**Makerspaces as learning spaces:**

**An historical overview and literature review**

by

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## Abstract

Makerspace is an open community center where “people with common interests, often in computers and machining and so on, can meet, socialize and collaborate” (Kelly, 2013, p. 1). Based on a literature review, this study starts with the definition and the historical development of makerspaces, and then digs into the current research and theories on making, learning and makerspace. To explore the definition of makerspaces, this paper begins by exploring the origin of hackspaces, the predecessors of makerspaces, and how hackspaces naturally grow into makerspaces. When it comes to defining makerspace, different scholars and practitioners provide different descriptions. To define a makerspace involves overall thinking of materials, tools and makers making together – it is a unique place where people get together and make; it could be any place, in all shapes, sizes and locations.

Although it is difficult to pinpoint the exact origins of the makerspace movement, this study divides makerspace history into three periods and identifies the milestones during each period: embryonic period (1870s-1990s), transition period (2000s-2010s) and outbreak period (after 2011). The earliest record of a makerspace could potentially date back to 1873, when a quilting and sewing social club was founded in Gowanda, which is now known as the Gowanda Free Library. Then hackerspaces start popping up in 1960s. In 2010s, the evolution of technology and do-it yourself (DIY) culture began changing towards a focus on science, technology, engineering and mathematics (STEM). Since then, the idea of making spread worldwide and began officially appearing in libraries and other institutions. After a century, there are over 1500 makerspaces all over the world (Maker Faire, 2016).

Using phenomenological approaches, Vilém Flusser defines gesture as a range of movements through which people express their being in the world (1999, p. 38). As we reach out our hands, the movements the hands make when they try to meet are gesture of taking in and opening up the future (Flusser, 1999). In constructionist theories of pedagogy, learning is “conceptualized as a process of being, doing, knowing and becoming” (Petrich & Bevan, 2013, p. 53). Papert demonstrates that learning happens when thinking is worked out through making things that “can be shown, discussed, probed, and admired” (1993, p. 142). Therefore, in a makerspace, when we see learners are observing or playing with the tools, they are exploring, testing, and responding with their hands; they are learning (Petrich & Bevan, 2013).

Over the years, makerspaces have developed into different forms in various institutions. This concludes by reflecting on the relationship between makerspace and different institutions, and analyzing an example makerspace in three diverse institutional settings. For instance, according to the historical development of makerspaces, public libraries have a long history of providing spaces for making – they have long been a variation of makerspaces to some degree. There are a number of similarities between public libraries and makerspaces. To name just a few, they both serve their communities for promoting lifelong learning; their key principles align with each other: to bring communities together and share knowledge. Other examples include schools, universities and other organizations.

## Makerspaces as learning spaces:

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## Introduction

Since the early of 2000s, makerspaces have been popping up all around the world. The maker movement represents a significant change in engineering, fabrication as well as education. Makerspace is shifting the way some educators and educational researchers envision teaching and learning. Today, makerspaces are found in community areas like public libraries and schools across the world. These makerspaces are usually filled with tools such as laser cutters, routers, sewing machines, 3D printers and the like which people can use to create a variety of products.

The makerspace movement is not a new phenomenon, even though it has been making much news in the past a few decades. Makerspaces have existed in some way, shape, or form for centuries. The earliest record of a makerspace could potentially date back to 1873, when a quilting and sewing social club was founded in Gowanda, which is now known as the Gowanda Free Library. After a century, there are over 1500 makerspaces all over the world (Maker Faire, 2016).

**What is a makerspace?**

Before exploring what a makerspace is, one must begin by exploring the origin of hackerspaces, which were the predecessors of makerspaces. In a hackerspace, people share the knowledge and help each other to find out things that they do not know to make or create (Baichtal, 2011). This notion aligns with the makerspace movement’s core values of making and sharing. Hackerspace in general refers to those physical locations within a community where hackers gather and share resources and knowledge to build and make things (Baichtal, 2011). They are often located in social centers, public schools, or on university campuses, as well as industrial or warehouse space when they need more room. Community-operated workspace, computers, science, technologies, and people with common interests: these are the same characteristics we can find both in hackerspace and in makerspace. Raison (2010) describes the makerspace as “real physical spaces housing old-fashioned, yet revamped, communities, as opposed to the virtual communities out of cyberspace” (Raison, 2010, p. 2). Both makerspaces and hackerspaces have evolved into worldwide communities, and have expanded to include circuit design, manufacturing and more.

Over the years, some hackerspaces gradually became into makerspaces. First, more and more maker tools started to appear in public facilities, because the price of tools such as 3D printers and laser cutters becomes more affordable. Second, to “hack” means using a computer to gain unauthorized access to data, which gives “hacker” negative connotations in the media. Comparatively, “maker” suggests a less negatively charged identity, and thus the term “makerspaces” is better suitable for these public locations.

Yet, who is a maker? In 1961, Chevrolet released a short film titled *American Maker*, which focused on industrial engineering and model making. It stated, “makers build for use as well as building for fun” (Gantt, 2013, para. 2). As of today, the meaning of “maker” and the spirit of making still remain the same. Anybody who creates things could be a maker. Makers use their abilities and resources to create and share. They are not afraid to fail; they like trying new ideas; they celebrate the process of making, not just the things they made; they are “creators”, not “consumers” (Smith, 1982).

When it comes to the definition of makerspace, scholars and practitioners give somewhat different descriptions. For example, Fleming (2015) defines makerspace as a metaphor for a special learning space that encourages making, play and exploration for all people. Other suggest that a makerspace could be any place where people get together and make new artifacts (or things). Every makerspace is unique. They come in all shapes, sizes and locations: it could be built in public libraries, schools, or any other organizations; it could be a dedicated room hosting a variety of new and old tools, from 3D printers to irons and sewing machines; it could also be mobile workshop or even a Lego table in a kid’s play room. The projects that people usually work on in a digital technology oriented makerspace are: 3D printing, laser cutting, Makey Makey, Lego Robots, Adruino, and so on. What seems to define any makerspace is that it involves a gathering of materials, tools and makers making together.

**The historical development of makerspaces**

While it is impossible to trace the exact origins of the makerspace movement, three historical phases may be discerned: the embryonic period (1870 – 1980), the transition period (1980 - 2000), and the current outbreak period (2011 – today). Please see the Appendix for a summary.

**Embryonic period**

*American Libraries Magazine* (2013) identifies several events between 1870s-1970s as key dates in the history of makerspaces. In 1873, for example, the Ladies Social Society was formed in Gowanda, New York, by a group of local women, who would meet for tea, quilting, knitting, sewing, and other social functions. In 1877, it became the Ladies Library Association, and then the Gowanda Free Library in 1900 (Gowanda Free Library, 2016). In 1905, The children’s department head of Carnegie Library of Pittsburgh, Frances Jenkins Olcott, first started outreach programs, in which she promoted the idea of having home libraries for children and organizing crafts for kids (“Frances Jenkins Olcott”, 2016).

In 1906, the Canadian Handicrafts Guild was founded in Montreal. Manitoba Crafts Museum and Library was established in this context. It was built in 1933, to preserve cultural heritage and resources for teaching basic craft skills (“Manitoba Crafts Museum and Library”, 2016). In 1960, Nebraska Library Commission, known as the Nebraska Public Library, it developed many kinds of activities, especially creative arts for community patrons (American Libraries Magazine, 2013).

Meanwhile, hackerspaces, which evolved from the “hippie counterculture”, started gaining popularity in 1960s (Doctorow, 2009). The first hackerspace, the Chaos Communications Club (CCC), was founded in Berlin in 1981, with the C-base - established in 1995 - being probably the most impressive example. Later, there were other notable hackerspaces founded, such as Metalab, founded in 2006, which is considered to have pioneered the funding principles of hackerspace; TechShop, launched in the end of 2006, was the first chain of commercial hackerspaces (Baichtal, 2011). There is a hackerspace in Edmonton, called the Edmonton New Technology Society (ENTS), established in 2009. Until 2014, more than 1,250 hackerspaces had been documented (Hackerspaces, 2014).

In 1976, a tool lending library was first built in Columbus, Ohio, and is now operated by Rebuilding Together Central Ohio. It offers over 4,500 tools for free to individuals and non-profit organizations (“Tool library”, 2016). In 1979, Merrimack (N.H.) Public Library added a children’s craft room after renovation (American Libraries Magazine, 2013).

**Transition period**

Initially, makerspaces were associated with academic institutions. The first known fabrication space began in 2001 at the Massachusetts Institute of Technology (MIT) as an outreach project (Center for Bits and Atoms, n.d.). The idea spread worldwide and began officially appearing in libraries. Since then, the evolution of technology and do-it yourself (DIY) culture has led to a change in programming offered in some of these spaces toward a focus on science, technology, engineering and mathematics (STEM).

In January 2005, the MAKE magazine released its first issue by Maker Media in San Francisco, CA. It is a bimonthly magazine that emphasizes on step-by-step projects on technologies, including electronics, robotics, woodworking and others (“Make (magazine)”, 2016). In April 2006, the Maker Media launched its first Maker Faire at the San Mateo County Event Center, and Make magazine assisted organizations to produce Mini Maker Faires in local communities after that (McCue, 2011). Then this Maker Movement instantly spreads throughout the United States, and quickly across the nation to Europe, Asia and Australia.

Another milestone of this Maker movement is the project Arduino. Arduino is an open source hardware and software project first introduced in 2005. It gives people an easy way to learn coding, and made resources more open and accessible for most people.

**Outbreak period**

In 2011, the Fayetteville Free Library in New York State was found as the first public library to create a makerspace in the United States (McCue, 2011). The interest of making then continues and is expanding to more universities, libraries and other fields. In July 2012, Westport Library opened its makerspace. The makerspace was built in the middle of the library, which allows people from the outside to see what other patrons are doing with technologies. The space hires local experts as volunteers and hosted a certified Maker Faire (Westport Library, 2016). Also in 2012, the first makerspace for kids was built in Toronto. Toronto Life Magazine named it as “Best Kids’ Workshops” (Makerkids, 2016). This makerspace runs camps and after school maker learning programs on technology for kids. Their makerspace has tools and space for woodworking, 3D printing, mechanical creations, and all kinds of other crafting and making (Makerkids, 2016).

In July 2013, University of Toronto Faculty of Information iSchool Institute led a symposium on Creative Making in Libraries & Museums at Toronto. The symposium brought together key leaders in the makerspace movement and explored this new movement from many perspectives and provided tips and areas for further investigation (Abram & Dysart, 2014). The maker movement grew as people came to realize the potential and personal fulfillment of using makerspace to create and build things. In November 2013, Edmonton Stanley A. Milner Library launched a soft opening for its newly built makerspaces (Haug, 2014). According to the Global News Edmonton, it is also one of the first makerspaces in Canada (Kornik, 2014). Feb 12, 2014 was the grand opening, with the Mayor cutting the ribbon to the delight of the gathered crowd (Kornik, 2014). The makerspace is in the first floor of this downtown library, featuring two 3-D printers, a digital conversion area, a green wall, three gaming consoles and two gaming PCs, and four Mac and four PC computers with specialized software (Haug, 2014).

In February 2014, New Milford High School built its own school makerspace. Since launched, this school makerspace immediately gathered national attention especially after reported on CBS New York (NMHS, 2016). The school Media Specialist, Ms. Laura Fleming, is the author of the book “Worlds of Making: Best Practices for Establishing a Makerspace for Your School”. Later, more and more makerspaces are popping up in schools. Many school makerspaces take the form of school libraries. Depending on the space and budget of different schools, a school’s makerspace could be any place in school where students can explore, make, share and learn from their making experience.

Today, this Maker Movement is still spreading further and deeper into more countries, communities and people’s lives. According to Maker Faire’s record, in 2014, 215,000 people attended their two Maker Faires held in the Bay area and New York, “119 independently-produced mini faires and 14 featured Maker Faires occurred around the world, including Tokyo, Rome, Detroit, Oslo and Shenzhen” (Maker Faire, 2016). The number of Makespaces worldwide went up to approximately 1500. In 2015, there were 2 Mini Maker Fairs featured in Canada, one in Vancouver BC, the other in Calgary AB. In 2016, 10 such fairs were featured world widely (Maker Faire, 2016).

**Literature review on making, learning and makerspace**

**The gesture of making**

Vilém Flusser defines gesture as a range of movements through which people express their being in the world (1999, p. 38). He analyzes each gesture as the expression of a particular form of consciousness; that is, as a particular relationship between the world and the one who gestures. In terms of particular movements, our daily actions open a surprising new perspective on the ways we share and preserve meaning. Using phenomenological approaches, Flusser (1999) reveals different meanings for a series of movements of our hands. To name just a few, when we first start reaching out our hands, the gesture of making is gesture of taking in and opening up to the future. In the meantime, the world was divided into categories between the hands’ two surfaces; “The movement the hands make as they try to meet is the effort to ground theory in practice and to support practice theoretically” (Flusser, 1999, p. 38).

**Papert’s Constructionism on Learning theory**

Papert explains that constructionism takes Piaget’s constructivism’s view of learning as building knowledge instead of a transmission of knowledge, and adds to it “a context where the learner is consciously engaged in constructing a public entity” (Papert, 1991, p. 1). To Piaget, learners construct knowledge via experience. Papert takes this step further by highlighting the “making public artifacts”. Constructionism is more “focusing on learning through making rather than overall cognitive potentials”, more “situated and pragmatic” than Constructivism (Ackerman, 2001, pp. 3-7). Papert demonstrates that learning happens when thinking is worked via the making of external artifacts that “can be shown, discussed, probed, and admired” (Papert, 1993, p. 142). Besides, Papert is also a proponent of bringing technology to classrooms. In 2005, together with other practitioners, Papert launched the One Laptop Per Child initiative to implement constructionist learning in the developing world (One laptop per child, 2016). In the meantime, there is a variety of programming languages that have been created to support the constructionist learning. One of the most recent languages is LEGO Mindstorms EV3. It is a “dataflow graphical” programming language. The educational edition was released in 2013, which now is available in most makerspaces (“Lego Mindstorms EV3”, 2016).

Learning through making makes sense to most of teachers and parents, but how it is impacting education or how effective it is to promote education is lacking research evidence. In “Learning in the making: disposition and design in early education”, Carr (2009) discusses what we learn over the course of various kinds of experiences, how learning takes place and how we encourage effective and rewarding learning in early education. Fourteen participants who came from two kindergartens and three childcare centers were observed on three different phases: from 4-year old to 5-year old, and then the first few months in kindergarten, with 4-12 hours of observation for each phase. Carr (2009) also divided learning into three parts: “inclination, sensitivity to occasion, and ability”, that is, motivation, recognizing when and how to do so and why (Carr, 2009, p. 5). In chapter five – building resilience: initiating and orchestrating projects- they demonstrate that participating in making activities gives children opportunity to “explore the shifting balances between competence and fragility, between being knowledgeable and being confuse, between authority and powerlessness, and to gain the confidence and ability to bounce back from the fragile, confusion and powerlessness” (Carr, 2009, p. 97).

**Makerspace as a learning space**

When students spend time in a makerspace working with materials and making things, how do we know if they are learning something from what they are making? What can be counted as learning in this process? Based on a four-year research study, Petrich and Bevan explore what learning looks like, and how we conceptualize learning through making (Petrich & Bevan, 2013). They describe what happens in their makerspace as “thinking with hands”. In makerspace, learners are “exploring phenomena, testing ideas, and responding to feedback with their hands” (Honey & Kanter, 2013, p. 53). In constructionist theories of pedagogy, learning is “conceptualized as a process of being, doing, knowing and becoming” (Petrich & Bevan, 2013, p. 53). While in makerspace, learning is more determined by the “dynamic relationship of self, setting, activity, and how it supports learning” (Honey & Kanter, 2013, p. 53). When learners make things, their learning can be reflected by the growth of their “knowledge, skills, interests, ideas and sense of purpose” (Honey & Kanter, 2013, p. 53). Petrich lists four tentative indicators of this form of learning:

* *Engagement*: active participation, which might include silent or still observation and reflection;
* *Intentionality*: purposeful and evolving pursuit of an idea or plan;
* *Innovation*: new tinkering strategies that emerge through growing understanding of tools, materials, and phenomena; and
* *Solidarity*: sharing, supporting, and pursuing shared purposes with other learners, or with the artifacts they made or used. (Petrich & Bevan, 2013, pp. 53-54)

When we see learners are observing or playing with the tools in a makerspace, trying different ways to implement their ideas, spending hours sinking in and making things themselves, they are of course, learning. The goal of makerspace is to develop an open and inviting atmosphere where learners can discover and pursue a project or purpose, use their creativity and imagination, and confront and overcome challenges, within a making context.

Based on a research program, “Learning in the Making”, Litts (2015) describes makerspace as a third place, which exists between work/school and home where people meet informally and offers people with a special and deep sense of worth. Litts specially focuses on three youth makerspaces--museum, afterschool, and mobile/library--and analyzes how young makers learn from making in those settings (Litts, 2015, p. 1). She develops an activity-identity-community framework, which she uses as her analytic frame. She compares the constraints and strengths of each makerspace; and analyzes how young makers approach and complete activities in those makerspaces: “learning happens when one ‘makes’ rather than ‘gets’ both knowledge and artifacts” (Litts, 2015, p. 18).

From preschools, K-12 environments, higher education, online communities, museums, and after-school spaces, many makerspaces aspire to offer greater visibility into the learning environment. For instance, they explore how to improve the current curricular model to better facilitate play, design, inclusivity and new technologies; how working from children’s varied interested-driven orientations may affect their individual participation and learning experience including length and depth of their learning engagement, the quality of their interactions, imagination, collaborations, and innovation. In a case study based on squishy circuit experiment, Peppler and Kafai (2016) choose four focal participants out of forty 3-5 year old preschoolers. By comparing their orientation to making, sustained engagement and elaborated outcomes, their study showed that children who merged practices participated more often and longer and had more elaborated products and processes. In the end, they concluded that a play-based curriculum model (called the playshop model in their study) can facilitate the interest-driven, equitable, and engaged learning, which merge rigorous STEM learning with creative innovation in the arts (Peppler & Kafai, 2016).

**Makerspace in institutional settings**

**Makerspace in libraries**

Why did makerspaces appear in public libraries? Dale Dougherty, founder of *MAKE* magazine and *Maker Faire*, at the “Maker Monday” event of the 2013 American Library Association Midwinter Meeting framed the question more clearly, asking “whether making belongs in libraries or whether libraries can contribute to making” (Colegrove, 2013, para. 3)?

Public libraries have a long history of providing community spaces for creation (American Library Association, 2013). To some degree libraries have long been makerspaces. Thirty years ago, people went to libraries only to borrow print materials or microfilms. From 1990s to 2000s, there were distributed code examples and ancillary documents on accompanying CD or DVD media available in libraries. Today, e-book versions combined with computer workstations appeared in the libraries, and the rapidly growing availability of web-based tutorials and support communities render a potent combination that customers of the library can use to quickly acquire the ability to create or “make” custom applications (Duncan, 2010). With the migration of the supporting print collections online, in the library further support in the physical spaces opened up. These include opening working areas and whiteboard walls that can further amplify the collaborative nature of such making, adding popular hardware development platforms to its collection of lendable technology, and enabling those interested to check out a development kit rather than purchase their own. “A familiar example of maker activity in libraries might include digital media: still/video photography and audio mastering and remixing” (Slatter & Howard, 2013, p. 276).

Wikipedia puts “Library Makerspace” as a secondary listing under “hackerspace”, and it defines it as “an area traditionally found in public libraries that offers patrons an opportunity to create content through various resources such as computers, 3-D printers, audio and visual devices, and traditional arts and crafts materials, including ecologic material. In the field of library science, maker spaces are classified as a type of library service offered by librarians to patrons” (“Library Makerspace”, 2016).

A review of the literature around public libraries and makerspaces shows that there are a great number of similarities between the two. Both institutions serve their communities in helping promote lifelong learning. When talking about makerspaces, many of their defining principles could be applied to public libraries. In “Hackerspaces and Meta-creativity,” Seckinger (n.d.) describes how maker-labs are community hubs that value the importance of sharing of knowledge. These ideas are arguably key principles of modern libraries: bringing communities together in a shared space and allowing knowledge to be shared. Alternatively, aspects of maker culture are also present when discussing libraries more generally. Even though the physical forms of makerspaces can differ greatly, their mission and vision are consistent with libraries’ core values: they both expand library services through increased technology offerings, offer spaces and activities; foster community engagement, involvement and participation; encourage participatory learning; “promote equitable access to tools such as 3D printers, that would otherwise be off-limits; and transform traditional understandings of libraries as places of consumption to places of creation” (Slatter & Howard, 2013, p. 276). These two services: libraries and makerspaces, can co-exist as they frequently do now, or they can blend together and embrace the differences, thus creating an enhanced library service (McCue, 2011).

The first public library makerspace was founded in 2011 by the Fayetteville Free Library in New York State (McCue, 2011). It began by delivering mobile services even before the space was built. The 3D printer was its signature equipment at that time. It featured tools and plans for unique courses, such as “Intro to Digital Fabrication” and “Computer Programming” (McCue, 2011). Their course offerings spanned from sewing classes to robotics to “how things work” sessions where patrons could take apart and rebuild electronics. Their 3D printer was portable, allowing movement to various events and locations. They also hosted a Lego League - “an international competitive LEGO Robotics team for 9-14 year olds that involved programming LEGO robots, completing a public service research project, and learning teamwork and cooperation” (Hordal, 2013, p. 12). Since then, closing the gap between libraries and makerspaces started to become much more achievable and popular, especially with technology like 3D printers coming down in price.

**Makerspace in schools**

A school makerspace may be equipped with a wide range of tools, equipment and materials; provide a flexible learning environment and guided activities for students, foster students’ creativity and self-directed learning, and further their interest and abilities in various fields. Not solely a fab lab, workshop or computer lab, a school makerspace may contain elements found in these spaces. It transforms technology learning from a computer lab into hands-on and minds-on workshop environment. At the same time, students often find fulfillment when they overcome challenges with the support of classmates by using new technologies. It is also a place for students to build cognitive and social skills by working together on projects.

There is existing research on how to build makerspace in school education and a series of cases demonstrating how making is integrated in school and in out-of-school learning places. The key components to learning are: think, create, share and grow (Preddy, 2013), and the goal of building a makerspace aligns with these principles. Introducing makerspaces to schools helps to develop guided experiences to establish basic skills and promote independent making opportunities. It offers a flexible environment for students, and it is a safe place for the students to creatively construct and learn (Preddy, 2013). By offering more hands-on opportunities to teachers and students, a makerspace can foster active learning. For instance, by changing the background of pictures or videos using the Green Wall, students can develop their own themed stories, or use a 3D printer to print out their 3D models. It is more meaningful to make projects by themselves when learning new technologies.

Today, schools are already filled with creativity. The challenge is effectively cultivating it and fully making use of it. Introducing makerspaces to schools can help students get firsthand maker experience, and foster creativity and critical thinking. Students can be more engaged in study and develop their own understanding in different ways. Makerspace allows students to take control of their own learning as they take ownership of projects that they have not just designed but defined (Educause Learning Initiative, 2013). Through makerspace activities, students can build their maker mindset: “dexterity, thinking, problem solving, following step-by-step instructions, group dynamics, patience, endurance, and the ability to try new things” (Honey & Kanter, 2013, p. 3). From guided learning experiences, students grow, develop skills and become inspired to try new things.

The first post-secondary, on-campus makerspace in Canada was founded in May, 2013 by four on-campus graduate students at Queen’s University, who were interested in tinkering and learning about new technologies (Sparq Labs, n.d.). Their idea of a makerspace came along with a vision to start a space where like-minded people could come together to share ideas and develop new technologies. It then attracted a group of students from various faculties to run a lab, which continues to allow any student to find the tools and resources they need to turn their ideas into a physical reality. The space offers various tools, such as a drill press, bench grinder, belt and disc stationary sander, 3D printer, and even a sewing machine (Sparq Labs, n.d.).

**Makerspace in other communities**

Except for public libraries and schools, other organizations also built makerspaces. The most famous example among them is “Google workshop” and “Google inside hackerspace”. One of Google’s employees described their private hackerspace as follows: “Once you’re in, you have a treasure trove of equipment at your disposal. While there are no restrictions on what employees can build for personal use, some pretty important hardware has come out of the Google hackerspace over the years” (Adafruit, 2011, para. 6). Google’s Street View was designed and built there, as were some components for their self-driving cars. One of their engineering lab managers reminded that the company actually started in a garage; and building the workshop was intended to replicate the same sort of playground for trying out and playing with their ideas (Adafruit, 2011).

**Conclusion**

This study began with the definition of maker and makerspace. It explored the history of maker movement, delved into the current research on making, learning and makerspace, and then analyzed the relationship between makerspace and different institutions. Constructionist learning theory helps us understand the process of learning when one is involved in making. To [accommodate](http://www.thesaurus.com/browse/accommodate) to this form of learning, it is important to build a better understanding of making and how it happens, particularly in makerspaces, and to practice with strategies and techniques for makerspace learning. From this starting point, I would continue to work on how to implement makerspaces in different settings and develop related programs and assessment for making. Makerspaces are now proliferating across different institutional settings. From academic laboratories to public libraries, schools and other organizations, makerspaces continually adapt their form and they are changing how we visualize engineering, fabrication and education. It is significant to comprehend how makerspace can influence a variety of institutions.

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**Appendix A: Timeline of makerspace (1873-2015)**

|  |  |
| --- | --- |
| **Milestones** | |
| **Year** | **Description** |
| 1873 | Ladies Social Society in Gowanda, New York, USA |
| 1905 | Carnegie Library of Pittsburgh, Pittsburgh, USA |
| 1906 | Canadian Handicrafts Guild, Montreal, Canada |
| 1933 | Manitoba Crafts Museum and Library, Manitoba, Canada |
| 1960 | Nebraska Library Commission, Lincoln, USA |
| 1976 | Tool lending library, Columbus, Ohio, USA |
| 1979 | Merrimack (N.H.) Public Library, Merrimack, USA |
| 1981 | Chaos Communications Club (CCC), Berlin, Germany |
| 1999 | Edmonton New Technology Society (ENTS), Edmonton, Canada |
| 2001 | Fablab at Massachusetts Institute of Technology (MIT), Cambridge, USA |
| 2005 | MAKE magazine; |
| Arduino |
| 2006 | First Maker Faire at the San Mateo County Event Center, California, USA |
| 2011 | Fayetteville Free Library, New York, USA |
| 2012 | Westport Library, Westport, USA; |
| Makerkids, Toronto, Canada |
| 2013 | Creative Making in Libraries & Museums symposium, Toronto, Canada; |
| Edmonton Stanley A. Milner Library, Edmonton, Canada |
| 2014 | New Milford High School, New York, USA; |
| 215,000 people attended two Maker Faires held in the Bay area and New York |
| 2015 | 2 Mini Maker Faires featured in Canada; 10 Minis were featured world widely |