nimble and adaptive tools and materials that allow Wells and his participants to model 3D figures. Wells has nothing against 3D printers, but he does not want the 3D printer to be the “sexiest thing” in the room. The facilitators try to incorporate it as a tool in the service of the design process.



VISION

Viewing the tools and materials of a maker program in service of the goal of that program is one way to ensure that there is alignment or coherence in one’s overall program. Taken to its extreme, **Wells aspires to someday have youth participants build their own tools and use these tools to carry out their design.**

CASE STUDY: PIECES & PARTS

Aligning Tools to Learner Goals

Cleveland Public Library: cpl.org/thelibrary/subjectscollections/techcentral/makerspace-2

TechCentral, the makerspace at the main branch of the Cleveland Public Library, is intended to provide a creative and collaborative design and fabrication space. This space, which opened in January 2014, enables adult patrons to turn their ideas into reality, using the library's collection of cutting edge equipment—**including a laser engraving and cutting machine, 3D printers and a vinyl cutter. TechCentral also provides patrons with access to professional-grade software for photography, videography, graphic design and music.**



TechCentral's tools and equipment have been intentionally selected to align with its mission of **enabling patrons to be creative, collaborative and able to bring their ideas to life.** CJ Lynce, Manager at TechCentral, says that their equipment is intended to support a deliberate shift in library service from content consumption to content creation. To be makers, the mix of the library patrons can span



from pure amateurs to sophisticated experts. There are opportunities for library patrons to make relatively simple products with everyday materials, as well manufacture professional-grade prototypes with advanced equipment and tools.



The physical space of TechCentral is purposefully located in the basement of the library next to the computer lab with a hundred stations. This enables the library to **share staff across the makerspace and computer lab.** However, this isn't the only reason the makerspace is located in the basement. As Lynce explained, "This space gets really noisy, especially when the laser engraver is going. This can get to be a really noisy, chaotic area at times." **While some libraries and museums choose to put a makerspace in the center of their space to convey a sense of organizational priority, this may not be practical depending on the use.**





While the tools and materials currently available at TechCentral emphasize digital production, Lynce and his team have discovered that their focus many need to shift as they expand their maker programs to branch libraries across the system. For example, they offer newer workshops on making with duct tape and how to brew beer.

Ultimately, TechCentral represents an intentional alignment between the goals of engaging patrons in creative, collaborative endeavors that enable the patrons to make their ideas tangible, and the tools and materials that meet those goals.



When considering this shift, Lynce stated that **these non-digital maker experiences still tap into their goal**. He said that the goal of the work is intensely focused on learning and creativity. They were able to address this, in part, by introducing patrons to the idea of creating work products. He emphasized, “We’re not just a consumer culture, but also producers. And being a producer can be an analog or digital experience.”



CASE STUDY: PIECES & PARTS

Activating Lifelong Learning with Tools and Materials

Chattanooga Public Library: chattlibrary.org

The Fourth Floor of the Chattanooga Public Library has been lauded for its innovative library services: a mixture of high-end and low-tech tools and the GigLab (a co-working and special event space). The Giglab provides public access to the city's high-speed connectivity ("the gig") for experimentation and learning applications. Less well known, the Second Floor offers a **similarly innovative yet more scaffolded maker experience for kids, tweens and teens**.



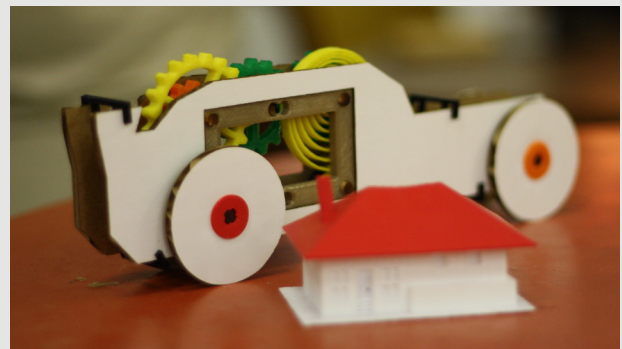
The Second Floor offers 3D printers, an augmented reality sandbox, zine making and video games, as well as a meeting space. Justin Hoenke, who previously served as a librarian on the Second Floor and is currently the Library Director at Benson Memorial Library in Titusville, Pennsylvania, describes the offerings on the Second Floor as reflective of what kids want these days. This includes a mixture of hands-on building activities, games, play, art and dramatic experiences. Ultimately, **these tools and materials demonstrate how important the intentional selection of tools and materials can be in achieving a program's goals.**



By serving as a bridge for young people to the sophisticated tools that are offered on the Fourth Floor, **the Second Floor carries out the library's mission to be the community's catalyst for lifelong learning.** In specific terms, this support is integrally tied to the tools and materials that are offered to the young patrons. Hoenke and his colleague Megan Emery described this as something like an assembly line: learning to use the button maker is not just for making buttons, but also exposes young patrons to the making or building process.



The Second Floor staff intentionally select activities that expose patrons to a variety of traditional and emerging technologies. A visitor is just as likely to see an old Ms. Pac-Man arcade console and record player on the Second Floor as they are to see a 3D printer and Arduino boards. Young patrons have even tinkered with the Ms. Pac-Man game, replacing parts like the joysticks with repurposed materials.





While **the tools and materials that the Second Floor offers seek to expose patrons to the inner workings of machines and demystify the building process**, the accompanying learning experiences are still driven by the patrons' interests. During the summer, the library offered a program where students learned to code, and the Second Floor received a grant to acquire some Chromebooks to support the learning process. Hoenke said that they saw this as being linked to the larger trend of STEAM learning, like many of their learning activities. But he noted that the youth wanted to learn to code because they loved video games,

wanted to make their own video games and engaged with the program as a way to learn.

Ultimately, the Second Floor at Chattanooga Public Library demonstrates how **the deliberate choice of tools and materials can align and support the goals of a makerspace or maker program.**





Partner Perspective: “Pieces and Parts at the NCSU Libraries Makerspaces”

Adam Rogers

*Emerging Technology Services Librarian
North Carolina State University*

At the NCSU Libraries, our makerspaces have been most visibly and easily defined by their pieces and parts—especially their technologies and physical spaces.

Our first makerspace, in the James B. Hunt Jr. Library, launched as a collection of tool-based services (3D printing, laser cutting) and devices available to borrow (Arduino and Raspberry Pi kits, 3D scanners, and more). Underlying this new program, though, was our library’s vision: to be NC State’s competitive advantage. With that in mind, we chose tools we hoped would have a big impact on a broad swath of our campus community, especially when made available with affordable, supported, and open services.

As our makerspace program has expanded and taken on new areas of technology (e.g. wearable technology and the Internet of Things), our main

motivations have been to enable access and facilitate literacy. So when we look at pieces and parts, whether it be designing a space or pop-up activity, or choosing an electronics kit, we ask questions like:

- How accessible is this to a total beginner? How easy is it to get started?
- What are the barriers to entry (e.g., unusable software, high cost of materials due to manufacturer lock-in)? Can these be eliminated or minimized by staff support?
- How would I teach this, and does it facilitate deeper learning?

Inevitably, the pieces and parts of a makerspace program reflect the people

who run it—the librarians or museum educators. The questions we ask and the design choices we make should evidence our values and principles. For instance, one might prefer a 3D printer, which is open source hardware (meaning its plans are free to study, copy, and re-use) and can print with any standard filament (not just that supplied by the printer’s manufacturer)—because they value openness and flexibility. At the NCSU Libraries, we have chosen to primarily support and teach software, which is free for students to download on their own computers—because we value independent learning and accessibility.

With the success of the NCSU Libraries' first makerspace, we had the wonderful opportunity to expand the program with a second, much larger location. Rather than duplicate our first space, the new D.H. Hill Makerspace was designed to strategically complement the first and to offer new and different experiences. The most significant pieces and parts of the environment we built are:

- a floor-to-ceiling glass wall which invites new users in, enables serendipitous discovery, makes visible the work that's done in the space, and more
- an entrance lobby with an open-door policy, which further invites in visitors and new users, engaging them with hands-on activities and compelling example projects
- entirely flexible furniture—tables and chairs on casters, ceiling-mounted power cord reels, movable ventilation—which allows for multiple uses and rearrangement
- a simple and reliable teaching setup: a projector and drop-down screen, a set of 20 laptops, and easy A/V connections
- very little fixed equipment: this privileges a one-to-one hands-on learning experience, and keeps the space open-ended, with new tools easily added.

So, clearly these pieces and parts were selected with purpose, by a thoughtful design team, with a lot of consideration of the people who would manage and use the space.

One thing to call attention to regarding pieces and parts, is the impetus to buy new and more stuff. Particularly in a technology-oriented environment, there is an impulse to chase after what's next, the latest and greatest. There is often a positive motivation here: we want to engage our users and offer them exciting, transformative experiences. But a few words of caution are in order: (1) every new purchase has hidden costs and implications in terms of setup, training, support, maintenance, and continued costs, and (2) tools and technologies are only made meaningful by what you and your users can do with them.

It can also arouse a consumerist urge to buy into new modes of engagement (e.g., buy a 3D printer, and you're supporting innovation). This surface view can obscure the hard work of redefining purpose, developing vision, learning new skills, and engaging communities in new ways. But—it can also be a way in, a prompt to figure things out and try new things. For most people, just getting started making and supporting making is the most important step—if it's a shiny new technology that gets you there, great. Just be prepared to think critically and ask questions about how it fits and what it really does for your users.



The magnetism of pieces and parts in the makerspace movement is no doubt because they are so malleable, so shiny, and often so affordable and seemingly easy. There are always new things to explore and experiment with. This makes our work really exciting, but it can also



Exploratorium

SECTION FIVE

LEARNING

The framework to support learning in museum and library makerspaces is intended to foster conditions for learning in those settings.

Once we begin to consider these elements, how do we know that learning is taking place? To answer this question, it may be helpful to first consider our perspective on learning and what we care about with respect to learning.

The theories and rationales for learning that advocates draw from when implementing maker-based learning experiences are varied. Some of these, like constructionism, constructivism and project-based learning have been covered elsewhere. Whether or not one chooses to connect the learning in their makerspace or maker program to a particular theory such as project-based learning or inquiry-based learning, the difficult question still remains, what does learning look like in your space or program?

To address this topic, we will provide two different but connected ways to approach the evidence of learning through making. First, an approach called Evidence-Centered Design as a way of conceptualizing learning in a program or space. Second, work from Children’s Museum of Pittsburgh to consider what learning can look like in a makerspace.

Learning Through Making: General to Specific

As we reviewed literature on makerspaces, conducted site visits nationwide and spoke with practitioners from these spaces, we always asked about the kinds of learning experiences they sought to support through making. This proved to be a difficult question for many. We noticed that many practitioners left the terminology for learning at a general level, focusing on popular learning outcomes. Some of the learning goals they spoke about were:

- STEM (Science, Technology, Engineering and Math)
- STEAM (Science, Technology, Engineering, Art and Math)
- Computational Thinking/Literacy
- Creativity
- Collaboration
- College and Career Readiness Skills
- Dispositions such as Persistence, Passion and Curiosity

Whether the overall goal of a makerspace is represented in one of the above terms or not, documenting evidence of learning proved to be challenging for our colleagues. It became even more challenging when we asked how they knew that their participants were learning the program’s particular goal.



Evidence Of Learning

A significant aspect of designing for learning is the ability to make evidence-based claims about the learning in a space or program. To address this question, many have advocated for asking some fundamental questions. What does learning look like in a makerspace or maker program?

How can we make learning more visible in a makerspace? And to what extent does the effect of maker-based learning experiences persist over time?

We can take a variety of approaches to answer these questions and gather evidence of learning. Below are some basic strategies. While not a comprehensive list, these strategies are intended to demonstrate the kinds of approaches that we can employ to collect evidence of learning in our makerspaces, and tell our stories of learning. Please note that these are strategies for collecting evidence of learning, and not the evidence itself.

Observation Notes: Whether you're the educator or the manager of a space (or both), writing down observations can be a productive way to document what learners are doing and saying while they engage with your space and programs. This can also include what family members and makerspace staff are doing and saying, since they are often partners in the learning process.

Interviews/Focus Groups: Speaking to learners and educators can create opportunities to understand the learning experience and accomplishments of learners in their own words. These can be written or recorded.

Artifacts of Work: To capture the material nature of maker-based learning experiences, the artifacts or products of what learners use and what learners create can serve as evidence of learning. The artifacts can offer windows into the learners' process like completing a storyboard or understanding of a particular concept like constructing an automata that moves in intended ways.

Video/Photographs: Visual documentation can offer a chance to document not only the artifacts of work and processes to create them, but who the learners are and their energy and emotions as they engage in their making.

Surveys/Written Responses: Asking learners questions can provide quicker access to their perceptions of the maker-based learning experience. Surveys can vary in length. Five minute surveys can be designed to be informative and still be less disruptive to the learning experience.

Taking into consideration which strategies are most appropriate for your space or your capacity and strategically utilizing them can offer evidence to address the question of what participants are learning in your makerspace or maker program. These strategies can be employed by those external to the makerspace (i.e., evaluators and researchers), as well as those internal to the makerspace (i.e., educators, volunteers and learners). Strategies might vary from program to program.

Models of Learning

Lisa Brahms and Peter Wardrip

Children's Museum of Pittsburgh

The strategies outlined above serve as a starting point for building a case for learning in a makerspace, but it's also necessary to tie them to some model of learning and engagement that supports the organization's mission and values. The approaches above essentially help us consider how to collect evidence of learning. However, models of learning provide us with notions of what kinds of learning we wish to support.

As a specific, illustrative example, Children's Museum of Pittsburgh has developed Learning Practices of Making, which serve as observable behaviors of learners in MAKESHOP®, the museum's makerspace. This work was funded by an IMLS National Leadership Grant (LG-25-12-0577-12) involving a partnership between the Children's Museum of Pittsburgh and the New York Hall of Science. The practices were developed collaboratively between the teaching artists of

MAKESHOP® and researchers to identify the kinds of learning that the museum values, how to adequately describe this learning and how to design to support visitor engagement in this learning.

In Table 1, we present these learning practices as a concrete example of how a space can identify and empirically track its own learning priorities. However, we recognize that these may not be appropriate for all makerspaces.

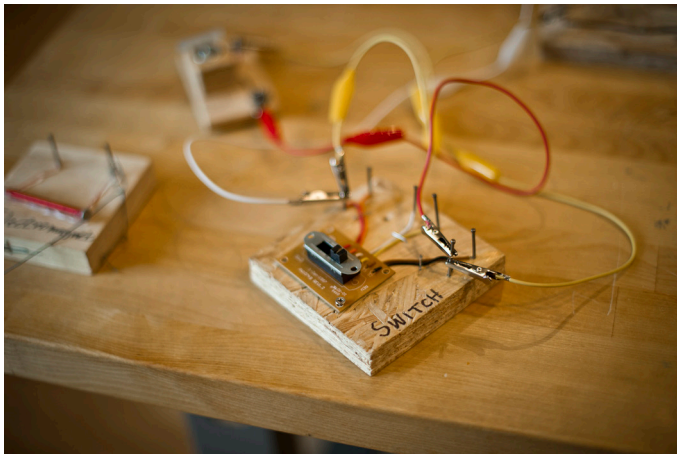
Other examples of learning models include the Dimensions of Learning from the Tinkering Studio at Exploratorium and Activation measures from Activation Lab at Lawrence Hall of Science. See makingandlearning.org

Table 1: Learning Practices with Descriptions

LEARNING PRACTICE	PRACTICE DESCRIPTION
Inquire	Learners' openness and curious approach to the possibilities of the context through exploration and questioning of its material properties.
Tinker	Learners' purposeful play, testing, risk taking and evaluation of the properties of materials, tools and processes.
Seek & Share Resources	Learners' identification, pursuit/recruitment and sharing of expertise with others; includes collaboration and recognition of one's unfamiliarity and desire to learn.
Hack & Repurpose	Learners' harnessing and salvaging of materials, tools and processes to modify, enhance or create a new product or process; includes disassociating object property from familiar use.
Express Intention	Learners' discovery, evolution and refinement of personal identity and interest areas through determination of short and long term goals; includes learners' responsive choice, negotiation and pursuit of goals alone and with others.
Develop Fluency	Learners' development of comfort and competence with diverse tools, materials and processes; developing craft.
Simplify to Complexify	Learners' demonstration of understanding of materials and processes by connecting and combining component elements to make new meaning.

Below, we describe and briefly illustrate each learning practice as it relates to learners' participation with the Circuit Blocks activity. The examples depicted come from data collected with visitors' consent to participate in research activities, through researcher observation using video and field notes.

The Circuit Blocks are a collection of wooden blocks with different components and power sources affixed to them. These blocks are made of a variety of materials such as small motors, buzzers, speakers, propellers and wheels – most of which are harvested from electronic toys or appliances. Each of these components is fastened to a separate wooden block, with its wire leads exposed and attached to conductive nails.



Blocks can be connected to one another using wires with alligator clips on the ends. A number of power sources are available, such as battery packs and cranks, as well as diverse forms of switches, including traditional light switches such as those found in a home, binder clips, paper clips and even conductive hair pins. Visitors may connect and reconnect the various components and switches to a power source with the loose wire leads.

Inquire

As a learning practice, it means that the learner is open and curious about the possibilities of the

context. This context is the making activity that may include tools, materials, processes and other makers. The maker's curiosity and openness can be seen in the exploration and questioning of the properties of the tools and materials available for the making activity.

Learners often engage in the practice of inquiring as an initial phase in their making process. When approaching the Circuit Blocks, children's inquiry is often expressed as curiosity about the materials before them or the function of the mechanism. A child may pick up a circuit block and ask "What is this?" or "What does this one do?" Oftentimes, these simple questions provide robust points of entry for deep exploration of process.

Tinker

As a learning practice, it relates to the learner evaluating the various properties of the tools and materials available to them in the making experience. This evaluation might be seen as purposeful play, testing or risk taking.

The tinkering we see with the Circuit Blocks includes learners swapping power sources, testing different wires or configurations of wires among circuit blocks, flipping switches on and off, and gently striking an alligator clip connected to a power source against different parts of other blocks, such as the nails, wire tails or holes within a component itself. Children often begin their exploration of the circuit blocks with phrases such as, "Let's see what happens when I try this," or "What if I do this?" As learners connect blocks, some connect and reconnect them in ways that complete the circuit and ways that do not complete the circuit, exhausting the possible combinations of connecting the wires. We also see tinkering when children work at repeatedly opening and closing the alligator clips or connecting the alligator clips to various surfaces.



Seek & Share Resources

As learners engage in a making experience, they openly rely on the resources available to them to understand how to use a particular tool, what the affordances of certain materials are and how specific processes may be used to pursue their goals. Seeking and sharing resources means that learners may identify, pursue and/or recruit the expertise of another in order to carry out their making activity. As participants in the making activity, these learners also share their own expertise with others who are participating. Ultimately, seeking and sharing resources as a learning practice acknowledges, on the learner's part, that he or she does not know some things related to the making activity, and desires to learn even more.

As learners engage with the Circuit Blocks, we've seen them seek and share resources in several ways. Children observe and show off what they have done to family members or nearby visitors. A child might say to friends or someone sitting near them, "Hey, look at this" when they've made a working connection between a power source and component, such as a light or motor. Once they've made the connection, children often offer an explanation of their process to a parent or Teaching Artist, as a way to process their developing understanding and simply express their accomplishment. A child might seek out information, or ask another child, parent, or Teaching Artist, "How did you make the fan move?"

Hack and Repurpose

Learners that hack and repurpose when engaged in making activities demonstrate the potential of materials, tools and processes beyond their intended use. When learners hack and repurpose, they modify, enhance and/or create a new product or process by salvaging or harnessing old ones. Hacking and repurposing disassociates the properties of an object from its most familiar use.

With Circuit Blocks, children's engagement in hacking and repurposing as a learning practice includes recognizing and using everyday materials in useful or new ways for creating complete circuits. The Circuit Blocks are made primarily of repurposed electronic components (motors, lights, buzzers, switches, etc.) that have been harvested from old electronic toys, appliances and devices. This act of deconstruction happens in MAKESHOP® as a "take apart" activity situated near the Circuit Blocks' table, allowing visitors to make direct connections between the toys and appliances and the repurposed elements of the blocks. Children will even "hack" the Circuit Blocks themselves, using an existing combination of power source, component and switch to teach themselves how a connection is made, swapping out different blocks to test variables.

Express Intention

As fundamental to the making process is the learners' ability to express intention. By this we mean more than the learner following their own path. Expressing intention involves the discovery, evolution and refinement of the learners' areas of interest through the determination of short- and long-term goals. These goals are pursued independently and collectively through responsive choices and negotiation of the making experience. Ultimately, this process of goal pursuit and interest development serves to foster the learner's personal identity.

When do learners exhibit intentionality? From the moment they decide to work with the Circuit Blocks and not with some other activity in MAKESHOP.® They may articulate a goal path, saying things like: "First, let's connect these wires together," or "I'm going to get all of these lights to turn on at the same time," or "I'm going to make the fan spin faster." Children will make explicit choices about which components they'll use and explain their rationale for such choices.



Develop Fluency

As learners engage in making, they can become more fluent in different components of the making activity. This includes the development of the learners' comfort and competence with a variety of tools, materials and processes. Ultimately,

fluency development may be seen as the cultivation of a learner's craft within a domain.

When making activities are shorter or less sustained over time, it can be difficult to observe fluency development. However, we've seen children developing craft, especially with circuits, in a variety of ways. Oftentimes, children will repeatedly connect and complete a circuit, demonstrating an understanding of how they work. Similarly, adding switches, dimmers, or other additional elements further demonstrates their understanding of circuits. Children may exhibit fluency by using accurate vocabulary and by identifying the right tool for the job, such as knowing the property of a switch.

Simplify to Complexify

In many cases, making enables learners to build and create using a variety of base materials. What do we mean by simplify to complexify? It's when learners combine and connect unique elements to give new meaning to those elements. This serves to demonstrate a learner's understanding of materials and/or processes and to enable learners to expand and deepen their understanding in boundless ways.

With Circuit Blocks, this practice is basic to building complete circuits. For example, when a child completes a circuit, he uses wires to connect a power source to some sort of output, like a light or a fan. Each of these components is given meaning through its relationship to the others. To a simple circuit (power source and output), the learner can add a switch. The Circuit Block table enables a learner to combine different components in nearly infinite ways, such as building parallel circuits or testing the limits of outputs relative to different power sources. Outputs, power sources and switches can be exchanged or added to explore possibilities and make new meaning.

These learning practices are meant to serve as an illustrative example of the kinds of identifiable learning taking shape in makerspaces. Perhaps they aren't completely appropriate for other spaces. However, the process of identifying important behaviors and actions within one's maker-based learning experience is key to documenting what learning is taking place and designing to support it.





Partner Perspective: “Open Portfolios: As Bridge Between Formal and Informal Learning”

Lisa Regalla and Stephanie Chang
Maker Education Initiative

No matter what the context, portfolios have proven instrumental for learners to develop a sense of who they are through the curation of their work and artifacts.

For years, portfolios have been actively used by artists and designers as a tool for professional and academic assessment (i.e., admission to schools, securing employment, etc.). Others have used portfolios as a tool for learning and reflection, creating opportunities for examining both the whole of one’s work, as well as the learning process over time. Portfolios have also served as a means of formative assessment – in conjunction with presentations, performances and competitions.

No matter what the context, portfolios have proven instrumental for learners to develop a sense of who they are

through the curation of their work and artifacts – be it within art, design, writing, engineering, and now, anything that involves making.

Maker Education Initiative (Maker Ed), in collaboration with Indiana University’s Creativity Labs, has been focused on rethinking the use of portfolios by youth, whether as part of maker-based learning experiences[1] or more broadly. The Open Portfolio Project aims to develop a common set of practices for portfolio creation, reflection, sharing, assessment, and technology solutions to create an open, decentralized, and distributed lifetime portfolio system for makers. Within the research project, open

portfolios are conceptualized to be part of “an openly networked, decentralized, and distributed portfolio system in which the maker maintains control of the content and curation process. Open portfolios seek to revisit the utility of portfolios as a central tool for lifelong learning and as a viable alternative to contemporary assessment practices, while leveraging new technologies to help address the shortcomings in prior educational initiatives.”

Open portfolios help youth develop and hone a variety of skills, including digital citizenship, digital literacy and metacognitive skills. Being able to comfortably present projects and

learning processes in front of a large online audience – and receive feedback and encouragement along the way – can also help build confidence and prepare the youth to thrive in the increasingly digitally-driven higher education environment and workforce.

Also, truly open portfolios are not solely tied to proprietary software or a private institution, enabling portfolio creators to take their assets with them beyond the program at hand and build on them throughout a lifetime of learning. This process of creating a digital portfolio encourages a level of analysis and reflection to be able to curate the collected artifacts into a certain identity. Youth are deputized to think about what persona they wish to present to whom, as well as what their digital footprint and persona might look like.

Since the purpose of one's portfolio and the setting in which it is created can vary widely, educators use various frameworks to organize portfolio creation and educational use. For instance, one possibility is to adopt the common writing framework RAFT (Role, Audience, Format, Topic) to help organize portfolio creation.

RAFT helps youth understand their roles as writers, the audience they will address, the varied formats to consider, and the topic they'll focus on. By adapting this strategy for portfolios, educators in museums and libraries can encourage youth to consider four important aspects of before diving in:

- **Role:** What is your role? Artist, expert, maker, applicant, yourself, a new persona?
- **Audience:** Who is your audience? Who will you share this with? Is this portfolio for an admissions board, personal use, adult makers, teachers, peers? How would a portfolio differ for each?
- **Format:** How will a viewer interact with your portfolio? How important are the design, aesthetics, hosting platform and curation?
- **Topic:** What question are you trying to answer? What gets you excited? What do you want to know?

The best way to envision what type of portfolios might work best, is to start by looking at examples of existing online portfolios, such as:

Individual Project Portfolio: "ljarin" documented the full process of the Touchless Trash Can Opener project on Build-in-Progress, a platform run by the MIT Media Lab. It's evident in the steps laid out, along with the descriptions (and comments!) provided, that the project encountered a few difficulties along the way but ultimately concluded in a successful finish. This project could be included as part of a larger individual portfolio and/or one could look at ljarin's profile to see what else has been made.

Group Portfolios: The largest art organization in the Bronx borough of New York City, the DreamYard Project, offers area youth a wide array of programming opportunities across a

number of art forms including theater, poetry, dance, visual arts, photography, video, music and audio production, fashion design and engineering. The DreamYard Art Center has a Tumblr aggregate page that hosts links to other Tumblr aggregate pages for each of their art form-specific programs. All hosted on Tumblr, these pages allow students to have a public-facing platform for sharing their work outside the group.

In today's digital age, it's particularly important to curate one's own identity and have control over how one's work is displayed. Having an online presence is an opportunity to create a brand, build an aesthetic, contribute work to share with the greater world and access a genuine audience. Open portfolios also help bridge the gap between formal and informal learning, allowing for the collection of learning and artifacts across multiple settings and along a continuum of growth. Portfolios may show professionalism beyond the norm, and even confidence in one's own work. A single project or artifact can prove that a student has completed something from beginning to end and can demonstrate his or her process, development and skillset. As an assessment tool, an open portfolio can provide a richness that captures depth of learning, voice and skills that a flattened test score simply cannot show.

For more information on the Open Portfolio Project, go to:
<http://makered.org/opp/>



Chattanooga Children's Museum

SECTION SIX

CONCLUSION

It's our goal to make every makerspace, and every maker-program, the best that it can possibly be.

The amount of momentum around makerspaces and making programs in museums and libraries has been substantial in recent years. The framework to support learning in these makerspaces is intended to provide new practitioners at various levels of an organization some guidance for the development of a makerspace for visitors and patrons of all ages. Moreover, the framework is intended to give professionals who are already implementing maker programs an opportunity to take stock of their program, reflect on what they've accomplished and potentially identify areas of refinement.

The framework reflects the diversity of makerspaces in museums and libraries across the country. Hands-on learning experiences in makerspaces and maker programs can look very different depending on their focus, the capacity of their educators and the tools and materials used to engage their learners. However, despite this diversity, this report documents how productive makerspaces incorporate an intentional approach to the design of learning experiences. This learning experience design is grounded in the purpose of the makerspace, the role people play in supporting the learning experiences and pieces and parts that engage the learners.

Thus, to create the conditions for learning in these spaces, maker educational professionals ought to first ask, "Why a makerspace?" and not "What do I need to buy?" As we have seen, there are a variety of goals and motivations educators might have to implement a makerspace or a maker program in a museum or library. However, the motivations or goals we have for the learners in our makerspaces influences the tools and materials we use.

We invite all museums and libraries to consider the three broad elements of the framework. We hope that this document will inspire you to foster the development of your unique makerspace or maker-program to be the best that it can possibly be for the benefit of the community you serve.

Beyond this report, we encourage you to go to our web site, www.makingandlearning.org to use the tools and resources available to carry this work forward.



Credits

We would like to thank the following organizations who played a role in the development of the framework and the publication through their participation in meetings and workshops held by this project's team.

AHA! A Hands-On Adventure, A Children's Museum

Akron-Summit County Public Library

Albright-Knox Art Gallery

Ann Arbor District Library

Anythink Library

Arkansas Discovery Network

Assemble

Barrington Area Library

Benedum Foundation

Benson Memorial Library

Betty Brinn Children's Museum

Brooklyn Children's Museum

Carnegie Library of Pittsburgh

Carnegie Science Center

Chicago Children's Museum

Chicago Public Library

Children's Discovery Museum of Illinois

Children's Discovery Museum of West Virginia

Children's Museum of Houston

Children's Museum of Illinois

Children's Museum of Pittsburgh

Cleveland Public Library

Columbia College Library

Columbus Museum of Art

Conner Prairie

Creative Discovery Museum

Cuyahoga County Public Library

Digital Youth Network

Discovery Center Museum

Discovery World Science and Technology Center

DuPage Children's Museum

Evanston Public Library

expERIEnce Children's Museum

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Great Lakes Science Center

Hagley Museum and Library

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Idaho Commission for Libraries

Iowa Library Services - North Central District

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Kohl's Children's Museum

Lawrence Hall of Science

Liberty Science Center

MacArthur Foundation

Madison Public Library

Maker Education Initiative

Meridian Library District

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ScienceWorks Hands On Museum

Scott Family Amazeum

Sprout Fund

Stepping Stones Museum

Tech Museum of Innovation

The Public Library of Youngstown and Mahoning County

Tulsa Children's Museum

Tulsa City-County Library

University of North Carolina at Chapel Hill

University of Pittsburgh

University of Wisconsin

Vermont Department of Libraries

Westport Library

Wilkesburg Public Library

Young Adult Library Services Association (YALSA)

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Publication design by:

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MAKING+LEARNING IS A COOPERATIVE AGREEMENT (*IMLS National Leadership Grant MG-00- 14-0074- 14*) **BETWEEN** the Children's Museum of Pittsburgh **AND** the Institute of Museum and Library Services. **THE PROJECT IS SUPPORTED BY THOUGHT PARTNERS FROM** the Exploratorium, the Chicago Public Library, North Carolina State University Libraries **AND** the Maker Education Initiative.