BY DALE DOUGHERTY,
founder and CEO of Maker Media.

Makerspaces Are Working Out

"IT'S LIKE A GYM WHERE YOU GET A MEMBERSHIP TO USE THE EQUIPMENT." That was the basic idea for TechShop, as explained to me by founder Jim Newton at our first Maker Faire in April of 2006. He asked me for a table so he could hang his sign, deliver his pitch, and see if people were interested. The fact that he showed up in a vintage military transport vehicle had some bearing on my decision to say yes. The interest proved strong enough for Jim to get backers and open the first TechShop in an industrial park in Menlo Park, California, in October 2006.

Almost from inception, TechShop was a dream — not only Jim's but one shared by its members — to have unlimited access to the tools of a machine shop, plus new tools for digital fabrication such as laser cutters and 3D printers, for a modest monthly fee.

What do people really do at TechShop? There are a group of makers who show up with a pretty clear idea of what they want to do. They have a project to work on. Often it has some practical or commercial application, and they lack a place where they could develop their idea into something real. Others show up and want to belong but don't have a project or purpose. They want to learn how to use the tools, and maybe that will lead them somewhere. David Lang was one of those people, and he wrote about his experience in the book *Zero to Maker*.

Some have tried to implement what TechShop has done. In Shenzhen, China, I came across TechSpace. Others, while similar to TechShop, are different in that they're locally owned and operated, such as Maker Works in Ann Arbor, Michigan.

Gui Cavalcanti, who started a similar shared workspace in 2004, learned some key lessons from its failure and started thinking of a new model. This became Artisan's Asylum in Somerville, Massachusetts, which now occupies a 24,000-square-foot space that was originally an envelope factory. He had a budget of $40,000 to open the space and outfit it. Most of the tools were used, either donated by members or acquired for the cost of removing them from a former worksite. Artisan's Asylum is most successful at building a community among its members, some of whom rent their own workspace. It has become not just a place to do your own work but a kind of "collaborative commons," to use the phrase from Jeremy Rifkin's book, *The Zero Marginal Cost Society*.

There are also quite a number of hackerspaces, which tend to be like clubs, almost always run by volunteers. Some are members-only and others are open to the public for free, like Noisebridge in San Francisco. Some hackerspaces are rather like an eccentric's garage full of scavenged treasure and forever awaiting someone to whip it into shape. A hackerspace is as much a meeting place as a workplace.

Artisan's Asylum represents what I might call a middle tier between large-scale TechShops and small-scale hackerspaces, a trend toward the professionalization of makerspaces. That is, they must be able to perform a core set of services to support membership growth. A makerspace needs to greet new members and provide basic safety training as well as offer workshops for members who arrive without project ideas.

Indeed, a gym is a good analogy to understand makerspaces. Today's health clubs started out years ago as bodybuilding gyms. They were designed to meet the needs of a narrow, largely male membership. They weren't particularly friendly to newcomers or casual users. Yet something changed in our culture around physical fitness, and health clubs became more open and accommodating, to broaden membership by welcoming women as well as men, and the serious as well as the casual member. This is what we're seeing as makerspaces transition from volunteer efforts serving a small group of members.

Neil Gershenfeld designed and built Fab Labs, the first of which was opened in Boston in 2004. Gershenfeld's Center for Bits and Atoms might be considered the R&D lab for digital fabrication, with state-of-the-art tools organized in service of an inevitable vision of our technological future. While there are a variety of settings, from science museums to community colleges, Fab Labs are funded and managed in a top-down fashion that's consistent with their academic origins. Independently, a growing number of makerspaces are getting established at universities, such as Yale, Georgia Tech, Case Western Reserve, and SMU. These spaces are designed for students and their projects.

It doesn't much matter what you call them — TechShops, makerspaces, hackerspaces, or Fab Labs. Makers are doing cool stuff, and having access to tools, community, and mentors really does matter. We need more local places for makers to work out new ideas.

Jeffrey Braverman

7 Cornerstones of Making with Kids

MakerKids shares their recipe for a successful makerspace.

By Jennifer Turliuk and Andy Forest

TORONTO-BASED MAKERKIDS IS ONE OF THE WORLD'S ONLY MAKERSPACES SPECIFICALLY DESIGNED FOR KIDS, and many people have asked us to share our recipe. We think of it as a brunch — there are many ways to make it delicious. Take the pieces of our recipe that work for you and make it your own. We're also available to help with this — we envision a future where there are MakerKids chapters all over the world.

MakerKids

The MakerKids Recipe

1. Dedicated Space: Even if just a cart, having a space that's set up to be inspiring and safe allows kids to feel like they have permission to take ownership and be creative beyond what's normally accepted or expected of them.

2. Real Tools: We have the same real tools that any adult makerspace would have. Kids as young as 3 use drills, saws, and soldering irons. To the frequent question "Can you do this for me? You're better at it than me," our answer is "That's why you should do it! Then you'll get as good as me." We'd rather help them learn to do it safely and become more comfortable, or find another way to achieve their goals. This helps them to develop feelings of competence, responsibility, and leadership.

3. Process Over Product: Value experiential learning. We celebrate the fact that they're making, not just what they make. The point is not to take home some shiny object that they've made. We emphasize that it's okay to fail — it's just an opportunity to learn.

A major part of making is researching how to accomplish goals. Instead of telling kids step-by-step instructions, we encourage them to figure out how to do it themselves, ask other kids, or research it online. We frequently answer the question "How do I do this?" with "Google will tell you!"

4. Interest-Driven: We try to let kids' creative interests define projects as much as possible. If we tell them exactly what to make and how, they quickly lose interest. If they're following their creative interests, they're much more engaged.

Recently, a group of kids were very interested in vehicles, so they designed and built a hovercraft. They learned a lot of skills as they went along: 3D printing (for the lift turbine), motors, Arduino programming, and more. When it failed to get off the ground on the first try, they got right to work reinventing the skirt to reduce weight and optimizing the turbine airflow.

Every activity we do, no matter how short, we incorporate something creative, something open-ended. Let them make it their own!

5. Kids Teaching: We encourage kids to share their knowledge with each other and with their teachers. A low student-to-teacher ratio is valuable in any learning environment, so encourage everyone to be teachers. Kids teaching also gain so much self-confidence. When a new kid asks how to hook up an LED and another kid says, "I can show you that," everyone is growing.

As the kids grow as makers and teachers, we encourage them to volunteer as helpers in classes. The next step is for them to lead classes themselves.

Sometimes kids know more than we do, especially on topics they're passionate about. In our *Minecraft* classes, the kids are the experts and we learn from them all the time. We make sure to listen and let them teach us, too.

6. Exhibition: Each program has a presentation to the parents, which kids get really excited about. It helps them to organize their thoughts, knowing that at the end of their project, they'll have to explain it to someone else. Having a deadline also helps them focus and move forward.

7. Community: We connect to the Toronto community and the global maker community through events like Maker Faire, local community festivals, school fun fairs, participation in online discussions, and interfacing with folks from other maker companies. We work with many other kids' organizations — for example, we've worked with kids in a music program to build props for their performance. Find out what the makers in your community are passionate about and connect with them.

So that's the summary of our recipe — the mix that makes our youth makerspace work. We want to know how we can help you to do making with kids in your community. We're developing curriculum modules for summer camps, after-school programs, schools, and more. Our board of advisors includes the CEOs of Maker Media and Arduino, and we've developed curriculum modules for clients and sponsors such as Intel and 3D Systems. Email us at info@makerkids.ca.

JENNIFER TURLIUK and **ANDY FOREST** are co-executive directors of MakerKids (makerkids.ca).

Audacious by Design

PROJECT H GIVES KIDS TOOLS, SKILLS, AND CONFIDENCE.

Interview by Stett Holbrook
Photographed by Jeffrey Braverman

STETT HOLBROOK is editor of the *Bohemian*, an alternative weekly in Santa Rosa, California. He is a former senior editor at Maker Media.

BERKELEY, CALIFORNIA'S PROJECT H OFFERS A WINDOW INTO THE FUTURE OF K-12 EDUCATION. And if it's not the future, it should be. Just don't call it a shop class.

Architect Emily Pilloton founded Project H out of a desire to do something more meaningful with her skills. That desire grew into a mission to offer kids the opportunity to explore what they can do with both their minds and their hands. Project H aims to use "the power of creativity, design, and hands-on building to amplify the raw brilliance of youth, transform communities, and improve K-12 public education from within."

In a unique partnership with Berkeley's progressive REALM charter school, Project H offers a design and build curriculum called Studio H for middle and high school students. While students learn to use radial saws, laser cutters, and welding torches, Pilloton hopes the confidence and self-knowledge they develop become a transformative force in their lives and communities. She also spearheaded a build camp for girls called Camp H.

We spoke to Pilloton about Project H ("Humanity, Happiness, Health, and Habitats,") and her work.

> *"NO GIRL SHOULD HAVE TO FEEL LIKE THEY HAVE TO DUMB THEMSELVES DOWN OR HIDE THEIR BRILLIANCE."*

What is Project H?

Project H is a nonprofit design organization that I started in 2008. It was founded on the loose idea that design can make people's lives better and, more specifically, it can be audacious. It can be focused on social issues and it can excite young people in a way — inside and outside of school — that is meaningful to them, is meaningful to their communities, and that helps them bring ideas to life in ways that they maybe didn't think were possible.

The documentary *If You Build It* highlights Project H's experience in North Carolina. Can you summarize your experience there?

In 2009 we got cold emailed from a school superintendent in Greenville, N.C.: Dr. Chip Zullinger. He had seen a project we did called the Learning Landscape, which is an educational playground system. There are about 40 of them built around the world. They're made from reclaimed tires, and you can play academic games within this playground, so it's an outdoor playground, a classroom, and a dynamic space for elementary and middle school education.

Dr. Zullinger had seen that project published in a design publication and invited us to come down and basically bring design as a resource to his school district, which was broken. It was one of the poorest performing in the state, and he was on this mission to change it and to use resources that the district hadn't traditionally been looking at, like design, to infuse a new kind of change and excitement for the kids and the teachers.

So we went down there, built four of these playgrounds in four days, and then discovered that Dr. Zullinger was this amazing renegade of an educational leader and had a whole list of other projects for us. To make a long story very short, we discovered a real love for Bertie County and for working with Dr. Zullinger. At a certain point, we just felt like we had to put design in the classroom and that the only real way to influence a school district using design is for it to be part of the academic experience of the students.

How did the partnership with REALM Charter School come about?

As we were realizing our tenure in Bertie County was not going to be as long lasting as we thought it might, for a whole host of reasons, I had been in conversation with Victor Diaz, founder and executive director of REALM [Revolutionary Education and Learning Movement] charter school. REALM's charter is written around project-based learning and creativity and design, so he had reached out to me, after having heard about Project H through a mutual friend.

We knew that REALM was a place not only where our ideas would be rallied around, but that it would also be a place for us to grow, thrive, and try new things and experiment and push the boundaries of what Project H could be.

We're in our second year at REALM, and we have 216 students in 8th, 9th, 10th, and 11th grade. We're building the school library. We built a classroom out of shipping containers last year. We're deploying geodesic domes around the city — just all kinds of crazy stuff. And I also started an after-school and over-the-summer girl's camp called Camp H for 4th, 5th, 6th, and 7th graders.

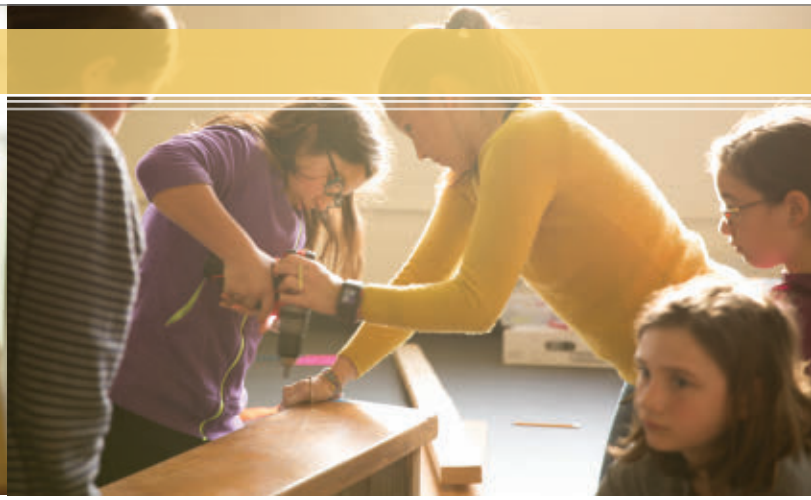
It's just an amazing school community to be a part of, where we can really push on our own practice, and see how much of this really works in the tight constraints of an urban public charter school with a very unique school population.

We're in Berkeley, but most of our kids come from Richmond and Oakland, and a lot of them are English language learners. There's a high percentage of special education students, so we really see it as an amazing opportunity to offer something different to kids looking for or needing something different from their school.

What personal experiences helped shape the creation of Project H?

Project H grew out of my own dissatisfaction with the status quo and just being really sick of doing work that wasn't meaningful to me and that didn't seem to be meaningful to anyone else. In the greater sense, the usual client-designer relationship is often based on luxury, money, privilege, and not that that's a bad thing necessarily, but for me the thing that got me excited about design as a kid — and more specifically about architecture — was the problem-solving, the kind of MacGyver-style eagerness of solving a problem in the moment under tight constraints. I love being constrained — having $10, one hand tied behind my back, and being blindfolded, having nothing and making something beautiful out of that.

I grew up in an extremely affluent, mostly white neigh-



borhood, and as a woman of color, I experienced my childhood with the lens of not belonging and having to really forge my own way to make meaning. The way I did that was often through very physical and tactile means, through building, exploring in the forest, and competitive sports.

Project H was kind of just an extension of feeling dissatisfied in my own career, knowing there was a different way to do it, not knowing how to do it, but thinking that if I set up a nonprofit and have to answer to the IRS and the Secretary of the State in California, then I'm going to figure it out and I have to.

How is it funded?

Project H is funded through a revolving and always evolving jigsaw puzzle of private foundation grants, the National Endowment for the Arts, and some public funding, as well as corporate sponsorships, in-kind donations of tools, materials, and equipment, and a broad base of either crowdfunded or small-scale donations that are more project-based.

How is Project H different from a traditional shop class?

Vocational education was born out of the trades, out of needing to train the next generation of workers for specific skill sets — masons, welders, etc. — and unfortunately in a lot of communities (we saw this in Bertie County), vocational education was a track intended mostly for kids who were not college-bound. And in a place like Bertie County, that often meant the black kids, so vocational ed became this weird fulcrum that really divided a lot of kids into the high-performing kids (often the white kids), the affluent kids that were going on to college, and then the rest of them. And as a class, vocational education has been based mostly on skills rather than critical thinking about why we're using those skills in the first place.

The tag line for Studio H is "design, build, transform." So while vocational education has traditionally only been focused on the build portion — like how we train the next generation of brick masons — we really believe that no kid should build anything that they have not designed themselves, and no kid should build anything that doesn't have some kind of meaning for a community beyond themselves.

In other words, I'm never going to hand a kid a set of drawings and say go build this birdhouse. I say birdhouse because we have built birdhouses in my girl's camp, but every girl designs their own birdhouse with a very specific bird in mind, and it's intended to be placed in a specific ecosystem for the benefit of a local community garden.

There's a way to still teach those skills, but to infuse meaning for the person building it, and then also for the community in which it exists. I think that shop classes in the future, Studio H included, are going to be less about trades and less about skill building and more about meaning, personal voice, and the community — what we're building, why, for whom, and why it's an extension of our own ideas. That's the difference.

> *"VOCATIONAL EDUCATION HAS BEEN BASED MOSTLY ON SKILLS RATHER THAN CRITICAL THINKING ABOUT WHY WE'RE USING THOSE SKILLS IN THE FIRST PLACE."*

The other thing I would say is that most people think of shop classes as really low-tech, like here's a chisel and a saw. We have all those things, and our students know how to use the most basic old school hand planes, but we also have a laser cutter. We use CNC technology, and there's really no difference. I don't think one is more important than the other.

We did these laser-etched skateboards that had to be pressed in a 20,000-pound bottle jack press that we welded out of steel. And we had to use a band saw and a table saw and a router to cut them, and then we laser-etched them, and every single step of that, the low tech and the high tech were just as important.

What do you say to parents who wonder why their kids are learning "blue collar" skills?

I ask them, "Well, are they really?" Because they just went to Carl Bass' shop, the CEO of Autodesk, and saw a crazy CNC router that

> *"THERE'S A WAY TO STILL TEACH THOSE SKILLS, BUT TO INFUSE MEANING FOR THE PERSON BUILDING IT."*

exists nowhere else in the country. I don't see them as blue-collar skills necessarily. I think what we are teaching kids is the broadest array of skills they could possibly imagine, so that when they wake up one morning and they say "I want to build a skyscraper that goes from here to the moon," they feel like, "OK, I've got 50 tools that I know how to use to at least see if that's possible." I don't think they are blue-collar skills so much as the agency to pull from a wide variety of tools to make anything possible.

How does Project H engage girls in traditional male-oriented activities?

Camp H, which is the after-school and summer girls' program, is really my baby. It's the thing for me that feels really personal, really special, and really intimate because I remember being a 10-year-old misfit girl and being really good at math and being really good at a lot of things and still feeling like I didn't belong and that it wasn't cool to know how to do stuff. No girl should have to feel like they have to dumb themselves down or hide their brilliance, and nothing against boys, but it's kind of ballsy for a 10-year-old girl to leave our camp saying, "I just learned how to weld" and there are boys around going "What? How come we didn't get to do that?" I love that.

I think pulling girls out of the coed class into a girl's-only space, they just have a totally different way that they approach making when there's no social tension around it, there's no "oh it looks like the boys go first" — they all pick up a welder and weld you under a table. They become much more confident and then they carry that confidence back into everything else.

So I have also been really intentional about doing things that are not in any way girlie. We will not be making jewelry boxes. I am not going to paint a drill pink. I am not going to give them the girl version of the toolbox. They weld with the same Lincoln Electric welder that our high school students use. I want them to feel like they are equals.

What do you hope kids get out of Project H?

I really want every kid to leave Project H thinking "I can't believe that was even possible and I really can't believe that we pulled it off" because that sense of agency and that sense of power, and the sense of confidence that going through your life anything is not only possible but totally achievable, that's what these kids need at this age.

I see it in my camp girls after they weld. These are 9-year-old girls who weld and fuse metal and they leave feeling like "I just fused metal — don't you dare tell me there's something I can't do." I love that. I love giving kids a little bit of a chip on their shoulder, but in a positive way.

✚ Check out Project H at projecthdesign.org.

PROJECT H SHARES LESSON PLANS AND ACTIVITIES ON THEIR SITE

They write, "By open-sourcing our own learning, our failures, our adaptations, and our content, we hope to create a more transparent and boundary-pushing community of educators and creatives."Here are a few examples. See them all at ***PROJECTHDESIGN.ORG/TOOLBOX***.

ROCK CLIMBING HAND HOLDS

Use the architecture of the human hand to make wall-mountable hand holds using a traditional sculpting, molding, and casting process.

RIGHT ANGLE BIRDHOUSES

Learn all the basic woodshop tools by building a unique, 90°-based wooden birdhouse.

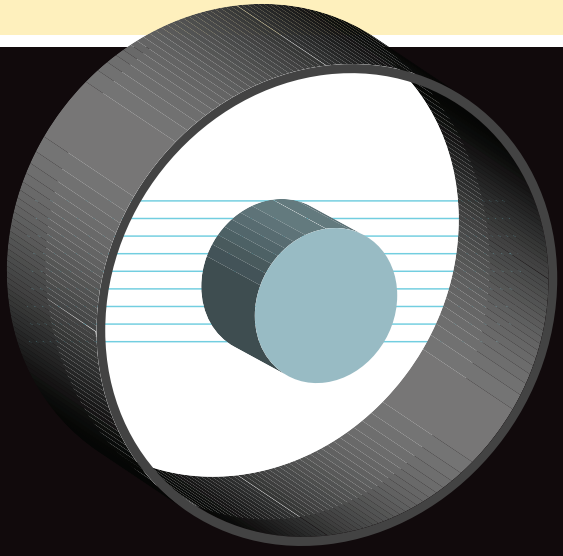
CONSTRUCTED SIGNAGE

Develop the capacity for seeing potential, develop and practice collaboration, and foster ownership through action.

GEEK CLUB

Illustrated by Jing Zhang

BIG TOOLS, HUGE BUILDS, SAVVY SUPPORT — MAKERSPACES HELP YOU LEVEL UP.



FROM TECHSHOPS TO FAB LABS, MAKERSPACES ARE POPPING UP AROUND THE COUNTRY AND THE WORLD, helping makers gain experience, develop support networks, and build bigger and better than ever before. Volunteer-run or professional, membership- or employee-based, non- or for-profit, they're offering tools, education, and space to makers who don't have a home shop or who want to go beyond it.

Part recreational shop, part product incubator, part R&D lab, part community center, they cater to — and help define — a growing, decentralized hub of the maker world. These are places where makers are safe, welcome, comfortable, and free to pursue their goals, where innovation and creativity is fostered, learning is encouraged, and community trumps just about everything.

In these pages you'll see some makerspaces up close, as well as look at what they can do and how they're growing. You'll see some of their tools and their builds, and maybe you'll be inspired to check one out in your area. Welcome to the Geek Club.

THE MOST INTERESTING MAKERSPACES IN AMERICA

WORKSHOPS COAST TO COAST ARE HELPING BUILDERS CONSTRUCT INCREDIBLE PROJECTS, BUT THE SPACES — AND THEIR MEMBERS — ARE OFTEN THE MOST NOTABLE CREATION.

WHAT MAKES A MAKERSPACE INTERESTING? It's not just the size of the shop or the number of active members. Nor is it the selection of tools or having an advanced RFID inventory system. Sure, those pieces count, but it's how a makerspace slots into its community —elevating and inspiring the makers — that makes it stand out.

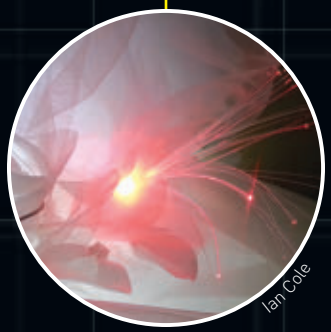
We've compiled 34 shops across the country that keep our attention, from those that have revived historic industrial sites to libraries that offer access to the latest tool technologies. There are hundreds more around the country; to find one or details on how to start a makerspace near you, please visit makerspace.com and get connected.


Trammell Hudson

NYC RESISTOR

Brooklyn, New York

NYC Resistor claims some big-time founders, including Bre Pettis, but its chops also derive from a wonderful junk pile that members mine for odd parts. Home of the original MakerBot prototypes.


Ian Cole

FAMILAB

Longwood, Florida

Near Orlando, Florida, 4,000-square-foot FamiLAB regularly gets global guests, who exchage ideas and inspiration. They also produce the Orlando Maker Faire and offer a slew of maker tools


Greg Richardson

7 HILLS

Rome, Georgia

Located in an old Masonic Lodge, 7 Hills is possibly the most beautiful makerspace to lounge or work, with murals featured on the walls and ceiling.


Chad Elish

HACKPITTSBURGH

Pittsburgh, Philadelphia

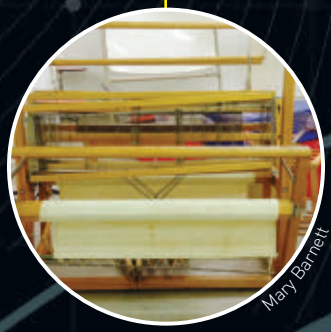
Members here are inventors, artists, scientists, engineers, and more, who meet in a garage uptown.


Keith Simmons

ARTISAN'S ASYLUM

Somerville, Massachusetts

Artisan's Asylum is one of the largest makerspaces in the country. Housed in the old Ames Safety Envelope facility, this village of 120 makers' studios under one roof comes with fabrication tools galore and offers classes for new makers on everything from bike building to lampworking. Don't miss Stompy, their Kickstarted giant hexapod robot (see page 49).


Mary Barnett

FOURTH FLOOR

CHATTANOOGA PUBLIC LIBRARY

Chattanooga, Tennessee

It's literally the 4th floor of the Chattanooga Public Library, where the focus isn't on consuming knowledge but creating it, using high- and low-tech tools, and the space is open to anyone with a library card.


Nova Labs

NOVA LABS, INC

Reston, Virginia

This space features giant lasers, a beautiful woodshop, and a 1940s jukebox which streams Pandora.


Yale Center for Engineering Innovation & Design

YALE CENTER FOR ENGINEERING INNOVATION AND DESIGN

New Haven, Connecticut

Engineers Without Borders, HackYale, and iGEM — the International Genetically Engineered Machine Foundation — are just a few of the student groups that use this campus space.


Ellen Jorgensen

GENSPACE

Brooklyn, New York

Genspace is a biolab, offering biotechnology education to adults and children, as well as opportunities for innovation and entrepreneurship.


R. Kelley Marchal of Merlin Productions.

THE COLUMBUS IDEA FOUNDRY

Columbus, Ohio

This massive makerspace — around 75,000 square feet, including a new rooftop addition — is thoroughly integrated in its community, partnering with the nonprofit Community Development Corporation, the Center of Science and Industry, and the 400 West Rich arts facility. All occur within two blocks of each other in a re-emerging neighborhood, and the Foundry is already showing its influence; a handheld scanner company that got its start there has leased space in the neighborhood as well.

Kelly Murphy

THE HACK FACTORY

Minneapolis, Minnesota

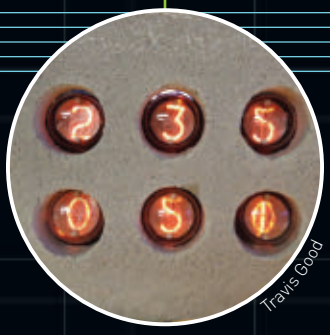
Minnesota's largest member-owned, multiple-discipline shop features a cabinetry-quality wood shop, a welding studio, and a machine shop, but it's most famous for its life-size game of Operation.


Tim Bruening

LORAIN COUNTY COMMUNITY COLLEGE

Elyria, Ohio

See the shop that President Obama visited and the CNC-milled sign that welcomed him.


Travis Good

ARCH REACTOR

St. Louis, Missouri

Electronics-heavy shop with an incredible roof-deck bar and view of the arch.


Omaha Maker Group

OMAHA MAKER GROUP

Omaha, Nebraska

Affectionately known as OMG, this space grew from a bakery basement ("The Makery") into a 40-member shop that will help host Omaha's first Mini Maker Faire.


Daniel Simser

BOZEMAN MAKERSPACE

Bozeman, Montana

A small but growing space in a building that used to house livestock auctions.

Benjamin Groves

DALLAS MAKERSPACE

Dallas, Texas

This community workshop also focuses on science lab work and art, and especially collaborative projects.


Jeff Cicolani

ATX HACKERSPACE CO-OP

Austin, Texas

ATX was the first hackerspace in Austin and, with 8,000 square feet and 180 members, is one of the largest in Texas. With full metal and wood shops, it houses electric car conversions, a 60-watt Universal laser cutter, and acts as a practice space for Arc Attack, the Tesla-coil band. Recent projects include "Alfred" the tool-retrieval robot and a colossal projection-mapped hexahedron sculpture.


Rodolfo Parisi - www.rivius.net

LAWRENCE CREATES

Lawrence, Kansas

Among other projects, this makerspace is home to a group of neuropsychology enthusiasts who are working on consciousness visualizations.


Eric Ose

HEATSYNC LABS

Mesa, Arizona

Home of Joey "Marshmallow Canon" Hudy and your typical scanning electron microscope hack; it's free and open to the public, sustained by community donations.


Pete Prodoehl

MILWAUKEE MAKERSPACE

Milwaukee, Wisconsin

Milwaukee Makerspace offers detailed online tutorials for much of its equipment; they also house an active electric vehicle club.


David Lewinski

I3 DETROIT

Detroit, Michigan

Their extensive list of tools and equipment makes this one of the most established and well-known spaces around.


CPL Staff

TECHCENTRAL

Cleveland, Ohio

The Cleveland Public Library moved its DVD library to make room for 3D printers, a laser cutter, kits, and collaboration space.


Mike Warot

PUMPING STATION: ONE

Chicago, Illinois

Beer brewing is one of the staples here, alongside fabrication and wood and metal working.


LVL1 Hackerspace

LVL1 HACKERSPACE

Louisville, Kentucky

Democratic roots run strong through the 8,000-square-foot LVL1, which started a "makerships" program for makers who can't afford memberships.


Quelab

QUELAB

Albuquerque, New Mexico

Famous for their interactive starship bridge, a four-headed 3D printer designed there, and the 80-watt laser cutter/engraver in their 6,800-foot space.


Beatrice Murch

THE CRUCIBLE
Oakland, California
A vast, well-equipped space for learning fine and industrial arts, from blacksmithing to glass blowing to jewelry to stone work.


Shears Adkins Rockmore Architects

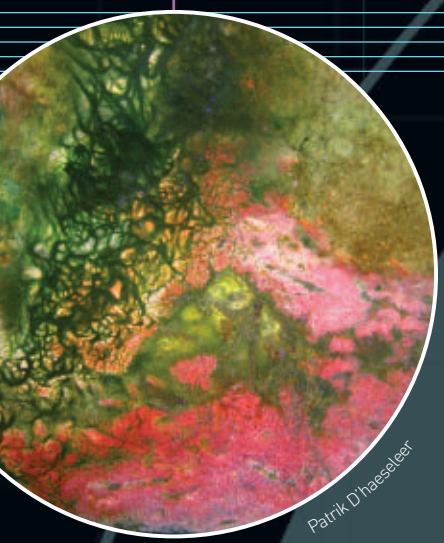
ADX
Portland, Oregon
ADX is one of a growing number of makerspaces that'll do the making for you; their Custom Design & Fabrication team helps design and build projects for clients. Of course, you can still build stuff yourself.


DeLaMare Library

DELAMARE LIBRARY, UNIV. OF NEVADA, RENO
Reno, Nevada
Lockpicking kits, 3D scanning and printing, and Arduino prototyping are available to all in UN-Reno's science and engineering library.


Mitch Altman

NOISEBRIDGE
San Francisco, California
A diverse space founded in 2007 that hosts a monthly series of lightning talks, called "Five Minutes of Fame," where members give lectures on a wide variety of topics.


Patrik D'haeseleer

BIOCURIOUS
Sunnyvale, California
Originally a cooperative lab in a Silicon Valley garage, BioCurious grew into a member-based makerspace for biologists, complete with wet lab and biosafety certification. Instead of laser cutters and 3D printers, BioCurious offers centrifuges and polymerase chain reaction machines. The nonprofit is one of a growing class of biohacking spaces that are making real science experiments possible, offering classes and workshops as well as encouraging community projects, where members and nonmembers work together on research and experiments.


Amelia Greenhall

DOUBLE UNION
San Francisco, California
A makerspace for women, in a comfortable, welcoming, and high-tech environment.


Gene Sherman

VOCADEMY
Riverside, California
All the right stuff, plus a commitment to bring industrial arts education back to schools.


Ace Monster Toys

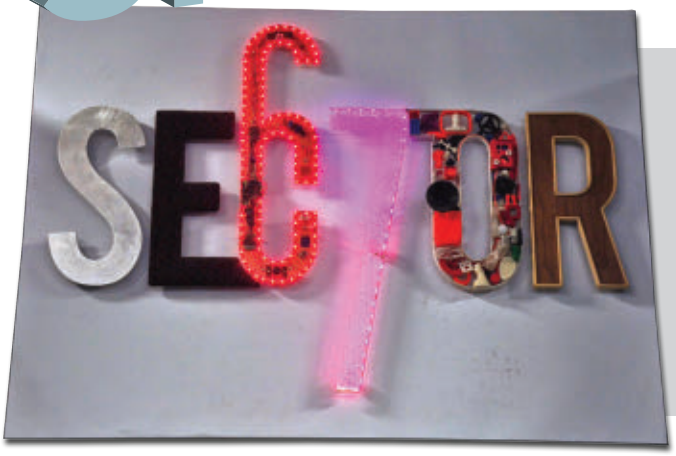
ACE MONSTER TOYS
Oakland, California
A giant laser, tools galore, and lots of LED signs are tucked away in this warehouse, which includes programs for kids.


David Schellema

AUTODESK PIER 9
San Francisco, California
Pier 9 belongs to Autodesk, and the company spared no expense building the ultimate makerspace. It has every tool a maker could want, but it's open only to Autodesk employees and artists in residence.

SNAPSHOT

A PEEK INSIDE SECTOR67, MADISON, WI

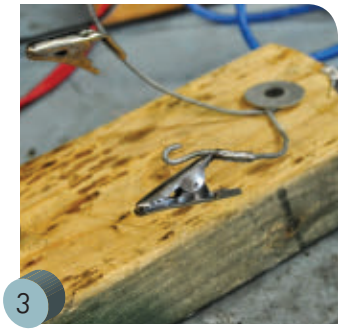


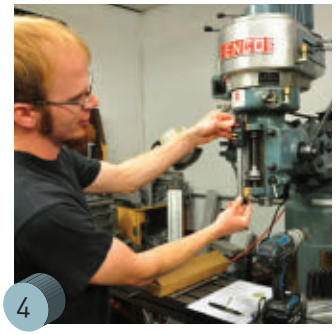
HOME OF THE THREE-TIME POWER RACING SERIES CHAMPIONS, SECTOR67 is a well-organized hackerspace near the state capitol in Madison, Wisconsin. The nonprofit was bootstrapped by Chris Meyer, the sole founder and benevolent dictator who launched it after taking a $7,000 second prize in a business plan competition. That's not a lot of money for tools, so Meyer and Sector67's members began rebuilding and refurbishing well-used (and sometimes broken) equipment, from CNC mills and routers to injection equipment and sewing machines. The nine shots here show just a bit of what's inside their 8,500-square-foot space.

Riley Wilkinson

1

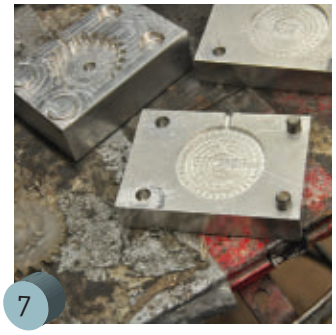

2


3

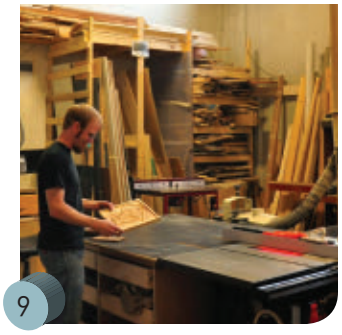

4


5


6


7


8


9

1. Cast iron, like this Valentine's Day pour and Minecraft pickaxe, is a big facet of Sector67.

2. Unsorted hardware is just junk in a box. These drawers hold lots of old-school electronics stock.

3. A well-used third hand, handmade from a block of wood, screw, washer, steel wire, and alligator clips.

4. Sector67's Chris Meyer works their manual milling machine.

5. Another cast-iron creation, this metal head was made from a 3D Kinect scan, sliced up into a laser-cutter file in 123D Make.

6. A 1980s Melco embroidery machine that has been converted to USB using an Arduino to emulate the output of the original paper tape reader.

7. Milled injection molds for Sector67 poker chips.

8. Cleverly crafted shelves use dowels rather than a solid platform to hold only plastic shoeboxes, helping keep Sector67's materials organized.

9. Meyer in the wood shop, where Sector67 keeps a Jet 12" planer/joiner, a Grizzly drum/flap sander, a Stinger CNC router, and racks of lumber, boards and other build materials.

The Fab Lab House, built at Fab Lab Barcelona

FAB LABS @ 10

Written by Members of The Fab Lab Global Network

TEN YEARS OF MAKING (ALMOST) ANYTHING.

FAB LABS ARE A GLOBAL COMMUNITY OF LOCAL WORKSHOPS *that enable invention by providing access to tools and guidance for digital fabrication. The fab lab concept sprang from an overwhelming student response to hands-on making enabled by the digital fabrication tools used in the MIT rapid prototyping class MAS: 863, How to Make (Almost) Anything. A 2001 National Science Foundation grant seeded the first fab labs as an educational outreach program.*

Revisiting our story in the premiere issue of Make: *magazine, we check back in with the Fab Lab Network team, which has grown to over 250 labs worldwide, about what they've been up to and where the community is headed.*

Elliot Clapp

The Fluxamaphonic, a physical interface to Elliot Clapp's computer-based FM synthesizer.

OPEN AND COLLABORATIVE

Fab labs empower individuals with tools, skills, and a knowledgeable community of experts once available only to specialized professions. A single maker can engage in all aspects of digitally fabricating things, from computer-aided design to electronics design, production, and programming, to machining, mold-making, and more. Fab labs share an open and collaborative philosophy and an evolving inventory of core capabilities that allow people and projects to be shared across globally networked local labs.

In early 2005, I read an article about fab labs in the first issue of *Make:* magazine. My reaction at the time was, "Wow, I didn't realize a vinyl cutter

Adria Goula © IAAC

is less than $2,000!" We immediately ordered one and started doing our own in-house signage for gallery shows at AS220, a community arts center in Providence, Rhode Island. Ten years later, AS220 Labs is a full digital fabrication lab and a Fab Academy instruction site (see *page 37*) for five years. The Fab Lab Network has achieved a great deal with a consistent vision, conscientious follow-through, and a methodology of embracing chaos.

—SHAWN WALLACE, AS220 Labs Director, *Getting Started with Raspberry Pi* co-author, artist, and programmer.

FAB FUTURE

When I did the inaugural interview in *Make:* about fab labs, I had no expectation for the explosive growth that was in store for both. "Making" has grown from a verb to a noun to a movement. And fab labs have been rapidly multiplying ever since, up to a network of hundreds of sites.

In retrospect, there was an inverse relationship between what I thought was easy and hard. The research roadmap to the *Star Trek* replicator is progressing nicely, from computers controlling machines to machines making machines to coding the construction of programmable materials. What was much more difficult was building the organizational capacity to match.

The technological goal of fab labs is to make themselves obsolete, by being able to make fab labs (see Fab 2.0, next page). Their real legacy is likely to be the .org/.com/.edu ecosystem that's emerging to support them. The personalization of fabrication challenges the historical separation of education, industry, infrastructure, aid, and art. This is a historical moment analogous to the appearance of the Internet that required the invention of new organizations to create and connect it. As important as that was, the ability to turn data into things and things into data poses an even larger question that fab labs are helping answer: How will we live, work, and play in a world where anyone can make (almost) anything?

—NEIL GERSHENFELD, Originator of the fab labs, Director of MIT's Center for Bits and Atoms and the Fab Academy. Author of *Fab*, *When Things Start To Think*, *The Nature of Mathematical Modeling*, and *The Physics of Information Technology*.

FAB CITY

In 2001, the Institute for Advanced Architecture of Catalonia (IAAC) and MIT began to collaboratively explore the impact of information technologies on the homes and cities of the future. We wanted to make Barcelona the first self-sufficient city in the world, using recycled materials to produce all the resources (things, energy, and food) we needed.

Elliot Clapp

Laser-cut woodblock prints produced during a AS220 Labs/Printshop class.

Fab Lab Kamakura

Fab Lab Kamakura, a former sake warehouse repurposed for a new age.

Adria Goula © IAAC

The Fab House produced at Fab Lab Barcelona for the Solar Decathlon Europe uses an intentionally anthropomorphic, climate-passive parametric design.

The implementation of Fab Lab Barcelona was our first step toward empowering a new entrepreneurial middle class. We envisioned a metropolis where our citizens could translate their ideas directly into production through digital fabrication.

I now work for the Barcelona City Council, where a new class of politicians are reinventing the urban landscape as we scale our fab labs to self-sustaining fab cities.

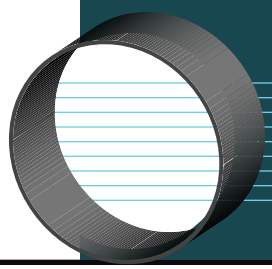
—VICENTE GUALLART, Chief Architect, Barcelona City Council. Founder of the Institute for Advanced Architecture of Catalonia and Fab Lab Barcelona. Author of *The Self-Sufficient City* and *Geologics*.

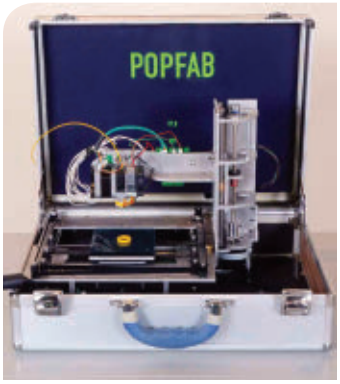
BEING FAB-ULOUS

Setting up a fab lab involves accessing the right tools for the curriculum. The current recommended inventory costs ~$50,000 in equipment and ~$10,000 in materials and includes:

- A laser cutter for press-fit assembly
- A 4' x 8' CNC router for making large, structural objects like furniture and molds for composites
- A sign cutter, to produce flexible copper circuits, antennas and printing masks
- A precision (micron resolution) milling machine to make 3D molds and surface-mount circuit boards
- Programming tools for low-cost, high-speed embedded processors
- A 3D scanner and printer
- Custom software to run any fab lab machine ("Turn Code Into Things," page 38)

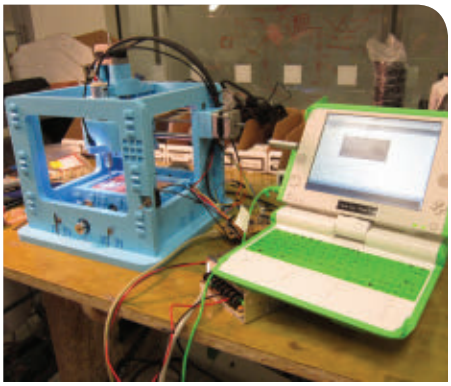
Details at:
makezine.com/go/about-fablab





Nadya Peek

The PopFab mill/printer/vinyl cutter in a suitcase by Nadya Peek and Ilan Moyer.



Nadya Peek

Jonathan Ward's MTM Snap-Lock, the precursor to the Othermill: http://mtm.cba.mit.edu

Anna Kaziunas France

"My Lungs Your Heart", by Lu Heintz. A hand-drawn sketch was scanned, etched into copper plate using Haystacks CNC router, then formed, patined and assembled using traditional metal working techniques.

Natalja Kent

FAB 2.0: MACHINES THAT MAKE

Going to a fab lab to use digital fabrication tools is great, but what if you want to use a particular machine all the time or add specific functionality that doesn't exist yet?

It turns out, the accuracy and precision of fab lab equipment is well suited to producing *more* digital fabrication tools. In fact, several companies have fab lab roots, including Ultimaker, Other Machine Co., Formlabs, and Taktia.

To make it easier to create homegrown "Machines That Make" we are developing modular hardware, software (*"Turn Code Into Things,"* page 38) and machine control platforms. In the near future, prototyping a new fabrication machine could be as simple as bolting together standard motion components, networking them in a fab-bus control system, and adapting an in-browser interface.

—NADYA PEEK, PhD student at MIT's Center for Bits and Atoms, Machines That Make developer (PopFab, MTM Snap)

FAB ART

Haystack Mountain School of Crafts became involved with the Fab Lab Network in 2009 when I invited Neil Gershenfeld to speak at our conference, Making: Past, Present, and Future. We wanted to examine ways that humans have used technology to create, from the simplest hand tools to digital manufacturing. Gershenfeld brought along a smaller version of a fab lab so conference participants could experience working with computers to make things. While we don't teach traditional crafts, our program is grounded in the traditions of craft — working with our hands to manipulate materials and having a deep understanding of the capabilities of those materials, including clay, metal, fiber, wood, and glass.

Gershenfeld compares bringing digital equipment to Haystack to Bob Dylan going electric at Newport. Many of those in attendance couldn't see the connection between our craft/material world and the digital world. To some of us, though, it seemed an important and vital one to make. The connection is this: Humans are toolmakers and these are new tools. The wisdom in working comes with knowing which tool to use when and what material to use in making work. Our lab has extended ways that we can work and reminds us of our legacy and our future as makers.

—STUART KESTENBAUM, Poet and director of the Haystack Mountain School of Crafts in Deer Isle, Maine

FAB10BARCELONA

FAB10 is the 10th international conference, symposium and annual meeting of the Fab Lab Network, an open, creative community of fabricators,

artists, scientists, engineers, educators, students, amateurs, and professionals of all ages.

This year's gathering will assemble fabricators from over 250 labs from more than 40 countries. Featured events include live onsite collaborative prototyping of a pavilion, an exhibition of 100 Barcelona-based makers, a Fab Kids program, and a 1,000 square meter "pop up" fabrication facility.

The overarching conference theme is, "From Fab Labs to Fab Cities," featuring Barcelona's unveiling of its road map for attaining self-sufficiency through digital fabrication in the years to come.

—TOMAS DIEZ, Director of Fab Lab Barcelona, FAB10 Barcelona conference co-chair, co-founder of Smart Citizen

FAB FOUNDATION

The Fab Foundation is an experiment in how to scale, support, and serve a globally distributed technical community. It began in 2009 to aid the rapid growth of the vibrant and culturally diverse fab lab network by providing some of the necessary connective tissue.

We have since evolved to become a foundation of foundations, supporting regional networks of fab labs as labs scale rapidly across continents and providing international services in areas such as finance, insurance, employment, education, communications, funding, and lab technical deployment. Recently, our nonprofit was awarded $10 million by Chevron Corporation to build and support labs across the USA.

The Fab Foundation is also seeking a Federal charter through the United States National Fab Lab Network Act, currently before Congress.

—SHERRY LASSITER, Director of the Fab Foundation, Program Manager Center for Bits and Atoms

FAB ACADEMY

Roughly equivalent to MIT's rapid prototyping course, MAS 863: How to Make (Almost) Anything, the Fab Academy provides advanced technical instruction through a unique, distributed, hands-on digital fabrication curriculum.

Professor Gershenfeld lectures globally through an interactive, two-way platform while experts mentor local student groups. Diploma completion is evaluated by a student's documented portfolio of skill-based projects rather than in time or credits.

If a 19-week prototyping marathon that tests your mettle as you and your classmates pull together to attempt every digital fabrication and electronics prototyping process possible in a fab lab sounds like fun (it is!) — join us next spring at a fab lab near you through fabacademy.org.

—ANNA KAZIUNAS FRANCE, Fab Academy Dean of Students and Digital Fabrication Editor at Maker Media.

Fab Lab Barcelona | IAAC

Elefab, a zip-tied, cardboard 3D puzzle elephant assembled at a Fab Kids workshop.

Open Source Beehives

The Open Source Beehives evolved from John Rees' 2013 Fab Academy final project; a collaboration with Annemie Maes of OKNO and of Green Fab Lab's Jonathan Minchin.

José Morraja © Guallart Architects, IAAC

"Hyperhabitat: Reprogramming the World", a 2008 IoT multiscale habitat installation by Guallart Architects, IAAC, The CBA and Bestiario.

FAB TIMELINE

Key moments in fab lab evolution.

- **1998** 1st MAS: 863 How to Make (Almost) Anything MIT Class
- **2001** Nat'l Science Foundation grant founds early fab lab educational outreach; IAAC inaugurated
- **2002** Experimental labs: Boston's Museum of Science, Vigyan Ashram in India
- **2003** 1st fab lab launched in Boston, followed by Costa Rica, Norway and Ghana, most future fab labs are self-funded
- **2005** Fab lab user group meeting "Fab1," Symposium on Digital Fabrication in Norway, "Fab2"
- **2006** Fab3: South Africa
- **2007** Fab Lab Barcelona founded, Fab4: Chicago
- **2008** Hyperhabitat: Reprogramming the World in Venice, AS220 Labs chartered
- **2009** Machine begin Making Machines/fab labs 2.0 begins, Fab Foundation incorporated
- **2009** Fab Academy program begins, Fab5: India
- **2010** Fab6: Netherlands, Fab Lab House built
- **2011** Fab7: Peru, MTM Snap, Haystack Lab realized
- **2012** Fab8: New Zealand, Fab Lab Kamakura organized
- **2013** S.1705: National Fab Lab Network Act introduced
- **2013** Fab9: Japan, PopFab
- **2014** Fab10 Barcelona

WHERE ARE THE WOMEN?

Written by Georgia Guthrie

INSIGHTS INTO THE LACK OF FEMALE MAKERSPACE MEMBERS AND WHAT CAN BE DONE ABOUT IT.

Corinne Warnshuis

GEORGIA GUTHRIE is an artist, designer, and maker. She is the director of The Hacktory (thehacktory.org) and was named Philly's "Hacker of the Year" by the blog Geekadelphia. Georgia also works as a designer at the Action Mill.

IF YOU'VE BEEN TO YOUR LOCAL HACKER/MAKERSPACE AND NOTICED THERE WEREN'T MANY WOMEN, did you stop to wonder why? Unfortunately a common reaction is to think, "I guess women just aren't into hacking or building stuff." As one of the few female directors of a U.S. makerspace, I know this just isn't true. Here's my perspective on the problem and what can be done about it.

When I was nominated to be director of The Hacktory, I decided to give it a try in an attempt to make the organization as inclusive as possible. Today The Hacktory, based in Philadelphia, has a pool of volunteers and organizers that is close to 50/50 men and women, tilting more towards women.

Frustrated with conversations about the gender gap that we witnessed at many tech conferences, we decided to take a deeper look at the issue. We designed a brief presentation and a workshop we call "Hacking the Gender Gap," where participants share positive and negative experiences they've had with technology. All the experiences are written on large Post-its, and placed on a timeline delineating relative age. The workshop concludes with a group analysis and discussion of where the positive and negative experiences cluster, and other emergent themes. The stories provide an incredibly rich context in which to understand how the gender gap is experienced in day-to-day life.

In the age range from birth to 10 years, many positive stories involve doing a tech-oriented activity with a parent, like learning to program or working with power tools. Another theme is a family member purchasing a computer or video game system, which participants use to build websites or gain confidence in their skills.

In the teen years, negative stories of teachers, guidance counselors, or other advisors discouraging girls' interests or questioning their abilities in STEM subjects are frequent. Some comments seem unintentional, like a tutor saying, "I don't know why this is so difficult for you — it's so easy." Others are brutal, like a female chemistry teacher with a Ph.D. telling students, "Women are bad at science."

Before designing this workshop, our team thought these kinds of experiences were in the distant past, but we've gathered many stories that occurred five years ago or less.

When reading through the stories, women often say, "I thought it was just me!" Many participants express relief and thanks for the chance to share their experiences — both positive and negative — in a non-judgmental environment, and have those experiences contribute to a larger outcome.

The results became more interesting with mixed-gender crowds. One crucial theme that emerged from the men's stories was frustration with women asking for help with a technical problem, following the assumption that men can fix it just because they're male. These stories helped us understand how our culture's association of masculinity with technical ability can be perpetuated by all genders.

In our research, we found the 2002 study "Women in Computing Around the World," which details how other countries don't have the same gender gap in STEM interests or careers. Female students in China have shown to be much more confident in their abilities with computers than male students. In Thailand, Italy, and Kenya, men were significantly more anxious than women about using technology.

Our most significant takeaways from doing this workshop include:

- Gender gap research in the U.S. lacks context. Recent studies seek to identify the age when girls "lose interest" in STEM fields, rather than the experiences that contribute to that shift.
- Women experience direct and indirect discouragement from teachers, guidance counselors, and tutors, something most men never experience.
- The gender gap is perpetuated by all genders, adding to its pervasiveness.
- Supportive or discouraging comments stay with people for years.

So what can a hacker/makerspace do to encourage women to start participating in their space and retain them? A good first step is to question the assumptions and biases present in your space. When a woman walks through your door, is the general assumption that she must be a beginner or that she's tagging along with someone else? Such assumptions may be based in real experiences, but to address this problem, lay these experiences aside.

There's something called "Imposter Syndrome," which is a constant comparing and questioning of one's own abilities to those of others, and a fear that you'll be revealed to not know as much as you claim. Women in science and tech fields experience this self-doubt at a very high rate, often halting them from revealing the skills and understanding they possess.

If your space has several women, including women in leadership positions, you're in good shape. To grow and empower this group, consider the following.

"A good first step is to question the assumptions and biases present in your makerspace."

Conduct an anonymous survey about what's working and not working for the women in your space. A lot of women won't voice issues to not rock the boat or because they just don't have the energy and are willing to put up with irritating conditions.

From the issues they raise, ask them to prioritize three things to address with immediate action without a vote from the larger group. A vote is exactly how the existing way of doing things will continue to reinforce itself, without allowing the concerns of this minority to be addressed.

Provide visual cues for women to show them they're welcome. This could include a designated greeter for your open house who wears a special pin or name tag. Other cues could include a well-thought-out and enforceable conflict resolution or "no jerks" policy displayed prominently in your space.

Hold open shop time or design classes for artists, crafters, or creatives. More women are comfortable identifying as these titles rather than as hackers or programmers. Many spaces have found success with offering classes for "women and their friends." This could be a good way to get more women to set foot in your space. Naturally, it would be ideal for a woman to take the lead in organizing such events.

If your hacker/makerspace has no women or just one, unfortunately it may be difficult to change. Evaluate if the regulars feel that the lack of diversity is something that "just happened" or a big problem. If the former attitude prevails, this group may view the tech world as a meritocracy and may reject the idea that the forces of culture and stereotype hold women back. Without the understanding that the urge to explore science, technology, and physics is an innately human thing, this group may not be able to suspend their judgment and make the changes necessary to attract women and other minority groups.

Rather than trying to change this underlying perception, find others in your community who share the value of inclusion, and start your own space. The time you invest in growing this space will pay off much faster than you imagine.

The Hacktory

TECHSHOP'S NOT-SO-SECRET INGREDIENT

Written by Nathan Hurst

TO ACHIEVE ITS PRODIGIOUS GOALS, THE MARQUEE MAKERSPACE IS DIALING IN A PRECISE METHOD TO MAKE EACH NEW SHOP POLISHED AND PROFITABLE.

1

2

Jeffrey Braverman

JIM NEWTON TALKS ABOUT THE HIGH-POWERED EQUIPMENT AT TECHSHOP like a car geek talks about fuel injection, horsepower, and torque. Many terms are even the same; as he walks past a Jet vertical milling machine, he mentions its 3-horsepower motor, variable speed, and digital display.

Newton is the founder of TechShop, the (arguably) first and (almost certainly) most well-defined makerspace. At 18,000 square feet, their flagship San Francisco shop is filled with his favorite tools and equipment.

He loves the Tin Knocker hand turret punch for its precision and the clean holes it creates, the cold saw (also from Jet) because he always wanted one but could never justify buying it for himself. He calls the manual lathe "one of the workhorses of the industrial revolution." All these tools — including 3D printers and laser cutters — add up to a big part of what makes TechShop TechShop.

The company stands out among makerspaces, while the "makerspace" category itself remains somewhat ill defined. TechShop tends to be the Platonic ideal. That's not to call it generic; it's simply come closest to defining the category, partly because of its standardization and partly because of its scope. With eight stores in strategic U.S. maker markets, they're the biggest membership-model shop around.

Still, TechShop has bigger plans. According to CEO Mark Hatch, it intends to scale up to between 60 and 100 locations around North America, essentially growing by around a factor of 10. To do so, it will need to depend on a fairly strict set of parameters and methods that will go into every new location, sort of a "TechShop protocol."

Hatch and the TechShop crew aren't secretive about it. He doesn't see much in the way of competitors because he doesn't think others can do the same — it's just too expensive. "It comes down to capital, and these are very capital-intensive businesses," he says. "It's hard. It's expensive. The price points are pretty low at $125 a month. This is not an easy business by any stretch of the imagination." Each shop, he says, costs between $2.5 and $3.5 million to open.

The newest one, in Arlington, Virginia, passed the 500-member mark prior to opening in June, with an additional 3,000 free memberships for veterans in a partnership with the Department of Veterans Affairs Center for Innovation. He partly attributes that success to a campaign that signed up 200 members before its April soft opening.

TechShop has a history of promising big things. The early promotion of the Arlington shop helped sell those memberships, but in a few towns it backfired. A franchising experiment went awry, and shops in Portland, Oregon and Raleigh-Durham, North Carolina closed, while one in Brooklyn has been in the works for three years without getting off the ground.

To Hatch, those are simply growing pains. They just need to stick to the protocol and adapt it to handle new challenges. The company no longer licenses franchise deals. Newton notes that the Portland and Raleigh shops were opened when they had just one location (in Menlo Park, California). "We didn't really know how we were

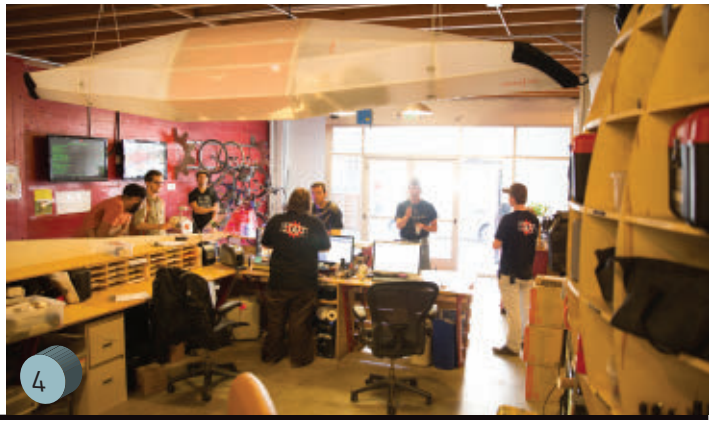
"IT'S QUITE A BIT DIFFERENT FROM A SMALL BUSINESS OPERATION. YOU HAVE DOZENS OF PEOPLE USING A TOOL, AND THEY'RE ALL USING IT IN DIFFERENT WAYS."

1. At TechShop San Francisco, 3D printers are housed on a quiet top level.

2. The company offers from 100 to 200 classes per month, like this one in the woodshop, from introductory to advanced.

3. A member works in the electronics lab.

4. TechShop designed and built all the elements in its lobby.



even running that one. I couldn't hand someone a franchise book and say, 'Here's how you operate a TechShop and make it profitable,'" he says. "What we told these guys was ... 'look at TechShop Menlo Park, figure out how it works, and you need to replicate it yourself.'"

Ultimately, Newton blames the location choices — neither the Portland nor Raleigh shop was near an urban center. Location is now essential in their protocol; each new shop should be situated where people want to be, near restaurants and bars and transportation.

That's a contrast to many grassroots makerspaces, points out Peter Hirshberg, chairman of the Re:Imagine Group and the Gray Area Foundation for the Arts. Makerspaces based on activities like machining and welding are often in industrial areas where they can take up space, says Hirshberg. "TechShop, on the other hand, is this new form of advanced manufacturing that doesn't need such a big space."

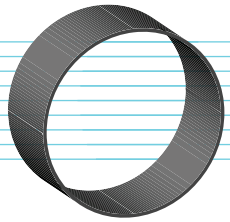
The company learned one other lesson from Portland: All new locations must feature brand new equipment.

Equipment is still probably the biggest single aspect of the company's protocol. TechShop's website has a list of core tools and equipment, and they don't vary much from location to location — down to the machines' brands and model numbers. This allows them to standardize training, repairs, and safety, and members can walk in and use equipment at any location, thanks to an RFID tag in their badges.

John Taylor, who helped with TechShop's national rollout, fought to standardize the list. He worked with architects to customize the locations, pointing out that the electrical engineers needed that information to correctly design the circuits and outlets. "Dealing with layout was a constant battle of trade-offs," he adds. "Executives wanted big open sight-lines, while those with a maker background expressed the need for walls, vertical storage, and partitioned program areas."

The San Francisco location compromised the two, and it's the only multilevel TechShop. On the top floor are quieter, cleaner tools like laser cutters and 3D printers, as well as a lounge area and a bank of computers loaded with company partner Autodesk's software. Below, on a split-level, a conference room with a glass wall overlooks the machine shop, where the vertical mills and hand punch live alongside a 60,000-psi Flow Jet water jet and a big, red and black Lincoln Electric ventilation system that clings to the east wall like a spider. A wood shop is set to the side, with four walls and a wide entryway emanating the whine of saws and the smell of sawdust, though a humming dust collector and air-filtration system keeps much of it from es-

"THERE'S MAGIC THAT HAPPENS AROUND THE COMMUNITY ASPECT. THEY WANT TO SEE THEIR FRIENDS, THEY WANT TO HANG OUT A LITTLE BIT LONGER."



5. In addition to 3D printers, the top floor incorporates laser cutters, a lounge with coffee and vending machines, and a bank of computers tricked out with Autodesk software.

6. Band saw practice in the woodshop.

7. The back entrance is oversized to allow large projects and materials. Beside it, a powder-coating station is big enough for a motorcycle body.

caping into the rest of the shop.

In the woodshop are two ShopBot CNC routers, a medium and a large one. "We've been working with TechShops and other kinds of makerspaces, trying to develop strategies for supporting customers in environments like that, because it's quite a bit different than a small business or a manufacturing operation owning a tool," says Ted Hall, ShopBot founder and CEO. "You have dozens of people using a tool in a given week, and they're all using it in different ways. Mostly, they're relatively inexperienced, so it's a tough environment for a technology tool to be robust and reliable in."

That's where Dream Consultants come in. Along with many other responsibilities, these TechShop employees help keep up the machines. They also police the equipment, offer general help, and act as a friend and liaison to the community.

"You're kind of a central hub for not only knowledge but social capital. You know what everyone's working on, pretty much, within the shop at all times," says Mel Olivares, who trains DCs, as he calls them, across the system. "You're part of the glue that makes the atmosphere happen. It's much more than just a manufacturing consultant."

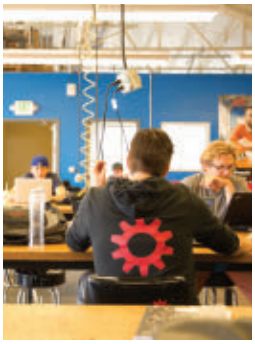
That community is a crucial part of the protocol, too, both Hatch and Newton note. They have settled on a minimum goal of approximately 500 paying members per TechShop, not just because that makes them profitable, but also because they believe that's where the community hits critical mass. "There's magic that happens around the community aspect once you hit 500 members," says Hatch. "There's a flip in their mindset; they come in because they want to, they want to experience the community, they want to see their friends, they want to hang out a little bit longer."

The community factors heavily into one of their favorite success stories: Type A Machines. Type A built 3D printers at the San Francisco location. As the company grew — it has sold more than $1 million worth of printers so far — it moved to a manufacturing facility in nearby San Leandro. Though many run businesses out of TechShop, it really isn't suitable for large-scale production runs, largely because someone may be using the machine you need when you have to get a shipment out. But Type A kept its headquarters in a rented office on the company's top floor and a membership for R&D and prototyping. "This TechShop location has an unbeatable team and we couldn't have done it the way we did without

6

7

8. Every tool has its place.



9. The Jet variable speed, 3-horsepower vertical milling machine, equipped with a digital display, allows TechShop members to adjust the tool without using the mechanical dials. "This would be a dream machine to have in your own home," says Newton.

them," says Miloh Alexander, co-founder and hardware engineer for Type A.

"We use the SF TechShop tools like the mill, laser cutters, and other tools to build parts for our plywood machines and our 2014 folded metal machines, which we ship fully assembled and offer service and support for," adds Alexander. "From the start we've needed TechShop tools to be able to closely manage the process of building strange machines that ... make a variety of strange things."

Building strange machines, in a way, is what led Newton to found TechShop. He entered a BattleBots competition and built a 220-pound fighting robot. He had no lathe or mill to build the gearboxes or axles, so he enrolled in a shop class at the College of San Mateo, just to use their tools, and it became a model. "I realized right there that ... it's so hard to get access to a good complement of equipment, that people would actually pay for access," he says.

Despite the demand, exhibited years ago by Newton and other makers enrolling or even teaching classes just to get access to shops, it remains a tenuous business model. "As more makerspaces come online with community at their core, I think a new sustainable business model will emerge," says Taylor.

TechShop attacks the problem via partnerships at its new locations. Ford in Detroit and Lowe's in Austin, Texas, have given employees memberships. In Arlington, TechShop also teamed with DARPA. In the next shops planned in Dublin and Munich, the company is partnering with Dublin City University and BMW, respectively. A planned Los Angeles shop is in partnership with a maker community called The Reef, and one in St. Louis is still seeking investors.

Hatch tossed out 2020 as a possible date for his 60- to 100-store goal, but added that he has no idea if that's realistic. Beyond that, he sees the company getting into distributed manufacturing, design, and prototyping services.

"We really see TechShop eventually looking and operating similar to how Kinko's operates today, where people can choose whether or not to come in and make something themselves, or they can ship us the file and we can make it for them," says Hatch, who was formerly director of computer services at Kinko's. "As manufacturing continues down the automation path, continues down the digitization path, and we continue to open up more locations, working on more sophisticated tools, we will be able to position ourselves as basically the largest distributed manufacturing company in the world."

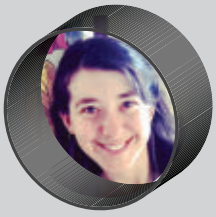
MASTERING TECHSHOP IN 12 EASY STEPS

- 1. Get set up with your photo-equipped RFID badge. You'll need it to get in the door and to get certified on TechShop equipment.
- 2. Meet the staff and Dream Consultants; they're there to help you and they'll get you engaged in the community.
- 3. Take a safety class for a machine you know you'll need.
- 4. Go shopping at the TechShop retail store. They have many of the materials you need in small quantities, perfect for a single project.
- 5. Build a project you've been planning — or dreaming of — for a long time. Hire a Dream Consultant if you don't know how.
- 6. Take a 3D design class; it'll introduce you to many tools, from 3D printers to laser cutters to CNC mills and routers.
- 7. Create something and give it away.
- 8. Buy an expert a beer and pick her brain.
- 9. Pick a class that looks interesting, something you've never tried before. That machine will become a tool in your belt — you'll see its potential and come up with ideas for how to use it.
- 10. Reverse engineer something.
- 11. Go back and build something again, but better. That's how you become an expert.
- 12. Create something and sell it. There have never been more ways to sell your projects, from Etsy to Kickstarter to Tindie.

HOW TO MAKE A MAKERSPACE

Written by Molly Rubenstein

SIX THINGS YOU DON'T REALIZE YOU SHOULD KNOW BEFORE GETTING STARTED



MOLLY RUBENSTEIN
An educator, performer, and community organizer by trade, she is a member of the team responsible for growing the Artisan's Asylum (artisansasylum.com) from a small maker clubhouse to a giant community center and business incubator in Somerville, Massachusetts. In her limited free time, she tries to help prepare makerspace founders around the world for success.

SO YOU'RE GOING TO RALLY YOUR LOCAL MAKERS INTO A COLLABORATIVE, COMMUNITY-BASED WORKPLACE. You'll need a location, which can range from a mobile pop-up stored in your van to an 80,000-square-foot warehouse. You'll need tools, which can be borrowed from members, donated by sponsors, or purchased. You'll need a business plan.

After that, it's all in the details. Here are six tips that you may not be thinking about yet but should be.

ASK FOR HELP

Your success will depend on finding a strong team to help you. Plus, there's nothing that unites a community like a good volunteer build-out. Call everyone in to clean the space, paint the walls, move things around, and build some furniture. It is a makerspace, after all — have the first group project be the space itself.

BUILD WHAT PEOPLE WANT

You can design a multimillion-dollar, state-of-the-art facility, only to discover that everyone just wants a place where they can draw on the walls. Design the space for the community you have.

TO DIY OR NOT TO DIY

There's always some member or volunteer who says we should do it ourselves. For building benches for the woodshop, that's great. But for legal contracts, accounting, and wiring, make sure you find an expert.

IMAGINE THE BEST ...

When planning your infrastructure and setting a vision with your community, imagine what you would do with a million dollars. Would you get the biggest space? Move to a prime location? Get the shiniest tools? Or offer all your services for free?

... BUDGET FOR THE WORST

Expect delays of all kinds. You might have to pay rent and utilities for months before you generate revenue. However long you think it will take to open, triple that.

YOU ARE NOT ALONE!

Others are solving these same problems all over the world. Visit their spaces, talk to the people who run them, check out Maker Media's handbook, *The Makerspace Workbench*. There might even be a local library, university, or economic development office that's thinking about doing the same thing.

Don't worry; what you're doing is hard but not impossible. Some of these things we did right at Artisan's Asylum the first time, and some of them we had to learn the hard way. Good luck!

Photo: Artisan's Asylum, Illustration: James Burke