

# MAKERSPACES THAT SET THE STAGE FOR LIFELONG LEARNING

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## Abstract

Survival in a knowledge society is not about knowledge alone. To be globally competitive, economies must focus on building a culture of innovation, beginning by creating a foundation for lifelong learning. From K-12 and university environments to the workplace, traditional spaces lack the necessary digital and analog tools to support activities that inspire a culture of innovation. In this paper, we examine the emergence of a variety of spaces within the lexicon of makerspaces that support the hands-on learning activities of the innovation process. Makerspaces are playing an important role in how and where people learn, from the foundational learning experiences of formal education to the adaptive learning experiences of lifelong learning.

## Introduction

Introduced about forty-five years ago, the term “lifelong learning” describes the continual process of building skills and knowledge throughout one’s lifetime. Advancements in technology have democratized access to new tools and technologies creating a “learn anything, anyplace, anytime” culture that empowers learners to own their learning experience. Learners who share common interests in tinkering and hacking are seeking out opportunities to leverage active tools in makerspaces where their learning experience is enhanced.<sup>1</sup> Makerspaces provide environments where learners of all ages and skill levels have the opportunity to explore, experiment, and create for their own personal fulfillment and/or to develop new skills that help them adapt to the changing workplace conditions that are a given in today’s global environment.

There is no one definition for “makerspace.” Some spaces are high-tech, some are low-tech. Some are labeled makerspaces, others innovation spaces. The common theme is that makerspaces provide all users with learning opportunities to “fulfill the human desire to make things” (Gustafson 2013). Throughout a person’s academic and professional career, makerspaces provide users with opportunities to learn and retool specific skill sets that will improve personal development and employability in an evolving, performance-driven world.

Students learn how to learn during the foundational learning experiences of the K-12 ecosystem. Maker activities supported by active tools for making provide opportunities for these young students to put what they learn in the classroom into context and explore their interests outside of the classroom. Elementary schools are experiencing the pull for makerspaces from their students. The students are showing interest in robotics, gaming, and app creation, as well as low-tech activities such as designing with Legos, model making, and sewing.

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<sup>1</sup> In her discussion of “Fabriken,” a public makerspace in Sweden, Nilsson pointed out that tools have the ability to affect how individuals “think, act, and behave”; as such, tools are active objects. <http://www.hermanmiller.com/research/research-summaries/innovation-through-experience.html>.



In high schools where administrators are challenged to engage students who risk not graduating or those who struggle to find their education pathway beyond high school, makerspaces are filling a need by engaging students in new ways. Maker activities provide hands-on learning experiences that build confidence leading to persistence; expose students to new learning experiences, leading to a desire to pursue further education or training; and encourage students to own their learning experiences.

There is a growing call to action to develop a culture of innovation on college and university campuses that requires some level of interdisciplinary engagement between students from multiple disciplines. Makerspaces provide opportunities for students from various disciplines to work together on projects that develop both design thinking and systems thinking skills for problem solving.<sup>2</sup> This has implications for what types of makerspaces are created, where they are located, and how they are designed to achieve optimum learning outcomes. Recently there has been an increased interest in facilitating interdisciplinary projects in healthcare education. New requirements for team-based patient care in the healthcare ecosystem has resulted in high value placed on graduates entering the healthcare workplace with the skills necessary for this approach to patient care.

Individually, nurses have been hacking solutions for patient care as long as the profession has been in existence. Many of the adjustments to products are one-offs or require such a low volume that those who are closest to the patient, the nurses, typically would simply hack the solutions that existed without sharing their innovations with others. Similar hacks were being made by physical and occupational therapists. The healthcare industry has begun to embrace the notion

of sharing innovative practices as part of the move toward more interdisciplinary patient-centered care (Interprofessional Education Collaborative 2011). To accommodate this paradigm shift, hospitals are providing makerspaces for healthcare providers in an effort to promote innovative practices. Additionally, organizations are hosting hackathons, which bring together the best and the brightest engineering and business students with healthcare clinicians and administrators to solve healthcare problems.

Similar practices are taking shape in the corporate workplace environment. Innovation is a strategic focus of most if not all of the Fortune 500 companies. The focus is not simply on empowering employees to generate ideas, but also providing them with training, resources, and support to develop the ideas (Robert Wood Johnson Foundation 2015). The notion of making takes on a wide variety of activities and spaces in the corporate workplace. This work can take place in the open plan neighborhoods of the corporate environment or in spaces that are specifically built and identified as innovation centers. According to a recent trend, employees outside of R&D (e.g., design, product marketing, logistics) are requesting access to 3D printers and laser cutters as part of their workplace environment. For those employees who are highly mobile workers who do not have a physical presence in any particular location, new membership-based coworking sites are providing the workplace experience with opportunities to connect, collaborate, and develop ideas. Coworking environments are driven by the purpose of creating a community of diverse practitioners (Herman Miller, Inc. 2015).

Beyond formal education spaces and workplace environments, there are community maker and hacker spaces that serve multiple purposes. These organizations might be found in public libraries, church basements, industrial parks, or adjacent

<sup>2</sup> [https://en.wikipedia.org/wiki/Design\\_thinking](https://en.wikipedia.org/wiki/Design_thinking) and [https://en.wikipedia.org/wiki/Systems\\_thinking](https://en.wikipedia.org/wiki/Systems_thinking).

to a college or university campus. These spaces create opportunities for members of a community to learn new skills, develop new ideas, prototype, and produce products. Engaging maker activities in community makerspaces enhances social inclusion, active citizenship, and personal fulfillment.

### Maker Communities of Practice K-12: Foundational Learning

According to Gustafson, “Learning in the twenty-first century requires a capacity to learn that reflects a range of dispositions; to be curious, resilient, flexible, imaginative, critical, reflective, and self-evaluative; educators today do not want to produce ‘human encyclopedias, mere repositories of facts’” (2013). Individuals learn how to learn when they are very young. They build on a scaffold of learning capacity and capability, interest and curiosity, motivation and relationships. This has relevance because the literacy and numeracy skills of young learners combined with character and relationship skills will impact the potential for success of those young people for the rest of their lives. It’s not about the 3D printer, cardboard, or the glue gun. When young students embrace their own learning and can envision that they own their future, that confidence will carry them through learning experience after learning experience, into post-secondary education, the workforce, and their communities<sup>3</sup>.



*Sarah Cramer, a librarian in training, consults with Jay Wambere, a 5th grade student, about his LittleBits electronic music composition at Mitchell Elementary School in Ann Arbor, MI. The school participates in the Michigan Makers program, a University of Michigan initiative that supports the use of makerspaces in schools.*

At Mitchell Elementary School in Ann Arbor Michigan, students learn about physics by making simple Big Mouth Tumblewings.<sup>4</sup> Big Mouth Tumblewings are described as walk-along gliders that rotate and spin along an axis traverse to the apparent wind.<sup>5</sup> Many of the projects that are created in elementary and middle school makerspaces are based on opportunities for students to learn how to code. One of the best examples of a learning platform for learning code comes out of the Media Lab at MIT. Scratch (ages 8 and up) and Scratch Jr. (ages 5-7) are collectively a programming language and online community developed in an effort to make coding accessible and appealing to everyone.<sup>6</sup> Mitchel Resnick, Director of the Lifelong Kindergarten group at the MIT Media Lab, describes the value of learning to code:

In the process of learning to code, people learn many other things. They are not just learning to code, they are coding to learn. In addition to learning mathematical and computational ideas

3 edutopia 2015. [https://www.youtube.com/watch?v=\\_MDOB5-ocQc](https://www.youtube.com/watch?v=_MDOB5-ocQc)

4 <http://mmitchell.weebly.com/blog.html>.

5 <http://thinkphysics.org/activity/tumblewings/>.

6 Scratch. <https://scratch.mit.edu/>.

(such as variables and conditionals), they are also learning strategies for solving problems, designing projects, and communicating ideas. These skills are useful not just for computer scientists but for everyone, regardless of age, background, interests, or occupation (2013).

Scratch, Minecraft, and other programming platforms offer opportunities to learn coding and game development for children who might otherwise never have them. Organizations like code.org are working to make sure that these online platforms are available in schools (Stuart 2015).

At Hartford High School<sup>7</sup>, in Room 212, students are in charge of their own learning. Their teacher, Mr. Hathorn, provides the topics and equipment and then gives them the freedom to explore their own ideas. One of the projects coming out of Mr. Hathorn's class is one where students are digitizing and "printing" their town's history. Mr. Hathorn's goal is to move students from being savvy users of technology to being creators of technology.<sup>8</sup> Dos Pueblos Engineering Academy (DPEA) is located in Goleta, California. Introduced in 2002, the Academy was one of the first high schools in the nation to focus on a STEAM curriculum, a program designed to teach twenty-first-century skills via project-based learning in science, technology, engineering, art, and mathematics (STEAM). The program originally started as a STEM program. Once DPEA added art, they discovered that they attracted 50% more girls and got more interest from parents, mentors, the outside community, and students. DPEA allows students to explore one project a year, rotating through each aspect of the STEAM program.<sup>9</sup>

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7 Hartford High School is located in Wilder, Vermont.

8 Hartford High School. <https://vimeo.com/119583269>.

9 DPEA. <https://vimeo.com/101665737>.

## Higher Education: Preparing for the 21<sup>st</sup> Century Workplace

Dr. Paul Jacobs, Executive Director of Qualcomm and University of California Berkeley alumnus, spoke to the importance of makerspaces in higher education at a Clinton Global Initiative conference in 2013: "In our interconnected innovation economy, it is not enough to provide our future engineering leaders with technical skills. They must also learn how to work in interdisciplinary teams, how to iterate designs rapidly, how to manufacture sustainably, how to combine art and engineering, and how to address global markets" (Rhodes 2013). His words were part of an announcement that the Paul and Stacy Jacobs Foundation would be providing a generous donation for launching the Jacobs Institute for Design Innovation and enabling the construction of Jacobs Hall on the UC Berkeley campus. In August 2015, Jacobs Hall opened, and the Jacobs Institute for Design Innovation moved into its permanent home there<sup>10</sup>.

Jacobs Hall facilitates the entire innovation process: from ideation to design, group work, prototyping, and fabrication. The common spaces within the building provide ample opportunities for students to intersect serendipitously and to intentionally meet with other students and faculty. The value of Jacobs Hall to the global community is best described by Dean Sastry of UC Berkeley's College of Engineering: "Our students will deal with issues related to user experience, sustainability, scalability and cost through hands-on immersion in design across the curriculum. They will also develop viable business and service models so that their inventions and ideas can deliver tangible benefits to the real world" (Rhodes 2013).

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10 <http://jacobsinstitute.berkeley.edu/>



Jacobs Hall

The think[box] at Case Western Reserve University is an example of an Innovation Center that opened after a couple of years of piloting makerspace activities. Through the collaborations of Professor Gary Wnek from the Master of Engineering and Management program and Barry Romich, who donated \$1M in support of a pilot space, the think[box] was developed in a 4,000 square foot space in the basement of the Case School of Engineering building that opened in 2012. The intent of the pilot was to create a distinct, on-campus environment where hands-on education, design and development, and product commercialization could all take place, and where these activities could interact and cross-fertilize (Herman Miller, Inc. 2015).

The think[box] pilot was incredibly successful at developing a community of learners that bridged disciplines, academic roles, and generations. Products with commercial appeal were being designed, prototyped, and developed, attracting the attention of area business leaders. University Trustee and pivotal think[box] supporter Larry Sears identified an underutilized seven-story on campus storage facility and garnered support for renovating this as the future home of think[box]. One of the benefits of the building was that it is more centrally located and accessible within the community than the basement of the Engineering school. The new think[box] location in the Richey-Mixon building opened in October 2015. To date, three of the seven floors have been renovated, with additional floors on line for renovation. Overwhelming interest from the community,

along with the generous amount of space within the Richey-Mixon building, means that the university is able to offer think[box] access to the broader Cleveland community. At any given time at the think[box], users might include students from the resident campus; students from the Cleveland Institute of Art; faculty; local business owners; students from the area K-12 schools; and professional entrepreneurs (Herman Miller, Inc. 2015).

### Healthcare Workplace: Improving Healthcare through Making and Hacking

Nurses have been hacking solutions to challenges for patient care since the days of Florence Nightingale<sup>11</sup>. Professor Eric von Hippel at the Sloan School of Management at MIT refers to nurses as “user innovators”<sup>12</sup>. Today’s healthcare user innovators are benefiting from access to materials and rapid prototyping tools for bringing their ideas to actualization, as well as the ability to connect, share, and learn from other user innovators through the internet (von Hippel 2005).

The MakerHealth™ Space located on a patient floor at UTMB John Sealy Hospital in Galveston, Texas is the first makerspace in the country for health care providers.<sup>13</sup> “The MakerHealth Space at the UTMB will help bring nurse making to the forefront of health care innovation,” said David Marshall, Chief Nursing and Patient Care Services Officer at the UTMB Health System. “We know nurses have breakthrough ideas for improving health care. Providing them with the space, tools and materials to create these solutions, rather than outsourcing them to engineers and designers, just makes sense” (Robert Wood Johnson Foundation 2015).

11 Florence Nightingale (1820-1910) is considered by many as the founder of modern nursing.

12 User-innovators identify product and services needs that cannot be addressed by commercially available products. Instead of waiting for the market to catch up, they and modify, adapt, and create the solution.

13 The MakerHealth Space, <https://www.youtube.com/watch?v=2MaqhaX6tyw>

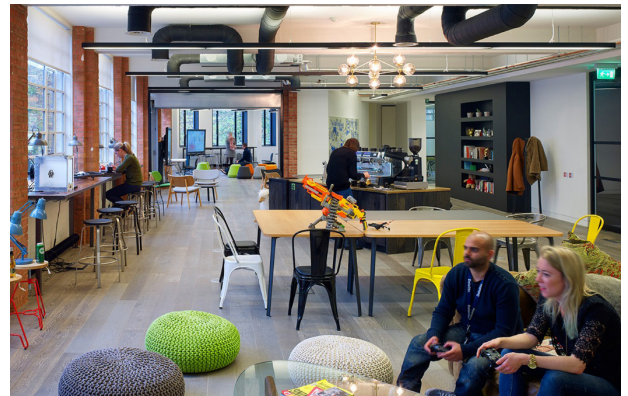
The makerspace is stocked with a range of tools, from pliers and sewing needles to 3D printers and laser cutters to address a specific medical challenge. Nurses can visit the makerspace to customize a wound dressing to fit a newborn, cut an IV shield down to size, or 3D print clips to keep feeding tubes, catheters, and other cables organized and out of patients' way. One of the areas in the makerspace helps user-innovators capture and take credit for their devices, and develop instructions so others can recreate their solutions (Robert Wood Johnson Foundation 2015).

Hackathons are also an emerging practice in healthcare. One example is the [Hacking Medicine](#) hackathon,<sup>14</sup> a fast-paced weekend event that brings as many as 150 MIT engineers and MIT Sloan business students working alongside clinicians and health care administrators to design and prototype creative solutions and innovative breakthroughs. Elliott Cohen, CTO of PillPack, describes the value of Hacking Medicine: "When you design a product that has taken the realities of the health care ecosystem and infrastructure into account, you've also taken the realities of providing care into account, so the product that pops out the other end—from a business perspective—is built to actually work, and—from a clinical perspective—is built to actually deliver real clinical value" (MIT Sloan Management 2013).

### **Corporate Workplace: Building a Culture of Innovation**

Corporations are strategically focused on building a culture of innovation through making, hacking, and coworking activities. Access to more affordable light-manufacturing tools and a highly mobile workforce are changing the way that employees work and innovate in the workplace. A visit to any of the firms located in Silicon Valley will confirm

that these activities are integrated into every aspect of business practices. More traditional companies are now seeking to model their corporate headquarters in similar fashion. No longer are these activities hidden in the back hallways of Research & Design. Innovation is on display, with the tools for innovation accessible to user innovators from facilities to product marketing, particularly in the manufacturing and product service industries.



*London Studio for Deloitte Digital<sup>15</sup>  
Photo Credit: Perkins + Will Architects*

Other types of spaces are being developed outside of corporate headquarters. Innovation Centers are detached from the corporation physically and financially in order to create opportunities for a business to take risks that the rest of the organization is unwilling to take on. Innovation Centers accelerate the speed of innovation, provide a fresh source of ideas, enhance risk-taking ability, attract talent, drive employee engagement, and build a culture of innovation (Capgemini Consulting 2015).

One example of an Innovation Center is the AT&T Foundry located in Atlanta, Georgia<sup>16</sup>. In this innovation space, work is not focused on developing new technology. It is more about transforming technology to benefit AT & T customers. Projects at the AT&T Foundry are typically on a 30-, 60- or 90-day plan with a proof of concept delivered within those timeframes. AT&T sees the

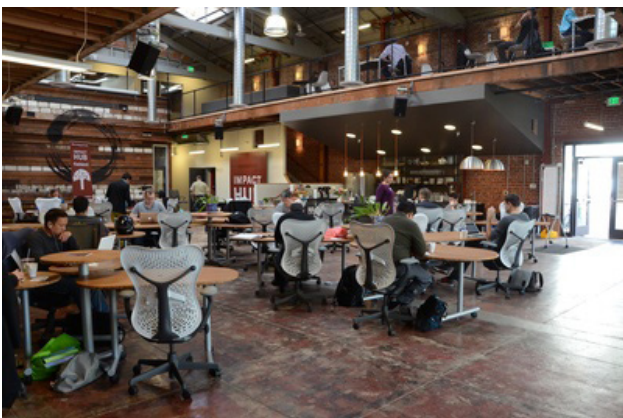
14 Healthcare's Grand Hackathon, <https://www.youtube.com/watch?v=IO-V9OdBlJE>

15 <http://www.deloittedigital.com/eu/about-us>

16 AT&T Foundry, <https://www.youtube.com/watch?v=2stlWyyplLQ>

Foundry as a symbol of change, which is evident in the appearance of the work environment at the Foundry, both physically and culturally. Other locations for the AT&T Foundry are Plano, Texas, Palo Alto, California, and Ra'Anana, Israel (AT&T n.d.).

Supporting the mobility of corporate employees and contingent workers are coworking enterprises like NextSpace and Impact Hub, which operate a business model in which funding is primarily based on memberships. The focus of activities in coworking spaces is less about “making” and more about building community—making connections between resources and people. The Community Curator at NextSpace describes the membership, “Sometimes our membership runs the full gamut in terms of what people do, what they are working on and the style of working. Are they working remotely from a large corporation, are they just freelancing, jumping from contract to contract? Are they a start-up or a small shop or something like that? There are all these different styles of work walking across all these different types of industries” (Herman Miller, Inc. 2015). Many coworking organizations have built coworking locations worldwide. NextSpace has ten US locations. Impact Hub has locations in 50 cities worldwide.



Oakland, CA Impact Hub<sup>17</sup>  
(Photo credit: localwiki.org)

<sup>17</sup> <http://oakland.impacthub.net/>

## Community Supported Makerspaces

Community supported makerspaces often provide environments where anyone can engage and learn anything they are willing to work at. From the novice who wants to learn how to work a computer to someone who was laid off from an obsolete manufacturing job who wants to retool or upgrade their skill sets to meet the needs of 21<sup>st</sup> century employers, a community makerspace can make a difference. A makerspace community can offer a bridge to that path by improving background knowledge and confidence as well as providing continual support to active members whatever their educational goals are.

Funded by the Kresge Foundation in 2009 and led by community leader Jeff Sturges, the Mount Elliott Makerspace is a neighborhood workshop located in a church basement in one of Detroit’s socioeconomically challenged east-side neighborhoods. In its five years of existence, Mt. Elliott has become established as a supportive community of makers where members express their creativity, developing a portfolio of skills that build confidence in lifelong learning regardless of age or educational background.<sup>18</sup> Community members of the Mt. Elliott Makerspace have become active members of the broader Detroit area maker activities. One of the community events that the members have become deeply engaged in is the [Hyper Interactive Hip Hop Carnival](#) which is a makerspace + arts + community related event designed to engage various community members as well as youth. Members also engage in Detroit area Maker Faires.

Transportation activities at Mt. Elliott Makerspace focus on a program that engages members in repairing and (re) building bicycles. The Bike Shop is a vital resource for community members given the affordability and usability of bikes and challenges

<sup>18</sup> Mount Elliott Makerspace, <https://vimeo.com/69048147>

related to poverty and inadequate public transportation. Communication activities focus on opportunities for members to take advantage of the Computer Lab. The Computer Lab is one of the most useful resources for community members of all ages, given the value of functional computers, printers, and high speed internet access with respect to job discovery, resume/cover letter composition, school work, etc. The Food and Wellness program resides under the stewardship of the church pastor. The Community Supported Agriculture (CSA) church garden has become a vital asset to the health and well being of the community (Herman Miller, Inc. 2015). The Mount Elliott Makerspace has changed the trajectory of the lives of many of the community members that it serves. One of its younger members, Dwight Roston, describes in the video linked below how his experiences in the makerspace have opened up the possibilities of dreams.<sup>19</sup>

Funded through the Chicago Public Library Foundation, The Maker Lab located in Chicago Public Library's Harold Washington Library Center opened in July of 2013 as Chicago's first free and publicly accessible makerspace. The space began as an experiment to understand the role of the public library in creating community-operated workspaces where people from the city could come to learn, collaborate, design, create, and do some rapid prototyping. The intent of the Lab is to serve as an introductory point for patrons to experience new technologies, test their making skills, and learn about further opportunities. The Maker Lab hosts multiple types of sessions: "Digital Toolbox" workshops, in which patrons learn how to make a simple object using digital design, "Special Sessions" in which patrons undertake non-digital crafting and art projects, and "Open Shop," where more experienced makers can work on personal projects. By offering

<sup>19</sup> Mount Elliott Makerspace, <https://vimeo.com/69048146>

introductory-level courses, Harold Washington Library Center is able to introduce a new segment of the public to the development of 21st-century skills (Herman Miller, Inc. 2015).

For the user innovators at Maker Lab, the value is in the opportunity to engage in new learning opportunities as a novice or master existing skills in a publicly accessible place, a place where they are part of a learning community. A team of doctors at the Loyola University Medical Center who wanted to make a model of a patient's skull before performing craniofacial surgery. Traditionally this would have taken three weeks and cost approximately \$4,000 in materials. Instead, they [went to the Chicago Public Library](#) and printed out a replica of the boy's skull using a 3D printer. Creating a prototype model of the child's skull took just 12 hours with a material cost of \$20.00. The surgeons had exactly what they needed to increase the possibility of a successful surgical outcome (Lynch 2015).

## Conclusion

As William Gibson once said, "The future is already here, it is just not evenly distributed<sup>20</sup>." This statement describes the state of the relationship between makerspaces and lifelong learning. As the cost of the technology and active tools for makerspaces decreases, and as the expectations and preferences for how students learn evolve, the activities of making will become embedded in the curriculums from K-12 schools. Because students learn how to learn in their foundational K-12 education, this will impact expectations for learning through post-secondary education and into the workplace.

Beyond formal education and work, makerspaces have the opportunity to create a positive impact on many societal issues in the world. Innovators and inventors are found in the most unlikely places. What the maker movement has done is open up opportunities

<sup>20</sup> William Gibson is an award-winning science fiction author.



for solving the world's wicked problems. These opportunities are accessible to anyone who wants to learn and has access to the tools and technologies that makerspaces have to offer. The foundations for building a culture of innovation in a knowledge society now begin in primary school makerspaces. While no one can predict the future, we can be certain that the activities of making, hacking, and collaborating will continue to expand opportunities for lifelong learning.

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