

# Innovation

## . Manufacturing



# Makerspaces

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For:



MASSDEVELOPMENT

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## Mini Maker Faire, Somerville, 2012

*Inspiring curiosity in science, technology, engineering, and manufacturing*

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# Introduction to Makerspaces



## What Is a Makerspace?

Makerspaces and maker groups are new and rapidly evolving hotbeds of innovation, which have been facilitated by the latest in prototyping technology while rooted in traditional pillars of manufacturing: engineering, design, science, and art. Coworking environments, such as innovation centers, accelerators, incubators, and hackerspaces, have begun to proliferate. Out of hackerspaces, so-called 'hardware' innovators have carved out a subgroup for makers. Making has always been a part of hackerspaces, whose walls are often stacked with racks of spare electronic parts for repurposing. In makerspaces, however, hardware innovation is primary and programming is secondary.

- Workshop-centered coworking
- Focus on hardware side of hackerspaces
- Design-Oriented Innovation: at the nexus of engineering, technology and art
- Primarily structured as a master lessee, with user members
- Most are not-for-profit collectives, a few are for-profit or public/private partnerships
- Enabled by: programmable prototyping tools (e.g. Arduino), 3-D printers (e.g. Makerbot), laser cutters, crowdfunding (e.g. Kickstarter), the internet, DIY, Lego's modularity, open source software solutions
- Influenced by: robotics, hackers, artists, set designers, innovation competitions, electronic component salvage, welding, lock picking, sewing, Burning Man devotees, craftsmen, custom bicycles, TED talks, Singularity

While MIT founded a precursor in 2002 called Fab Lab, this new version of fabrication shops called makerspaces is less than five years old and is still defining itself. Already, however, makerspaces have expanded from the electronics-centric hackers to a stronger emphasis on multi-disciplined groups that more deliberately include an array of woodworkers, sculptors, machinists, robotics engineers, bicycle makers, jewelry-makers, photographers, printmakers, and fashion/costume/set designers in an ever-diversifying list of participants.

## What Is the Purpose of a Makerspace?

Like the incubators of yore, maker groups seek creative stimulation, collaboration, encouragement, and even friendly competition with their fellow makers. Technology, however, has dramatically impacted how entrepreneurs and inventors are innovating since the last generation of incubators. The internet has resulted in increased open-sourced information because the dissemination of information is now deemed to be virtually inevitable. As a result, tinkering privately in a garage or basement is disadvantageous when compared to makerspaces where one can exchange information and methods in the company of likeminded entrepreneurs, while benefitting from the economy of shared equipment and space. Makerspaces have developed due in part to the drive toward interdisciplinary collaboration in industry, which requires informational and physical connectivity. Technology has also enabled inventors to self-develop prototypes using laser cutters and 3-D printers, which is cheaper and faster than relying on third-party prototype development, but necessitates inventors to have access to a new level of workshop equipment. Makerspaces provide a new level of organization and facilities in response to these needs beyond the loose confederations of post-collegiate inventors that for years have been meeting in garages and living rooms.

## Where Do Makerspaces Form?

Likely locations for makerspaces depend upon the locations of individual founders and of a potential pool of members. Both conditions are most likely to be met in areas with a concentration of engineers, designers, and creative types including artists. In Massachusetts, makerspaces developed first near MIT, but new shoots have appeared in Worcester, Springfield, and Taunton. As the maker movement develops, proximity to Worcester Polytechnic Institute, Olin College, and UMass Dartmouth's Center for Advanced Manufacturing are likely locations for makerspace growth.

## What Makes a Makerspace?

Makerspaces share many characteristics with other coworking spaces, places where members share some or all of the facilities and services and may operate as a collective on some decision-making and governance. Like coworking centers, makerspaces feature white boards, couches, indoor bike storage and coffee bars, but the defining component of the makerspace is the workshop. The typical elements of the workshop are: Computer Numeric Controlled (CNC) laser cutters, 3-D printers (e.g. Makerbot), and Milling Machines (e.g. Bridgeport), pictured below.

Downsizing manufacturers provide ready sources for much of this equipment, especially to not-for-profit makerspaces that can offer tax deductions. Initial makerspace members often contribute their own equipment for member use, motivated by twin desires to 'get it out of the garage' and to have the equipment jointly maintained. The CNC equipment usually needs to be purchased new, and its cost and maintenance are key drivers for maker groups coming together.

Makerspaces are all about customization. Do-It-Yourself'ers tend to value their personal connections to the design and construction of the workshop. Attempts to standardize or pre-package equipment, or to create a maker version of plug n' play coworking, have met with resistance by many makers, who proudly showcase each recycled component and innovative creation when giving tours of their spaces. There is a trend toward adding a coworking area to the workshop, in the form of personal workstations, workbenches or work cubes where projects can be assembled and developed without interruption, and materials can be stored.





## How Do Makerspaces Form?

The majority of maker communities begin with the people rather than the space.



Typically two to five founders take on initial and ongoing responsibility for forming and leading the group, often meeting in their living rooms or community spaces during inception. Advertising for members begins before searching for space, including online through blogs, Meetup.org groups, flyers, and word-of-mouth. The strength of these groups varies depending upon their innovation wattage, the diversity of their artisans, and the leadership capacities of their founders. A key test of a maker community's resilience is how it handles succession when a founder leaves, often to focus on his/her own innovations rather than the makerspace's demands.

Alternatively, some groups originate with the space, then attract the members, often with weaker results. First are landlord-founded makerspaces which are, to date, untried in Massachusetts. Second are intermediary corporations that operate based upon a fitness club model, such as Tech Shop. Tech Shop relies primarily on corporate sponsorship for income and, after attempting to create a Massachusetts franchise, reportedly has abandoned its efforts due to an inability to find an affordable, prime Kendall Square location. The Collaborative/Gateway Consulting has an ongoing effort to create landlord founded makerspaces in partnership with community development corporations, also as yet unproven, described later in the report. There is no guarantee that "if you build it, they will come" but rather if the maker team gels, a space will get built.

## Why Not Repurpose Existing Facilities?

Many vocational technical, high school, college, and university workshops could incubate and/or house maker groups, yet they decisively prefer to start from scratch. Today's inventors and entrepreneurs are influenced not only by technology, but by the social mores of its Millennial and Gen Y participants, whose emphasis is on flexibility and freedom. This translates into a work culture that is 24/7, and integrates social and professional activities. Makerspaces provide an alternative to the restrictions of existing workshop facilities with respect to use and access.

The conflicts between student and professional demands on the workshop create another point of friction with existing, academically-based, workshop facilities. The pressures of student project deadlines tend to butt up against the continuity of professional project development. Younger students tend to devote less attention to caring for the equipment and materials. Bottom line: students operate under short-term goals, whereas professional makers have longer-term objectives, and this difference causes frustration for both parties.

Furthermore, makers strongly desire participation in the design and governance of their facilities, which they cannot do in institutionally-controlled, academic settings. Makers seek freedom from bureaucratic constraints on all levels, such as departmental silos, that could interfere with interdisciplinary collaboration.





## Mini Maker Faire, Somerville, 2012

*Middle schoolers learning to weld*

# Stages of Makerspace Development



To be qualified as a makerspace for the purposes of this study, the maker community either has or intends to have a shared, multi-disciplined workshop. Seven are considered to be in the Early Stage, including two that have not yet taken space and five that have taken space. Two groups have very rapidly progressed to the Growth Stage by expanding in space, services and membership. Only one has ascended to the Mature Stage, although a second is poised to move up to this stage in the near future.

## Early Stage

Searching/Negotiating for Space

- South Coast Innovator Labs, Taunton
- The Collaborative, Multi-Site

Occupying or Committed to Space

- BOLT Accelerator, Boston
- Geek Group at Indian Orchard Mills, Springfield
- Xylem, Somerville
- T.E.S.L.A./WAG, Worcester
- Haverhill Hardware Competition Accelerator

Parts & Crafts in Somerville and Einstein's Workshop in Burlington both focus on educating youth but are not included in this report.

## Growth Stage

- Artisan's Asylum, Somerville
- Industry Lab, Cambridge

Greentown Labs in Fort Point Channel focuses on cleantech but is not included in this report.

## Mature Stage

- Fab Labs - South End Technology Center and Roxbury Mobile Lab

Three collectives of small, fabrication companies are also of note as Next Stage locations for the commercial development of products. Headquarters Boston in South Boston and Fringe in Somerville are comprised of companies working in a range of disciplines and share space but not equipment, and are therefore in a post-incubation stage. Archangel Woodworks CO-OP in Worcester includes a shared workshop used solely for woodworking purposes.

## Early Stage

Founders form the nucleus of their maker communities through their contacts from college, another maker community, a shared hobby, and/or social networks. They may draw in others to plan a makerspace by hosting potluck living room discussions or holding regular meetings in a community room. Founders spread the word via Meetup.org groups, hackerspace.org wiki, e-mails to entrepreneur groups, weblogs, and flyers at other makerspaces.

Meeting attendees exchange ideas on the purpose and character of the community they want to create, and consider questions such as:

- What type of making and membership will be supported and solicited?
- Will there be onsite classes?
- Will there be individual workspaces in addition to the workshop?

Early meetings serve to inspire current work by sharing and validating each other's latest ideas. The meetings also handle practical matters such as:

- Where to locate
- How to equip a workshop
- How to prioritize and make decisions
- What legal structure to use (non-profit or profit)
- Budgeting
- Membership fee structure
- Insurance
- Membership requirements

The early team begins to do due diligence on how to meet the needs of the group both on an interim basis (e.g. shared space, borrowed equipment) as well as on a more settled basis.

Groups tend to begin informally and solidify in structure when looking for a home. Finding a minimum of 1,000 – 2,000 SF of suitable space for the community and programming its design justify the charging of membership fees as well as provide for the acceptance and housing of loaned or donated equipment. With leases and bank accounts come decisions about legal structure and insurance. With tenant improvements come issues of code compliance and life safety (e.g. fire protection and hazardous materials storage). The tone for the community going forward is set by how these decisions get made and problems get solved.

## Early Stage Searching/Negotiating for Space

### South Coast Innovator Labs (SCIL), Taunton Area

This group of twenty engineers is less than two years old. SCIL formed primarily through word of mouth and Meetup.org. SCIL meets on a weekly basis in a public meeting room in a shopping center in Taunton, and actively seeks workshop and classroom space. SCIL has entered into lease negotiations several times and appears poised for progressing to the facilitated step of the Early Stage.

SCIL's annual budget for rent is \$1.00/SF for up to 2,000 SF, which would barely offset a landlord's taxes and expenses. SCIL currently does not charge dues and only plans to charge \$35/month when space has been taken, two factors that explain its minimal rent budget. Unable to find a home in its preferred locations of Taunton and Raynham, at the end of 2012, SCIL was negotiating on raw warehouse space in Fall River that will require significant electrical infrastructure investment in addition to a do-it-yourself build-out, but that too has proved cost prohibitive. The group is now seeking to partner with small commercial ventures to share space.

## Early Stage Searching/Negotiating for Space

### The Collaborative/Gateway Consulting, Lawrence, Dorchester and Statewide

Gateway Consulting, headed by Jon Davey, intends to establish makerspaces called The Collaborative in partnership with Community Development Groups on an advisory basis. Davey seeks to set up as many as thirty workshop or kitchen-driven spaces in gateway cities across Massachusetts in spaces owned or controlled by Community Development Corporations. Gateway Consulting will develop on a turnkey basis each Collaborative of user groups (artists, inventors, entrepreneurs, and chefs) who will lease and operate its own makerspace but also be networked with other Collaboratives. The first project planned is a 6,500 SF makerspace included within a broader multi-purpose arts project at Union Crossing (image below) in partnership with Lawrence CommunityWorks. This Collaborative hopes to open a shared-use, creative arts community for business in May 2013 that will include a membership or drop-in workshop for woodworking, metalworking, industrial fabrication, small electronics, and robotics. A second, larger project, under negotiation with Dorchester Bay Economic Development Corporation, is expected to have a kitchen lab and a live-work emphasis.





## Early Stage Searching/Negotiating for Space

### BOLT, Boston

This newly formed accelerator is currently accepting applications for up to fifteen teams of hardware inventors who will incubate together in a six-month class. BOLT aims to accelerate the development of a product or process idea into the marketplace. BOLT will cover all expenses of a team for six months in exchange for a stake in the company, with extensions available for six additional months at low cost. The founders, led by Ben Einstein (image below), have raised a \$3.5 venture fund primarily from strategic partners such as Logitech and Autodesk. Angel investors contributed the remainder. They have also been networking among start-ups to form their June 2013 inaugural class. In December, they also created Boston Hardware Startup Meetup group, which already has 245 members, 74 of whom attended its inaugural meeting in February. Within two years, BOLT expects to scale up to twenty-five teams per class.

In March, BOLT signed a 10,000 SF lease in Boston's Downtown Crossing and construction is underway creating a workshop, meeting/class room, and offices for the venture capital partners. BOLT intends to have a 1:1 mix of workstations to workshop, which falls between Artisan's Asylum at 4:1 and Tech Shop at 1:2. More than twenty world class expert mentors (e.g. Mick Mountz of Kiva Systems, Eran Egozy of Harmonix Music Systems, Brad Feld of Foundry Group) have been recruited to provide coaching in the areas of hardware engineering, product design, and financing. Bolt will directly employ a fulltime staff of eight.





## Early Stage Occupying or Committed to Space

### The Geek Group of Western Mass, Indian Orchard Mills, Springfield

Founded in 2010 by a mechanical and a software engineer who have sponsored the space to share with others on a sliding scale basis, the Geek Group has built a membership of 132 mostly not-yet-dues-paying or donating-in-kind members through word-of-mouth and Meetup.org. The Springfield entity is the first spinoff chapter of The Geek Group in Grand Rapids, MI. Its space consists of 1,500 SF in a large mill that houses dozens of lock-and-key artist studios and small business stalls. The Geek Group has a large array of donated equipment, including a Bridgeport milling machine, thanks in part to excellent freight elevator access to its second floor location. The Geek Group lacks, however, internet access, which tops its wish list.

A member of The Geek Group has already produced a profitable product: a 3D printer kit called Prusa Mendel, made by Mary Robison of Robison Industries (image below).



## Early Stage Occupying or Committed to Space

### Xylem, Somerville

Founded in 2012 by Declan Keefe of Place Tailor, a green design-build firm, Xylem combines a workshop/office with a collaborative interdisciplinary environment. Xylem has completed remedial waterproofing of its partially below-grade 3000 SF space, and set up an array of woodworking and metal shop equipment that it received via an in-kind donation from one of its members. By word-of-mouth and from flyers at nearby Artisan's Asylum (which has a 250-person waitlist), Xylem has already signed up eight of the twelve members needed to fill its space. Xylem would like to add welding and printmaking participants. Xylem still needs help with funding for additional dust collection/ventilation, electrical infrastructure, web design, working capital, and a salaried shop manager.





## Early Stage Occupying or Committed to Space

### T.E.S.L.A./WAG, Worcester

This unique maker community consists of a cluster of unheated makerspaces populated by a diverse group of independent makers that functions like a collective. Participants include T.E.S.L.A., a hacker/makerspace with 24 members that do both software and hardware electronics innovation; a woodworking makerspace (image below) that houses a half dozen members; and Worcester Artists Group (WAG), which has recently taken space for studios that it plans to construct. A blacksmith, urban gardener, and assorted welders and craftsmen round out the group. A full array of electrical, ventilation, and other basic improvements are needed, and class programming is also a goal.



## Early Stage Occupying or Committed to Space

### Haverhill Hardware Horizons Competition (H3C), Haverhill

The City of Haverhill sponsored the initial year of this public/private partnership effort designed to build on Haverhill's manufacturing brand. Lightspeed Manufacturing will provide circuit boards and testing services, Burgess Business Park will provide flex office/industrial space, and other business and engineering consultants will also contribute their services to H3C. The program provides innovation and business acceleration services to finalist teams for four months and then awards \$10,000 to the best product team. Of the thirteen entities that applied, H3C selected six finalists in November 2012. By the beginning of 2013, one group had elected to use the flex space provided for the competition at Burgess Business Center, and more groups were expected to use temporary workbenches in Lightspeed Manufacturing to get closer to the circuit board testing process. Together, these workspaces serve as a makerspace for the first year of this accelerator program. Many applicants have participated previously in MassChallenge and, as with the MassChallenge guidelines, winners do not have to locate in Haverhill.



## Growth Stage

A makerspace reaches the Growth Stage when it grows roots and stabilizes its identity, location, and member base. Milestones during this phase include establishing facilities, prioritizing creative functions that determine the necessary equipment, putting systems in place, and establishing educational and social event programming. This identity varies depending on the group, and its space and workshops are customized to fit the group's developing needs.

Unlike predecessor incubator models, the more varied the creative functions the group and space serves, the better. Locations with design and engineering density, such as Artisan's Asylum in Somerville and AS220 in Providence, have accordingly flourished. Makerspaces are an interdisciplinary movement, and compartmentalization of disciplines is therefore a hindrance.

Committing to a consistent location for meeting and working is critical to the bonding of the makerspace participants. Makerspaces serve as workplace, clubhouse, social hub, and training center. The more functions the space serves, the more attractive it is to the community, and the more the community bonds to it. In some cases, members actually move nearer to these locations.

In early stages, groups may relocate frequently depending on physical conditions or membership growth. Makers often experiment with location until they find what works for their members. Make It Labs, for example, started in Lowell but quickly moved to Nashua, NH to reduce lease costs. Artisan's Asylum moved twice in a year before settling in and rapidly expanding at Tyler Street in Somerville. Industry Labs has moved once and expanded at least three times in its current location. All three of these groups have indicated in retrospect that real estate advice would have proven beneficial regarding feasibility, lease negotiation, tenant improvements, and code compliance. Makerspaces face code issues as the electrical and ventilation demands increase. Lease issues come to the fore as improvements or expansion need to be accommodated. The do-it-yourself learning curve can be steep, and the mistakes unnecessarily costly.

Also during the growth stage, a wide array of systems become necessary: billing, accounting, website development, website maintenance, and member database management. Eventually, there will be payroll for administrators, teachers, and shop managers. In keeping with the do-it-yourself culture characteristic of most makerspaces, outside help from contractors, attorneys, real estate brokers, and accountants is sought only when those skills cannot be found from within the membership of the makerspace itself. While a marked savings often results from relying on volunteer or bartered resources, especially when building out space, sometimes extra costs are incurred when experienced professional assistance is not sought in time to avoid costly mistakes in permitting, code compliance, and lease negotiations. Some makers report missing opportunities to put time-saving operational systems in place.

More than half of the maker groups surveyed have, or plan to have, educational components to their communities. Typically these components are in place by the Growth Stage, and the community's response often results in further expansion and customization of class programming. A sample of Artisan's Asylum's well developed educational program follows:

### **Saturday, September 29**

9:00am	Crash Course: Programming-CEMI Electronic Media Institute
12:00pm	Basic Machine Tools Training
12:00pm	Metal Lathe Testing
2:00pm	Manual Milling Machine Testing
3:00pm	What the Fluff? Festival!
3:00pm	Basic Metalworking Machine Tools
4:00pm	CNC Mill Testing
7:00pm	CEMI Weekly Jam

### **Sunday, September 30**

12:00pm	Public Robotics Lab Office Hours
1:00pm	Organic Modeling in Blender
2:00pm	Oxy-Acetylene Tool Training
2:30pm	CNC Mill Tool Training
4:00pm	3D Printer Tool Training

### **Monday, October 1**

7:00pm	Bicycle Maintenance II
7:00pm	Lathe: Intro to Woodturning

Artisan's Asylum and Industry Lab are the first growth-stage makerspaces to emerge in Massachusetts. Remarkably, each have achieved this evolutionary progress in less than three years. And, Artisan's Asylum actually has one foot into the Mature Stage already by addressing when to grow, having companies spin off, and having a partial leadership succession underway.



## Growth Stage

### Industry Lab, Cambridge

This makerspace brands itself as being on the cusp between technology and art. Industry Lab has a small, but well-equipped, shared workshop and two conference/classrooms, as well as a mix of open coworking stations, dedicated workspaces, and lock and key space. The impetus for the group was a landlord's offer in 2009 to discount his tenant's rent if it attracted similar small hardware startups to his building. The tenant was Leaf Labs, the company of MIT graduate A.J. Meyer, who took up the charge and formed Industry Lab. In order to expand, Industry Lab moved within Cambridge from Central Square toward East Cambridge in 2010. Its Growth Stage classification comes from its occupants prototyping new products, even as they commercialize other products. One such company, 12-person FormLabs, raised \$3 million last September on the crowdfunder website Kickstarter, a record raise for technology, to produce a cost effective, high resolution 3D-printer. Industry Lab recently doubled in size to 10,000 SF, and is considering further expansion to 13,600 SF once it fills eight remaining open seats from its last expansion. This would increase the occupancy from 45 to more than 60 heads. Growth has necessitated official incorporation and raised insurance costs.



## Growth Stage

Industry Lab seeks to improve its visibility and grow its collaborative consulting capacity into a steady stream of projects going forward. Industry Lab's cross pollination between companies has already been fruitful. For example, 12-person FormLabs, used LeafLabs hardware and libraries as a basis for producing a high resolution 3D printer that raised a technology record \$3 million on the crowdfunder website Kickstarter last September. Another relationship, between LeafLabs and Kendall Research Systems, has led to several collaborative projects, as well as a client referral that produced a six figure contract and a potential upcoming SBIR grant. Plus Fabrication and Common Sensing turned their mutual support and networking into a business arrangement in March, that has accelerated Common Sensing into its first round of \$1 million in seed funding which is nearing its close. In each case Industry Labs has been credited with sparking innovation through the proximity, collegiality, and awareness it enables between its occupants. Industry Labs' founders seek to ramp this collaborative commercial potential up, and to do so seek assistance with marketing, public relations and business development services.



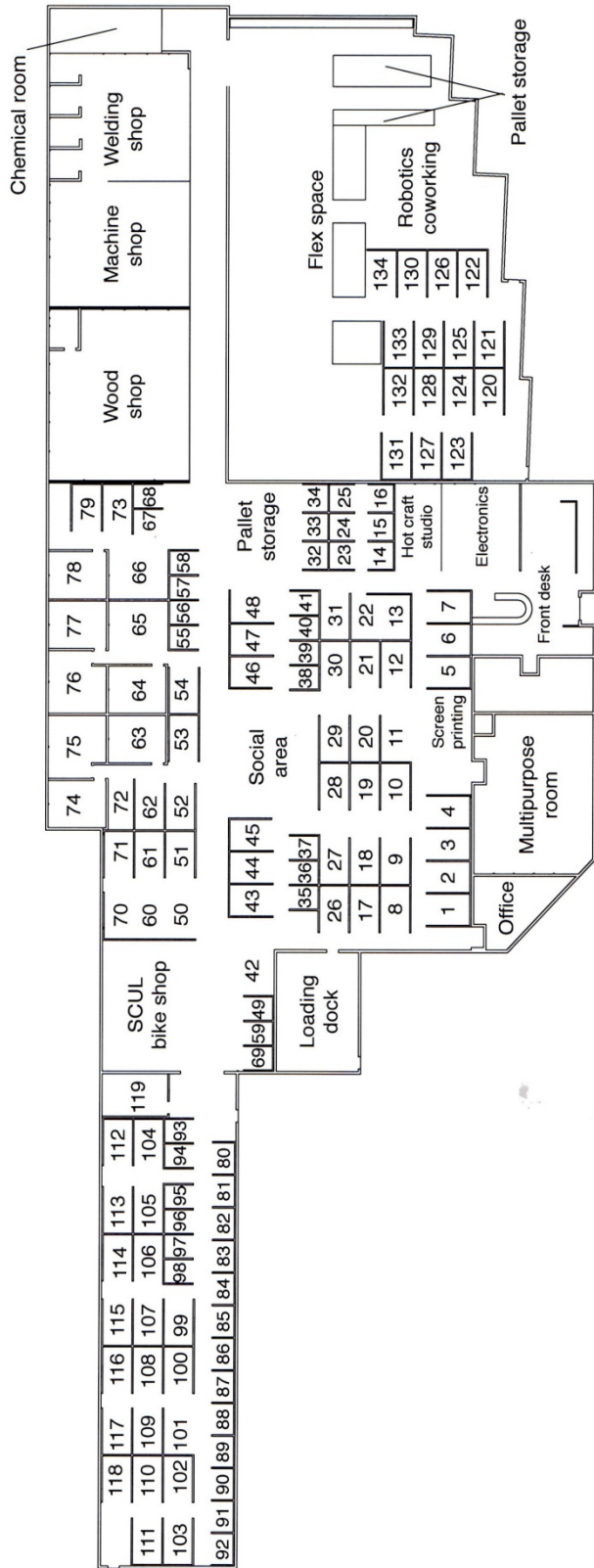
## Growth Stage

### Artisan's Asylum, Somerville

Artisan's Asylum began in 2010 in 1,000 SF of space after a year of meetings in Olin College alumnus Gui Cavalcanti's living room. Within four months and \$40,000 in seed capital the space and membership grew to 10,000 SF and 450 participants. As of early 2013, it has stabilized at 260 members using 31,000 SF of workspace, including 20% workshop space (image below) and 80% cube space (142 fully rented). This ratio contrasts sharply with Tech Shop makerspaces, which are designed to be 80% workshop space and 20% coworking cubes. Artisan's provision for dedicated space for storage and ongoing project assembly, for a price, lends itself to more professionals than hobbyists. It also has an additional 9,000 SF of special project space for a super-large scale robotics project called 'Stompie' the hexapod (floor plan follows). Artisan's maintains a waitlist of more than 250 people for cube rental and/or general membership, with members moving or commuting from as far as Brooklyn to participate in the community. This maker community has become the trendsetter for makers in Massachusetts for both the strength and loyalty of its community, even as it rapidly expands.



# Artisan's Asylum





## Growth Stage

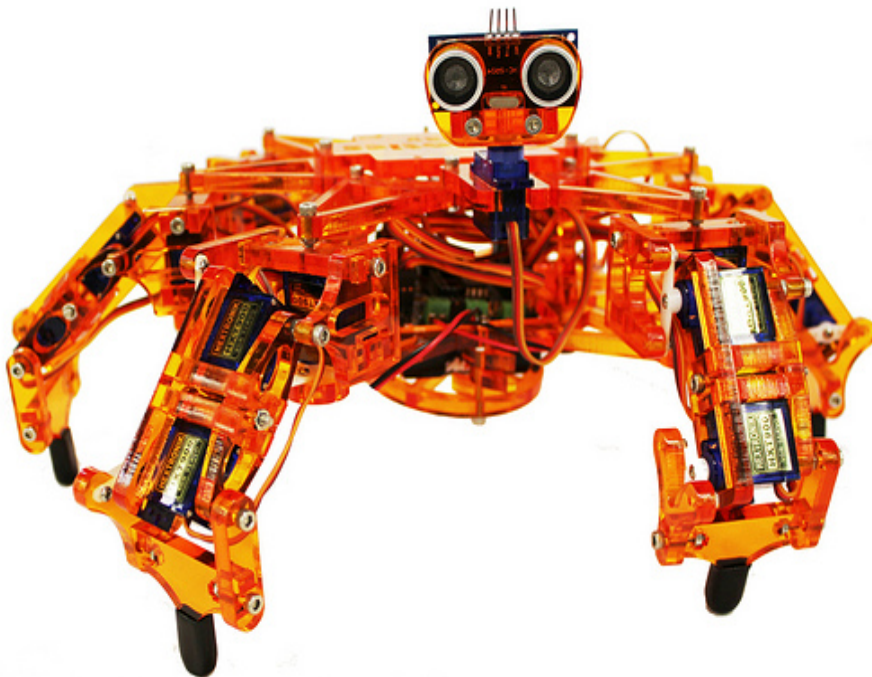
Artisan's Asylum's educational programming has strengthened the community's interdisciplinary skills, stimulated creativity, and improved its income. Its joint projects and competition entries have created a strong innovation bond in the community. And Artisan's Asylum's scale has benefited its members by enabling it to support salaried managers for the shop and for administration, as well as compensation for trainers. Efforts are currently focused on recruiting larger sponsors to help sustain the organization such as Mathworks, Solidworks, and the William and Karen Tell Foundation. Potential opportunities for growth continue to present themselves in the form of landlord-initiated offers of space to lease, strategic alliances with other groups, buildout of additional coworking cubes, and the introduction of an incubator area or accelerator program.



## Growth Stage

Members of the Artisan's Asylum community have begun to generate profitable businesses, such as ArcBotics, Wobbleworks, and Rascal Micro, which are sparking the community's spirit of innovation. Their momentum is precipitating discussion about how to support business development after the prototyping stage. Both of these trends indicate that Artisan's Asylum is rapidly moving into the Mature Stage.

Recent Worcester Polytechnic Institute grad Joe Schlessinger created ArcBotics, which developed "Hexie" (image below), a small, relatively inexpensive (\$250), human responsive, open source robot that raised \$168,000 in Kickstarter preorders in 2012. Schlessinger is a serial entrepreneur, having launched two major commercial ventures since graduating from college in 2010. In addition, Schlessinger previously founded a makerspace called Make-It Labs in Lowell that has since moved to Nashua, NH, but decided he preferred to devote himself entirely to inventing rather than makerspace organizing. To further his work in robotics, he moved to Somerville to incubate at Artisan's Asylum. ArcBotics then progressed into its own space adjacent to Artisan's Asylum and now has moved to Industry Lab, but Joe Schlessinger nonetheless maintains a membership at Artisan's Asylum.

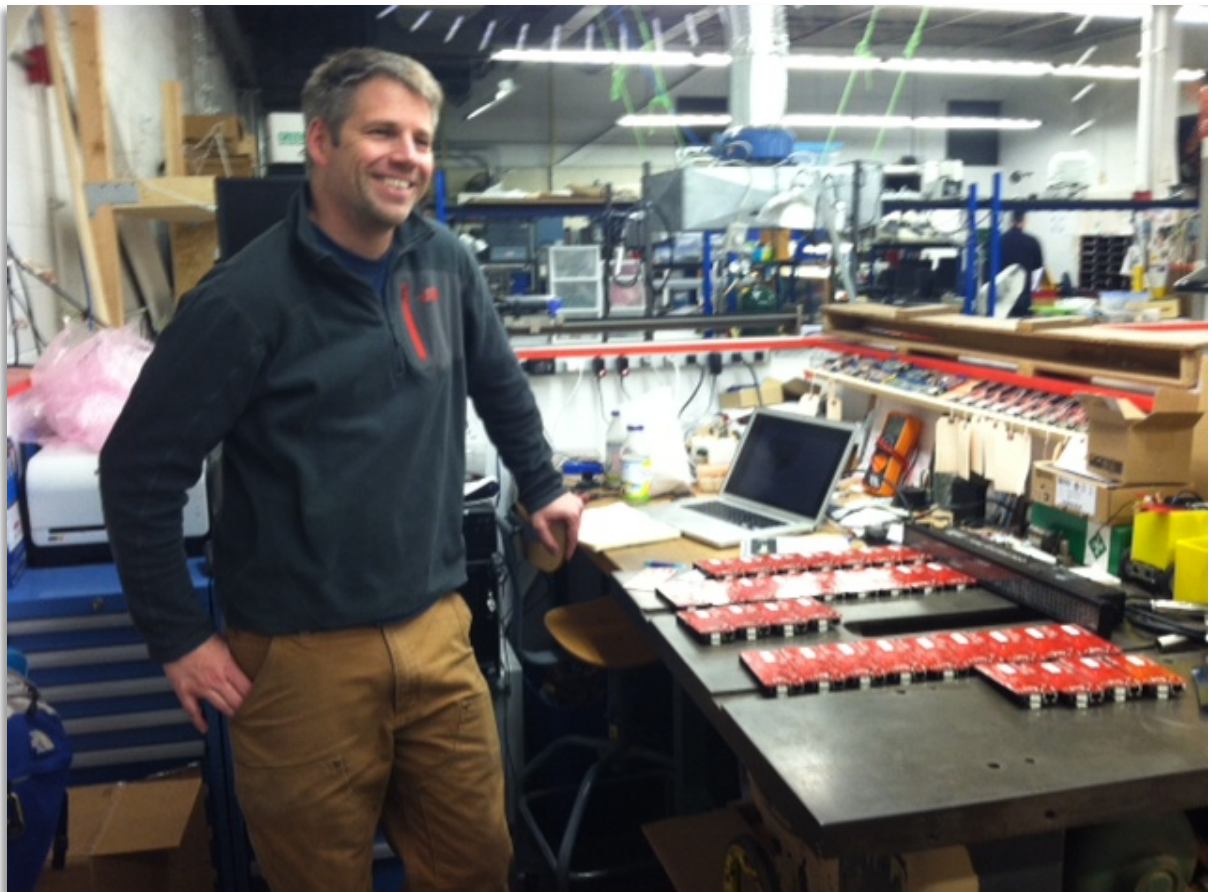




## Growth Stage

Wobbleworks was founded at Artisan's Asylum, where it developed the prototype for the 3Doodler, a 3D printing pen. The 3Doodler raised a remarkable \$2.3 million in March 2013. Fellow Artisan's Asylum members provided prototype testing of the 3Doodler for artwork applications.

Stafford has developed an easily customizable circuit board for connecting and controlling electronics through a USB port. He is the designer, software programmer, and assembler of Rascal composed of parts manufactured in Colorado and China. He has a backlog of orders for his one-man operation, is achieving a breakeven pace of 300 units annually, but foresees a market for as many as 1000 units per year, given a modest marketing effort. Progressing from do-it-yourself assembly to increased productivity processes is the next hurdle for businesses like Rascal Micro.



## Growth Stage

### Artisan's Asylum, Somerville

### Membership and Cube Pricing

Membership	Cost per Month	Weekday	Weekend	Rentals Permitted
Weekend Warrior	\$60	None	10 am - 10 pm	Shelf Storage only
Weekday	\$100	9 am - 7 pm	None	Shelf & Pallet Storage, 50 sf studio, shared 100 sf studio
Nights/Weekends	\$100	6 pm - 11 pm	10 am - 10 pm	Shelf & Pallet Storage, 50 sf studio, shared 100 sf studio
Unlimited	\$150	Unlimited	Unlimited	Unlimited
Institutional	\$200	Unlimited	Unlimited	Unlimited

Cube Type	Cost per Month	Membership Required	Dimensions	Move-in Terms	Utilities Included
Workspace-50 sf	\$100	Daytime, Nights/Weekends, General, or Institutional	6' x 8.5'	1st and last months	Shared electrical, wireless internet
Workspace-100 sf	\$150	Daytime, Nights/Weekends, General, or Institutional	12' x 8.5'	1st and last months	Shared electrical, wireless internet
Workspace-200 sf	\$300	General or Institutional	12' x 16.5'	1st and last months	Shared electrical, wireless internet

## Mature Stage

Makerspaces enter the mature stage when they begin to address when and how to grow, to spin off companies, and to determine leadership succession. In addition to refining the quality of the makerspace experience and optimizing and stabilizing its size, groups may consider whether to replicate in another location or locations. Mature makerspaces may consider how to network with other existing groups to better advantage. The motivation comes from both a desire to stimulate and empower the individual maker to a higher level as well as to be a part of something bigger.

While few maker groups have multiple sites, Massachusetts lays claim to likely the best international example: the Fab Labs. Founded by Neil Gershenfeld in 2002 with funding from the National Science Foundation at MIT's Center for Bits and Atoms, Massachusetts locations of the Fab Labs include the South End Technology Center (SETC) and the Mobile Fab Lab currently located in Roxbury at the Madison Park Technical High School. Outside of Massachusetts, TechShop is the best known example of a multiple site maker organization. Both rely heavily on foundation grants and/or corporate sponsorship. With its higher level of self-funding, Artisan's Asylum is emerging as a counterexample to the trend.

## Mature Stage

### Fab Lab, South End Technology Center (SETC) and Mobile Lab, Roxbury

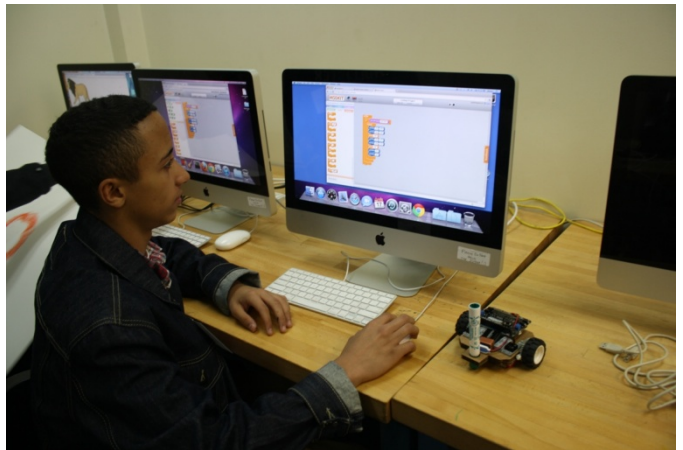
Fabrication Laboratories, or Fab Labs, are basically kits for creating a makerspace for open source digital fabrication, including prescribed equipment, processes, and networking with the international group of Fab Labs. These groups are as unique as the communities that create and house them, but the equipment and program are wholly standardized. The vitality and usefulness of these first makerspaces have varied over the course of their first decade in spite of the heavy National Science Foundation funding of equipment and facilities that Fab Labs received. The ability to thrive consistently depends on leading makers being present onsite and on active programming to attract and inspire community.

Massachusetts currently houses two Fab Labs, the Fab Lab at South End Technology Center founded by Dr. Mel King and the Mobile Fab Lab (image below) temporarily situated in Roxbury at Madison High Vocational Technical School, currently operated in partnership with the Technology, Innovation and Entrepreneurship Project, Inc. founded by Donalyn Stephenson. The Mobile Fab Lab offers only one class per week and urgently needs funding for programming and materials.

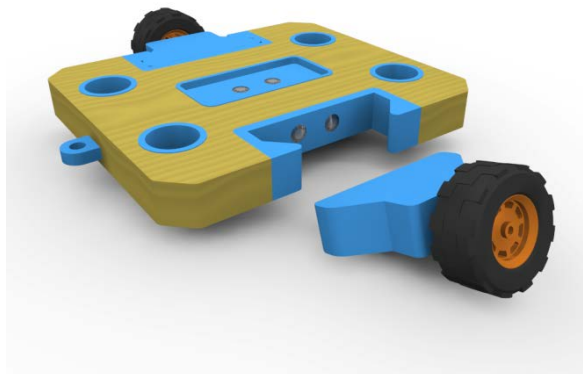


## Mature Stage

South End Technology Center's Fab Lab has succeeded in inspiring urban youth to develop an interest in engineering and skills in teaching through its Learn 2 Teach/Teach 2 Learn model, which consists of young people sharing knowledge as they are learning it. Although SETC's Fab Lab (image below) has had both active and dormant years in the past, the current leaders have increased programming and as a result participation has surged to the point of needing more space than SETC's multipurpose organization currently has available to offer.



SETC has also trained, inspired, and spun-off entrepreneurs like Ed Baafi, whose ModKit electronic components and educational tools (image below) have become viable commercial ventures.





# Economic Development Benefits



The direct and indirect economic development benefits of maker groups range from support jobs at makerspaces themselves, to maker self-employment, to spinoff company jobs, to the attraction of venture and grant capital.

- **Job Creation**

- Bolt is ramping up to eight fulltime staff by June
- Artisan's Asylum
  - ✦ 5 full-time staff
  - ✦ 30 part-time instructors, with an average monthly salary of \$1,000 each
  - ✦ houses 35 manufacturing businesses
  - ✦ trained 400 welders, 300 machinists, 300 woodworkers, and 300 electronics assemblers

- **Capital Attraction**

- BOLT raised a venture fund of \$3.5 million in Spring of 2013
- at Industry Lab, member company FormLab has attracted \$3 million
- multiple groups at Artisan's Asylum have raised Kickstarter capital
  - ✦ \$2.3 million by Wobbleworks for a 3D printing pen, '3Doodler'
  - ✦ \$168,000 by Arcbotics for a cost-competitive, small robot, 'Hexy'
  - ✦ \$97,800 for the collaborative hexapod project, 'Stompie'

- **Grant Potential**

- Defense Advanced Research Projects Agency (DARPA)
  - ✦ MAKE Zine – tool kit, a blueprint for makerspaces
  - ✦ Cyber Fast Track
  - ✦ Small Grants
- Next Generation Manufacturing Center, National Science Foundation
- Foundations
- Workforce Development Funding
- Small Business Innovation Research (SBIR) Grants – SBA coordinates for multiple agencies



# Conclusion



The Maker movement is evolving a fresh approach to innovation in manufacturing, free of the constraints of conventional engineering environments. Barriers of compartmentalized space, time, education, and social fabric are being rapidly dismantled in favor of a leaner, more direct, more efficient, and more merit-based approach to innovating together. Among the Millennial and Gen Y innovators, the idea is king, and departments, hierarchies, and closed doors are arcane. Makerspaces have evolved to provide the ultimate in flexible workspaces and responsiveness to opportunity.

Makerspaces can contribute to closing a critical workforce gap, both directly and indirectly, by promoting engineering. Directly, makerspaces offer training via onsite classes. Indirectly, makerspaces inspire excitement in hardware production, engineering, design, and technology.

How to support the growth potential of the movement without binding up its flexibility remains an open question. Current standards of intellectual property are challenged by open sourcing. As with most start-ups, makerspaces agitate conventional business models, but offer compelling rewards. Industry Lab and Artisan's Asylum have demonstrated that makerspaces can incubate individual businesses; cross-pollenate businesses and design disciplines; and grow at collectively enviable rates even in the recently rocky economic climate.

Notably, these younger innovators and their companies are highly mobile, and are neither rooted in locational allegiances nor bound to the glacial decision-making speed of large corporations. If the grass is greener, innovators will leave. Other states are courting Massachusetts' graduates and entrepreneurs with increasing success. Crain's New York Business reported in 2012 that, "according to Jonathan Bowles, executive director of the Center for an Urban Future, ... New York recently passed Boston as the second largest city for tech startups." New York City has been banking on the Creative Economy by investing in technology start-ups and their communities, and is already seeing positive results. In 2013, a CB Insights report revealed that Massachusetts had fallen to fourth place in technology mergers and acquisitions deals with 87, behind Texas with 91, New York with 138, and California with 455.

Massachusetts has an enviable storehouse of intellectual and creative resources, but the Commonwealth must retain innovators and their creative economy communities, and enhance their chances for growth, or lose them to a place that makes a better case. A menu of recommendations follows.

# Recommendations



<b>Create a Makerspace/Makergroup Directory</b>	List on MassDevelopment or a new MA Makerspace website
<b>Promote Maker Groups</b>	Define on website; continue outreach and networking; host roundtable with founders of makerspaces; connect with artist groups on diversification
<b>Promote Maker Events</b>	Calendar on website
<b>Sponsor a Mini Maker Faire</b>	e.g. MASS MoCA in North Adams, or per Make Zine
<b>Sponsor 'How to Make a Makerspace' Workshop</b>	Artisan's Asylum
<b>Offer consulting advice and services</b>	Zoning and permitting, lease negotiation, organizational structure, bookkeeping, public relations, marketing and business development
<b>Provide Grants or Loans for Code Compliance Capital Improvements</b>	Fund costs that are barriers to growth such as code compliance costs for workshop ventilation; electrical upgrades and flammable materials storage
<b>Continue Involvement and Outreach in the Rapidly Evolving Makerspace Movement</b>	Identify opportunities and needs as they develop
<b>Keep Current with Maker News</b>	Subscribe to Make Zine