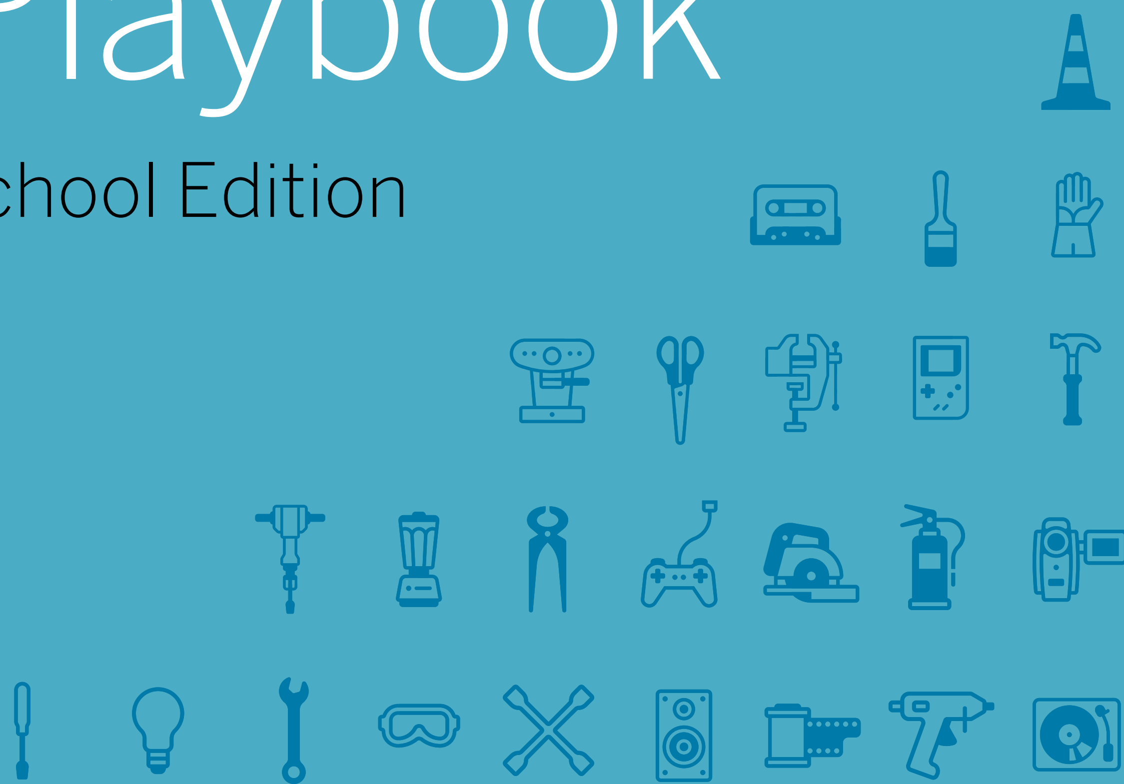
Makerspace

# Makerspace Playbook

## School Edition



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The majority of this Makerspace Playbook was written by the Makerspace team, including Michelle Hlubinka, Dale Dougherty, Parker Thomas, Stephanie Chang, Steve Hoefer, Isaac Alexander, Devon McGuire, with significant contributions from Aaron Vanderwerff, Barry Scott, and other MENTOR Makerspace pilot school teachers. Some sections were adapted from the Mini Maker Faire and Maker Club Playbooks written by Sabrina Merlo, Sherry Huss, Tony DeRose, Karen Wilkinson, Mike Petrich, Suzie Lee, Shawn Neely, Darrin Rice, and others.

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# Welcome...

to a community of people who have a passion for making things, and who want to share that with others by making with others by setting up a Makerspace. This playbook will help you establish a wonderful new resource in your school, neighborhood, or wider local community. It shares the knowledge and experience from the Makerspace team as well as from those who have already started Makerspaces.

We know that the thought of getting a Makerspace started can be daunting, whether it's finding a facility, engaging members or students, recruiting mentors, dealing with liability, etc. We want your Makerspace to succeed, to expand the Maker community and grow the Maker movement, to share the Maker mindset and DIY mentality, and to engage and stimulate your neighborhood, school, town or region. We wrote this playbook for Makerspace advocates like you—teachers, parents, Makers, etc.— to make it easier to launch a space and get a program up and running.

In our effort to continually improve the material we provide, we heartily encourage you to contact us with anything we can refine, add or share. Please report your experiences to us so we can enrich the book with new insights, advice, illustrations, and anecdotes. We would like this document to grow and reflect new practices and current experiences. If you are reading this in a PDF or printed format and would like to contribute comments via email, please address them to **contact@makerspace.com**.

For more information and continuing updates, visit **makerspace.com**

We like to say that if you can imagine it, you can make it. So let's make your Makerspace!

Makerspace Playbook

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# Beginnings

Makerspaces come in all shapes and sizes, but they all serve as a gathering point for tools, projects, mentors and expertise. A collection of tools does not define a Makerspace. Rather, we define it by what it enables: making.

Learning environments rich with possibilities, Makerspaces serve as gathering points where communities of new and experienced makers connect to work on real and personally meaningful projects, informed by helpful mentors and expertise, using new technologies and traditional tools.

We're enabling new makers — and makers of makers — everywhere to create spaces, find the tools they need, and create the programs for the spaces. We know that, while digital design and fabrication tools may be within reach of some, the much greater need of providing adequate staffing and expertise often eclipses the costs of equipping a space. Stuff is not enough. So our team is tackling five areas to make establishing a Makerspace easier for you. You can access each of them at **makerspace.com** as they become available.

1. ***Network***. Get access to an open and collaborative network of educators and members of the worldwide maker community, all doing this work too. Share insight, ideas, and best practices from one Makerspace to another. Connect on a local level with makers on the ground and community partners who support making.

2. ***Project Library***. Our flexible, modular projects introduce skills and allow new makers to filter projects based on their own interests, ability, and available equipment. These projects make it easy to get started and get better, and they're backed up by all a facilitator needs to know to make the project work with a group.

3. ***Learning Lab***. Maker Media and the greater Maker community have already generated a large body of content to bring new makers up to speed on making. We provide better ways for learners to discover and access relevant content.

4. ***Training and Support***. How do you run a class in making? Engage students in projects? Create the right learning environment? Mix disciplines? We nurture a vibrant community of practice among Maker-educators with online workshops & hangouts and in-person professional development. These introduce new ideas and projects and provide ongoing feedback and support.

5. ***Tools (both hardware and software)***. Our pre-packaged kits reduce the barrier of creating a space. We've designed a basic "Makerspace in a Box" kit with the standard set of tools needed to complete skill-builder projects like simple chairs, soldering, soft circuitry, etc. Advanced kits would add 3D printers and other optional expansion modules.

We describe elements of some of these five areas of our work in this Playbook. We encourage you to get involved with our efforts by visiting us online at **makerspace.com**.

## The Maker Movement

Makerspace grew out of Maker Media, the force behind MAKE magazine and Maker Faire and a leader in the Maker movement. We find that the Makers we meet share many things in common with one another, even when they are working in very different disciplines.

We hope you will see this mindset reflected in your Makerspace. We want everybody who participates in a Makerspace to see themselves as Makers.

What makes a Maker?

- Makers believe that if you can imagine it, you can make it. We see ourselves as more than consumers — we are productive; we are creative. Everyone is a Maker, and our world is what we make it.
- Makers seek out opportunities to learn to do new things, especially through hands-on, DIY (do-it-yourself) interactions.
- Makers surprise and delight those who see their projects, even though the projects can be a bit rough-edged, messy and, at times, over-stimulating. (Think punk rock.)
- Makers comprise a community of creative and technical people that help one another do better. They are open, inclusive, encouraging and generous in spirit.
- Makers are generally not in it for the money. This isn't about filing patents or making a profit.
- At the same time, we're not anti-commercial—Makers sometimes start businesses, and we celebrate that...but we don't make it a focus as it would change the spirit of the movement.
- Makers celebrate other Makers — what they make, how they make it and the enthusiasm and passion that drives them.

The Maker movement continues to gain momentum. We can see the growth of maker communities online as well as the development of physical community workspaces, called Makerspaces, and the spread of Maker Faire around the world. The Maker movement is spurred by the introduction of new technologies such as 3D printing and the Arduino microcontroller; new opportunities created by faster prototyping and fabrication tools as well as easier sourcing of parts and direct distribution of physical products online; and the increasing participation of all kinds of people in interconnected communities, defined by interests and skills online as well as local efforts to convene those who share common goals.

## Maker Faire

One way the Maker movement convenes like-minded individuals is through Maker Faires, both those organized by Maker Media and the Mini Maker Faires that are organized by local communities, and popping up in school cafeterias, public parks, and empty warehouses around the country and the world.

Maker Faire is (literally) an explosive environment—full of blasts of imagination, invention, and creativity... oh, and some propane too. If you haven't been to Maker Faire before, words don't really do it justice. It's the premier event for grassroots American innovation and a festival/celebration of DIY (do-it-yourself) culture, organized by **Make Magazine**. Nowadays, over 900 Makers of all ages convene for one fantastic weekend to show off a spectacular array of projects that combine arts, craft, engineering, food, health, music, creative reuse, performance, science, and technology. Rockets to robots, felting to beekeeping, pedal-power to mobile muffin cars, hardcore hardware to silly software — you never know what you'll see.

Maker Faire creates conversations with Makers. It is a show-and-tell for people of all ages that brings out the "kid" in all of us. Maker Faire is a community-based learning event that inspires everyone to become a maker and connect to people and projects (and passions!) in their local community. Maker Faire provides a venue for Makers to show examples of their work and interact with others about it. Many Makers tell us that they have no other place to show what they do. It is often out of the spotlight of traditional art or science or craft events. DIY is often hidden in our communities, taking place in shops, in garages and on kitchen tables. So the goal of the event is to make visible the projects and ideas that we don't encounter every day. Makerspace projects are a perfect fit.

At a typical Maker Faire, you'll find arts & crafts, science & engineering, food & music, fire & water — but what makes our event special is that all these interesting projects and smart, creative people belong together. They actively and openly create a Maker culture. Makers are fascinating, curious people who enjoy learning and who love sharing what they can do.

Maker Faires are about exhibition, not competition. We don't see Makers pitting themselves against each other. We hope each student using a Makerspace gets useful feedback on what they are working on, and that the feedback is offered in a spirit of generosity and received with similar openness and magnanimity.

Makerspace is our strongest effort to infuse schools with the spirit of the Maker movement, to re-energize education with the creativity, innovation, curiosity, motivation, technical know-how, and playfulness that characterize our maker community.

## The Importance of Play

The origin of the Maker movement is found in something quite personal: what we might call experimental play. Makers are enthusiasts who play with technology to learn about it. A new technology presents an invitation to play, and makers regard this kind of play as highly satisfying. Makers give it a try; they take things apart; and they try to do things that even the manufacturer didn't think of doing. Whether it's figuring out what you can do with a 3D printer or an autonomous drone aircraft, makers are exploring what they can do and learning as they explore. Out of that process emerges new ideas, which may lead to real-world applications or new business ventures. Making is a source of innovation.

In his book, *Play: How it Shapes the Brain, Opens the Imagination and Invigorates the Soul*, Dr. Stuart Brown tells the story about how the Jet Propulsion Laboratory realized that, although it was hiring the best and brightest college graduates, they were the wrong kind of people. Something had changed in the kind of people who came to work at JPL.

> *The JPL managers went back to look at their own retiring engineers and ... found that in their youth, their older, problem-solving employees had taken apart clocks to see how they worked, or made soapbox derby racers, or built hi-fi stereos, or fixed appliances. The young engineering school graduates who had also done these things, who had played with their hands, were adept at the kinds of problem solving that management sought.*
>
> *Those who hadn't, generally were not. From that point on, JPL made questions about applicants' youthful projects and play a standard part of job interviews. Through research the JPL managers discovered that there is a kind of magic in play.*

We must try to bring the youthful magic of play into schools, hard as it may be. Formal education has become such a serious business, defining success with abstract thinking and high-stakes testing, that there's no time and no context for play. If play is what you do outside school, then that is where the real learning will take place and that's where innovation and creativity will be found.

## Why Making Matters for Learning

Making is innovative and resourceful. Makers build off the ideas of others and choose the best tools for the job.

Makers are intrinsically motivated. They identify their own challenges and solve new problems.
Making provides ample opportunities to deeply understand difficult concepts. Makers seek out STEM content to improve their projects, and they cross disciplines to achieve their goals, rather than staying within one specialty.

Makers take risks and iterate from "failures" to achieve success. Makers have a growth mindset that leads them to expend the energy to learn. Making fosters character- building traits collectively known as grit, including creativity, curiosity, open-mindedness, persistence, social responsibility, and teamwork, among others.

Makers collaborate and give advice and guidance to their peers. Makers are often more interested in open sharing and exhibition, not competition.

Frankly, we don't want everyone to be an engineer, but we do want everyone to be able to think like one when they need to do so. In our work incubating Makerspaces, we are most interested in developing the physical and mental context that allows students to get started and continue to develop new skills that lead to choosing more challenging projects and more interesting opportunities for themselves in the future.

## Potential Impact on Education

As leaders in the resurgence of the DIY (do-it-yourself) movement, we are dedicated to sparking the DIY spirit in all those whose lives we touch. So we don't see any reason why we, as a society, can't transform education into a system that nurtures individuals to adopt the habits of mind that Makers have and to become the engaged citizens we want our kids to be.

Our biggest challenge—and the biggest opportunity for the Maker movement—is an ambitious one: to transform education. Our hope is that the agents of change will be the students themselves. Increasingly, technology has given them more control over their lives, and even the simplest cell phone can change a person's sense of agency.

We hope to bring the Maker movement to education in a few specific ways:

- Creating the context that develops the Maker mindset, a growth mindset that encourages us to believe that we can learn to do anything.
- Building a new body of practice in teaching making—and a corps of practitioners to follow it.
- Designing and developing Makerspaces in a variety of community contexts in order to serve a diverse group of learners who may not share the access to the same resources. (This Playbook serves a role here.)
- Identifying, developing and sharing a broad framework of projects and kits based on a wide range of tools and materials that connect to student interests in and out of school.

- Designing and hosting online social platforms for collaboration among students, teachers, and the community.
- Developing programs especially for young people that allow them to take a leading role in creating more Makers.
- Creating the community context for the exhibition and curation of student work in relationship with all makers. Making sure that new opportunities are created for more people to participate.
- Allowing individuals and groups to build a record of participation in the Maker community, which can be useful for academic and career advancement as well as advance a student's sense of personal development.
- Developing educational contexts that link the practice of making to formal concepts and theory, to support discovery and exploration while introducing new tools for advanced design and new ways of thinking about making. (Practically, this means developing guides for teachers, mentors and other leaders.)
- Fostering in each student the full capacity, creativity and confidence to become agents of change in their personal lives and in their community.

***Impact Areas***

- *Inspiration* : inviting students to participate in the creative economy and to direct their own future
- *Innovation* : serving as a catalyst for grassroots invention
- *Education* : building a connection between the community and learners

We are particularly interested in how our approach might reach students who don't fit well into the existing system or who have already dropped out of it. At Maker Faire, there are no winners or losers — anything that's cool is fair game. It's not a competition, and there aren't prizes, so there are no judges deciding who has succeeded and who has failed. Yet Makers — some with two PhDs, others who never graduated from anywhere — are motivated to spend long hours in their studios, shops, kitchens, and garages finishing their projects. Makers work in art, craft, engineering, music, food, science, technology, health, and often in several of these areas at once. Their projects are thoughtful, challenging, and innovative. But most importantly, we notice that all Makers are curious and motivated people.

In its National Education Technology Plan (2010), the Office of Educational Technology, Department of Education wrote,

> *The model of 21st-century learning described in this plan calls for engaging and empowering learning experiences for all learners. The model asks that we focus what and how we teach to match what people need to know, how they learn, where and when they will learn, and who needs to learn. It brings state-of-the art technology into learning to enable, motivate, and inspire all students, regardless of background, languages, or disabilities, to achieve. It leverages the power of technology to provide personalized learning instead of a one-size-fits-all curriculum, pace of teaching, and instructional practices.*

This is our challenge. It isn't enough to train current students for the world of today — we have to train them for tomorrow, a tomorrow that will require them to master technologies that don't yet exist. Think about it: a child in middle school today will be entering the prime of their careers in 2040. We have no idea what the world will be like then. Therefore it is crucial to develop timeless skills such as curiosity, creativity, and the ability to learn on one's own. These are precisely the skills that are honed by efforts such as the Makerspace.

We believe the Maker movement captures something about the future for a new direction in education. We know that many teachers are re-energized by their annual visit to Maker Faire, and a few join us in our optimism for making as a way to learn. We hear this **time and again from teachers**.

The Maker movement exemplifies the kind of passion and personal motivation that inspire innovation. We can engage students as makers who learn how to use tools and processes to help them reach their own goals and realize their own ideas.

How can we translate this intrinsic motivation to education? How can we channel these core values, a shared spirit, ethics, discipline, mutual respect, reciprocity, self-directed learning into how we teach? Or more generally, in a future world, what could schooling look like?

And how can Makerspaces shift how we think about achievement?

These are the questions we hope to answer ... and we will answer them, with your help!

# 2

# Places

Makerspaces are physical spaces for people, including kids, to work together and review their projects. Making can happen anywhere—on a kitchen table or in a high-end Fab Lab, a living room or a garage, a school or a community center—but in this playbook we define guidelines we think can make a real difference in how enthusiastic and successful your students are in making and achieving their project visions.

## A Different Approach

Makerspaces follow in a long tradition of learning by making and through apprenticeship, adding emerging tools for personal fabrication, community sharing, and project collaboration and research. They share some things in common with CTE (career technical education), vocational education, hackerspaces, and FabLabs, but differ in certain ways as well.

Makerspaces borrow somewhat from the tradition of *career technical education* or *vocational education*, but they diverge by metaphorically, sometimes literally, tearing down the walls between the silos of classes in woodshop, computer science, home economics, automotive repair, etc. in pursuit of a more interdisciplinary goal. Makerspaces also recognize that making enriches the educational experience of students who are motivated to different extent in school. Sadly, technical education gained some stigma as the academic track to which guidance counselors sent failing students, and this led many schools to get rid of thousands of dollars worth of valuable equipment. We should mention here that our friends at **ITEEA** ask us to emphasize, "Shop class isn't dead"!" CTE (career technical education) changes with the times, and many shop teachers welcome the Makerspace approach.

Makerspaces suggest a different model to contrast with the outdated notion that shop class is for only one track of students. We find that making engages the student that is teetering on the edge of dropping out as effectively as it captures the interest of the 4.0 student in AP classes. We hope that Makerspaces can lead to a resurgence of technical education for all. Makerspaces are like *hackerspaces*, but they differ in the same way that hackers and Makers differ. Makerspaces focus primarily on learning and education, whereas hackerspaces often focus on hobbyists who make to have fun and relax, or who use the space as an incubator for their emerging small business. And while many hackers consider themselves Makers and vice versa, hackerspaces often have an adult atmosphere that's not always very welcoming to kids. In part this is because safety issues crop up when you open your door to minors, and many hackerspaces feel ill equipped to confront these. Nonetheless, some hackerspaces do actively invite kids to use their space, such as **Ace Monster Toys** in Oakland, California, which hosts a Hacker Scouts Open Lab event.

Makerspaces are like community FabLabs, in that both provide a wide variety of technologies for fabrication to people who might not otherwise have access to such powerful tools. Makerspaces differ from the FabLab model in that we try not to be prescriptive of any single set of tools and equipment a Makerspace should have. As a result, Makerspaces also tend to embrace a wider range of domains and types of projects. There's some overlap between what we are doing and with the research being done by Paulo Blikstein's **TLTL** (Transformative Learning Technologies Laboratory), a multi-disciplinary group designing and researching new technologies for education at the Stanford University Graduate School of Education. Blikstein too is trying to find lower-cost options that can be used in classrooms around the world.

## The Multipurpose Space

A school or community center could have a Makerspace that serves as a resource room used by different classes and in different contexts. That is, multiple teachers and multiple classes could use the space: a physics class might use the space for a unit, an afterschool robotics team might build there. It's not necessary to dedicate a Makerspace to just one particular class on making.

We imagine a variety of uses for a Makerspace:

- Classroom for physics and robotics classes (read about Lighthouse Charter School in Snapshots)
- Specially designed elective classes
- An interdisciplinary tool and materials resource center used by many different teachers and classes
- Fellow teachers going there on their own in their prep periods to build teaching materials and demos
- A Maker Club meetup space (perhaps managed by the club members)
- Community / neighborhood after-hours access

## Choosing a Location

It is surprising how much can be done with limited shop facilities, so don't let getting everything exactly "right" deter you from getting your Makerspace going. Makerspaces can be everything from temporary places set up in a lunchroom after school to a tent in the park to permanent buildings built to order.

Consider repurposing an existing space at your school or community center. Partner with an existing, possibly underused or disused room yearning to be transformed into a portal to 21st-century innovation.

- ***The Computer Lab***. Instead of replacing your old computers with new desktop computers, take out most of the stations in your computer lab, buy a few tablets and laptop computers, and invest the rest of your budget in fabrication tools your students need and want. We heard from an Arizona school who did this to their lab. See before and after images, below.
- ***The Library***. Many departments at your school already think of this as a shared resource. Some public libraries have had tool libraries for years (Northern California has a few: Berkeley, Oakland, Santa Rosa, San Francisco), while others have started fundraising to get Maker tools and hackerspaces into their libraries (Westport, Connecticut and Fayetteville, New York). School libraries may be close behind!
- ***Partner courses***. If you are, for example, a teacher in science and engineering, think about teaming up with the art teacher or the vocational ed department to share space and students. These match the Maker spirit well, and you'll probably find that unexpected results emerge when you work with teaching peers in other departments.
- ***Home Economics / Photography Darkroom***. Some classes, regrettably, have fallen out of fashion in recent decades. A class in home economics or photography can provide some nice pluses, with sinks and large surfaces. We also enjoy the history that these kinds of spaces have, bringing together art and science.
- ***Stagecraft***. A teacher we know in Santa Rosa was faced with few choices, but landed on a perfect solution: there was a space behind the stage in the auditorium which had plenty of space for creating props and some tools to do so. He has worked out a space-sharing deal with the drama teacher, and the students will be able to make better props for their performances! Stages and backstages often provide some of the most ample vertical clearance, too, for building and testing projects.
- ***Outdoors***. Alice Waters pioneered getting gardens into schools in the belief that growing vegetables can connect children to the process of making food but also teaches them about healthy food. A Makerspace building can be constructed and placed next to the garden, and perhaps even used by young gardeners to build tools. One outdoor structure we like is the Shelter 2.0 project, which we first saw at Maker Faire as solution for temporary housing for Haitians after their devastating earthquake. Shelter 2.0 provides housing in areas that have been hit by a disaster, using a simple, digitally fabricated shelter that is in

BEFORE: Verrado Middle School's Computer Lab

AFTER: the same room at Verrado, transformed to a Makerspace between a house and tent. It can be put together (and taken apart) with simple tools in a matter of hours, even by the students themselves. The standard components ship in a 4×8 crate and comprise a 10x16 footprint when fully erected. For those interested in something upcycled, consider a used shipping container, as some art collectives have rented or bought to house artists' studios.

If you are not creating a Makerspace in the context of a school campus, there are many options for finding a space in the community. Some ideas for potential partners:

- Nationally organized groups with local chapters (e.g. 4-H, FIRST Robotics, Girl Scouts, Boy Scouts, Boys & Girls Clubs, YMCA and YWCA, Intel Computer Clubhouse)
- Community art centers and art collectives
- Libraries, museums, and science centers
- Hacker meetups and hackerspaces that are welcoming to the under-18 crowd
- Schools: even though you don't have one, that doesn't mean you can't find one that will welcome your idea! Check with public, private, charter, or homeschooling collectives; especially certain tracks or departments in engineering, art, science, crafts — and consider from pre-K to college

## Designing Creative Environments

A Makerspace houses a community of Makers. It's a place where someone would come to learn how to use a new tool or material in a new way, or to see what others are working on because they might want to help out on that project or start something similar. Ideally, your Makerspace should be conducive to inspiration, collaboration, and conversation.

As you design your Makerspace, you will want to balance two seemingly divergent objectives: promoting social interaction and preserving privacy for unencumbered tinkering. Make sure you allow for groups to be able to work together easily with large surfaces when possible, but also design the layout to provide adequate isolation for kids who want to work on their own until they are ready to share. Also do your best to locate the workspaces close enough to one another so that ideas can "cross-pollinate" from one Maker to another. It's a delicate balance, and if possible, it's probably best to design for easily changed layouts to your room so you can make adjustments as you get a sense of how your space gets used.

Design some "hang out" areas that can also be used to gather, organize, or review and critique. Not every area of your room should be designated for a particular use. You might want to have a large open tabletop to allow for an ample, comfortable workspace and planned or happenstance cooperative work. Comfortable chairs where people might take a moment to resolve designers' block could also be a corner where they might strike up a conversation with someone working in a very different kind of project who may nevertheless have some new ideas for the maker. Ideally keep this area away from noisy, dirty, or too heavily trafficked areas of the Makerspace.

Stock up on diverse tools and materials. Make sure that what you have on hand gives your members the nudge to make projects in any or all of the content areas of a typical Maker Faire: arts, craft, engineering, food, green design, music, science, technology.

Make a wide variety of materials available, but also visible and easy-to-find. You might use clear or mesh containers that members can scan visually when they're looking for something specific or letting their imagination wander as they have Maker's Block.

Keep something like an "idea rummage box" in the space, where members can throw in cool clippings and clever objects they think could inspire others.

Show off the products and the process. Choose well-placed shelves and wall space for showcasing examples of past projects and current activities to seed ideas and inspiration.

Be conscientious of the needs of diverse practices. If you find a great woodshop to use, find an area within it that is more isolated from the sawdust to set up a soldering station or a sewing machine, for example.

Scott Doorley and Scott Witthoft of the Hasso Plattner Institute of Design at Stanford University compiled the manual *Make Space: How to Set the Stage for Creative Collaboration* to share helpful insight and tips gleaned from years of making (and remaking) the d.school's environment as it was moved from building to building.

The **Exploratorium's Tinkering Studio** inspires us with its environmental design principles, "guides for the design and use of the studio setting":

- Examples from past projects and current activities are situated to seed ideas and inspiration.
- Studio layout supports individual initiative and autonomy.
- Activity adjacencies encourage the cross-pollination of ideas.
- Activity station design enables cross-talk and invites collaboration.

## Designing Safe Environments

The larger a space, the more people it takes to run it effectively and safely. Very quickly it becomes necessary to have some organizing principles to help keep the space a safe and positive place to work and learn. What form that takes is entirely up to you and what best serves the space.

Organize your workspace so that it is tidy and spacious enough to provide enough room to move around working makers freely and without danger. Keep pathways to tools, exits, and safety equipment clear. The space needs to be well lit and ventilated.

The space needs to be big enough that work areas can be separated enough to be used safely. For example, the person using the table saw should have enough space so that they don't interfere with the person using the planer.

We cover the topic of Safety in Chapter 4.

## Logistical Issues

Typically the first limitation for what space to use is what is available. If there's nothing available, then you have to consider what you can afford to build or reconfigure. When budgeting, be sure to include one-time expenses such as remodeling as well as ongoing expenses such as electricity, heating, permits, etc.

In addition to supporting the members, the space needs to support the equipment. Be sure that it can provide the electrical power needs, that it can support the necessary safety equipment, and that you don't run afoul of local zoning ordinances. A loading dock and/or a freight elevator is very useful if you expect your Makerspace might support larger projects or machinery.

Be sure to have storage space for materials and to stow away students' in-progress projects. Some Makerspaces choose to assign dedicated workbenches for each member. Shelves give participants a place to keep their projects when they're not in the space.

Don't forget to make it especially easy to access supplies for cleaning up when done, and for first aid when injuries happen.

Some possible requirements you may want to keep in mind when you are looking for a space:

- Soldering stations should have sufficient ventilation or be outside.
- Messy projects need easy-to-clean environments.
- Internet access (ideally wireless) will allow your members consult expertise online while they work. They might consult static pages or interactive chats. They might even want to Skype with a remote expert Maker.
- Projects and machinery with sensitive electronics need to be protected from moisture and sawdust.
- Some projects may use fire effects, and so will require outdoor space with pavement, no overhead foliage, and lots of room to test them.
- Some projects need relative quiet, while others are so noisy that they need to be acoustically isolated.
- Some projects use 220 volts or even three-phase power.

Larger spaces benefit from having separate areas for different types of work. While darkrooms and paint booths are necessarily separate, other categories of tools are often isolated from one another, such as woodworking, metalworking, electronics, craft, kitchen, and computer areas. Grouping some activities together brings together similar equipment and safety materials, and isolates noise and dust, while also helping connect people, which in turn encourages skill sharing.

## Furnishing the Space

Many elements of the workspace, such as workbenches, shelving, and whiteboards can be made significantly cheaper than buying ready made.

That book we mentioned earlier, *Make Space*, is full of ideas for building your own furniture and hacking together off-the-shelf products into new kinds of classroom furniture.

## Reading More

We also recommend you take a look at two other documents we've produced for suggestions, checklists, and images of gadgets, tools, workspaces, and more:

1. Make: magazine's special issue, the *2011 Ultimate Workshop and Tool Guide*
2. High School Makerspace Tools & Materials

# 3

# Tools & Materials

Once you have a space where you can work, you'll want to outfit it with the tools, equipment, and materials your Makerspace needs in order for your students to accomplish their projects.

But before you go on a shopping spree and max out your credit card, assess what your Makerspace will actually require. You don't necessarily need a fully equipped shop. Sometimes an empty countertop might be more valuable than a fancy new machine. You may be surprised at how many projects can be completed with a few hand tools, along with some simple power tools such as an electric drill, jig saw, and circular saw. For engineering-oriented projects, an appropriate shop would be a traditional woodshop or metal fabrication facility. However, for more craft-oriented projects, a shop could consist of large tables, adequate light, a sewing machine, a quilt frame, and so forth.

## The Perfect List

Ha ha! We don't have it! Equipment lists are as individual as the space and its members.

Of course, we have suggestions, but it's up to you to find the right combination of tools and materials for your students. We recommend you take a look at two other documents we've produced for suggestions, checklists, and images of gadgets, tools, workspaces, and more:

1. Make: magazine's special issue, the *2011 Ultimate Workshop and Tool Guide*
2. *High School Makerspace Tools & Materials*

## Budgeting for Tools *and* Their Care

Tools can be everything from a $1 screwdriver to a computer-controlled industrial milling machine the size (and cost) of a luxury car. The cheapest tool can end up being more expensive in the long run, though, as cheap tools and must be replaced. And that high-end CNC machine could cost you much more in maintenance and parts.

No matter how durable the tool, equipment always begets more equipment. Hand tools need toolboxes or cabinets to organize them. Battery-powered tools need charging stations. A vacuum is needed wherever there are cutting tools. Some equipment has safety considerations, such as fire extinguishers, air filters or eye shields. First aid kits should always be well stocked and at hand throughout the space.

In addition there is maintenance. Filters get dirty, alignments need to be recalibrated, blades become dull, and sometimes things break. Welders use wire and/or gas. A laser cutter's tube will need to be recharged. 3D printers need filament. Be sure to budget for this when acquiring your equipment. It may be worth looking into maintenance contracts for more expensive tools such as laser cutters and mills.

We have developed a list of tools and materials that we've used to help stock up some schools' Makerspaces. Our tool list, below, appears with more detail in the Resources section at the end of the playbook.

## Reusable Tools List

JOINING
- staple gun
- hot glue gun
- hot glue gun
- pop riveter
- box rivets
- big sewing needles
- paint brushes (1" and 3")
- straight pins
- splice set
- tap and die (SAE + Metric)

MECHANICAL
- screwdriver set (precision)
- screwdriver set (big)
- allen (SAE + metric)
- claw hammer
- mallet
- combination wrench
- ratchet set
- joint pliers (channel locks)
- miter box
- PVC pipe cutter
- socket set
- driver bits
- hollow-shaft nut drivers

ELECTRONICS
- Arduino
- LilyPad
- soldering iron
- soldering tips
- crimper tool
- wire cutter
- wire stripper
- diagonal cutter
- solder sucker
- digital multimeter
- solder tip tinner
- 1/2 size breadboard
- third hand
- tweezers
- solder
- heat gun

CUTTING
- hole saw
- metal file(s)
- file card
- chisel/rasp set
- tin snips
- box knives
- X-acto knife
- scissors
- drill bits
- sanding block
- hacksaw
- wood-saw
- block plane
- deburring tool
- countersink
- awl
- cutting mat
- hand-crank (rotary) craft drill

FIXTURING
- vise
- C-clamps
- bar clamps
- needlenose
- locking pliers
- adjustable wrench
- binder clips
- locking pliers

BATTERIES / POWER
- AA NiMH and charger
- AA NiMH
- 9V battery clip
- 4 AA battery holder
- 3 AA battery holder
- 2 AA battery holder
- alligator clips

TEXTILE/SOFT CIRCUIT
- Fabric scissors
- pinking shears
- seam ripper
- cloth tape measure
- sewing needles
- iron
- embroidery needles
- needle threader
- snap setter
- Serger

STORAGE TOOLS
- containers
- labels
- camera
- broom
- dust pan and broom
- Shop Vac

POWER TOOLS
- jigsaw (electric)
- sewing machine
- drill
- extension cord
- Dremel

EXTENSION
- 3D printer
- CNC mill
- laser cutter
- circular saw
- orbital sander
- table saw
- hot wire foam cutter
- plastic bender

ETC
- tool box
- workbench
- saw horses
- CNC router

## Strategies for Stocking Up

Few spaces can afford to buy all the equipment they want, especially at retail price. Used equipment and tool donations can be a big help. Some equipment makers will offer discounts to educational and non-profit groups. Tool rental or leasing is also an option for larger equipment.

Acquire general-use equipment before task-specific tools. Get simple and affordable tools ahead of advanced and expensive ones. Before getting a major piece of equipment, be sure there is a both a need for it and the expertise to use it. There's nothing more lonely than a big expensive tool laying unused because no one knows how to use it.

Third-party services can make up for a lack of some tools. Laser cutting, 3D printing, milling and other services that a smaller space might find hard to afford can be hired out. Or you might be able to work out a deal with your local hackerspace or TechShop to use time on one of their high-end machines until you're ready to purchase one for your space. It's also possible to get pricing breaks if several project teams combine their orders. If you do hire out the fabrication, keep in mind that the price of these tools drop over time, and there's really no substitute for hands-on experience using them.

The more you spend on a tool the more speed, precision and capability you typically get. Computer Numerical Control (CNC) tools provide a way to reliably and precisely reproduce items. Additionally laser cutters and 3D printers provide quick and precise fabrication that is difficult or impossible with non-computerized tools.

Makerspaces have taken a few different approaches to equipping their shops:

- **Find an advocate with a wallet**. Sometimes, you can stock a shop using funding from a foundation or a local corporation who shares your vision for a new kind of shop facility for kids. Our Resources section has a sample proposal and budget to submit.
- **Beg and borrow**. Do a tool drive in your community. Your neighbors may have some of the tools you need and be happy to share these with a new generation of Makers. You may also be able to find Makers or other Makerspaces that are near enough to you that they'd be willing to loan you a hard-to-find tool for a single use. And don't forget to check to see if your community happens to have a "tool library", where you can check out tools the way you can check out books.
- **Buy used**. Tools, especially power tools, have very long lifetimes, so buying used expensive tools can save you 50% or more on cost with little or no loss of functionality or quality. Keep your eyes open on sites like Craigslist for hobbyists' estate sales and fabricators who are liquidating their shops. And this is an environmentally friendly approach. (Reduce, reuse, recycle, right?)
- **Lure kids in with the latest and greatest**. Sometimes, having just one hot new machine to give your students a glimpse of a fab-friendly future world can open their minds to new possibilities in their projects. They may not know what to make on a MakerBot, but the experience of using one may transform their thinking.
- **Just-in-time purchasing**. You don't have to have a fully equipped shop to get started. It can be very effective to wait to purchase a new tool only when a project comes along that needs it.
- **Wait for critical mass**, and for prices to come down. You will surely feel frustrated when your $3000 machine is superseded by more powerful, smaller, cheaper cousins rolling off the manufacturing floors, unless you know that you got $3000 of use out of it before it started collecting dust in some forgotten corner of your Makerspace. If a project "needs" to use a laser-cutter, you might find that it's more economical to rent time on one or send your digital files out to a service that can create the part for you. Once there's momentum and you see that your members really can't create their projects without that tool or machine, you have some great anecdotes and visuals to support your claim that you need it as you fundraise to buy one.
- **Build out your capacity modularly.** We cover this in the next section.

## Modular build-out and Makerspace "levels"

Because the Maker movement takes such an interdisciplinary approach, it's certainly tempting to enable every kind of making in your Makerspace right off the bat. Or you could concentrate on one or two kinds of making and stock up on the tools and materials you'd need for your students to delve into projects very deeply with the most sophisticated tools.

You could choose to have a few simple tools for some kinds of making, keeping the capacity at a "basic" level there while building out another area of making to a level that might be considered "intermediate" or "advanced." We define *basic* as relatively low-cost while still useful and easy to use, while "intermediate" tools and materials add more capability to the Makerspace, allowing makers to create more ambitious projects and work with more materials with greater precision.

In the companion document *High School Makerspace Tools & Materials* we define several different modules, and each section contains checklists in two categories, and these constitute the bulk of each section. Checklists include the common name of each tool, general pricing information, and when necessary, a more specific description and web link to an example.

- **Tools & Equipment** — including Safety, Accessories, and Consumables related to those tools
- **Materials & Parts** — the actual "stuff" that will be used by the students in their projects, that you want to have on hand.

The modules defined in *High School Makerspace Tools & Materials* cover eight areas:

- Workspace
- General tools commonly used on a wide range of projects
- Woodworking
- Metalworking
- Electronics (from basic circuit design to microcontrollers, robotics, and other electromechanisms)
- Textiles (all flexible materials such as cloth, vinyl, leather, rope and string, including soft circuits and wearable electronics)
- Computers (hardware and software necessary for planning, design and fabrication)
- Digital Fabrication
    - 3D Printing (additive manufacturing to build up detailed, complex objects)
    - Laser Cutting (cut and etch materials quickly and with high precision)
    - Computer Numerical Controlled (CNC) (accurately cut & sculpt various materials.)

## Materials Inventory and Maintenance

Tools aren't much use without something to transform with them. Of course, you need materials! Get materials everywhere: the nearest street corner to the local home center; attics to eBay. Many spaces reserve areas for used, scavenged, contributed, and cast-off materials. It is up to each space to determine how much of each material to have on hand.

We have developed a list of tools and materials that we've used to help stock up some of the schools participating in the Makerspace program. Our consumable materials list, below, appears with more detail in the Resources section at the end of the playbook.

### Consumable Materials List

ADHESIVES
- wood glue
- white glue
- epoxy
- hot glue sticks
- super glue (CA) medium + debond
- CA glue thin
- spray adhesive
- PVC cement

TAPE
- packing tape
- paper Kraft tape 2"
- electrical tape
- duct tape
- masking tape
- scotch tape
- blue painter's tape

ELECTRONICS
- conductive thread 2ply
- conductive thread 4ply
- breadboarding pins
- batteries AA
- batteries 9V
- 9V battery snaps
- battery holders
- heat shrink tubing
- breadboards
- resistors
- switches
- buzzers
- motors
- photoresistors
- jumper wires
- wire
- crimps
- beeswax
- LEDs
- batteries

WOOD
- 2"x4"x96" wood
- 4'x8' 1/4" plywood
- balsa wood

FLUIDS
- small plastic syringe
- plastic tubing
- Luer connectors
- 1-way valve
- T-connector

HARDWARE
- hack saw blades
- jig saw blades
- jewelers' saw blades + lubricant
- X-acto and utility knife blades
- lubricant
- acid brushes
- popsicle sticks
- paper mixing cups (Solo)
- plastic mixing cups (medicine)
- toothpicks
- caliper battery

ABRASIVES
- sandpaper (80/200/400/600)
- sandpaper (80/200/400/600)

FASTENERS
- fasteners (screws, nails, etc.)
- staple gun staples
- pop rivets
- Mr. McGroovy's Box Rivets
- zip tie assortment
- binder clips

TEXTILES
- thread
- adhesive tape
- sewing machine needles
- felt
- fabric
- sewable battery holder
- snaps
- bobbins
- metal beads
- plastic beads

FIRST AID KIT
- gloves
- dust masks
- safety glasses

MISC
- Shapelock (or Instamorph)
- Nichrome wire
- string
- rope

A retention policy, such as "first in, last out", or 6-month expiration dates, keep contributed materials from piling up. Segregate project storage to prevent the accidental dismantling of someone's project.

For things that aren't available at local suppliers, consolidate online orders to get bulk discounts and save on shipping costs. Some spaces keep an order form on a clipboard for members to log what they need bought on the next hardware store run.

Organization and maintenance can be very time-consuming and cause burnout. Be careful not to be sucked into it all by yourself! Require users to do their part in maintaining the stockroom. Delegate the task of doing inventory and sorting unused items that have been left behind to a someone you trust (who knows what's what!) or to a knowledgeable volunteer. Or organize an occasional community cleanup to take care of the background maintenance that may not be done on a day-to-day basis.

# 4

# Safety

No matter how you equip your shop, it's likely that if you are doing anything interesting with your members there are some risks involved. Be sure to emphasize safety to the members of your Makerspace. Learning how to use a tool isn't all that helpful unless you also learn all the risks and precautions you have to take in order to come out of your project build with all your eyes, ears, fingers, and limbs intact.

It's a fine line, though, between informing kids about the potential dangers and scaring them from ever using any interesting tools! While accidents happen when the proper steps aren't taken, many millions, perhaps billions, of people make with dangerous equipment every day without incident. Our goal is to make safety second nature for kids, so that they feel at ease when they use the tools because they know they have protected themselves and prepared as much as they could before lifting the tool or clicking its power switch.

It doesn't take much to cause permanent disability. The more powerful and more complex the tool, the more damage it can cause, and the faster it can cause it. While we all hope the worst doesn't happen, you and your students must be aware of the danger and prepare.

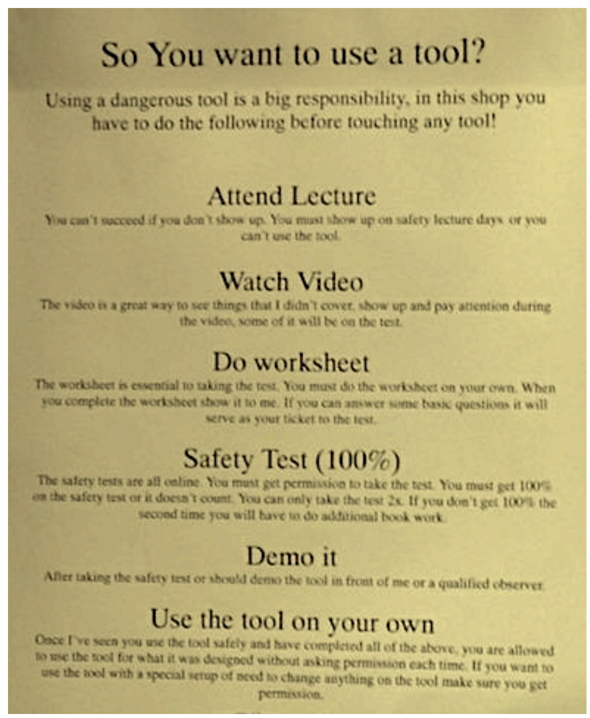
Consider creating a "Maker mantra" that covers potential risks in your shop, that your Makerspace can chant as you get started with each build session.

Perhaps something like:

*Protect. Double-check. Aim away.*
*Clamp it. Focus. Never play.*

## Planning for Safety

Stimulating a culture of safety can dramatically cut down on shop mishaps as members are encouraged members to watch out for the safety of each other and respect the equipment. You can accomplish this by modeling safe behavior in your own actions and in how you set up the space, setting up a strict training regimen, and posting signs and checklists.




Makerspace users of all ages need to be trained in safely operating tools before using them. And they also need reminders. In Hillel Posner's woodshop in Pittsburg, California, he has a multi-step process for being certified on a machine before the student is able to use it independently. Then he also posts a sign on each machine to explain its ideal application and some key safety guidelines.


Cleaning up is not just a measure of respect for the workspace, it also removes hazards. Plan to easily and regularly remove trash and debris. Enforce a strict cleanup policy throughout the workspace. Keep work areas tidy as well by minimizing the number of wires running around. Extension cords quickly become tripping hazards, and power strips also cause trouble on the ground or as they tumble erratically on a desktop. We suggest you provide access to grounded outlets all along the perimeter of the room and/or dropped from the ceiling for each workbench.

Tools need to have enough space to be operated safely and not endanger the operator or other people in the space. People need to concentrate when trying new tools, especially ones that can injure. Make sure there is enough real estate to use a tool safely. Work areas need to be well lit and clean. Ventilation and/or air filtering is required for many tools.

The equipment itself needs to be as safe as possible. Tools should be well maintained and not have safety features removed or defeated. This is especially important when using second-hand tools that might not have a perfectly safe heritage. When acquiring new tools consider spending the extra money on models with advanced safety features, such as a SawStop table saw.

Make well-stocked first-aid kits visible and easily accessible throughout your space. Post clear and visible warning signs on all equipment and where necessary.

Provide personal safety equipment such as goggles, earplugs, gloves, etc. to those who don't have their own.

Accidents may happen. They probably will, and let's hope they are all minor. Nonetheless, do make sure that there is a legal entity that owns the space so that the effects of a serious injury don't extend the horror with legal ramifications. If you house the Makerspace at a school, the district's coverage would likely suffice. If there's no legal entity, we suggest you form an LLC or a corporation to shield individual members from any liability.

## Common Rules

It seems like every teacher writes their own rules, often adapting someone else's rules to the idiosyncrasies of his or her own space, and adding more as they go along (and students reveal new rules that need to be written!) Rules work best when they are in your own voice, as you'll be repeating them often.

William Gurstelle wrote a piece called "The Safe Workshop: Rules to make by" for our 2011 Ultimate Workshop and Tool Guide, and we've included the text in Chapter 12, Resources.


Common safety rules we've seen posted in shops and other making classrooms are listed on the next page.

# Common Makerspace / Workshop Rules

**The emergency phone number is**

# 9-1-1

*(or describe your emergency procedure here.)*

**Report all injuries.**

- Do not attempt to remove foreign objects from the eye or body.
- If chemicals get in the eye(s), wash eye(s) for 15 minutes in an open flow of water before proceeding for medical treatment.

**Use protective gear. Dress right.**

- Wear eye protection: safety glasses with side shields, goggles, or face shields at all times, whether working or not!!
- Do not wear loose-fitting clothing around moving or rotating machinery.
- Remove ties, jewelry, gloves, etc. especially around moving or rotating machinery.
- Tie back or cover long hair to keep it away from moving machinery.
- Wear only shoes that cover the entire foot, no open-toe shoes or sandals.
- Wear suitable gloves when handling hot objects, glass, or sharp-edged items.
- Wear appropriate clothing for the job (i.e., do not wear short sleeve shirts or short pants when welding).

**Prepare.**

- Safety is your top priority when using the shop. If you are not sure what you are doing, ask.
- Know all the locations of all first aid, fire, and safety equipment.
- Never use a tool unless you've been trained to use it safely.
- Never work alone when using power tools. Two persons must be present and be able to see one another.
- Sign in before using any equipment.
- Do not work in the shop if tired, or in a hurry.
- Do not fool around, startle, or distract anyone (not even with a conversation) while either one of you is using a tool.
- Think through the entire job before starting. Prepare prints or drawings with all dimensions and specifications prior to using machines.

**Use tools right.**

- Use tools only as they were designed to be used. (A wrench is not a hammer.)
- Never use a broken tool.
- Report any broken tools or machines immediately.
- Do not remove tools from the room.
- Never walk away from a tool that is still on.
- A hard hammer should not be used to strike a hardened tool or any machine part. Use a soft-faced hammer.
- Operate machines only with all required guards and shields in place.

**Clean up.**

- Clean up every time whenever you leave an area, including sweeping the floor.
- Clean and return all tools to where you got them.
- Use compressed air sparingly; never aim it at another person or use it to clean hair or clothes.
- Shut off and unplug machines when cleaning, repairing, or oiling.
- Never use a rag near moving machinery.
- Use a brush, hook, or a special tool to remove chips, shavings, etc. from the work area. Never use the hands.
- Keep fingers clear of the point of operation of machines by using special tools or devices, such as, push sticks, hooks, pliers, etc.
- Keep the floor around machines clean, dry, and free from trip hazards. Do not allow chips to accumulate.
- Mop up spills immediately and put a chair or cone over them if they are wet enough to cause someone to slip.

## Specific Safety Guidelines

Tools are safe when used responsibly. But even simple hand tools can cause accidental scrapes, cuts, and pinches. Hammers can crush or produce flying debris. Here are some other more specific safety guidelines often connected to certain kinds of tools.

- **Flying objects.** Safety glasses should be worn at all times in the shop, especially while working near hammers and power tools to protect eyes from flying debris. Enforce eye protection while members solder.
- **Invisible dangers.** Safety doesn't only mean avoiding gushing blood. Foster good habits of consumerism by encouraging your students to choose materials with full knowledge of the potential long-term effects of their use. For example, never use a laser cutter to cut PVC or other chlorinated plastics. Lexan and PC board are also strongly discouraged. PVC gives off chlorine gas, which is dangerous for any nearby people and also highly corrosive to the machine. Many shipments are accompanied by a material safety data sheet (MSDS), and if they aren't, then these are usually accessible online.
- **The air you breathe.** Respirators (masks) should also be worn when sanding with either a power sander or by hand. Any kind of soldering generates fumes from the rosin core of the solder so the area should be ventilated. Under normal soldering conditions, solder containing lead poses no health risk, though makers should be encouraged to wash their hands after a long period of handling leaded solder. Lead-free solder is available but less recommended because the rosin gives off much more toxic fumes when soldering, is more corrosive to soldering tips, requires higher temperatures to solder with, and is generally harder to work with.
- **Note the name: "power" tools.** They are powerful. Some power tools are heavy and should be not be used by makers who don't have the strength to control the tool well. Power tools can grab anything that dangles near them. When using any power tool long hair should be tied up, and loose clothes and jewelry should be secured.
- **Multiple risks.** Electric saws have high-power moving blades that can quickly cause traumatic injuries. However the chance of injury is small when properly maintained and used with care and attention. In addition to safety glasses, respirators (masks) and earplugs should be worn during use of electric saws.
- **Fire**. Heat guns and handheld torches can generate fires if used without proper attention to the work and surrounding areas.
- **Burns**. Make sure there's cool running water nearby for burns. Use the lower-heat glue guns when possible. The tip of a soldering iron heats to about 400°F, hot enough to cause burns. It should be handled attentively. Steam irons (used in sewing) do get hot enough to cause burns.
- **Sewing** can cause a small prick from a needle, but sewing machines and sergers both have enough power to put a needle through a finger when used carelessly. Sergers also have blades that can cut a careless finger.
- **Metalwork** areas need welding screens or curtains to prevent eye damage in passersby. Visors should be worn while welding.

## Safety Plans

Makers who display, operate, or use any items that pose a danger to others — such as fire (including all heat-producing or open-flame devices, candles, lamps, etc.), explosions, internal combustion, flammable liquids, compressed gases, hazardous chemicals, launches, sharp or otherwise dangerous materials or tools — will have to explain what they'll do to keep others safe when they exhibit their project to others. Whether or not your showcase event will require a written Safety Plan, creating one is a wise habit to establish among your students. We've included a template for a Safety Plan in the Resources chapter.

Safety plans make you and your students more confident that you are all aware of the foreseeable risks, considered possible consequences, and have taken all the precautions you could to ensure everyone's safety.

Maker Faire requires safety plans for any projects that would display, operate, or use any of these:

- Lamps and other heat-producing devices including hot glue guns
- Open flames, burners, candles, etc.
- Internal-combustion engines
- Flammable liquids, compressed gases, or dangerous chemicals including propane and helium
- Any potentially hazardous electrical / mechanical device or chemical / biological substance

Safety plans typically include a description of the exhibit or demonstration, the names, qualifications and previous experience of people working the exhibit, a description of general safety precautions, and the emergency plan. If the project includes fire, the safety plan should also describe the fuel source, how much is onsite, where and how it is stored, how much is burning and in what amount of time it burns, and if the valve has an electronic propane sniffer.

By the way, there's usually a different process for people who plan to serve food to people they don't know (the public), which involves getting a city permit.

# 5

# Roles

In a Makerspace, with students following their own passions and designing dozens of different kinds of projects, the old way of running a classroom just doesn't work anymore. In this chapter, we describe the new roles we see emerging in Makerspaces: what to expect of the teacher, students, and possibly others.

Nobody who uses the space needs to be an expert, not even the teacher. The most important thing is to have a passion for and a curiosity about making in many different forms. Once you establish safety and basic competency, members can teach themselves what they need to know.

We find that projects that a member is passionate about are one of the best motivators for learning. Students and mentors can tap online resources, or access the expertise and know-how of the local community and other members to fulfill that passion. Skills can be brought, taught, or bought.

## A New Kind of Teacher

With 5–40 students in a Makerspace at the same time all doing different things, it's time to throw out a number of the rules-of-thumb you may have learned as you trained to be a teacher. Hang onto all your good habits, get rid of the bad, and introduce some new ways of running this new kind of classroom. Time for a different brand of leadership! You may want to use these metaphors as you adopt your new persona:

- ***The Project Manager***. We borrow the project manager metaphor from the design industry. It's usually used for large-scale projects where a large team works together to attain a shared goal. The project manager oversees the team and a project's plans, risks, schedules, budget, and conflicts. A project manager knows how to create objectives that are clear and reachable. They define requirements and make judgment calls about budget, timeline, project scope, and desired outcomes. They also give feedback on quality of work done by their team.
- ***The Principal Investigator*** (or PI) While college lectures are often passive, university labs and research are usually richly active. Think of a Makerspace teacher in the role of a PI, the head of a research lab. Graduate students collaborate with one another and with their advisors while pursuing research that is usually based on their own interests and expertise, towards what they want to learn. Professors check in regularly with their students to give them advice and feedback. Similarly, in Makerspaces the students are learning from and consulting with the teacher and with one another while pursuing projects that are generally of their own design.
- ***The Coach***. Good coaching can be as hard to come by as good teaching. It requires a certain economy of talk and limited praise with a lot of thought going into how to convey lot of information with minimal interaction, i.e., giving feedback without riding the players too much. The best coaches learn what works well with their players and improve their "curriculum" and technique from season to season. (Read more about coaching in Gallimore R. & Tharp R. "What a Coach Can Teach a Teacher, 1975-2004: Reflections and Reanalysis of John Wooden's Teaching Practices" *The Sport Psychologist*, 2004, 18, 119-137 Human Kinetics Publishers.)
- ***The Research Librarian***. One teacher described his viewpoint of teaching in a Makerspace, "I don't lead them, I aim them." This resembles the role of a librarian. A librarian listens to a patron's needs, desires, and interests, and then helps connect the

reader with the resources that might satisfy their hunger for knowledge. They bring the library visitors over to the right shelves, pull a few books a little farther off the shelf, suggest some other books or resources that may be of interest, and then go back to their desk to work with another patron. They provide strategies for finding the right materials, and help unlock the powerful search tools that readers can use to find what they want now and in the future.

No matter what metaphor works best for you to help you work effectively in a roomful of divergent projects, there are a few tasks that are chiefly your responsibility as the teacher.

- Recruit students.
- Recruit adults to mentor and/or manage the Makerspace (paid or volunteer).
- Delegate some of your responsibilities to advanced students and adult volunteers.
- Assign or help match mentors to project teams.
- Schedule meetings and group build sessions.
- Engage with other Makerspace teachers to ask and answer questions.
- Stay in touch with the Makerspace core team and participate in surveys and other data collection to help improve the whole community.
- Share documentation collected from students.

## Students

Students in a Makerspace are passionate about do-it-yourself, hands-on projects in a variety of domains. In a Makerspace, their primary job is pretty clear: to make stuff! Getting from nothing to something, though, is where the students gain valuable skills, not just of the mechanics of how to make the thing they want to make, but also in defining and managing their responsibilities.

There are some other more subtle things that all your students must commit to do, and you may want to ask them to agree to these goals as a precondition to using the Makerspace.

- Engage in their own learning and exploration.
- Define a project and work with other students and mentors to exhibit their completed project (or evidence of what they've accomplished to that point) by a preset deadline. be in the areas of technology, art, craft, engineering, music, science, green design, or other Maker themes.
- Use the facilities, tools, and materials in a safe way.
- Alert fellow students, mentors, and/or program leaders when facilities, tools, and materials are being used in a way that could cause harm to themselves or others.
- Come to meetings.
- Apply good time-management and project-planning skills (optional, but very helpful!)
- Give others working on other projects feedback and help make their projects the best they can be, in a positive, creative, dynamic spirit.
- Improve or "plus" projects—only if such feedback is welcomed—with helpful suggestions, tips, and assistance when they see a way other students' projects could benefit from what they have to offer, while respecting their projects.
- Tell program leaders changes they'd make to the Makerspace to improve it for future users.
- Work one-on-one with an expert and/or in groups to design and produce their project. Meet regularly with a team and/or a mentor for design and build time. The amount of time needed varies considerably depending on the project vision.
- Document their projects as they create it.
- Commit to work as a team and to be a part of the Makerspace community.
  *Hint: If use of the Makerspace begins anew each year or semester, or if all users begin at about the same time, kick off your time together by asking them to try generating the rules for using the Makerspace—they might spontaneously come up with many of these on their own.*

You may opt to have students "apply" through a non-competitive application process as part of their application or initiation to your Makerspace. They could to write a short paragraph about why they want to use the space, what kinds of things they have made in the past, or what they'd like to make. Sometimes this helps you sniff out which kids have been signed up for the program involuntarily, such as by a parent, rather than on their own initiative.

If for some reason you're short on students and need to recruit more, these are the kinds of organizations in which other Makerspaces have started, or which we recognize as sharing in our mission.

- Nationally organized groups with local chapters (e.g. 4-H, FIRST Robotics, Girl Scouts, Boy Scouts, Boys & Girls Club, YMCA and YWCA, Intel Computer Clubhouse)
- Schools: public, private, charter, or homeschooling collectives— consider from pre-K to college, especially certain tracks or departments in engineering, art, science, crafts
- Community art centers and art collectives
- Libraries, museums, and science centers
- Master gardening programs, beekeeping clubs, urban greening groups
- LEGO user groups
- Hacker meetups and hackerspaces

For more about working with young people, see our *Maker Club Playbook*, created for the Young Makers program.

## Shop Host / Chief / Coordinator

You have a great space with great equipment, but that's all for nothing if no one knows how to use it and nobody has the job of maintaining equipment and supplies. Every Makerspace needs a manager, which could be the same person as the teacher, or another volunteer or staff person helping coordinate the space and the program. Sometimes, one person serves several roles, so this could be the teacher. But it's a lot of work to do both. At Georgia Tech, the Makerspace is jointly operated by the college students who use it.

The shop host controls access to shop facilities and knows about the usage and safety of tools in the shop. This person should have the same skills outlined for Mentors, as their interactions with the students will likely have a profound effect on the kids' confidence as Makers and continued interest in making.

A school could have a non-certified role of a manager who works with teachers, knows the equipment, does purchasing, etc. This role might be especially critical in a school where the Makerspace is a resource center used by different classes and in different contexts. That is, multiple teachers and multiple classes could use the space: a physics class might use the space for a unit, an afterschool program on robotics might build there. It's not necessary that it be dedicated to just one particular class on making.

Besides managing the space and the fabrication tools, shop hosts should be willing to:

- Work with project groups to help them achieve their project visions.
- Run safety training for all who use the Makerspace; monitor that safety is practiced at all times.
- Help project teams to acquire skills with tools, tool safety, and other aspects of hands-on fabrication.
- Track use of consumable materials, re-order as needed.

## Mentors

A project team might consist of a single student who wants to work alone, or a group of students who have decided to benefit from one another's complementary talents. We feel that either model works best when every project team has a mentor clearly assigned to them.

Mentors are adults who are interested in working with youth and who may be experienced in one or more forms of making. Mentors answer technical questions, address supply issues, pass on their knowledge of tool usage and safety, and help manage realistic project-build schedules. Along the way, mentors might exploit "teachable moments" to explain underlying math, science, and engineering concepts.

You will probably want to find different kinds of mentors. There are those whose curiosity, sense of adventure, project management skills, and positive attitude can help carry young people through the difficulties of a project toward a successful completion (or at least a valiant effort!) Then there are those who have extensive skills in lots of kinds of making, or a deep expertise in one kind of making. Sometimes you can find both modes of mentoring in the same person. You probably need the first kind of mentor as you start the Makerspace, and you'll probably need to match the Makerspace with the expert-at-making mentors as they progress in their projects.

As soon as the students have chosen their projects, they'll probably have questions—how to get started, how to finish before the deadline (that is, how to write a project plan), how to resolve a technical issue. Often Makerspaces tap into their network of the parents and friends of families to serve as mentors for this kind of problem-solving. We find that at this stage especially, the best mentors are curious, patient, and flexible, and they have the skills to find out how to do something.

The role of a mentor is to help one or more project teams find a *project vision* if they don't already have one, and then to help them realize that vision for *exhibition* at Maker Faire. Along the way, we encourage mentors to exploit the *teachable moments* that naturally occur during making to expose the underlying math, science, and engineering principles involved. But they aren't teachers so much as guides. We also expect mentors to pass on their knowledge of proper *tool usage and safety*. Finally, an important role for mentors is to demonstrate to Makerspace the importance of *failure as a means to success*. That is, to expect and embrace failure as a normal part of the making process.

It is difficult to be a good mentor. No matter what our age, we appreciate mentors whose facilitation is welcoming and intended to spark interest, provide focus for our attention as needed, strengthen our individual understanding and clarify our intentions through reflective conversation. We like how the **Exploratorium's Tinkering Studio** describes facilitation and activities in its design principles:

*Facilitation: Principles that inform the interaction between staff and museum visitors*

- *The facilitation is welcoming and intended to spark interest.*
- *Facilitators try to focus visitor attention, based on individual paths of understanding.*
- *Facilitation should strengthen understanding by helping learners clarify their intentions through reflective conversation.*

*Activity Design: Thoughtful approaches to interacting* *with materials, tools, and technologies.*

- *Activities and investigations build on visitors' prior interests and knowledge.*
- *Materials & phenomena are evocative and invite inquiry.*
- *STEM education is a means, not an end in itself.*
- *Multiple pathways are readily available.*
- *Activities and investigations encourage learners to complexify their thinking over time.*

The Intel Computer Clubhouse has invited mentors to support the creative projects of young people since 1995. They define the role as a "balancing act [of] being aware of the complexity of your role as both a knowledgeable guide and a friendly partner.... Although mentors wear many different hats, the primary goal of a mentor is to guide and support—rather than direct or teach." In Clubhouses, much like in a Makerspace, a mentor could be an observer, guide, resource, role model, active participant, catalyst, or friend. For more of the Clubhouse's Tips for Mentors, see Resources at the end of this playbook.

While there is no simple recipe for how to mentor, mentors will be most effective if they think like Makers: staying curious, interested, respectful. Mentors should always focus on the students' interests, not their own, but they can share what they love to do so that the students can see that mentors are passionate about Making too. Mentors should try not to lecture, but instead ask questions and model habits of mind that will help your students discover answers on their own (even if, in the end, this takes longer than just answering their questions or doing the work for them!) Good mentors encourage students to support one another and help each other with the problems they face to build community within your Makerspace. They are ready to learn from the kids.

Mentors should be willing to:

- Work one-on-one with students or in groups of up to 4 members, or with one or more project groups to develop projects to meet their milestones and final deadline.
- Give project feedback and help make projects the best they can be, in a positive, creative, dynamic spirit.
- Exploit the "teachable moments" that naturally occur during making to expose underlying math, science, and engineering concepts in an inspiring and engaging manner.
- Attend meetings as scheduled.
- Identify students who might need extra support or encouragement.
- Provide general help to students.
- Offer encouragement to students.
- Offer specific guidance or workshops in areas of expertise, if applicable, in technology, art, craft, engineering, music, science, green design, and other Maker themes, or demonstrate the curiosity and commitment necessary to develop such skills
- Help organize logistics for projects.
- Bring any serious concerns/issues to the attention of the teacher.
- Engage in their own learning and exploration.
- Provide some technical support of project documentation (video, photos, sketchbook, lab notebook, blog) if needed.
- Establish contacts to obtain in-kind donations, sustain member projects, and to give members and mentors possible tips and resources.
- Model and pass along good time-management and project-planning skills (these are very helpful!)
- Experience meeting new people and sharing ideas (i.e. they may not be a good fit if they consider themselves "shy")
- Commit to work as a team and to be a part of Makerspace community
- Desire to support the Makerspace philosophy
- Help young people build skills and confidence

## Recruiting Mentors

If you're an experienced Maker and have lots of Maker friends, you already have a source of mentors. Other places to look for mentors are neighbors who are handy with tools. Don't forget to think about retirees (older men and women too) who might be looking for ways to give back to the community. They often have significant hands-on experience. If you're having trouble finding mentors, let us know. We may be able to help.

Once you get past those initial questions, however, even with the best mentors you may need to find some specialized expertise. Mentors don't need to possess all the skills and knowledge that might be needed to complete a project — they just need to be willing to try to find those who do, or to learn alongside the student. Or this can mean active outreach to identify and draw in talent from the community. That piece is a little bit like community organizing.

*Tip: At the end of the chapter on Projects we list community resources that may be a source for mentor recruitment.*

By the way, parents provide invaluable help! Parents should be encouraged to participate, as mentors, managers, or shop hosts, or as general volunteers willing to support the Makerspace in whatever ways are necessary.

# 6

# Practices

Much of what we've shared up to this point covers how one can set up a Makerspace. You can find a space, acquire tools and materials, and recruit students, but we will not have succeeded unless we are able to foster a Maker mindset.

Carol Dweck, a Stanford psychology professor, has written a book called *Mindset* that distinguishes between people with a fixed or growth mindset. A person with a fixed mindset tends to believe that his or her capabilities are set, as though these abilities were out of their control. A person with a growth mindset tends to believe that one's capabilities can be developed, improved and expanded. A person with a growth mindset tolerates risk and failure while a person with a fixed mindset avoids it and the accompanying frustration. It is obvious which kind of mindset helps a person adapt to and contribute to a world that is constantly changing. Dweck points out that many who do well academically have a fixed mindset that limits them to explore only the areas that they were told they were good at. Conversely, many who do poorly in school have taken too seriously the judgment of others about their ability in subjects like math or science. In both cases, such limiting views of oneself are self-defeating and can hold us back from exploring new areas and developing unknown capabilities. Making is about developing one's full potential.

Dweck's growth mindset maps very well to the maker mindset, which is a can-do mindset that can be summarized as "what can you do with what you know." It is an invitation to take ideas and turn them into various kinds of reality. It is the process of iterating a project to improve it. It is a chance to participate in communities of makers of all ages by sharing your work and expertise. Making is a social experience, built around relationships.

Fostering the maker mindset is a fundamentally human project – to support the growth and development of another person, not just physically but mentally and emotionally. It should focus on the whole person because any truly creative enterprise requires all of us, not just some part. It should also be rooted in the kind of sharing of knowledge and skills that humans do best face to face.

One might reasonably fear that making will be reduced to another failed approach at reform. Making can be described as "project-based learning" or "hands-on learning," yet doing projects and working your hands is only what making looks like, not what it is. In his book on education, *To Understand is to Invent*, Jean Piaget wrote that educators should "lead the child to construct for himself the tools that will transform him from the inside – that is, in a real sense, and not just on the surface." That kind of transformation, that kind of personal and social change is what making is about.

### Our Challenge

Education happens everywhere. Learning happens in our community, not just on campus. Our current education system struggles to tap the resources available in the community, yet our culture is richer with information and opportunities than ever before.

Changes in technology over the past few decades have led to a shift toward more focus on the individual and a move away from decentralization in many parts of our lives. Big city newspapers to bloggers. Large-scale manufacturing to personal fabrication. A handful of Hollywood studios and television networks to millions, perhaps billions, of online "amateur" video options. Lobbyists in Washington to grassroots, Internet-based political financing. Factory farming to slow food eaten by localvores. A vast power infrastructure to living off the grid with solar panels and windmills. We can produce and consume as *individuals* within a networked community in all these areas.

The glaring exception to this is in how we teach our kids. Somehow, we've allowed education to become increasingly centralized, where we let public officials say that children will be pumped out of the school machine at age 18 knowing the same facts and gaining all the same skills. Learning standards reflect the uniform expectations our governmental agencies have of all children of a certain age. Teachers are preparing them for a world that none of us want to live in, and one that doesn't exist anymore. We know that all kids are individuals, and yet in schooling, our public officials and administrators expect them all to be the same. Arguably, the diversity of educational options was greater two centuries ago than it is now.

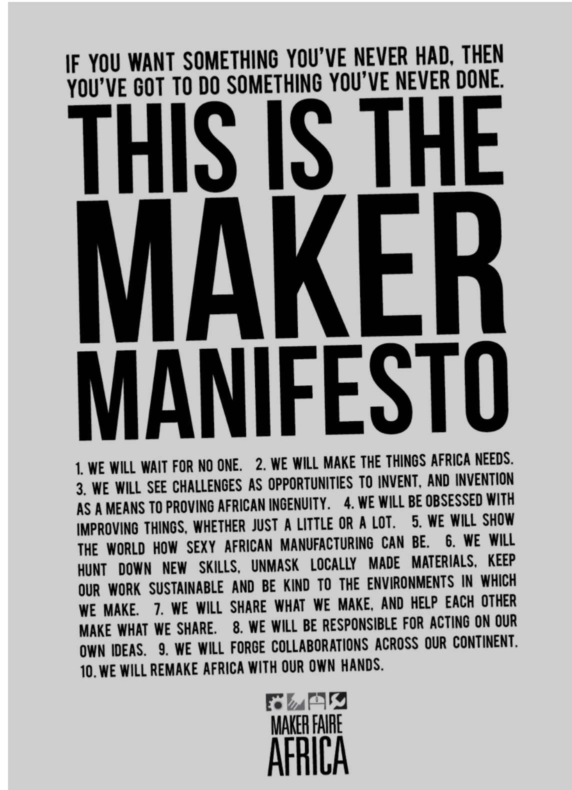
Our kids can be learning more efficiently—and as individuals. We imagine that schools can become places where students learn to identify their own challenges, solve new problems, motivate themselves to complete a project, engage in difficult tasks, work together, inspire others, and give advice and guidance to their peers. We see all that happening already in the Maker community. And, increasingly, we recognize there is a real hunger for the resources and infrastructure for kids and adults to be spending more time making, too.

We're working to support that hunger for making in several ways. Makerspace is one initiative. Through it, Young Makers (a club-based program), and other efforts, we seek to develop self-motivated, self-directed learners. We aim to help the youth of our nation regain the spirit of innovation, ingenuity, and curiosity that has been dormant until recently.

State-of-the-art technology has changed the way we make and also how we learn. In the 21st-century classroom, we can better enable, motivate, and inspire all students—regardless of background, languages, or disabilities—to achieve as never before.

Part of our goal with Makerspace is to help teachers match what and how we teach with what people need to know, how they learn, where and when they will learn, and who needs to learn. We hope to leverage the power of technology to provide personalized learning instead of a one-size-fits-all curriculum, pace of teaching, and instructional practices.

When running a Makerspace or a class that uses a Makerspace, you may find it daunting to stay ahead of your students. Let it go. The most important thing to know is how to help your kids find answers and connect with expertise. That's not always so simple, either, but just be reassured that nobody expects you to be an expert in everything.




## A Makerspace Manifesto

Part of having your students be a part of a Makerspace is to invite them to participate in the Maker movement and adapt some of the liberating philosophy many Makers share. This is illustrated in the Maker Manifesto put together by Maker Faire Africa, right. But what would we put in a Makerspace Manifesto?

There are a few fundamental understandings that we'd want any student participating in a Makerspace to come away with:

- Everyone is a Maker.
- Our world is what we make it.
- If you can imagine it, you can make it.
- If you can't open it, you don't own it.
- We share what we make, and help each other make what we share.
- We see ourselves as more than consumers—we are productive; we are creative.
- Makers ask, "What can I do with what I know?"
- Makers seek out opportunities to learn to do new things, especially through hands-on, DIY (do-it-yourself) interactions.
- The divisions between subjects like math and art and science dissolve when you are making things. Making is an interdisciplinary endeavor.
- It's all right if you fail, as long as you use it as an opportunity to learn and to make something better.
- We're not about winners and losers. We're about everyone making things better.

- We help one another do better. Be open, inclusive, encouraging and generous in spirit.
- We celebrate other Makers — what they make, how they make it and the enthusiasm and passion that drives them.

One note on that first point: "Everyone is a Maker." Everything we do is an act of creation, and our use of tools to transform our environment is what distinguishes us the most from other species (usually for positive effect, one would hope!) And so some have suggested that we call our species *Homo faber,* the creative people, instead of *Homo sapiens,* the thinking people.

### From Personal to Social: DIY and DIT

The 2010 President's Council of Advisors on Science and Technology Report states that "the problem is not just a lack of *proficiency* among American students; there is also a lack of *interest* in STEM fields among many students." When students and teachers develop personal connections with the ideas and excitement of STEM fields, their learning is most successful.

We often use the phrase "DIY movement" as a synonym for the "Maker movement", but we find that "doing it together" is a lot better than DIY, doing it yourself. Making begins as something very personal, because it starts with your own interests. Those interests and your work connect you to other people, and so it is also very social. We'd like to celebrate each Maker's initiative and creative inspiration within that collaborative context. **Saul Griffith wrote about this topic** in MAKE Magazine.

While we feel that community collaboration is a critical piece of any Makerspace, we also want to avoid the pitfalls of doing it together. School is too often simply about doing things together. We all take the same subject, taught to us as a group and assessed the same way. A lot of hands-on learning is pushed out for everyone to do the same thing. It's not personalized. Collaboration is a good thing but we're also interested in how personal engagement drives us and connects us to a community.

**Teacher tip:**
**Model muddling.**

Use your own downtime well. Your services may not be required every moment that you are working in your Makerspace. It's OK to feel superfluous sometimes — hopefully that means the kids are perfectly engaged with their work. You can sit back and watch for opportunities to point out something interesting (those teachable moments), or you can work on your own project alongside the students, either making something or picking up a new skill. (Just be sure you seem open to interruption!) The students might learn something by seeing you plan out your project, muddle through a problem, or struggle with a new tool. You can also use this time to get to know your students better by just chatting about things that might not have anything to do with Making.

### Community Initiation

Having a beginning, middle, and end to using the Makerspace adds a bit of "ritual" to your students' experience and will pay off in more enthusiasm from your Makerspace users and in continued participation from year to year. Start with some low-key initiations.

For example, you can ensure that every Maker who'll use your space has something like a Maker's **Notebook** where they can start jotting notes, making sketches and diagrams, and capturing things they find inspiring. Encourage your student(s) to keep this notebook for jotting down their ideas. Paper is low-tech and affordable by all. Graph paper is a useful tool for discussions of physical scale: OK, you want to build that... say one square represents six inches... draw how big you imagine it. (Or one square represents one decimeter... let's talk about the potential benefits of metric units.) Ideally, the notebook would have rings or a pocket for inserts, pages printed from a computer, etc. A notebook is also a useful tool for keeping track of tangential ideas that can't be explored right away for the current project, but may be good fodder for next year.

You might also have users of the space sign an **Agreement** that spells out the things they should expect of their experience and the commitments they've made. See the Resources section for a sample Participation Agreement.

## Plussing as a Community

Pixar uses the term "plussing" to mean finding what's good about an idea and making it even better. We have used the term in the Young Makers program, where plussing sessions provide an opportunity for project teams to share their ideas, progress, challenges, and next steps with the participants in the program on a monthly basis. You can hold plussing sessions in your classroom or Makerspace as well.

Plussing sessions provide...

- a glimpse of the creativity and breadth of ideas of the entire group—teams can see other projects develop through the season.
- a chance for project teams to talk about their failures in a positive and constructive way.
- an opportunity for project teams to practice talking about their projects in advance of exhibiting at Maker Faire.
- a time for participants to get to know each other, helping to build the kind of community and culture we're trying to promote.
- a deadline so that project teams can pace themselves and aren't faced with one huge deadline (Maker Faire) months in the future. In the Young Makers program we held them monthly, but in a Makerspace you can have them as often as suits the pace of your classroom.

We organized plussing sessions to be like small Maker Faires, where half the group shares their work at the same time—with their materials laid out on a table for discussion—as others circulate and ask questions. Then the two groups switch, with the other half staffing their stations, and half circulating. You can also try a show-and-tell format so that everyone can hear about all the projects and give feedback if your students know each other well. (Otherwise, everyone tends to be a little shy, and any adults in the room will end up talking too much!)

Here are a few of the kinds of questions students can ask one another during their plussing sessions:

- What is your project vision? What are you hoping to do?
- What inspired you to pick this project? Why are you doing it?
- Do you know of other people who have done projects that are similar, or is this one-of-a-kind?
- What other project ideas have you toyed with?
- What kinds of projects have you built in the past?
- What do you think the hard parts are going to be? What are the easier parts?

At your first plussing session, members shouldn't worry if they don't have anything to share. There will be time for that over the months you work together. If they have several ideas for a project but haven't yet decided upon one, they might consider briefly describing them all. If they have work in progress, they'll certainly want to bring visuals—photos, sketches, models, artifacts or other materials—to help illustrate or demo their ideas.

Through the Makerspace program we are modeling and sustaining a collaborative culture, and having highly interactive plussing plays a key role in reaching that goal. Admittedly, the adult mentors and volunteers tend to have had the most to say during the Young Makers' plussing sessions. It takes a lot of work to get kids to comment on one another's projects, but it is critical you put the effort into encouraging the kids to plus too.

By the way, the kind of feedback we foster in plussing sessions does not have to happen only in person. We would love to see more online discussions and conversations among Makers, and if you find a good way to get those going within your Makerspace, please share your success stories with us.

## Content: How to Cover a Lot of Ground

Makers cover a wide range of practices and approaches, so teaching a class on making is an ambitious task, to be sure. What we need is a non-linear, electronic, co-editable making textbook to provide a way to navigate the domains, skills, tools, and materials you'd want to touch upon as you introduce your kids to making.

From what we've observed, most teachers like to start the year with some skill builders to help beginner students get up to speed, while more advanced students can brush up on those skills or help their peers feel comfortable. Classes often then move to some more involved, projects in which students can apply some of the skills and concepts that they gained with the introductory skill builders. Finally, they end with students working individually or in teams of two to five pursuing more ambitious projects to exhibit at Maker Faire or another big, showcase event. For a more detailed example of this process, refer to the chapter "A Year of Making" later in the Playbook.

So there are at least three different kinds of projects we imagine happening within a Makerspace:

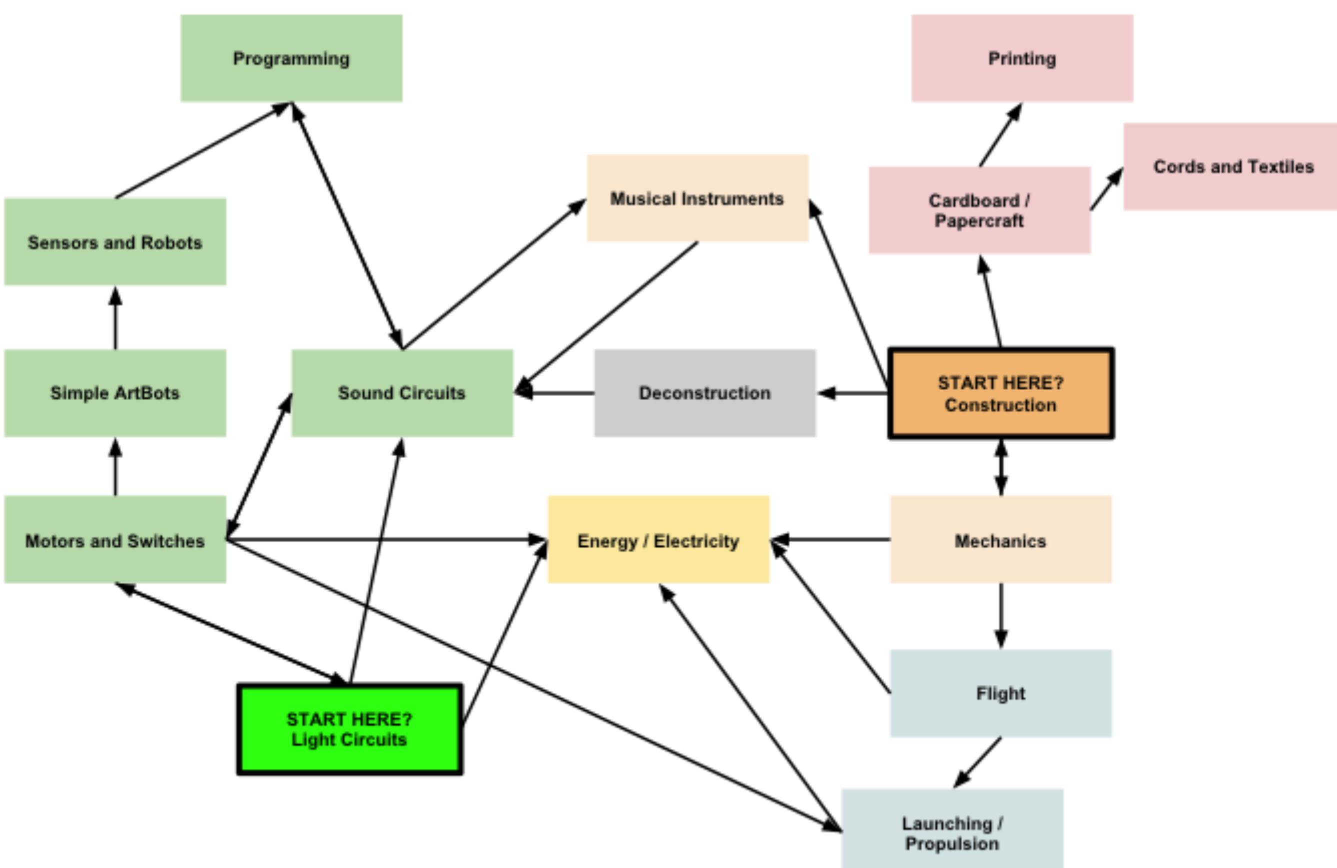
- **Exploratory**: Workshop project sets in skill building; a sampler of a few brief projects that expose students to some of the basics within a given domain.
- **Applied**: More involved, cross-disciplinary projects which may or may not cross domains and ask the students to extend the skills that they acquired in the introductory, skill-building workshops.
- **Portfolio**: ambitious projects largely of the students' own design, made by individuals or teams and exhibited at Maker Faire or another big, showcase event.

We've identified domains that span most of the skills we want kids to familiarize themselves with before they begin on more ambitious projects. Our goal within these domains is to give the students wide exposure and familiarity: an inch deep and a mile wide, before they settle into projects based on their passions.

Our 19 suggested domains are listed at right, and below you can see howsome of the learning paths we imagine can connect one domain to another.

- Light Circuits
- Sound Circuits
- Motors and Switches
- Simple ArtBots
- Sensors and Robots (Interactions)
- Launching / Propulsion (Rockets & Projectiles)
- Flight
- Deconstruction
- Construction
- Musical Instruments
- Cords and Textiles
- Mechanics
- Printing
- Energy / Electricity
- Papercraft / Cardboard Construction
- Programming
- Woodworking / Carpentry
- Architecture
- Soft Circuits / Wearables

## A Course in Making: Learning Paths



You may decide that taking a domain-by-domain approach is not your cup of tea. Here are some other ways to approach giving your students a whirlwind introduction to making:

- **Skills**. Determine the skills you want the students to have, and then find projects that give the students a lot of practice in these: for example, a letter-building project for measuring skills; circuit design for troubleshooting skills; etc.
- **Tools**. You may want to familiarize your students with the operation and safety guidelines for using particular tools. This could mean having all your students learn to use the same handful of tools, or having a few students become the "resident experts" on the use of a particular tool, and then rotating through the class.
- **Materials**. Students can learn a great deal by exploring a material deeply over several meetings. Whether it's a familiar material like fabric, paper, or cardboard, or something that may be novel to them like mylar, electroluminescent wire, shape-memory alloy, many materials lend themselves to experimenting and researching. You can ask all the students to explore one kind of material and compare and contrast what they discovered, or have each student examine a material on their own and then report their discoveries to the class.
- **Multi-Domain Projects**. Projects often cross several disciplines. A chair project at the start of the year is a nice get-to-know-you project, as each Makerspace student ends up with a unique seat to use during class meetings or plussing sessions. The domains covered could include: (1) woodworking: building a wooden chair from a pile of lumber; (2) craft: decorating it; (3) fiber arts: making a pillow to put on its seat. Add soft circuitry for some kind of electronic whoopee cushion to make it a classic Maker project!

Of course, you may find that you'd like to combine several of these modes of inquiry, doing one or two starter projects that focus on domains like alternative energy and musical instruments, then having the students focus on materials. You'll know what would work best for your students. The table below sketches out the lay of the land for making: topics, skills needed, tools and materials Makers use.

| Topics | Skills | Tools | Materials |
|---|---|---|---|
| • alternative energy<br>• animation<br>• architecture<br>• aero/astro<br>• biohacking<br>• crafts<br>• electronics<br>• fashion<br>• fiber arts<br>• fire arts<br>• food / culinary arts<br>• gardening<br>• Halloween / horror<br>• light (LED, EL)<br>• mechanics<br>• microcontrollers<br>• music<br>• musical instruments<br>• papercraft<br>• photography<br>• programming/software<br>• recycling<br>• robots<br>• spying/surveillance<br>• sustainability<br>• toys<br>• vehicles, incl. bicycles<br>• video<br>• water<br>• woodworking/carpentry | *general, cross-disciplinary*<br>• safety<br>• measuring<br>• design<br>• construction<br>• troubleshooting<br>• testing<br>• using instruments (like multimeters)<br>• choosing the right tool<br>• programming<br>• mapping<br>• tracking<br>• reading schematics<br>• following patterns<br>• sketching<br>• documentation<br>• observation (reverse engineering)<br><br>*specific*<br>• woodworking<br>• soldering / welding<br>• sewing by hand<br>• knitting/crochet/knots<br>• molding, casting<br>• interaction design | • scissors, box cutter<br>• sandpaper<br>• hand tools: *saw, screwdriver, hammer, wrench, pliers*<br>• power tools: *drill, orbital sander, jig saw, chop saw, circular saw, table saw, drill press, lathe, belt sander, angle grinder*<br>• sewing machine<br>• breadboard<br>• soldering iron<br>• TIG welder<br>• MIG welder<br>• 2D printers (including presses)<br>• laser cutter<br>• 3D printer<br>• Processing<br>• Scratch<br>• C (esp. for Arduino)<br>• CAD software | • wood<br>• cardboard<br>• fabric<br>• metal<br>• paper<br>• plastics<br>• LEDs<br>• motors<br>• inks, dyes<br>• paints<br>• Arduinos<br>• glue |

# 7

# A Year of Making

***Editor's note:*** *This helpful chapter comes from Aaron Vanderwerff of Lighthouse Community Charter School.*

In describing a year in a making classroom, we envision projects on a spectrum from teacher-led to independent. Students all make the same object, with slight variations, in teacher-led projects. Independent projects are student-led from the concept to the product. Most projects fall somewhere between the two extremes.

For example, some student projects are entirely the students' own vision, some are hybrids of projects they have seen in Make magazine and on the Internet, and some projects are pulled from a website, following the instructions they read online. Students learn different concepts from different types of projects.

***Teacher-led projects*** *teach students...*

- *to be creators, not only consumers.*
- *new skills (hands-on, design, collaborative.)*
- *to have pride in their work.*

More independent, student-visioned projects allow students to see their own idea come to fruition. For many students, this is the first time they have participated in a long-term, open-ended project. This experience mirrors the post-high school world much more closely than a majority of schoolwork. The very process of thinking up an idea and creating it is the major learning goal for independent student projects. This process is not self-evident, and is best learned by going through it multiple times. Each time students complete the design and build process, they gain confidence to complete future projects.

***Independent projects*** *teach students...*

- *to take a concept and turn it into a real prototype, allowing students to experience the full journey of creation (including bumps and difficulties.)*
- *to use resources (mentors, teacher, internet, magazine, etc.) to create a project.*
- *to grow creation skills (sewing, woodworking, programming, circuitry, soldering, etc.)*
- *to explain their project and their creation process to an audience.*

## Year-Long Timeline

- ***August – November***. Students build their skills. They learn C programming using robots and develop basic skills in woodworking, crafting, soldering, and use of Arduino for making. Through this period, they work for two weeks on robotics followed by one week of making skill building.
- ***December – March***: Students develop their own vision for a Maker Faire project and create a first draft of the project to show at a local LCCS Maker Faire (school organized); they continue working on robots. Through this period, students work one day in class each week on making their independent project. The remainder of the time required happens outside of class.
- ***March – May***. Students refine their Maker Faire project for exhibition in San Mateo; they also compete in a robotics competition. Through this period, students continue making in class once a week until mid-April, when they are able to use all class time to finish their project and prepare for exhibiting at the Maker Faire.

## The Class Context

The students participating in making are enrolled in Robotics class, which is in its fourth year at Lighthouse. During that time, students have participated in the regional Botball competition each year. Two years ago, by participating in Young Makers, we added an independent project to the curriculum, which students showcase at the Maker Faire in San Mateo each spring. From August through November, the robotics curriculum supports basic skill development in collaboration, programming, mechanical design, and creation skills (woodworking, soldering, sewing, etc.). The remainder of the year is spent preparing for the Botball competition by running mock competitions using last year's rules and preparing for Maker Faire by working with mentors to hone each small groups' project vision and bring it to fruition. In the spring, all students participate in a robotics competition and take a project to the Maker Faire.

Students in the Robotics class are 11th and 12th graders, low-income, and are usually the first in their families to attend college. The class generally has about 24 students enrolled and runs for 70 minutes four times each week. In the past, most students in the class did not choose to take Robotics and were intimidated by the class at the beginning of the year; this year, however, students have some choice of which science classes they take, but they are ultimately assigned to the class.

The classroom space we use for making is a science lab. We do most 'clean' activities such as soldering, programming, and assembly inside the lab. Outside the lab are picnic tables that we use for 'dirty' activities like woodworking.

The primary purpose of the Robotics class is to give students multiple opportunities to work on long-term, collaborative projects which more closely reflect what students will encounter in college and the work world. The class is designed to expose students to a variety of technical careers and prepare those who are interested in studying technical areas for their post-secondary studies. Making provides an additional component, allowing students to conceive of an idea, try it out, and make it happen. Along the way they fail, change their plan, try it again, fail again, learn from others and try something different. They learn that making a vision reality is not easy, but that it is within their reach.

## PHASE 1
## BUILDING SKILLS

*(1 to 2 weeks per skill, Mid August - End October)*

After having worked with students on independent projects our first year, I decided that I would use fun, interesting, skill-building projects in the beginning of the year to get students more comfortable with the idea of making. Projects were designed to develop skills many student groups needed in order to complete their independent projects. I wanted to expose all students to different types of projects so they would not be intimidated by a specific project because it involved a saw or a sewing machine. These skill-building projects were done between two week robotics projects to maintain student interest. I had students work in same-gender pairs to discourage gender stereotyping of who should be using specific tools. In the end, all students developed some proficiency in all areas.

Our areas of focus were:

- Soldering
- Woodworking
- Crafting
- Using an Arduino and Shield

### Soldering

Working in same-gender teams of two, students assembled **Elenco Soldering Kits**. (Two pairs of students shared a soldering iron, so I needed one soldering iron per 4 students.) The kits have soldering practice areas for students to try before they are assembling electronics they might burn up. They come with step-by-step instructions and a description of the different electronic components. After showing students the basics of soldering, pairs showed me their first few soldering joints, and I was able to give them individual feedback. Throughout the week, I circulated through the class, providing feedback to students and ensuring that all students were participating in soldering. At the end of the week students passed the projects if their kit worked.

Pairs whose projects didn't work had to check for incomplete solders or soldering joints that were bridged. Students struggled to desolder incorrect joints and often delaminated the pad because they would heat it too much. Students whose projects didn't work the first time were given a second kit if the first was beyond repair and had to solder it on their own time.

## Woodworking

Working in same gender teams of two, students built chairs based on the 'stud chair' (*Make* magazine, volume 27, page 122). To complete the project, students learned to use a small circular saw, a hand saw, and a drill. This year, I plan to either use a different plan or use lumber that is already the correct dimension (2"x2"s and 1"x4"s), so that we do not have to use a table saw.

Students started by cutting the 8' - 2"x4" into the proper lengths. Another teacher brought a table saw in to make the rip cuts. He made the cuts during class, showing students how to safely use the tool. Students then assembled the chair, squaring corners, pre-drilling holes, and gluing joints before they screwed the boards together. Keeping all corners square proved to be one of the major difficulties for students, but the end products made it clear why taking time to work carefully made a difference; the more precise the cuts and the more square the chair, the sturdier the chair was.

During this project, I gave each student an extremely short lesson on the tool they were using and assessed their knowledge before they were approved to use that tool. This tool lesson was meant to increase competence and decrease fear. For example, when using the cordless circular saw I asked students to show me how they would hold the saw – reminding them that both hands must be on the two parts of the handles (it's hard to cut your hand if it is holding a handle).

Next I asked them to turn it on and turn it off right after so they knew what it felt like when it was on. I followed by showing them how to line the saw up with their mark and back it off the wood before they started the saw. Finally, I allowed them to cut. I also provided small group instruction on using the square and the drill. Students showed me their clamped together parts before they pre-drilled the holes so I could measure how square it was.

The class shares a circular saw and a few hand saws. Having multiple goggles, drills, squares, clamps, and bottles of wood-glue (one set of each per four students) allows this project to flow more smoothly. These materials can be borrowed for the week if your school doesn't have them.

## Crafting

Staying with their partner from the woodworking project, students decorated their chairs and made a cushion for the seat. Students started by painting and decoupaging their chairs. Students embroidered a design onto a piece of fabric that would be the front of their cushion. They were required to include one button in their design. They traced their designs from something they drew or printed by placing fabric (recycled sheets) over the design on a window.

Each partner took turns hand embroidering the design. Students learned to use the sewing machine to sew the back and front of the pillow together. They stuffed the pillows and sewed the final edge together by hand.
A part-time teacher assisted in the instruction of students in sewing. After initial instructions on each of the areas of crafting, we both circulated to help students when they were not sure how to proceed. After students completed the embroidery of their pillow, both of us worked with students to safely use the sewing machines.

This year, I plan to have students start the week developing a cohesive vision for the design of all parts of their chair, and I'll add a simple electronic component to their pillow so they can start to see the intersection of crafting and technology using soft-circuits.

This project requires a sewing machine for the class and an embroidery hoop and needle for each pair. Students also need paint, brushes, decoupage glue, thread, and fabric.

## Using an Arduino and Shield

Working with a partner, students put their soldering skills to the test again. Students were provided with an Arduino shield kit (**LoL Shield** and **WaveShield**) which they assembled. I chose these shields because of the inherent appeal of making an iPod-like device and a message/screen device. The LoL shield took the entire week to assemble because there were so many LEDs to solder. LoL shield users were able to assemble and run a couple quick programs from the library. Generally they were able to change the message on the shield, but didn't get too much further than that in programming the Arduino. WaveShield users were able to finish soldering earlier, which was good because music must be reformatted to be compatible with the shield. On a Mac this is relatively easy, whereas on a PC it took some time to find and install the correct programs. Students were able to get their shield up and running and show me it worked by playing a song of their choice. They also played a bit more with programs in the library than the LoL shield group was able to do. Initially there were also small issues in installing the libraries. I ended up installing them on all the computers because of the Admin password issues (putting files into the Program Files folder).
This year, we are planning to completely change this project. We have two ideas currently and plan on choosing one based on the group of students in class and their preferences.

- **Option 1: Using the Examples** – Students will use the examples already built into the Arduino program. By doing this they will learn to use example code and relate it to the C programming they already did in the robotics portion of the class. In addition, they will learn to interpret the circuit descriptions in these example files. Students will work through a series of these examples chosen to highlight specific electronic components and programming skills. They will be asked to modify the programs to make a visible change (e.g. make the light turn off twice as long as it was on while it blinks) and to combine multiple programs (e.g. make the light blink when the button is pushed).
- **Option 2: Semi-Independent Project** – Students will be provided with a menu of options for a semi-independent project. Since the next thing students will work on is a vision for their Maker Faire project, this would give us a chance to help them think through some of what they will encounter in working on their own projects. These projects will be designed to take seven days in class and will use an Arduino and basic electronics/sensors. Students will provided with instructions for the project of their choice. The directions will be pulled from the Arduino cookbook or online.

## PHASE 2
## INDEPENDENT MAKER FAIRE PROJECTS

Starting an independent project can be a daunting task, especially if your students have never been asked to take something like this on before. For my students it is especially intimidating because of the six-month timeframe of the project, the fact that they will be required to learn new skills that will be different from their peers, and also because they are being asked to innovate in some way.

During the first two weeks of November (at the same time as the Arduino project), students were given the assignment to look through Make magazine and find projects that interested them. Each week they were given the opportunity to see more projects and share interesting projects in a class discussion. At the end of the second week, students were asked to form groups of one to three based on common interests and compatible schedules (because they need to work outside of class on projects). The week before Thanksgiving break, they were given the task of coming up with a project concept for something they were interested in pursuing. The major requirement was that they thought it would be something that would hold their interest. Over Thanksgiving break, they started their initial project plan. The Monday after Thanksgiving, students met mentors for the first time. I split students into three groups and mentors circulated, giving feedback and ideas to each project group. This gave students a chance to get feedback and hear how feedback is given to other groups. After the class, mentors gave preferences for groups they thought they could best support. Students were given their mentor assignments later that week and shared their initial project plans with mentors.

The process we have developed at Lighthouse is intended to help our students make their way through creating an initial project vision. We've defined five stages of getting started on an independent project:

- Explore (2 months)
- Share ideas (2 weeks)
- Individual ideas (1 week)
- Project proposal (1 week)
- Project presentations and refinement (continual through project deadline)

We describe each of these stages in greater detail below.

### EXPLORE (2 months)

***Goal***: *Students exposed to new ideas learn new skills.*

Students are given multiple opportunities to explore because they generally have had little exposure to DIY style projects (from any genre). The first exposure to new types of projects comes as we work on our skill builders, where students are exposed to woodworking, design, embroidery, soft-circuits, soldering, and using the Arduino. As we started to work on the basics of Arduino, and during the following three-week period, students were shown videos of different projects at the beginning of class that could inspire them to think about different ideas for their own projects. In the second and third week of our Arduino unit students have the opportunity to carry out a project that is similar in process to their individual projects, except that they will be assisted with the steps by a teacher throughout; this provides students with a glimpse at how a more complicated project could come together. As students are exploring and sharing ideas, they are recording the ideas they find the most interesting in their journals.

### SHARE IDEAS (2 weeks)

***Goal***: *Students use print and Internet sources to find ideas for projects.*

At the same time as they work on their Arduino projects, students checked out Make magazines and were encouraged to explore **Instructables**. After looking over these materials, students shared a project they found interesting and explained why they found it interesting. It is important to remind students that at this stage they are not choosing a project, they are only sharing something they found in order to better inform themselves and their peers. This process can be repeated multiple times and can be used to start discussions with the group about what students and teachers are looking for in a project.

## INDIVIDUAL IDEAS *(1 week)*

***Goal**: Students express their own ideas, hear other students' ideas, and start to get excited about them.*

Our students then write up individual ideas for projects. Although we eventually want students to work in teams of one to three, we ask them to complete this step individually to push them to have agency in the project they eventually choose. Listening to each other's ideas encourages them to choose who they work with based on project interest more than peer-relationships. We find this important because students in groups bound together by a project have historically shared the work more evenly as long as they could find time to work together; whereas groups of friends often don't share the work equally because they don't have equal levels of interest in the project.

Students were provided with the following prompt and will present their idea to the group during class.

*Be sure the project you describe is something you think you will be interested in over the 6 months you will be working on it. Remember, it does not need to be a robot or electronic - it can be mechanical, sewing, crafting, an interactive experience, programming, electronic, robotic, etc. Finally, you must work on this proposal on your own and be open to working with people whose ideas you like, but who you don't know as well.*

1. *Describe a project have thought about that you would like to make. You may base your project on those we have seen over the past couple of months.*
2. *What does it do and how does it work?*
3. *Why is it interesting or exciting to you?*
4. *If this project is based on another project, how will you make it your own? How will you improve or change it?*

During the class discussion, all students share their ideas. As each student shares, their peers are encouraged to ask clarifying questions. It is helpful to remind students that this is not their final project; they are just putting an idea out to the group to add to the diversity of ideas. In addition, students take notes on at least three project ideas they thought were the most interesting. The teacher, meanwhile, is taking notes and pairing up project ideas in order to offer suggestions at the end of the presentations. Once everyone is done presenting, the teacher asks students to identify their top two projects. Each student is then asked to go discuss these projects with the project's originators. This was the first year we tried this step in the process and it did mix the groups more than has happened in the past. Since we have some tight knit groups of friends in the class, we asked students to talk to others they don't know as well. Through these discussions students are asked to decide who they want to work with based on common interest and availability (outside of school schedules). They give their group lists to the teacher before leaving for the day.

## One Project Team's Story

When everyone else had a team and a vision, these three girls found themselves left without either. In fact, they hadn't really wanted to be in the class in the first place. So they decided to be a team. They toyed around with many ideas. They saw articles in *Make* about a magic mirror that got them thinking about how to create a project that would interact with people, and they saw others made from recycled materials that inspired them to think about creative reuse as well. Still, they had trouble putting it together into a concrete idea.

Their first idea was to create a picture frame out of recycled materials, integrate a webcam into the frame, and have the picture in the frame be the person looking at it. They wanted it triggered somehow, maybe even changed in a playful way, but they couldn't figure out how. They discussed this idea with each other for weeks, researched online, talked with their mentor, but they couldn't get past the idea stage.

At some point, I am not sure why, they decided to scrap their first idea and start over. But the recycling theme stuck and they discovered that if you cut a plastic water bottle in a spiral it makes a pretty cool looking curl. This was the a-ha moment. A spiral of clear plastic became the centerpiece from which they built. They had to figure out how to make it work, and the process took many iterations, but when they were done, they had created their own recycled LED chandelier. At Maker Faire that spring, many people stopped to look at it, intrigued by the same curls that had finally inspired the team.

## PROJECT PROPOSAL (1 week)

***Goal**: Students express the object or experience they would like to create.*

Groups of students work together prepare a project proposal in order to get ready for a final pre-project presentation to their future mentors. In our class, this work is done as homework, but it could easily be done in class with teacher guidance. Each group is given the following format for their proposal:

*If you are having trouble coming up with an idea - or aren't satisfied with your current idea, there are a bunch of websites with ideas at the* **Young Makers site**, *my* **blog site** *which I will keep updating, or even go look at what some* **suppliers** *have to offer. In addition, you can come up with hybrid ideas (meaning two ideas that already exist combined into something new) by cutting out pictures from magazines or printing some out from the web and arranging them in pairs until you find something interesting!*

- *Name of Project:*
- *Participants (who is your time manager?):*
- *Primary Mentor (To be determined):*
- *Mentor Contact Information:*
- *Project Description (1 paragraph):*
- *Divide your project into smaller projects – in other words what are the different types of tasks you will need to accomplish in order to complete this project? (e.g. electronics to control lights and motors/ mechanical systems to be able to grasp an object)*
- *What is your plan for splitting these sub projects among your group members?*

*Your homework will be to spend a minimum of two hours per week per person working on your project. You will keep track of this work in your project journal (online) and it will be assessed each month. Part of your homework will be to communicate with your mentor, update your plan, and attend Young Maker events (dates to be announced).*

- *How do you and your team plan to decide what homework you are giving yourselves – and how will you split it up?*

## PROJECT PRESENTATIONS AND REFINEMENT

*(continual through project deadline)*

***Goal**: Students receive feedback from a knowledgeable source and to break the project into smaller pieces that can be worked on concurrently.*

Students presented their project ideas to a group of their peers and a mentor. After each presentation, students were given feedback, mostly by mentors.

Mentors generally need guidance from the teacher about what type of feedback you want students to receive so it is helpful, yet not overwhelming. Our mentors were asked to help students split their project into sub-projects because students often struggle with this key step, but it helps projects move forward efficiently.

After receiving this feedback from mentors, students start to work out the sub-projects they will need to plan for. Students use the organizing table below to start planning the sub-projects:

*Sub-projects: Write a description of each sub-project below. Then fill in the table.*
*Confidence: Rate how well you understand this step from 1 (I have done it before) to 5 (I really don't have a clue how to do this and will need to do research / talk to mentor and teachers to accomplish it)*

| Sub-project | Skills Needed & Confidence | Materials Needed | Time Needed | Who is in charge? | Time with modifier |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |

## Bringing an idea to life

Every year it is a pleasure to watch students move towards creating a project vision. Getting a group of students to their own idea of a creation is often not at all linear and you generally end up asking yourself how they came up with the idea they present. After completing the process earlier this year, one of my students told the group that it is "exciting to think that right now we have a bunch of creative ideas, and in six months these ideas will have come to life." Each year we go through this process it seems to get easier for students to find a vision. I wonder if that is due to our teaching practice improving, or if it is because students have seen those in earlier classes come up with ideas which has shown them what is possible.

# 8

# Projects

Making things, and your love for making things with others, may be your main reason for starting a Makerspace. We hear from Makerspace managers that they can feel somewhat daunted doing the thing they and the kids love most! You might not know how to get started. That's OK. Don't overthink it, just start making!

## Starter Projects

We recommend that you make something together to get your feet wet and see what it's like to work together. It can be customizable or not. It could be one large group project or a simple project everyone can do. Of course, your Makerspace students may have very different levels of expertise. On the next page, we've listed some sources for simple workshops and starter projects you might consider as first projects.

When choosing a starter project, consider the diverse interests and skill sets of the members of your Makerspace, and make sure that the project you choose is open-ended enough to welcome all kinds of budding Makers into the culture. You may also want to keep in mind these activity design guidelines adapted from the Exploratorium's Tinkering Studio:

- Build on the kids' prior interests and knowledge.
- Choose materials and phenomena to explore that are evocative and invite inquiry.
- Think of STEM education as a means, not an end in itself.
- Provide multiple pathways (i.e., don't ask your kids to adhere to rigid step-by-step instructions)

## Starter Project Resources

**Seek out simpler Instructables.**
**Crafts for kids** has projects on making playdough, oobleck, seed bombs and much more.

**Build Howtoons projects.**
Check out Das Bottle, mini-motor, Frankenmouse, nocturnal robot, turkey baster flute, speaker cup, cigar box guitar, marshmallows launcher, blimp, ornithopter, homemade strobe, light bending, tower, ice cream, and their **Guide to Visual Communication**.

**Browse Make:Projects.**
We've seeded this DIY project-sharing site with projects straight from the pages of Make magazine, and it has grown with many more submitted by our most creative readers. You can access step-by-step instructions and materials lists for hundreds of projects, but here are some tips for finding the simpler ones.

- Some of the "Easy" projects should be do-able by new Makers and adaptable to challenge intermediate Makers: the **Wind Triggered Lantern**, **Soda Bottle Rocket**, or **Cigar Box Guitar** provide easy starting points.
- The "**Kids" topic page** is a good place to start, too, but the projects are not all ones for kids to build; some they'd enjoy playing with.
- You might also want to check out the **most popular projects**.

**Tinker and explore.**
The **Exploratorium's Tinkering Studio** developed some terrific hands-on explorations for our Open Make sessions. These are all documented with an overview of some of the reasons why you might want to do the project with your members, images of the process of making and using the project, and a discussion area at Projects include BlinkyBugs, BristleBots, Bling, Cardboard Automata, Chain Reaction, Circuit Boards, Circuit Necklaces, Get in the Groove (sound and vibration), Light Painting, Light Play, Marble Machines, "Mmmtsss", Piezo Drum Circle, Plastic Fusing, Scribbling Machines, Sew a Circuit, Toy Take-Apart, and Wind Tubes.

## Brainstorming Main Project Ideas

Coming up with an exciting but achievable project can be very challenging. If your members already have a clear idea for a project, congratulations! That's great. They can start working on their designs and prototyping them. If they don't know what they want to do, we've collected a few strategies that might get them going.

**Figure out what you want to learn.**
Another strategy is to pick a set of skills that you'd like to acquire (such as knitting, soldering, or welding), or a medium that you'd like to experiment with (such as wood, metal, or ceramics). Once you've narrowed it down, there are a few ways to get started:

- Don't hesitate to ask questions of people who have the knowledge you're seeking. People are generally very happy to share what they know and are happy to help. If you find a Maker who has exhibited at Maker Faire and who has skills related to your project, they may be available to advise you—sometimes they include their email addresses on their project pages, or just tell us who you're trying to get in touch with and we'll try to make the connection.
- See what others have done—often the enthusiasts will document their passions with great detail, enough to recreate and learn from them. Do web searches related to the skills and media you've been working with. You'll very likely find countless blogs, websites, and organizations related to your interests.
- Go buy some of the materials used in the medium you are interested in and tinker with them.

**Cut and collect.**
Disney Imagineers cut out a collection of images they find interesting, then they start arranging them in pairs or triplets to see if that triggers any interesting hybrid ideas.

**Play with something new.**
Stimulate ideas by playing with a new material. Mylar, electroluminescent wire, shape-memory alloy,... any new material (or even an old material used in new ways) can jolt your imagination. Spend a long time with the material, experimenting in as many different ways with it as you can imagine, or look to see what others have done with this material by searching online.

**See what's out there.**
To get your idea generator going, look at many examples of what other people have done. You can try to replicate the project exactly, but more likely you will add your own twist along the way. Some project sharing-sites most popular with Makers include...

**Instructables**
This vast database of thousands of projects submitted by a large user base contains a nearly inexhaustible resource of step-by-step instructions for a million different projects of all difficulty levels. Find both simple projects and deeper expertise when you get stuck on a project. You could spend half a lifetime browsing this site. (And don't forget to contribute your project to the site after you've finished it, in order to help others.)

**Past Maker Faires**
Maker Faire booths, both what Makers have shared at Maker Faire and what we have previewed at events where we promoted an upcoming Maker Faire, also offer a lot of great ideas for projects. **Browse nearly 4000 projects** that have exhibited at previous Maker Faires in the Bay Area, Austin, Detroit, and New York City.

**MAKE magazine**
Every edition, filled with detailed project ideas and plans, is a well-spring of ideas. Aaron V. used his complete set of Make magazines, distributing one issue to each student in the class and asking them all to choose a project that appeals to them. As of late 2011, Make magazine has published 27 volumes. One note of caution: a few of the issues are out of print, so share your copies of the magazine carefully.

**Makezine blog**
Each day a number of posts describe thought-provoking projects, sometimes with links to instructions. Comments made by readers can also be very helpful.

**Make Projects**
A great source for starter projects as well as more ambitious ones, this user-contributor DIY project-sharing site has projects from MAKE magazine and its readers.

**Go shopping for stuff.**
An art teacher once said, "Half of art is shopping." You could take your members on a field trip to an art, hardware, electronics, plastics, fabric, dollar, or thrift store. If you can't go to a real-world store, poking around online might work too. You can use your shopping trip as a time to talk about budgets and the hard task of finding supplies for projects. At the store, your members may find odd things to hack together, or new materials they hadn't considered. **IKEA Hackers** is full of ideas for repurposing materials.

**Go window-shopping.**
Look at the wacky inventions in SkyMall magazine, found in many airlines' seat-backs. If you know someone going on a flight, ask for some copies of SkyMall, and get a kick out of seeing what silly inventions people buy at high altitudes. You may also consider sites like Etsy and eBay, two sites rich with unconventional ideas from creative, resourceful people who sell vintage and handmade objects. Or search on Pinterest.

**Do what you love.**
Focus on things you like, such as music, video games, or holidays. Halloween and Christmas provide great opportunities. For Halloween you can make costumes or props for the yard. For Christmas, you can make wonderful decorations for your tree, your home, or your yard.

**Have lots of Ideas.**
Dr. Linus Pauling famously said that the best way to have good ideas is to have LOTS of ideas. That is, create a list of as many ideas as you can, then start focusing on the ones that appear promising. Eventually you'll winnow the list down to the good ones. Don't be surprised if only a fraction of your initial ideas turn out to be good. That's normal.

Some design educators swear by IDEO's seven rules for brainstorming. These four are most relevant to brainstorming students' projects: defer judgment, encourage wild ideas, build on the ideas of others, and go for quantity. To see all the rules explained, visit **IDEO's write-up on the seven rules**.

## Choosing big projects

For a final portfolio project, students should aspire to choose projects that are ambitious, yet attainable. Attainable means reining in the idea just enough to acknowledge what expertise the student has and hope to gain, as well as the expertise of their current or potential mentors. Of course, attainability also means that the teams will need to keep an eye on budget.

Many great projects have been created with materials that have been scrounged, reclaimed, donated, and borrowed. If the materials aren't on-hand, part of the work of the Makerspace will be sourcing the materials and supplies they need. And if they don't have the money to pay for these out-of-pocket, like so many artists, engineers, and scientists, they may have to spend some of their project time writing to local and large businesses requesting discounts and donations.

Every once in a while several makers will work together all on one big project. The Young Sparks all worked together on the **Water Totter**. In our experience, though, most Makerspace members work on individual or team projects of their own design.

Speaking of large endeavors, don't forget that a project doesn't necessarily have to be an object. It can also be a performance or an experience created for others to enjoy, and these also require a great deal of logistical forethought and planning. (Learn more about project selection in the chapter on Projects.)

## Ensuring Diversity of People and Projects

The Maker movement attracts a wide variety of people, and we think that's one of its greatest strengths. Why is this? Perhaps because Makers are open to relating to a similarity in the depth of passion for one's work and a way of working and being curious about the world, without necessarily sharing a prior interest in what is being made or how it is being made.

Makers might demonstrate a skill or craft, show a finished piece of work and explain it, and/or teach a skill or lead a hands-on activity. Makers can be anyone from yarn-spinners to hackers to terrarium makers to alt-energy vehicle designers to facilitators in the learn-to-solder booth. They might be performers: Musicians and dancers and snake-charmers fit this group. They might take a slot on the stage, or offer a guerrilla performance.

As you introduce the idea of making in your Makerspace, check that examples you share set the stage for a real variety show! Starter projects should include materials and phenomena that invite inquiry and provide multiple pathways for different kinds of skill sets and expertise. If you put together a slideshow of inspiring exhibits and performances from earlier Maker Faires, pull examples from all the categories of Making: arts, craft, engineering, food, green design, music, science, technology. Or you could think in terms of common theme areas usually present at Maker Faire, and encourage your students to distribute their projects across these areas: Electronics, Music, Crafters, Robotics, Lego Park, Bike Village, Farm / Food.

Keep the bar low for the newcomers: counterbalance the novelty and "geek factor" of the examples you share with projects that are, perhaps, not novel at all. Throw in some more common yet creative / delightful / lovely projects in with your examples. Some Makers might want to build their own Adirondack chair rather than a nifty Arduino-based gadget. That's completely fine. Anyone who makes something gets into the whole universe of materials, tools and techniques. That "normal" Adirondack chair can always come back next year and get geeked out with a built-in infrared remote that controls the lawnmower. Or they can some back and build a fine replica of a piece of 18th century furniture. You never know.

If you have students who bring widely varying levels of experience, it's fine to pair a "newbie" with a project team that is working on something more advanced, as long as the newcomer and the team are all right with this. This approach helps newcomers participate at their skill level but contribute to something that would be beyond what they'd be able to accomplish on their own. For Saphira, the fire-breathing dragon, two of the team members were brothers who had worked on Maker Faire projects for three years together already. The third member brought in new expertise but less experience bringing a project from idea to Faire. It worked out very well for all.

A project for Maker Faire, and likewise for a Makerspace, does not necessarily need to be some kind of physical object that can be exhibited on a tabletop. In fact, some Makers are better featured performing, or talking, or teaching, or interacting with other Makers. Preparing for performance, hands-on interactive experience, or a live demonstration can require at least as much thinking ahead and logistical coordination as creating a new object.

For a hands-on workshop, your students might want to teach Maker Faire attendees how to ride a goofy bike, silkscreen a piece of clothing, play a musical instrument, launch a rocket, operate a remote control robot, or explore a cardboard jungle. Fairegoers line

## Communities of Makers in Your Community

**Arts**: Art Cars, Art Museums, Blacksmithing, Burning Man, Comic Groups, Filmmaking, Fiber Artists, Fire Arts, Holographic Groups, Kinetic Art Groups, Local Chapters of AIA and AIGA, LEGO Users Groups, Metal Arts, Neon Art, Painting, Photography Groups, Pinball Groups, Recycled Arts, Steampunk, Yo-yos

**Crafts**: Bazaar Bizarre, Bobbin Lace Makers Guild, Bookmaking and Bookbinding, Cardmaking, Ceramics & Pottery, Clothing Design, Craftster, Crocheting, Dollmaking, Embroidery (groups, associations), Etsy, Felting, Fiber Arts Groups, Folk Art, Glass Blowers, Jewelrymaking, Journalmaking, Knitting, Lacemaking, Modelmaking, Moldmaking, Mosaics, Museums of Craft and Folk Arts, Open Source Embroidery, Origami, Painting, Quilters, Renegade Crafts Fair, Scrapbooking, Sewing, Silkscreening Groups, Smart Materials, Soapmaking, Swap-O-Rama-Rama, The National Needle Arts (TNNA), Wax Sculptures, Weavers and Spinners, Woodworking

**Engineering**: 3D Printers, Amateur Aviation Groups, Amateur Radio Groups, Amateur Rocketry Groups, American Engineering Association, Arduino Groups, ArtBot Groups, ASME, BEST Robotics, Bicycle Groups, Car Repair Groups, Catapult Groups, Circuit Bending, CNC Groups, Combot Robots, Computer Modders, Computer User Groups, DIY Drones, DIY Energy, DIY Radio Groups, Dorkbot, Electric Cars, Engineers Without Borders, Fab Labs, FIRST Robotics, Hackers Groups, HAM Radio Operators, IEEE, Insect Bots, Intel Computer Clubhouse Network, LED Art, MIDI User Groups, Model Railroad Makerspaces, Odyssey of the Mind, R/C Model Makerspaces, Repair Groups, Rube Goldberg Groups, Soapbox Derby, Solar Cars, TechShop, Underwater Robotics, WALL-E Builders, Women In Engineering Groups

**Food/Sustainability**: Audubon & Bird Groups, Beekeeping, Beer Brewing, Cakemaking, Cheesemaking, Chocolate-making, Citizen Science, Composting, Cooking Classes, Culinary Programs, Edible Schoolyards, Edible Communities, Farmers' Markets, Homegrown.org, Local Foragers, Master Gardeners, Molecular Gastronomy, Mycology, Permaculture, Preserving, Seed Saver Libraries, Slow Food, Vegetarian Groups, Winemaking, Urban Roots

**Green**: Calcars.org, Co-Housing, Community Bike Groups, Composting, Eco Modding, Fix Your Bike Groups, Green Arts Groups, Green Cleaning, Hybrid Car Groups, Recycling Groups, Solar Groups, Solar Ovens, Treehugger, Water Groups, Wind Power

**Science**: Adult Education/Community Colleges, Astronomy Makerspaces, Chemistry, DIY Biology, DIY Energy, DIY Forensics, DIY Science, Kitemaking and Flying, Paper Airplane Making, Robots, Rocketry Groups, Science and Technology Centers, Science Workshops, Space Exploration, Teachers Resource/Support Groups, Telescope Makers, Tesla Coils, University Programs, Zoology

**Music**: Circuit Bending, Dance Troupes, Electronic Music/Theremin, Instrument Hacking, Instrument Making, Jug Bands, Marching Band, Taiko Drummers, Theater Groups

**Play**: Board Games, Chess Groups, Computer Gaming, Halloween, Hula Hoops, Juggling, Star Wars Makerspaces

up for workshops like "How to Make Jam" or "How to Prune a Bonsai Tree." Your students might demo something they learned together as a starter project or in class, like how to shake cream in a baby food jar until it becomes fresh butter.

A few Maker Faire hands-on exhibits that have entered the lexicon of "greatest hits," and your students might volunteer to run these at a Maker Faire:

- How to solder
- How to take apart anything
- How to build a simple circuit (like LED throwies)
- Science experiments for kids
- Make a rocket and launch it
- Make a musical instrument
- Fix your appliance
- Learn to knit or sew
- Clothing hack and swap: piles of donated clothing get picked through and transformed with hand-sewing, machine stitching, silkscreening, gluing, etc.

If your students do create a hands-on activity for fairegoers, they will want to keep in mind these tips for designing exhibits that engage the complete amateur:

1. Offer as many facilitators as possible.
2. Use signage or handouts to help guide the user.
3. Supply sufficient lighting and safety gear.
4. Design your booth to manage the people you interact with (e.g., one chair per user).
5. Provide a place for people to wait their turn.
6. Model safe use of tools and materials in your space.

If you have performers in your group, encourage them to transform the talents that they usually share with audiences by adding a Maker spin to their act. Musical acts that feature homemade or altered instruments fit well on a Maker Faire stage.

Kids who don't usually consider themselves "performers" may also create a large demonstration that wows a crowd. Kinetic sculpture performances (e.g. big robots) or demonstrations (like the Coke and Mentos fountains pioneered by Eepybird).

Demonstrations might also be onsite builds where a maker sets up a shop and creates an item from scratch over several hours, such as an igloo formed out of empty gallon milk jugs. Some Makers create film or video projects to premiere at Maker Faire (although not all Maker Faire-inspired events set aside a space dark and quiet enough to screen a film—this may require some extra planning on your part.)

Finally, encourage your kids to **think big**! They might propose working together to create a large maze out of cardboard or a giant web of string. These large installations require a lot of testing and prototyping before the event site is open, but the payoff in big smiles could be as huge as the art they create.

One of the most surprising, stimulating and identifiable traits about Maker culture is the diversity of fields it encompasses. You can look far and deep into the nooks and crannies of your community to find inspiration for your students. Here is a list from the staff of Maker Faire for places to look for Makers. You can use it to brainstorm possible sources for Makers in your community who might come to your Makerspaces as special guests or mentors. Or you might take your Makerspace on a field trip to visit a studio or shop run by one of these Makers.

### Organizing a Maker Faire

If you don't have a Maker Faire happening near you, your Makerspace or school can take the lead in organizing one for your community or host it at your school. For more about creating a "Mini Maker Faire", contact Sabrina Merlo **sabrina@makerfaire.com** and ask for the Maker Faire Playbook.

### Defining scope

Give the participants free range in choosing their project and then help them narrow the scope through planning and experimentation. Part of the Maker's process is dealing with the realities of time and budget as well as developing new skill sets, and it's more fun to watch the kids think through their goals than to give them "assignments".

For example, if a student says they want to build a spaceship, definitely encourage them (and agree how cool that would be), but then ask some probing questions about what part of the experience they're most interested in so you can adapt the project accordingly. If they want to physically crawl into a box and perhaps feel a sensation of weightlessness, then maybe we'd start a discussion about constructing an isolation/flotation tank. If they are more interested in propulsion, then maybe a scale model rocket might be an appropriate starter project. Interested in the view looking back down onto the earth? Start an exploration about the possibility of a remote camera attached to a balloon. Encourage the kids' wild ideas, but then engage them in thinking about where you might find the construction parts, and whether they would need to be purchased or could be salvaged or recycled. This kind of discussion will lead the students to their own realizations about what might be practical but still allow them to fully define their own project goals.

### Setting schedules

Unrealistic expectations about time-budgeting for projects happens all the time with Makers young and old. In this program, building the projects usually happens outside of group meeting time. Individual projects may be developed by the students during evenings at home or on weekends in a collaborative workshop setting with available mentors. This may be a scheduling challenge for kids with a lot of extracurricular activities like team sports, music lessons, etc. but *the kids get out what they put in over the duration of the program*. Students who won't see their mentor(s) frequently enough may find weekly phone chats or Skype check-ins useful for trying to build momentum early on so the work doesn't fall onto the last weekend before their deadline.

Help with project management can come from you or just about anyone who interacts with the student—

other mentors, fellow students, their parents, but when all is said and done, this is the final responsibility of the students, not you. Project Plans can help them with time management, and we've included a template in the Resources section. These consist of a list of tasks or action items, each one matched to a person responsible for its completion, and due dates assigned to each action item. Any mentors assigned to the team should get a copy of the Project Plan so they can check in on progress with the team or with its individual members. (A Project Plan template is in the Resources section.)

### Teaching new skills & keeping it fresh

Don't get so caught up in the logistics of creating your Makerspace that you forget why you're doing this. Make some quick projects together all along the way, even if the project isn't directly related to any of the projects being built in your Makerspace. (It may help the teams think about their project in a new way!) Do something your students already enjoy doing, or take on a project that includes new talents the students want to add to their skill set.

In the Bay Area, the Young Makers program (a cousin of Makerspace) has partnered with the Exploratorium's Tinkering Studio, which has been introducing some new approaches and techniques during the **Open MAKE sessions** including both "Skill Swaps" on the museum floor, and a mini Maker Faire with five to ten Makers sharing their projects, often with a hands-on element. See the chapter on Projects to get a sense of the kinds of projects you can do in a short time frame.

Don't forget to expose students to new ideas, even if these don't have an obvious connection to the projects they are creating. During each Open MAKE session at the Exploratorium, we ended the day with Dale Dougherty interacting with a panel of three to six inspiring Makers. These presentations and discussions, called **"Meet the Makers" are archived on the Exploratorium** website.

**Make magazine**, and the **Make blog** provide great reading and some video links, as do TED talks and **Instructables**. Encourage your students to go to lectures, events, and a variety of museum exhibitions, to talk to friends, to spend some downtime exploring the web and letting their imaginations roam.

### Working together and apart

Sharing a Makerspace as your workshop or studio means having abundant opportunities to share progress on projects and getting helpful feedback, and unsticking those who are stuck. In our experience meetings can get in the way of getting work done, so you'll want to hold them sparingly.
With more ambitious projects, students may need to plan extra time to work on their projects, and to look at their project plan and identify the things they can do on their own at home (sketches, designs, research, programming, etc.) and what they need to do in the Makerspace with their partner. The number and duration of build sessions will depend on the progress and scope of the projects being made in your Makerspace. Between meetings, students might discuss their projects on social networks, chat rooms, email, and so forth. If you find an online discussion tool that works for your students, please tell us about it.

One thing to keep in mind is that in preparing for a showcase event where your students my exhibit their work, such as a Maker Faire, the work is unlikely to progress linearly. That is, it's rare to meet someone who can pace themselves equally across a four-month timeline. More likely, a project will be 5% done in the first month, 10% more over each of the next two months, and the bulk of the work—at least ¾—in the final month. (Yes, a project may require over 100%!)

In the final month before a project deadline, teams will be very busy finishing their projects and preparing to talk about them with attendees of the showcase event (like a Maker Faire.) This is a good time to set aside an intensive work session when your students can spend a large chunk of time getting their project 95% of the way to being finished—and if not finished, then at least presentable. The energy of lots of people working together in an intensive build session propels everyone forward. You'll want to have lots of enthusiastic and supportive mentors on hand to help get the projects where they need to be. Those mentors can also help revise designs and cheerfully manage expectations and refocus on a modified goal as needed.

**Teacher tip:**
**Encouragement (without empty praise)**

Encouragement takes a lot of work. Stay on top of the teams to see how they are doing, and to make sure they haven't abandoned their work in a moment of deep frustration. Compliment the way that kids try different things at least as much as you heap praise on the results. That is, something like "I admire how you worked through that hard problem. I noticed how you tried [x], [y], and [z] and you stuck with it until you figured it out," effectively fosters confident learners, more than a thousand "Good job!" comments.

## Refining scope

Around the mid-point of working on any project, creative people often experience a dip in their enthusiasm for its completion, and new, younger Makers are no exception to this. Sometime a little over halfway through your time working together, start a conversation about refining the scope of the projects. Refining scope is a dear companion to the original task of defining scope, and many engineers, designers, and makers of all stripes take this necessary step when the hours left to work on a project are more tangible. Many makers get started with fantastic ideas, and after working on these for a few months or so there's a definite risk of losing their enthusiasm as the reality looms. That reality is the overwhelming feeling of all that needs to happen before the deadline as the initial excitement of coming up with the idea fades into the past. All Makers face down discouragement.

## Finishing up

The interest and excitement students can expect from attendees at Maker Faire is worth it. Try to find out if there is anything you can do to help your students achieve their vision. And thank them for setting such an incredible example of what can be accomplished when kids and adults come together to make things.

Some of your students will have projects nearly done ahead of schedule, and you can congratulate them and challenge them to find ways to enhance their projects or the way that others interact with it or understand their process, or to document how and why they made their project to share it on the web and generate some buzz for their cool project. Generally, far more students, especially in the final month before your deadline, feel that they don't have much to show yet and that they are running out of time. Don't let them lose heart! Remind yourself and them that the extraordinary creativity and innovation that they've all demonstrated is really inspiring. We frequently see an expression of wonder and surprise as we describe to people the projects undertaken by students, even when those projects are nowhere near complete.

Here's another way to look at projects that are incomplete. Maker Media sponsors the "Most Spectacular Failure" award at The Tech Challenge at The Tech Museum of Innovation in San Jose. While the award's name makes people laugh, it also recognizes that there is no shame in taking on something beyond one's reach. As long as they have put in real effort, your makers will have done their best work. That alone is something to be proud of. Encourage them to keep going. As they hit stumbling blocks, have them document what those challenges are, and be proud to share whatever progress they made at the showcase event (such as a Maker Faire). Whether the project is a tangled heap of lots of great ideas that didn't pan out

## Getting Past Makers' Block

- To trick yourself back to work, tell yourself that you'll work on it for "just 10 minutes." Often you'll find that the time flies by and before you know what happened you spent 45 minutes advancing your project!
- Revisiting or creating a new project plan can help. Plan ahead and scale back. You may have lots of ideas and not know which one to tackle first. For this version of the project plan, look at all the things you want to do and decide which ones are "musts", which are "nice to haves" and which are "things we're not doing now but we may do them laters." Try to map those things onto a calendar, giving yourself milestones along the way. If you don't finish everything for your deadline, it's OK. Get as much as you can done and be prepared to talk about what you'll add for next year!
- Make sure that you break up your project into manageable, bite-sized tasks. Often something seems daunting because you're seeing the task as the entire project. If you break it up into small micro tasks, then you can feel a sense of completion and accomplishment EACH TIME you complete one of the micro tasks.
- When you find that a project is rapidly becoming overwhelming or you come to it at the start of your build session, and you have so much on your plate that you just don't know where to start, just pick a place and begin. Don't angst over whether or not it was the best place to jump in, the priorities and sequences of activities will come to you once you're working. Many of us get hopelessly bogged down trying to sort of priorities, which task to do first, etc.
- Tell others about your project to get you psyched all over again—and motivated to continue on!
- Connect to why you decided to do this in the first place. First, look at how great it would be to have it done: "the benefits". Then, connect to "the costs" for not getting it done. Finally, look at what's possible and state what can get done and by what date. - Feeling how great it would be and why it's important. And make sure not to beat yourself up for not getting it done yet.
- Anne Lamott's book *Bird by Bird* refers to a school project on birds that her brother waited until the last minute to start on, when they were kids. Her brother sat at the kitchen table, a stack of books on birds and a pile of 3x5 cards in front of him. He was paralyzed by the task. His dad came in, patted him on the shoulder and said: "bird by bird, son, just take it bird by bird." So when Anne is stuck in her writing, she thinks about those 3x5 cards and the bird project and tells herself that she just needs to take it one bird (one paragraph, one simple task, one 3x5) at a time. This can be very helpful when you get overwhelmed.

when they sit down to show it off—or it's a fabulously finished realization of their original design—assure them that attendees will be impressed, especially if they tell a compelling and interesting story.

## Exhibition, not competition

What distinguishes the work of makers in education is our emphasis on exhibition, not competition. We feel that the pressure of a deadline and wanting to put your best work before many observers motivates adequately without adding in the extra noise of battle or judges. Makers can tell if their project has succeeded or failed, or at least if they have succeeded in communicating their project, by how much interest their project generates with Maker Faire visitors. Attendees vote with their feet and the time they spend interacting and asking questions. The interest visitors pay to a project provides evaluative feedback and give makers a sense of accomplishment. We think that's very appropriate: in the real world, it's rare to have a head-to-head battle or a panel of judges deciding whether your work gets its just reward. Maker Faire is a marketplace of ideas, just like the world of business.

Depending on your showcase event, the students' projects will be seen by dozens to many thousands of attendees. Obviously, your students won't interact with every attendee, but they need to plan ahead to make sure that those who do see their project can understand what makes it wonderful. As months of work finally come to a close, your students should prepare to show off not just what they made, but also evidence of how they made it — sketches and prototypes or anything else that can help them explain their process. (Compare examples of telling the story behind the projects in our Documenting chapter.)

Give your participants some talking points for Maker Faire, as people may ask them how they can start a Makerspace or get involved in the Maker movement. Give them any data you have, like how many projects your Makerspace made, how many aggregate person-hours you worked on the projects, how many people attended any events you may have hosted, etc. If you have any links to great images, photo sets, videos, or media mentions, share those too—whether those cover the event, your Makerspace or its projects. Share them with people who ask, and share them with us too! Send links to **contact@makerspace.com**, and we'll send them along to others.

During the event, be sure to congratulate each student on their project, and try to get at least one picture of their project and of them exhibiting it. You may need these for your debrief, website, scrapbook, etc.

**Teacher tip:**

**Embracing failure, and keeping it safe**

Let the kids fail, while monitoring their safety. Occasional failure, and the accompanying recovery and adaptation, are an important part of the learning process. If you think you see something faulty, point it out (in advance if possible), but try to avoid insisting things be done a certain way **unless safety is an issue**. You'll be surprised how many different paths lead to the same goal, or what new ideas are developed by accident.

9

# Startup

Before or as your Makerspace opens its doors, you will have many details to arrange in order to make your own Makerspace. We have people trying all kinds of models for Makerspaces. Regardless of whether you are building a shared community resource or an in-class program, you will need to take care of a few steps we expect all Makerspaces will take.

## Get listed

Join our network by adding your Makerspace to our list of affiliates. The network is growing around the country and the world. More people are going to want to find you and learn what you did and how you did it!

Our website, **makerspace.com**, will list your Makerspace in our "Makerspace Directory" if you fill out the form for us there.

## Get connected

Go to makerspace.com to join the Makerspace list. We send announcements relevant to most of the network. The list currently posts announcements only, so to interact with others, join discussion groups too.

Members of the Makerspace Google group help each other, generate discussion, and share resources and ideas. If you haven't been added to our Google discussion group for Makerspaces and would like to be, please write **contact@makerspace.com** and request to be added. We are working on developing more resources for our Makerspace partners, including webinars and conference call trainings.

MAKE Magazine, Maker Faire, and Makerspace team are thrilled about the Makerspace movement, and we are willing and able to help you promote your Makerspace and its projects through our media channels. If you have news to share, be in touch! Please write **contact@makerspace.com** with news to share.

## Spread the idea

You may have enough members and mentors before you start, but if you are having a hard time recruiting, it's a good idea gather support by identifying partners and engaging the community as you build your Makerspace. You can share news of the Maker movement with schools, colleges, preschools, local businesses, the human resources departments of larger companies with local branches, youth centers, libraries, museums, art centers, and so on. Really, anywhere that people experience community in your community is a place where a community of members and mentors for your Makerspace might grow.

Get the word out by having a visible presence at community events. This can diversify your member pool with people you don't know personally. When you work a table, have a simple banner to hang, postcards and printed materials to distribute, sign-up sheets for volunteers and members, and something "Maker": an activity or object demonstrating what Makers are all about, while also giving shy or curious passersby an excuse to come up and interact with you. For example, we often help people put together LED throwies at events. If you don't have the energy to "table" an event, you can attach posters to poles and business windows just before a fair or other community event you think would attract your target audience.

A slide presentation can convey in an organized and compelling way what the Maker movement is and explain (in pictures!) what a Maker Faire and a Makerspace are.

## Identify student makers

You may have a few kids ready to sign up to use your Makerspace. But if it's just you and a kid or two, you don't have enough of a community yet! But how big should the group using your Makerspace be? Too few members can lead to a lack of energy, dropping the group below "critical mass". Too many members can be difficult—and potentially dangerous in a shop environment—to manage. *The most important thing is to pick a size that is most comfortable for you*. You may want to start off small in your first year to test things out. You need at least a few kids to get the kind of interactions we imagine in all Makerspaces to happen in your local affiliate too.

## Set up a website and/or a blog

*We strongly urge all Makerspaces to create a website.* We also encourage every project team within a Makerspace to maintain a blog to track their project's progress.

A website is a great tool to use to connect to your Makerspace members, as well as connecting to other Makerspaces, and the greater community of Makerspace supporters that we're trying to build. You can use it to document projects made by your Makerspace, to recruit new members, and to maintain a schedule of build sessions. Building a website has gotten easier, but it's still not "turn-key."

Feel free to use whatever tools and platforms you're already familiar with. Unless your Makerspace has an individual (possibly one of the students!) who is an expert and is committed to owning the development of a custom website (no small feat), we recommend you utilize a building and hosting application such as Wordpress or Google sites:

- **Wordpress**. Basic Wordpress is **free** (though you can **pay** a little for some customization), and has a good **tutorial** on how to build a blog or website using their templates and servers. It offers over 100 templates (designs) to choose from, clear analytics (usage data on your site), and an easy-to-use management interface.
- **Google sites** is another easy-to-use, free service (our original Makerspace web site was hosted there). When your site is created, contact us to let us know the address. We'll link to it in your blurb on the Makerspaces Directory.

If you'd like to register your domain name (URL), GoDaddy offers an inexpensive domain purchasing and registration site (but don't purchase their hosting). Or you can also do it all at Wordpress: **registration**, site building tool, and free hosting. Then, if you are using Wordpress, map your domain to your site. Wordpress names your site within their own domain (such as "wxqMakerspace.wordpress.com").

Your site should probably include a home page, an "About Us" page with your Makerspace's back-story and text about Makerspace, Maker Faire, Make Magazine, and Maker Media (see the Resources section for the wording.) Set up a page to show off the projects being made in Makerspace, too, where you can capture images of their projects in progress, or, better yet, link to the teams' project pages. Plan to archive your project page each year and keep it on the site as a scrapbook as you continue from season to season.

*HINT: Be sure to add plenty of tags with phrases and words related to Maker culture (science, engineering, DIY, do it yourself, art, kinetic sculpture, hands-on, progressive education, Makerspace, maker faire, make...) These tags help Google find your website.*

If your members have a social network where they are all hanging out, try to carve out a space there for online discussions about their projects with one another. Or if you find an online tool that works for them and generates a lot of discussion, we'd like to hear about it!

Get into the habit of documenting what is happening in your Makerspace. Here are some basic types of website / blog content that your members may appreciate and that aren't too demanding to produce:

- **About Maker Faire.** Stir emotions with your passion for Maker Faire. Tell everyone why you're in it, and who is in it with you. Introduce your audience to Makerspace, Young Makers, Maker Faire, Make, and Maker Media. Please see Resources for the particular language you can use to describe all these entities.
- **Meet the Maker.** Publish interviews or profiles of individual Makerspace in your group. Show them off! Give them the attention they deserve. Check out makezine.com for **examples of maker interviews**.
- **Looking for a Mentor!** Describe the expertise that you are seeking, or ask a mentor to describe an experience from working with your members.

## Set some ground rules

Make sure that everyone who uses the Makerspace has a shared understanding of a few important items:

- *Purpose*: Why does the space exist?
- *Membership*: How does one gain access to the space, how can this membership be revoked?
- *Space Use*: Who can use the space for what activities?

- *Emergencies:* What are the procedures? Does everyone know where the first aid kits and fire extinguishers are, and how to use them?
- *Tools*: How do we train newbies to use the tools safely? Are there prerequisites and requirements for experienced tool users? What measures are there in place—such as checklists—to refresh users' memories before they touch a potentially dangerous tool?

Please refer to the chapter on Safety for more rules that your Makerspace users should agree to.

### Come up with an identity

One advantage of working in a shared Makerspace is the opportunity to create a shared identity. Such things as adopting a mascot, designing a logo, having T-shirts made, having a website, and picking a fun name can all help to create a sense of shared purpose and belonging. You'll probably want to pick an identity with member input, but don't spend too much valuable meeting time wordsmithing your group's name.

Then, in true Maker spirit, ask one of your students to create the logo, and perhaps even manage the website. Some project teams may want to create a T-shirt to wear when they exhibit or present their project.

### Find funding for your Makerspace

Your Makerspace may not need much of a budget to operate, if you have a space you can use for free, tools to borrow, and materials found or donated. For some Makerspaces, the ones with lots of parental involvement, many of the projects are self-funded. But if your Makerspace takes place at a school without as much family support, or if you simply do not have this all in place, you may need to research community or family foundation grants to fill in the gap. It's possible there could be city or other government agency grants available to get your Makerspace what it needs. Sometimes you can find the funding with a "planning grant." If you are partnering with a non-profit, get advice from the fundraising staff who may be able to suggest the right foundations to approach. Ask around.

Online tools like Kickstarter and Indiegogo might help you conduct pointed fundraising campaigns towards a specific goal. There are many sites like this – search on "crowdfunding" for more suggestions. While it's not a Makerspace, we know that the Rhode Island Mini Maker Faire used this tactic to launch a Maker Faire. Maybe it could work for a Makerspace too.

You could invite business sponsors to donate and back up the expenses of your Makerspace, just as local sports teams have support from their community businesses. In general, Maker demographics are a desirable audience for businesses (techies and smart families). Remember that the earlier you establish it, the more valuable the sponsorship would be to the business, so don't procrastinate.

Be flexible—you may have to "wheel and deal" a bit to secure sponsors. To get funding, you would identify potential sponsors and devote time and energy approaching them, following up, and then—when they sign on—representing them on your website and other materials. But keep in mind you may not be able to feature their logo too prominently at Maker Faire itself. Check in with your event staff before making any promises to potential funders.

Barry Scott of the Da Vinci Center of the San Joaquin County Office of Education in Stockton, California has put together a very helpful blog called **Grants for Makerspace schools** which is full of links and tips, some of which we've quoted here:

*Makerspace schools need more resources than most educational programs. It's not as hard as you might think to find supporters.*

*National competitive grants may be offered by private sector foundations, nonprofit organizations, or government agencies. Government grants tend to require more complicated applications, while others, like the ING Unsung Heroes grant may be very brief (three pages maximum).*

*Regional grants are often offered by utility companies and corporations to support families in their communities. These are often less competitive and are usually easy applications to complete. PG&E and Los Alamos National Lab are examples.*

*Non-published grants and gifts to schools are often made by both large national organizations and smaller local companies and agencies. Most large corporations have a foundation or charitable contributions division which can be contacted for potential support.*

*Look at your community's largest employers as potential supporters. They want to provide community support, improve school programs, and they want schools to produce a bright workforce as much as anyone.*

## Checklist for Grant Planning & Development

### General considerations

- Your project demonstrates basic understandings of sciences and content involved.
- Your grant is based on some things you already do with kids.
- Your grant is not dependent upon (or an extension of) another grant, if so it must stand on it's own merit.
- Your project includes a "kids teaching kids" component.
- Your students will work with other classes at your site.
- Your students will work with students at other schools.
- Your project involves students' homes or families.
- Your project has interaction with local businesses.
- Your project will impact the community.
- Your project will have a positive effect on your school's culture.
- Your project has a long-term vision and may carry on into the next school year.
- You have "buy in" from your administrator.
- You've consulted any school facilities staff that may need to be involved.
- Your application is concise, brief, and "paints a picture" of your "finished project". (less is more!)
- You have considered ALL of the potential obstacles to completion of your project
- You've allowed at least two peers to review your draft and provide feedback, including one non-science person.
- You're composition style is easily comprehensible and you've checked the spelling of your document.
- A detailed budget is provided and all the funds are allocated.
- Letters of approval and support are provided.
- Follow the application format carefully, it is your blueprint to success, don't be repetitive.

### Specific considerations

- Project Title is brief and suggestive of the project's goals or activities.
- Project Description includes specific goals.
- You have identified the target audience (this may include more than students).
- You describe specific student activities including the energy science content studied.
- Student leadership and service learning/community involvement goals are described.
- State Content Standards correlations are delineated (this can be at the very end)
- An Evaluation section explains how you will evaluate the success of your project.
- An Expansion section describes how your project might be replicated or expanded.

*— by Barry Scott of SJCOE*

### Set a deadline and meeting dates

Locate a Maker Faire or Mini Maker Faire near you that you think is timed well for exhibiting your students' finished projects. If you don't have one near enough to where you are, **you can make a Maker Faire**.

Set meetings to be regular: monthly or every other week. Include time for "plussing sessions," round robins where the project teams share their progress, make connections with other teams facing similar challenges, and get feedback and tips. Regular meetups serve as important milestones along the road to your deadline and also provide some structure and motivation along the way to ensure that a project can be finished in time for the showcase event you choose as a deadline. They are also an opportunity to introduce those lightweight "rituals" that make belonging to a Makerspace more fun. When done in a spirit of good will and making everyone's projects better, they are good for building community, socializing new members, and boosting morale.

Meet as often as you need to in order to make, but don't plan to have "meetings" too often. Too many meetings are burdensome for busy and self-directed Makers; sometimes there is a finite amount of time available and a meeting might take up precious time otherwise spent on actually getting something accomplished on the project.

### Get your Makerspace Starter Kit

We want to offer our Makerspace partners a few Maker Media items to use in promoting the Maker movement and a sense of belonging once you have members. The Makerspace starter kit support package is yours for the asking. It includes:

- promo code for a gift subscription to MAKE Magazine
- five MAKE T-shirts
- five Maker Notebooks

**Maker Shed** is working on developing some promotional products and ways to partner with Makerspaces; stay tuned to the Managers group for more information.

# 10

# Documenting

It's not enough to just make something—it's also important to be able to tell others about the projects and why they are great. To tell their stories better, your Makerspace's project teams will want to think ahead to make sure they have the tools they need to document their process and their final project.

Exhibiting at a showcase event such as a Maker Faire is a golden opportunity to take a step back and tell the story of how and why a project was made. But once the event is over, how will your members be able to show off what they've done? It's possible that their project is too large or the pieces of it too temptingly reusable that the project won't last long. Spend the time after Maker Faire adding the project to your Makerspace members' portfolios, or starting some kind of portfolio.

As they prepare to exhibit, ask your members to collect documentation that tells the story of how and why their projects came to be. One team member on each project could take on the role of documentarian along with their other making duties. Maker Faire attendees love to know how and why Makers created their project, and so you will want to encourage your members to gather evidence of their process. This can go all the way back to the brainstorming phase—one exhibiting group "Awesome is What We Totally Are" proudly shared the dog-eared spiral notebook which they had used for their original brainstorming session. In it you could see a full page of great project ideas scribbled down. The ideas were all over the place and each one looked like the next great project.

## Forms of documentation

Documentation could take many forms, but whatever medium the members choose to tell their story, the important thing is that it captures why and how they made what they made. Some ways that your project teams may choose to capture their projects follow.

***Notebooks***. At our first meeting, we often distribute a Maker's Notebook to make sure that each Young Maker has a place to sketch concepts, jot down notes, paste in inspiring clippings and printouts, and so on. Students have found it helpful to bring their notebooks to Maker Faire so that they can answer questions about what they've done and also show off the hard work they put into their project. Paper is low-tech and affordable by all.

***Blogs.*** Blogging software is pretty easy to use, and multiple teammates can contribute to a blog, whereas it's harder to share a notebook. If members keep Maker's journal online, adding photos as they go along, they'll have a pretty rich record to tap later.

***Project Binders.*** Simplify and revise what has been recorded in the notebooks to create scrapbooks of the projects. Three ring binders are wonderful tools since they allow you to collect all sorts of different printed material (component spec sheets, press clippings, sketches on napkins...) in one place. You may prefer a binder to a bound notebook because of the flexibility. It is also helpful to date everything you put in the binder. That provides an accurate historical record that becomes increasingly interesting over time.

***Photos.*** Take candids of the team working together and time-lapse shots of the project forming, as well as well-staged explanatory photos in case you want to write up their project as a "how-to" someday. Snap pictures of materials before and after adding them to the project. Sure, it helps to have an amazing camera, but you can also just ask the Students to use their phone's camera. If you create a **Flickr** set or collection of photos online, please be sure to add "youngmakers" to your tags. License photos as **Creative Commons** images as appropriate, and then email any links to sets to **contact@makerspace.com.**

***Posters.*** After Maker Faire, Aaron Vanderwerff asked his students to create posters describing their project. The posters were designed to be similar to those that scientists and engineers create to share their work at professional and academic conferences. The posters

included a description of the project, a key scientific concept the project exhibited, an explanation of how one piece of technology worked on their project, and the students' conclusions about the project.
***How-tos.*** Give back to the DIY community and the Maker movement by having your Students write up their projects and add them to Make:Projects, Instructables, or another DIY community website. Having to explain how to do something to another person often helps learning "stick" better in the long-term.

***Slideshows***. Have your members tell their stories through a slideshow. You can give them free rein with the length and number of slides, or challenge them to use a quick-and-lively format like **Ignite** or **Pecha Kucha**, both of which limit the number of time and images the speaker can share. Using the slideshow format gives you automatic content for future fundraising and recruitment presentations.

***Videos***. Bring a digital video camera to all build sessions and meetings. Joseph, from the team that created Saphira, created a **fantastic "trailer"** to show off the animatronic, fire-breathing dragon he helped to build and the months of work that went into it. And don't forget, video is much easier to move around than a machine with propane and an 8.5-foot wingspan. While a good microphone would be great for capturing the conversations and sounds of building, it's not essential as you can always add voiceover or an energetic soundtrack over the footage you capture.

***Digital Stories.*** Digital storytelling combines photos, video, animation, sound, music, text, and often a voiceover to create a short 2- to 3-minute multimedia narrative. The Center for Digital Storytelling has used this technique to have their storytellers reflect on their lives and work, and it has also been used with young people to reflect on creative projects of their own design. While we don't have any favorite tools for classroom or Makerspace use, and video editing is getting easier all the time, a quick online search of "digital storytelling" will get you some of the latest news on how you can bring this to your students. Often, the voiceover in a digital story is recorded with a quality microphone.

***Project Books.*** At the end of the project, you can put together your best photos of the finished project and the process of making it, and print these out on a nice printer so that the members have a permanent record of the project. Or consider printing custom photobooks (from Blurb, Apple, Lulu, etc.) that the members can keep in their portfolio to show off how they spent their months of work.

Regardless of the form your members choose to document the story of their project, the questions they can answer are not unlike those that they may have answered at the plussing sessions and Maker Faire.

- What was the project vision? What were we hoping to do?
- What inspired us to pick this project? Why did we do it?
- Have other Makers done similar projects, or was this one-of-a-kind?
- What's next? Are there other project ideas we have toyed with?
- What kinds of projects had we built before?
- What was hard to do? What was easier to do? Did that surprise you?
- Were there any interesting, surprising, or spectacular failures?
- Were there any interesting or surprising behind-the-scenes stories?

Along with adding to your personal record of what the Makerspace has accomplished together, you can also share this documentation with us and we will consider it as a post on our active blog at **makezine.com** or in Make: magazine.

You made it! (Literally!) They made it! How can you keep on making? This chapter covers the steps you should take to keep the momentum going and also to give back to the network so that others can learn from your experiences.

## Congratulating the students

As soon as you can manage to do so after the event, reach out to your participants to congratulate them on their good work. Thank everyone who participated in the program as makers, mentors, supporters, and in various other roles you might not have witnessed. Offer a special congratulations to the amazing Makers who exhibited and to the dedicated, patient, and talented mentors who helped bring so many wonderful projects to fruition. Tell them again that you are very proud of the results of all their hard work. For those who helped set up and cover your area, or special patrons or sponsors of your Makerspace or its projects, be sure to offer a hearty thanks as well.

Give your participants some talking points for between seasons, as people who hear about their experience may ask them how they can start a Makerspace or get involved in the Makerspace. Give them any data you have, like how many projects you made, how many aggregate person-hours you worked on the projects, how many people attended the event, etc. If you have any links to great images, photo sets, videos, or media mentions, share those too—whether those cover the event, your Makerspace or its projects. Share all these things with people who ask, and share them with us too! Send links to **contact@makerspace.com**, and we'll send them along to others.

Pass along to the members any great feedback you heard about their projects — and request that they share some of the things they heard from visitors this weekend or to let you know if they know that they happened to speak to anyone from the press. Send a survey to your participants to gather feedback for improvement next year. Welcome any advice, suggestions, or tips that can't fit in the survey.

## Surveys

Within one or two weeks after your members exhibit their final projects, you should reach out to them, their parents, the mentors and other volunteers and offer them a chance to weigh in, offer suggestions, and give compliments. Use an online survey tool such as Google Forms or Survey Monkey to give your participants the option of anonymous responses. Or, at least, send an email where you ask for feedback.

**Questions we have asked in past surveys include...**

- If a friend asked you to describe your Makerspace in 10 seconds or less, what would you say?
- What did you think of the project vision?
  ...the completed project?
  ...the experience exhibiting?
  ...meetings?
  ...workshops?
  ...plussing?
  ...shop facilities?
  ...overall: the whole program this year?
- For students: How much help did you get from your mentor(s)?
  - What part of your Makerspace was the most fun for you?
  - What was the least fun or most frustrating?
- For adult participants: How many projects did you help with?
  - Were any of the team members you helped your children?
  - How engaged were the project team members?
- If you could change one thing about the program, what would it be? This is the place to give more feedback that didn't fit any of the questions we've asked. Suggest changes would you like to see for next year, or ways to reduce any frustration you felt.
- Share your success stories! Tell us anything we might share when we try to get other kids and adults excited about the program. Students, you can tell us about things you learned or new skills you gained. You can even describe anything at Maker Faire that interested or inspired you.
- Do you think you'll use a Makerspace again in the future?
- Spreading the word: If you know someone who should hear about this program, please give us their email address(es) here.

In asking these questions and analyzing the results, your goal is two-fold: to continually improve the Makerspace, and also to gather great stories and data to help sustain the program.

## Debriefing your work as the Makerspace leader

What your group did will inspire other Makerspaces, so be sure to share what happened with us and keep a copy of it all for yourself and future students.

- Ask someone to write up what your Makerspace did in a blog post or make a video about it.
- Write down some notes about what you did, what worked especially well, and what you might change for next year. Include any highlights or summaries from the survey you sent to your participants.
- Pull together any documentation your members made of their projects. Keep a record of all the projects that emerged from your Makerspace in one place, probably a page of your website.
- Before you lose touch with everyone, ask the members if there's anything they wish they knew before they started their projects.
- Ask the parents, mentors, and volunteers to write or revise their job descriptions so that next year everyone can start the season ahead of the game.
- Organize any photos taken along the way and put them in a place you can find them later.

Everyone has a digital camera these days, so it's easier than ever to crowdsource the task of documentation. Encourage members, parents, and mentors to use a Flickr tag for your Makerspace (e.g. "Makerspace-SF-2012") as well as our generic "Makerspace" in advance. You can also ask them to share pictures via email.

It's handy to organize your photos in a place everyone can access, but it can be a big job too. Google Docs Collections seems to be a solid, free tool for managing these visual assets and keeping them available in the "cloud." Other people pay for a subscription to DropBox for similar functionality.

Make the effort to get an image of every project. When kids don't see a record of their work on your website, they notice and could take it personally. They might assume you don't appreciate their hard work.

## Reporting and sharing with other Makerspaces

The network of all Makerspaces would *very much appreciate* your sharing some notes, write-ups, images, and videos from your time making together. These help build the national and international community of Makers, and we can sometimes feature your Makerspace's efforts in MAKE Magazine or on the **makezine.com** blog.

There are a few specific things we ask that you do as members of a supportive Makerspace network.

### Maker List

Maker Media is building an international database of Makers and their projects with the ultimate goal of starting a Maker Guild. We'd also like to offer subscriptions and contact your makers for potential editorial coverage in MAKE magazine or the blog. Submit.csv or.xls files to **contact@makerspace.com**. These are fields that would be helpful:

- Name
- Makerspace Name and Location
- Website URL
- Exhibit name
- Exhibit description
- Email address
- Snail mail address, if you have one

### Share best practices

Our hope is to learn more about how we can support making more Makerspaces, and to know more about what works and what doesn't. We may send you a simple survey to ask questions about your year, like:

- How many members? mentors? other volunteers?
- How many completed projects?
- What was your Makerspace's budget?
- Most successful innovation?
- Priority improvement areas for next season?
- Will you do it again next year?

Take a moment occasionally to report back to the Makerspace core team.

### Contribute to this playbook

The Makerspace Playbook is intended to be a living document, evolving as the collective experience of the network and its community of Makerspaces grows. Please email your comments, helpful anecdotes, or a snapshot to **contact@makerspace.com**.

### Share images and video of your accomplishments

Every day **makezine.com** offers up inspiring content about Maker projects. We would love the opportunity to feature documentation from your Makerspaces on our blog. Consider one of these ways to share what you did:

- Make a three-minute (or shorter) video documenting your Makerspace's season. One format is to get each of the exhibiting Makerspace to introduce themselves and say "I Make..." Here are some examples from Maker Faire that you can follow:
  - **youtube.com/watch?v=Usw4t7NVnt0**
  - **youtube.com/watch?v=Cn9ST2ay6c4**
  - **youtube.com/watch?v=TRjNOoAHaGg**

- Create a **Flickr** set or collection of photos and tag them "youngmakers". License them as **Creative Commons** images, and then email the link to **contact@makerspace.com**.

# 11

# Snapshots

## Analy High School

*Note: This snapshot is written by teacher Casey Shea*

When I was in school, along with my regular academic classes, I had the opportunity to take practical arts classes in drafting, cooking, and sewing, as well as shop classes working with wood, metal, and autos. These experiences, in addition to summers tagging along with my jack-of-all-trades grandfather, helped to instill in me not just an enthusiasm, but a need to fix, create, and make things.

After a decade of teaching high school math, when presented with the opportunity to teach a new class that promised to let kids just make things, naturally I jumped.

Over the summer, a dedicated handful of students and I moved tools and equipment from an abandoned lab on the campus of Analy High School in Sebastopol, California, to a mostly vacant space down the hall from the headquarters of MAKE magazine. We built the tables and storage units, rummaged through surplus electronic components, and prepared to sail into the uncharted waters of Project Make.

The initial class consisted of 29 students ranging from sophomores to seniors, from AP students to those struggling in basic classes. The blend of grade levels and academic abilities provided a unique mix from which I believe all the students benefited.

Through the class, students have learned some basic construction tools and techniques, explored electronics by putting together simple and complex circuits, and dabbled in design, computer programming, and blogging. For several students, Project Make provided a first opportunity to use a power drill or pick up a soldering iron. Knowing that several people learned a new skill or understand a little bit more about how things work — how threads are cut into galvanized pipe, for instance — has been a very gratifying experience for me, regardless of whether or not they ever use the skill again.

As any maker knows, frustration and failure are most often a part of the process. Rarely does something work exactly as expected the first time; iterative adaptability is a requirement for success. One of my goals at the outset was for the students to develop tenacity and willingness to learn from challenges, to redefine and even embrace failure as a necessary part of the learning process. Results have been mixed but far more successful than in my regular classes. These lessons are hard to teach in a traditional classroom setting where success is measured through more standard means.

Besides sharing the joy and challenges of making, another goal of mine has been to develop and experiment with projects and activities that I could bring into my traditional math classes to help students grasp abstract concepts. Time and energy constraints have conspired to limit the achievement of this goal, but my idea notebook is full of sketches and possibilities that I intend to pursue over the summer for inclusion in Project Make version 2.0.
From the start, the response from the community has been extremely enthusiastic. Parents have donated supplies and hackable gear, requests for visitations from school and community members have been numerous, and the reactions overwhelmingly positive.

## Lighthouse Community Charter School

*Note: This snapshot is written by teacher Aaron V.*

Walking into Aaron Vanderwerff's Robotics class on a Tuesday in the spring, you would have seen 20 students working in small groups, heads bent over computers, soldering circuits, using new-found carpentry skills, or conferring with each other and their mentors. As Maker Faire approached, the students' visions became more certain and activity in the room became more focused. This image of students working independently with the support of mentors on a project they envisioned had been something Aaron had tinkered around the edges of throughout his career; in that first year when he adapted Makerspace to his curriculum, the vision and support of the program, he says, helped make it a reality.

Aaron is a Physics, Chemistry, and Robotics teacher at a small K-12 charter school in Oakland, California. The students in his first Makerspace group were enrolled in his Robotics class. Students in the class were generally 12th graders, low-income, and went on to be the first in their families to attend college. Most students in the class did not choose to take Robotics and were intimidated by the class at the beginning of the year. The students learned basic electronics and programming as a part of the Robotics curriculum.

Aaron's Robotics class introduces engineering as a possible career to his students. Building a complicated project of their own allows them to really see themselves as Makers. Exhibiting at the Faire gives them a real audience for their project, which forces them to be able to communicate about their project as well as bring it to fruition.

Soon after the first large Makerspace meeting, Aaron returned to school and announced that the class would be creating Maker Faire projects. Aaron knew that none of his students had ever attended the event and none of them had ever developed their own project from scratch.

A few days before winter break, Aaron spread out his personal set of MAKE magazines before his students and asked them to look through an issue for a project that caught their imagination. After 20 minutes, students shared a project they found in the magazine with the rest of the class. Their homework that night was to dream up a project – either something based on a project they heard about that day, or something completely original. Students returned the next day with individual ideas for their projects and presented these ideas to the class. After the presentation, Aaron asked students to form groups based on common interest and start working on a shared project vision. He emphasized that they should choose something they thought they would enjoy working on for five months. Before leaving for break, each team gave Aaron a proposal for their project.

After break, Aaron handed the project ideas back to students to get them thinking about the project they proposed again. Mentors attended their first full class session after break, and they used one student's project to showcase project plussing to the whole class. After hearing the student present, mentors asked him questions about the project and gave him ideas to help him get started on the project. After the first full class plussing, mentors circulated to the remaining groups and helped them plus their projects.

The Robotics class met every day for 70 minutes. During the spring semester students met in their Young Maker groups once a week. This weekly meeting included students and mentors. In the month before Maker Faire, students met five days a week for 70 minutes and had the opportunity to work on their projects outside of class. In the final week many of them took advantage of this extra time.

Aaron encouraged his students to develop projects that were novel ideas, extensions of others' projects, or even project that had been done before, but would be difficult to carry out. Although the class is a Robotics class, students were not required to complete a "technical" project, they could pursue a craft project, or a building project. Twenty students worked on 12 projects. These included:

***LED Soccer Ball***: Different color LEDs light up depending on the direction of acceleration. In a project like this one, students ended up learning to program an Arduino, used technical specification sheets to use an accelerometer and to figure out how many LEDs one LilyPad Arduino can power, modified a soccer ball to protect the circuitry, and soldered the circuit together.

***Interactive Plastic Chandelier***: Artfully repurposed, reshaped water bottles surround LED lights, and a distance sensor makes the light display interactive. The three girls in this group started out with a vision of creating an interactive photo frame composed of recycled materials, but after a Makerspace regional meeting at the Exploratorium where they heard from artists working in plastics, they decided they wanted to recycle landfill-bound plastic into a light fixture.

***Steerable Hovercraft***: Based on designs he found online, this student first built his own working hovercraft. This task alone took the student a couple months as he had to work through many pitfalls on his own. In order to create a working hovercraft, the student modified his first design multiple times and in the end had to build a whole new design. After getting the basic hovercraft working, he embarked on designing a system to steer the craft. This student learned carpentry skills, physics, as well as the power limits of circuits at school; his biggest lesson was, however, that creating a project is an iterative process.

Mentors played the role of an outside consultant; coming from the "real world" gave them quite a bit of credibility with the students. Mentors met with students every one to two weeks. They would check up on the groups' process and help students set goals for the next time they met. While they were meeting, mentors would often teach students to locate and read technical specifications, to find appropriate materials and tools for their projects, to program in a new language, as well as techniques in building their project. It took many of Aaron's students a couple of months to acclimate to working with their mentor, but in seeing their conversations in the last month of the project, it was clear that mentors were an integral part of the process.

To prepare for Maker Faire, Aaron briefly discussed with the class what they could expect to see there. He focused mostly on making sure that they would all be able to get to Maker Faire and bring all the materials they needed to present. They also thought about how they could present their ideas to people as they walked by. (Next time, Aaron says, his students will be doing much more prep before the event.)

After Maker Faire, Aaron asked students to create posters describing their work on the project. The posters were designed to be similar to posters which scientists and engineers create to share their work at professional and academic conferences. The posters included a description of the project, a key scientific concept the project exhibited, an explanation of how one piece of technology worked on their project, and the students' conclusions about the project.

As school began a few months later, Aaron started his Maker timeline in August, a few months earlier than in his first year (when the program's regional kickoff happened in December.) In the first few months of class, students had "Maker Weeks" focused on soldering, crafting, building, and programming an Arduino. In addition, students mined MAKE Magazine for interesting ideas as a weekly assignment over the first few months. His Robotics students worked on their programming and building skills for two weeks. Then they had a focused introduction to important Maker skills for a week. After the initial phase, students started working on projects in a similar way to how they did it in Aaron's first Maker year, with the added benefit that students had more exposure to the kinds of projects and skills they would later possibly pursue.

## The Athenian School

Nestled in the golden oak-studded hills of Danville. California, The Athenian School has enjoyed a number of making programs for quite a few years– including a handful of making-heavy classes, a robotics program, and an aviation project–but more recently they've been bringing them together in a more coherent whole called The Makers Studio, funded in part by Athenian Parent Association's fundraising efforts.

About ten years ago Athenian added a new space adjacent to the old barn, and now Athenian enjoys an ample 60 foot x 40 foot workspace. What began as three distinct shops for three different programs was redesigned two summers ago to integrate metal shaping, woodworking, welding, and materials more seamlessly. As part of the re-haul, the Athenian Parent Association sponsored two machines that teacher David Otten appreciates greatly for how much they open up the range of projects the kids can do — a laser cutter and a SawStop table saw. A third donor-sponsored addition was added this summer – a Makerbot Replicator 3D printer.

The Makers Studio supports nine Athenian programs/classes:

- Applied Science and Engineering classes
- "The Art and Science of Making" class
- Athenian Engineering Collective (AEC)
- FIRST Robotics
- "Spirit of Athenian" Airplane Project
- General Science Classes (Conceptual Physics: Rocket Boxes; Chemistry: Valence electron models; Biology and Environmental Science: Quadrangles)
- Electric Car conversion
- Applied Science Club
- Middle school "Innovation and Design Thinking" class (new this year)
- ...and they use it to make science department equipment too!

The Applied Science class begins with a brief introduction to engineering, including that old favorite: the marshmallow tower. Then the students move on to an electronics unit, including learning to solder. They eventually move onto microcontrollers, ending the term by building a line-following robot. In the second semester, they are free to invent something, anything, using the skills the acquired over the first few months in the course.

***First Semester***

- Ongoing self-guided review and integration of Physics, Chemistry, and Biology
- Fundamentals of creative problem solving, including up to 4 small-scale projects (electric vehicle, appliance dissection, microcontroller line-follower)
- Augmenting students' engineering toolkit (engineering drawing and CAD, rapid prototyping, hand tools, some machining/woodworking/metalworking, soldering and circuit layout, microprocessor use and programming, etc.)
- Starting final projects

***Second Semester***

- Main phase of final project
- Interim assessments
- Final project presentation and demonstration (Athenian Faire and Maker Faire Bay Area)

The Athenian Engineering Collective (AEC) had been focused primarily on robotics, and was founded around the students' desire to add a FIRST robotics team to the school. Last year they turned their attention to "giving back", and they extended their scope to do outreach to inspire younger students in their community to love engineering.
Thirty-one fifth-graders took workshops exposing skills the AEC members use in their robotics design work, such as: welding, milling, lathe, laser cutter, and design software. The AEC members really enjoyed getting a chance to teach what they knew to the younger kids, like how to use the machines and how to drive the robots. The AEC members also came up with a clever cardboard design that the younger students then assembled and programmed to complete a simple task. The AEC members gave the fifth-graders a pre-written program that they then helped them modify to execute exactly what they wanted to. David noted that in hacker culture more generally, there is a tradition of starting with something pre-existing and modifying it, and so he advocates this as a solid instructional strategy–not just in programming but in other domains that have yet to take this approach.

The "Spirit of Athenian" airplane project is one of Athenian's most popular offerings. A local benefactor named Marsh, who spent his career in aeronautics, wanted more young people to fall in love with aviation, and so he started this program with a large donation (facility, equipment, and volunteer time). It has proved so popular among the students, It now gets a good deal of support from the administration as well. It is fully funded and has in the neighborhood of 90 students participating. When the airplane is finished there is a lottery among the students who spent the most hours building the airplane to figure out who are the lucky few who get to do a test drive of it up in the air with one of the instructors.

A fully functioning shop space enables students to take on other ambitious projects, like the electric car conversion project. Athenian students designed and fabricated a motor mount so that they could replace the gas motor with an electric one and fit it within the existing chassis. It's a good illustration of the power of using digital design tools, in this case SolidWorks, to make the modifications necessary to realize an ambitious vision. Beyond designing and machining it, they also prototyped it using cardboard to make sure that their design would be accommodated within the space constraints of their existing engine.

The tools Athenian has include a laser cutter, mill, two lathes, three drill presses, brake, shear, belt sander, grinder, TIG and MIG welders, oxy-acetylene, table saw, two band saws, air compressor, dust collection, an electronics bench, 3D printer, and much more. Over the coming years, they hope to add a digital oscilloscope, another 3D printer, panel saw, planar / joiner, router table, casting/forging, and vacuum molding.

David imagines that this space can eventually support the entire school, not just the science and engineering programs. Future interdepartmental connections he hopes to make include:

- Computer or research lab model
- Fine arts (set design, costume design)
- Humanities (ritual drum-making, historical clothing)
- Textiles and sewing
- Science and Culture of Cooking
- Lost Art of Living (a unique course introducing survival skills, or all the things that people knew how to do two or three centuries ago: how to catch food, prepare meat, sew clothing, make failure, but we've lost those skills. Athenian students will be the ones to survive a global catastrophe!)

As David began to research what the shop should look like a few years ago he embarked on a tour of about 15 other shop spaces in educational settings. I asked him to cite a few that he thought were especially interesting:

- UC Berkeley Mechanical Engineering and Physics
- Laney College Woodworking, Metal Shop, and Carpentry
- The Exploratorium
- The Crucible
- TechShop in San Francisco and San Jose

A lot of the evolution of Athenian's Makers Studio program was driven by the interests of the students, responding to things that they wanted to have happen on campus and expanding to satisfy those needs. It's a sure-fire strategy for success.

## Independence High School

Last December, Beth Alberts spent hours collecting driftwood to prepare for a lab class. In some ways, it fits right in at Beth's school, Independence High School, a public high school about 6 blocks from the glistening ocean in San Francisco's Outer Sunset area. In this lab, Beth challenged her students to use their knowledge in gravity and balance to create a driftwood mobile that didn't wobble dramatically or tilt drastically. They manually drilled steady holes through the driftwood, carefully tying together string, wood, and a few additional beads for balance. They went through multiple iterations and lots of knots before accomplishing a perfectly balanced mobile – and identified the center of gravity along the way.

In another lab, Beth's students opened the heavy covers of their science textbooks without using their hands. There were string and pulleys everywhere, including a successful attempt at linking the opening of a window to the opening of the textbook. Beth notes that students are becoming more persistent, not getting so easily frustrated at small, initial setbacks, and just coming to school more often.

At Independence High School, Robert Maass, school principal and active maker, and Beth Alberts, science teacher and inspiring/aspiring maker, are tirelessly working to create an environment that allows safe, engaging exploration. They have revamped Beth's classroom into an interdisciplinary welcoming space – for students and teachers alike – to build hands-on projects, try out new skills, or just hang out and sketch. Beth teaches both "project" and "lab" classes each week: project classes can be on any topic and on any project, from hacking toys and beading to designing stencils and created stained glass pieces. Robert teaches project classes too, when he can. Beth's lab classes are more science-focused, with a key concept that she addresses, but also seamlessly integrate hands-on projects that require some exploration, some frustration, and lots of manual dexterity.

In one Friday's project class, a small group of teachers and students learned how to work with stained glass. With the instruction and facilitation of Mei Lie Wong, a friend in the community, students learned how to use glass tools to carefully score and break pieces of colored glass into the shapes and sizes they desired. They fiddled with smoothing rough edges, arranged their pieces into an optimal design, and applied copper tape. At the end of the hour, all participants had their own unique – and beautiful – version of a window ornament. In the next session, they would learn how to solder all the pieces together.

Unlike the vast majority of high schools, Independence High School does NOT require students to attend every class from 8am to 2pm, Monday through Friday. Rather, it's an independent study school.

Students are required to meet with a teacher or advisor at least once per week, for a full class period, but are otherwise welcome to be at school for as much – or as little – time as they desire. Naturally, they're encouraged to attend electives, connect with their fellow students, join in activities, study, etc and in fact, many do. Bianca comes to school every single day. Sometimes, students even bring friends (who attend other high schools) to Independence.

With an unusually supportive principal and a teacher who never runs low on new ideas, Independence is creating a fun, engaging space for the whole school community. More teachers are involved, bringing in new ideas and hobbies, interested in helping or leading a project class; more students are coming, and coming back. And everyone is just more excited to learn and do.

## Pittsburg High School

Pittsburg High School in Pittsburg, California, started on the path towards "making" many years ago, when Andreas Kaiser was teaching math and started an afterschool club to get kids involved in LEGO robotics, while in his math classes they built house models. He started this effort because he wanted his students to experience the kinds of things that he enjoyed in high school and in college. Eventually he persuaded his administration to take the plunge and start a computer-aided design course, later adding an architectural design and a robotics class. In those first few years, Andreas and his students were jammed into a portable classroom, with little elbow room to work on projects. But Pittsburg High School recently moved to a brand-new building in which both Andreas and his colleague, Hillel Posner, enjoy ample room for their students and their projects. Hillel is the woodshop teacher, and he and Andreas have worked together to create an introduction to Makerspace course.

Andreas' classroom has banks of computers at the front of the class, and in the back he has a shop with tables and storage, including a great accumulation of repurposable items that he's collected over the last few years, including two projects in the back of the shop: a disassembled electric scooter and a kid's PowerWheels toy vehicle, which students were troubleshooting and repairing.

Andreas says his classrooms are very much a work in progress. In one class he has 40 students, so one challenge he faces is how to manage a class that large, when so many students are working at different paces and later even on different projects. He is also trying to find ways to organize the shop so that it can be almost self-sufficient, meaning that students know how to use what's back there and how to put away things once they're done with them.

One way that Andreas and Hillel collaborate is having the students design furniture in 3-D using SolidWorks, printing out small prototypes using the 3-D printer, then going over to the CNC to cut out the full-size version. Hillel has a 4×8-foot CNC router with a vacuum head. Hillel's students created this rocket-shaped shelving unit using Autodesk's 123D Make.

This year Andreas has a couple of large projects—Balsa wood bridges and gliders—that he and his students will pursue through the MESA program. MESA stands for "Mathematics, Engineering, Science Achievement," and it is run statewide by the Office of the President of the University of California, but other states have their own MESA programs. After designing their MESA projects on the computer and realizing them through advanced fabrication tools, in the next semester, after the students have gotten the hang of making things, they will work on projects of their own design.

Many if not most of Hillel's woodshop students start the year without being able to read a ruler, to add and subtract fractions, or to use a computer. For kids who already have the skills, they can take on an open-ended challenge such as "design a board game." Instead, Hillel feels that a more systematic approach—that is, taking small steps to get them used to the tools and the making mindset over the course of a semester or year—yields more success. Hillel tries to find that happy medium: where the most students can succeed, without stifling those who are ready for more personalized and creative project challenges.

Hillel noted that in his decade of teaching woodshop (including CNC and laser cutting), in classes of 30–40 students he will see just two or three students who get past the basics to begin to realize the creative potential of the advanced tools available to them. Hillel identifies students to work as teaching assistants after they have succeeded in a beginning class, where they help both with instruction and with organizing tools. These TAs handle the day-to-day tasks. Andreas took this bit of advice from Hillel and for every class of 40, he always finds four students to play this kind of leadership role.

One goal that Hillel and Andreas have this year is to design their courses in a way that gives all of their students an opportunity to experience using these higher-end tools. To give an example of his more deliberate approach to teaching, Hillel described a basic drafting exercise, using triangles and a T-square on paper. You can find these kinds of exercises in many drafting textbooks. In doing this, his students are learning basic skills such as measurement and drawing. From there they go to the computer and render it in 2D graphics. Then they go to SketchUp to represent their designs in 3D. Finally, they take those images to the woodshop and manufacture on the CNC and laser cutter. By the end of the semester the students would be making a simple deskplate with their name on it. In another class project, students create finely crafted cutting boards which are then sold in local gift shops, and all proceeds support the program back at the school.

## The Menlo School

In one corner of the classroom sits a hand-built air hockey table, designed and created from scratch by two high school girls in Dr. James Dann's Applied Science Research (ASR) class at the Menlo School in Atherton, California. It's perfectly functional, a second iteration with at least 500 individually drilled miniscule holes to allow for the correct rate of air flow. On another table nearby is a motorized go-kart, and an Induction Maglev track sits close-by as well. Models of student-designed motors – the first project of the year in ASR – are stored high above a set of cabinets. In order to build the motors, students had to learn about and put together a number of concepts and skills: magnetic fields, torque, alternating/direct current, wood construction, 3D printing, etc. And hidden behind cabinet doors are materials for the second project of ASR – a high-altitude weather balloon that needs to launch (often 1000 feet above ground), collect data about atmospheric conditions via its various sensors, and transmit data about its position in order to be retrieved. These projects are only a sample of the ingenuity, creativity, and real learning that happens in Dr. Dann's classroom. He talks about them – the projects, the class, his students – with a light-hearted chuckle that belies the true passion and care that accompanies his teaching. In June 2012, he was given the Distinguished Teacher award, a designation voted on by students and a plaque that he proudly displays in his office.

A scientist by training who had a career at CERN before he dove into education, James teaches not only Applied Science Research but also freshman physics and AP Physics C. There is no doubt that he likes teaching physics overall, but it's obvious that he loves teaching physics in a hands-on, project-based, non-traditional way that eschews standards and test prep and instead focuses on design, building, iteration, analysis, and presentation. The juniors and seniors who voluntarily take ASR as an elective jump right into projects. In line with James' teaching philosophy, skills and topics are taught on a need-to-know basis, where they'll be utilized and applied immediately. This way, students don't learn about the ideal gas law four years too early and then, have to re-learn it again when it becomes useful for calculating atmospheric pressure. Instead, they learn how to strip wires, program sensors and Arduinos, calculate magnetic fields, create 3D CAD sketches – all for the purposes of their projects. In other words, they make.

Students spend the first five to six weeks of a 14-week semester making a motor. They must learn the concepts, build a functional motor, take measurements to prove and understand how it works, and write a paper about it. This is no small feat, as a motor is actually quite a complicated machine that takes into account all aspects of physics: mechanics, electricity, and magnetism.

The second project, which takes up the remaining weeks of the first semester, is one based more in scientific research: making, launching, and collecting data via a weather balloon in order to better understand and interpret atmospheric science. Two months worth of work culminate in a 12-hour Saturday where James and his students head up to Marin and launch each group's weather balloon. There, they hope that all the mechanics, radio transmitters, GPS chip, backup data collectors, and sensors work perfectly – if for no other reason than to easily track the landing location of the balloon. Otherwise, the day extends a bit longer with wild-goose weather-balloon chases through woods and over rooftops. Back in the classroom, students, fully immersed in their scientific responsibilities, review their data in order to interpret their findings and conclusions. Last year, the class had 3 groups go up above 120,000 ft. and the students were able to recover all three payloads and all data. Here's one group's video of their balloon heading up to space.

Students in ASR embark on a second-semester project of their own choosing. Some work individually, others in groups, and they all spend at least one full week brainstorming and researching different project ideas and wishes, often using MAKE Magazine and Scientific American as starting points. Some focus on variations of tried-and-true engineering projects, including modified scooters and go-karts, but others venture down a more scientifically-inclined route, building Helmholtz coils for deeper scientific research. Whether they choose to work as a group or on an individual basis, all students inevitably collaborate with one another. Students have differing levels of academic and practical knowledge, and those with expertise in one area trade secrets and strategies with students with experience in another realm. Whether intentional or not, the classroom becomes a lively, messy, and collaborative space for hands-on, real-time learning.

The final products of the class are visible – they sit on floors and tables and are often displayed at Maker Faire in May. They also survive as models for the next year's class. In addition to the actual projects, there are other products too: research papers. James asks students to write scientific research papers for each of their projects, providing constructive feedback on progressive drafts throughout the semesters. He meets with them periodically, and he grades them on their concepts, analysis of data, clarity of explanation – all components of actual papers published in journals. There are abstracts, historical background, graphs, charts, 3D drawings, formulas, technical specifications, calculations, scientific theory and calibrations, conclusions, and appendices. Papers range from 20 to 60 pages in length and force these juniors and seniors to translate their learning into a real-world format. Along the way, they learn how to write too. There are no tests, no quizzes, no high-stakes evaluations, just papers that show the students' processes and demonstrate their understanding.

With more than six years of ASR under his belt, James has triggered an increased appreciation and interest in learning through making. Before the beginning of this 2012-2013 academic year, James' classroom was a typical science classroom, bright and sunny with wall cabinets and floor cabinets jammed full with measurement tools, woodworking equipment, electronics parts and sensors, and a sole 3D printer. It contained about 4 big benches, along with a few small tables and chairs, and one side was lined with 6-8 iMacs. Originally, James had to do a lot of wheeling-in and wheeling-out, and students spent a solid chunk of their 55-minute class period setting things up and putting things away. This past summer though, the plows and backhoes were out in full force, as they cleared out and repurposed the Upper School's basement storage space into a new ASR space: officially christened the Whitaker Lab in late October. The dusty basement is now a well-lit, vast expanse of workspace, complete with movable desks and carts, a conference room for brainstorming and presentations, an equipment area with a table saw and laser cutter, a Robotics wing, and even a sunny patio. It is well-used too, housing not only James' classes but also Engineering, MBEST (Menlo's Bridge to Engineering, Science, and Technology program for girls), and Robotics. James sets up – and leaves out – vacuum and temperature chambers, woodworking and electronics tools, and measurement stations. At long last, the space matches the aspirations of James' classes and intentions.

He hopes to continue teaching Applied Science Research – and offer more of it – to students (and girls especially) in the years to come. James acknowledges the steep learning curve that he embarked on as he uncovered how to best teach a class like this, and he happily and willingly offers his experience and wisdom to other teachers who are bringing making to their classrooms and schools – with whatever supplies and whatever budget. It's obvious that he's done a remarkable job in just a few years; a graduated senior stopped by his classroom to say hello during our summer conversation and ask about when he could drop by to do some work. This particular student entered Menlo School with an unlikely background from a struggling socioeconomic sector, and he walks away headed to Duke, supported by his experiences learning from and with Dr. James Dann.

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# Resources

- Program Team
- Tips from Mentors of the Computer Clubhouse
- Grant Ideas
- Samples:
    - Proposal and budget to submit to a funder
    - Student and Mentor "Job Descriptions"
    - Liability Waiver
    - Project Match for Students
    - Project Match for Mentors
    - Mentor Request Form
    - Project Plan
    - Proposal Form
    - Safety Plan
- The Safe Workshop
- Recommended Suppliers
- Makerspace-in-a-Box lists (tools and consumables; first, next, and additional)

# Makerspace Program Team

**Dale Dougherty** *Founder*
is the founder and publisher of MAKE magazine and the creator of Maker Faire, which leads a growing maker movement. An early Web pioneer, Dale was the developer of Global Network Navigator (GNN), the first commercial Web site launched in 1993 and sold to America Online in 1995. He coined the term Web 2.0 as part of developing the Web 2.0 Conference. Make Magazine started in 2005 followed by the first Maker Faire in the Bay Area in 2006. In 2010, Maker Faire was held in the Bay Area, Detroit and New York City. He was a Lecturer at the UC Berkeley School of Information from 1997 to 2002. He was named a "Champion of Change" in 2011 by The White House.

**Parker Thomas** *Project Director*
is an entrepreneur and product manager who has started and sold two companies. A passionate maker, he's built two airplanes and flown them around the country. He's now concentrating on building two makers named Hana and Kobi and helping them build treehouses, zip lines, decks, play structures, go carts, ponds and anything else they want to build. He is a founding member of the design team for Urban Montessori Charter School, a new charter school in Oakland based on the teachings of Maria Montessori, arts integration and design thinking.

**Stephanie Chang** *Program Developer and Liaison*
spent five years with Galileo Learning as the Director of the Tech Museum Summer Camps, and then earned a master's degree in the Learning, Design, and Technology (LDT) program at Stanford's School of Education. She has also worked in other informal science and experiential education settings. In her spare time she is refurbishing a VW bus, and enjoys photography, glassblowing, and galloping around in the sunny hills and waters of the Bay.

**Michelle Hlubinka** *Writer/Designer*
is the Education Director for Maker Media, overseeing educational outreach and programming. Before joining the Maker Faire crew, she worked at the Exploratorium's Center for Museum Partnerships and MIT Media Lab's Lifelong Kindergarten group. That work built on previous research at the Harvard Graduate School of Education, as a long-time mentor in the Intel Computer Clubhouse Network, and as a curriculum designer for various publishers and educational researchers. When she's not supporting future makers, she does some making of her own, most often as a visual artist.

**Devon McGuire** *Events and Community Manager*
tends the website and devises ways to keep the community jumping—both online and in person. Prior to joining our team, she wore a wide variety of hats at TechShop Inc., including Event Coordinator for TechShop San Francisco and Corporate In-Store Event Director, designing many of TechShop's core events and internal processes along the way. She has a Maker heart and loves finding new ways to make people excited about what they can create with their own two hands. When she's not on the clock, she enjoys costumed events (and building the costumes to wear to them!), ballroom dancing, drawing, comic books and anything Jim Henson.

**Maker Media**
Maker Media is a global platform for connecting makers with each other, with products and services, and with our partners. Through media, events and ecommerce, Maker Media serves a growing community of makers who bring a DIY mindset to technology. Whether as hobbyists or professionals, makers are creative, resourceful and curious, developing projects that demonstrate how they can interact with the world around them. The launch of MAKE Magazine in 2005, followed by Maker Faire in 2006, jumpstarted a worldwide Maker Movement, which is transforming innovation, culture and education. Located in Sebastopol, CA, Maker Media is the publisher of MAKE Magazine and the producer of Maker Faire. It also develops "getting started" kits and books that are sold in its Maker Shed store as well as in retail channels.

## Email **contact@makerspace.com** to reach the Makerspace team.

# Tips from Mentors of the Computer Clubhouse

**Be yourself.**
Work with kids in a way that is comfortable for you.

**Be reliable.**
Makerspace should know when to count on you coming. Your absence will be noticed!

**Be consistent.**
Be consistent not only in your own attendance but in making sure that you treat all Makerspace fairly and equally. Although you may find yourself engaged with an individual kid, try not to give the impression that you have a favorite Young Maker. Be open to having others participate. The more consistent you are, the more Makerspace will trust you and start to call on you for help and conversation.

**Be approachable.**
It is important for Makerspace to know that you are available for questions. If you have a chance to work on your own projects, make sure that you are still open to the Makerspace around you. Invite Makerspace to take a look at what you are doing, or ask them for advice on your project. Make sure people know who you are and that you are there to help and to talk.

**Be patient.**
Everyone learns in different ways, yourself included. Be patient with your own learning and with the learning process of others. Sometimes this means stepping in to help, or stepping back to let Makerspace work to solve a problem themselves. Be patient especially when showing someone how to do something that you may know how to do very well. Try not to do it for the Young Maker, unless safety is an issue. Each person will go through a very different learning process and will take different amounts of time to learn something new.

**Participate actively...and avoid lectures.**
You are not here to be a textbook. Engage in your own learning while you are mentoring. Collaborate on projects and experiment.

**Listen.**
As adults we often don't take the time to really listen to the ideas and thoughts of young people. Take the time; you might find you learn amazing things. Show your interest and excitement, observe, and ask questions.

**Go with the flow.**
Be prepared for the unexpected! Bring ideas for what you would like to do, but be prepared to go with the flow of kids' changing ideas.

**Get to know kids and let them get to know you.**
Engage a Young Maker in conversation. Ask questions. Offer to share something you know. However, understand that it will take time for the kids to begin to feel comfortable with you.

**Treat all participants with respect.**
Make sure everyone—young and old—feels welcome, important, and a part of the program. Learn names and greet each other by name. Show your interest in their projects—and in their presence. Respect the kids for who they are and where they are developmentally. We all come from diverse backgrounds and experiences. Take the time to get to know everyone individually. Avoid prejudging who they are, their skills, or their cultures.

**Treat kids as individuals, not as a group.**
Each person has different learning and communication styles. Get to know the Makerspace, their interests, and the way in which they feel most comfortable interacting. For some it may be through conversation, others through working on a project or showing you what they are doing.

**Discover and innovate together.**
Don't be afraid to share your ideas, give advice, and be a resource for creative ideas and new knowledge, opportunities, and possibilities. Show a Young Maker a new tool. Challenge them to try something new, or take on something new yourself. Try saying:

- "Have you tried this?"
- "Do you know about this?"
- "Gee, I don't know the answer to that question—let's go find out together."

**Figure out your own interests.**
Experiment with our resources, work on your own project, and then share your ideas and excitement with Makerspace. One of the best ways to be a role model is to share your own engagement in working with tools, people, and ideas.

**Give off energy.**
Show your excitement about what Makerspace are doing, and your interest in learning from their work. Share your own excitement and engagement in your ideas, and your own work as a Maker.

***Note: This page of tips is adapted from the Mentor Handbook of the Intel Computer Clubhouse Network,* computerclubhouse.org*, which serves as one model for the Makerspace.***

see makergrants.blogspot.com

*Note: These were generously compiled by Barry Scott of the San Joaquin County Office of Education.*

***American Honda Foundation***. National. Engages in grant making that reflects the basic tenets, beliefs and philosophies of Honda companies, which are characterized by the following qualities: imaginative, creative, youthful, forward-thinking, scientific, humanistic and innovative. We support youth education with a specific focus on the STEM (science, technology, engineering and mathematics) subjects in addition to the environment.

***First Energy*** (Ohio, West Virginia, Pennsylvania, Maryland, New Jersey schools) STEM Classroom Grants: FirstEnergy proudly supports classroom projects and teacher professional-development initiatives focusing on STEM.

***Google RISE***. $5K - $25K. (now closed; get on mailing list) "Roots in Science and Engineering." Promoting, supporting STEM and Computer Science education initiatives. Grant awards to organizations working with K-12 (primary & secondary schools) and university students to provide enrichment programs in these fields.

***Grants Program for 6-12 Science and Math Education*** provides small grants of up to $5K and large grants of over $5K to teachers who are passionate about making science and mathematics more engaging for their students. Applications for small grants may be submitted throughout the year. Amounts over $5K are reviewed only twice a year.

***ING "Unsung Heroes"***. Each year, educators submit applications by describing projects they have initiated or would like to pursue. Projects judged on: Innovative method, Creativity, and Ability to positively influence the students. Annually, 100 finalists receive a $2K grant, payable to both the winning teacher and his or her school. At least one grant awarded in each of the 50 states. Selected by Scholarship America, a national non-profit educational support and student aid service organization. Additional financial awards: $25K: 1st place; $10K: 2nd place; $5K: 3rd place.

***Intel's community grant program*** supports schools and organizations near communities where Intel is located. Education – K-12 programs in STEM. Environment – Education in science and ecology, recycling and resource conservation projects. Community—Youth programs, food banks, shelters and other local human service programs with the potential for Intel employee volunteer involvement. Intel Community Grants fund programs located in Intel communities that improve teaching in math and science, increase classroom technology use, improve access to technology in classrooms, and encourage students to consider careers in technology related fields, particularly women and minorities.

***Lockheed Martin***. Public schools in communities with Lockheed employees. Education: K-16 Science, Technology, Engineering and Math (STEM) Education. This area includes Lockheed Martin's K-12 STEM Education Initiative, Engineers in the Classroom, as well as STEM-focused curricular and extracurricular programs that provide employee engagement opportunities in local communities. Lockheed Martin dedicates 50% of its support to STEM education programs and activities.

***Los Alamos National Laboratory Foundation*** (New Mexico). Focus is STEM Education in the areas of teacher professional development, curriculum enhancement, educational technology supporting classroom instruction, and support for student learning. 98% of all 2011 grants made by the LANL Foundation supported STEM ed programs.

***Motorola Solutions Foundation***. Helps teachers engage today's tech-savvy students and to stretch limited resources to educate remote communities. Helps clinicians deliver effective patient care and first responders to save lives in the toughest conditions. Helps businesses and governments decrease their carbon footprints by eliminating inefficiencies in supply chains, logistics and energy grids.

**National Science Foundation**. The Advancing Informal STEM Learning program invests in research and development of innovative and field-advancing out-of-school STEM learning and emerging STEM learning environments.

***NEA Foundation***. Student Achievement Grants provides grants to improve the academic achievement of students in U.S. public schools and public higher education institutions in any subject area(s). The proposed work should engage students in critical thinking and problem solving that deepen their knowledge of standards-based subject matter. The work should also improve students' habits of inquiry, self-directed learning, and critical reflection. Proposals for work resulting in low-income and minority student success with honors, advanced placement, or other challenging curricula are particularly encouraged. Amount: The grant amounts are $2K and $5K

***Office of Naval Research (ONR)*** Sponsoring a STEM Grand Challenge to develop adaptive, generalizable intelligent tutors for STEM initiatives or development, and naval training and education.

***Pacific Gas and Electric Solar School "Bright Ideas" Grants***. Up to $10K. $300K available. Usually, we do not get enough quality grant applications so I encourage you to work on this and to feel free to ask for assistance in crafting a winning proposal.

Toshiba America Foundation (recurring) The mission of the Toshiba America Foundation is to promote quality science and mathematics education in U.S. K-12 schools. The Foundation provides grants through the following two initiatives: The Grants Program for K-5 Science and Math Education provides grants of up to $1K to teachers in public or private schools in order to improve the teacher's science and math teaching units. Deadline is October 1, annually.

***Toyota USA Foundation***. National. Continuous. ($50K-$200K). Supports K-12 education programs with a focus on math, science and environmental science. Partners with leading organizations and institutes serving diverse populations across all 50 states. Also: "Leaders in Environmental Education in partnership with the Nature Conservancy.

***US Department of Defense Missile Defense Agency***. MDA STEM Outreach serves as an educational liaison unit for the Missile Defense Agency. STEM Outreach's goal is to increase the awareness of K-12 and college students to Science, Technology, Engineering, and Mathematics (STEM), in order to enhance the number of U.S. scientists and engineers capable of solving future missile defense challenges in the Government, industry, and academia. Activities provide opportunities for students, school site personnel, parents, and others involved in educational and career decision processes.

***US Department of Education***: Minority Science and Engineering Improvement Program. Assists predominantly minority institutions in effecting long-range improvement in science and engineering education programs and increasing the flow of underrepresented ethnic minorities, particularly minority women, into science and engineering careers.

# Sample Proposal and Budget to Submit to a Funder

We propose creating a Makerspace. [*Describe your own motivations and what the Makerspace will do here.*]

Projects made by typical Makerspaces utilize common tools and supplies in new ways and uncommon ones to build surprising new things. Our Makerspace will need to purchase and acquire tools, a storage shed to keep the tools in, and materials for the students to create their projects. Typically, as a project gets more complex, it tends to become more expensive to build. So greater support from your organization will make more ambitious projects possible.

For example, a grant at the $17,000 level would furnish the Makerspace shop with a laser cutter, which would allow students to create parts for their project out of plastic and wood that are cut very precisely. At the $25,000 level, the Makerspace's shop would be fully equipped with a set of tools which would allow students to build in wood, metal, and plastic as well as design parts on a CAD workstation.

| | | |
|---|---|---|
| **$2,000 grant** | Compound Miter Saw | $500 |
| | Hand Tools | $150 |
| | Arduino Microcontrollers | $150 |
| | Student-generated list of consumable materials | $1200 |
| **$7,000 grant** | **All items above** | **$2000** |
| | Power Tools | $3000 |
| | Tool Storage Shed | $1500 |
| | Additional consumable materials needed for more complex projects | $500 |
| **$17,000 grant** | **All items above** | **$7000** |
| | Epilog Zing24 Laser Cutter | $10000 |
| **$25,500 grant** | **All items above** | **$17000** |
| | 2 CAD Workstations | $5000 |
| | Laser cutter accessories | $2000 |
| | Additional consumable materials needed for more complex projects | $1500 |

# Sample Makerspace Member "Job Description"

Makerspace brings together like-minded young people, adult mentors, and fabrication facilities to help more kids make more things. Its collaborative community celebrates an open-ended culture of creativity, innovation, and experimentation, melding diverse disciplines—math, science, art, craft, engineering, green design, music, and more—into ambitious projects.

**Summary**
Members make a project to display at Maker Faire, while also learning new skills for making things.

**Responsibilities**

- Create something to display at Maker Faire: this can be in the areas of technology, art, craft, engineering, music, science, green design, or other Maker themes
- Document your project as you create it
- Work one-on-one with an expert and/or in groups to design and produce your project
- Improve / "plus" projects with helpful feedback and tips to others (while respecting their projects)
- Engage in your own learning and exploration
- Apply good time-management and project-planning skills (optional, but very helpful!)

**Time Commitment**
January–May; 6+ hours/month, **plus** project work time (increases just before Maker Faire)

**Cost**
Materials for projects are not provided and must be purchased by project team members (although some may be obtained through a donation from retailers or manufacturers.) Any members who cannot afford these costs will be considered for scholarships and discounts. (That is, nobody will be excluded from participation for financial reasons.)

**Qualifications**

- Aged 12 to 19, and in middle or high school
- A desire to bring to Maker Faire something you created yourself (and/or with a group)
- Enthusiasm and willingness to learn and make things
- Experience and/or strong interest in working with others
- Open to meeting new people and sharing ideas (i.e. you may not be a good fit if you consider yourself "shy")
- A commitment to work as a team and to be a part of the Makerspace community

**Benefits**

- Priority admission to four Open Make: events at the Exploratorium, held monthly on the third Saturday
- Admission to Maker Faire for you and a parent; access to discounted tickets for additional guests
- Orientation to Makerspace by staff from Disney/Pixar, the Exploratorium, and or Make Magazine / Maker Faire.
- Training as needed, available, and appropriate, in the areas of technology, art, craft, engineering, music, science, green design, or other Maker themes
- A creative, supportive environment to explore one's own interests alongside others.
- Build something with expert help
- The opportunity to network with other members, program staff and mentors throughout the region

# Sample Makerspace Mentor "Job Description"

Makerspace brings together like-minded young people, adult mentors, and fabrication facilities to help more kids make more things. Its collaborative community celebrates an open-ended culture of creativity, innovation, and experimentation, melding diverse disciplines—math, science, art, craft, engineering, green design, music, and more—into ambitious projects.

**Summary**
Mentors assist, support, and encourage Makerspace members as they learn new skills for making things and complete a project to display at Maker Faire.

**Responsibilities**

- Guide members (in grades 8 to 12)
- Identify members who might need extra support or encouragement
- Provide general help to members
- Offer encouragement to members
- Work one-on-one with members or in groups of up to 4 members
- Offer specific guidance or workshops in areas of expertise
- Organize logistics for projects
- Bring any serious concerns/issues to the attention of program staff
- Engage in your own learning and exploration

**Other Optional Duties**

- Technical support of project documentation (video, photos, sketchbook, lab notebook, blog)
- Establishing contacts to obtain in-kind donations, sustain member projects, and to give members and mentors possible tips and resources.
- Good time-management and project-planning skills (these are very helpful!)

**Time Commitment**
Spring 2010 (January–May)
at least 6 hours/month, **plus** project work time (which increases greatly just before Maker Faire)

**Compensation**
Unpaid, and/or for course credit

**Qualifications**

- Enthusiasm and willingness to learn and make things
- Experience and/or strong interest in working with young people ages 12-18
- Skills with technology, art, craft, engineering, music, science, green design, and other Maker themes OR curiosity and commitment to developing such skills
- Open to the experience of meeting new people and sharing ideas (i.e. you may not be a good fit if you consider yourself "shy")
- A commitment to work as a team and to be a part of Makerspace community
- A desire to support the Makerspace philosophy

**Benefits**

- Free admission to Maker Faire
- Volunteer status at the Exploratorium upon completion of 40 hours (benefits include a one-year Museum membership with associated benefits, including a 20% discount at the Exploratorium store and café, and invitations to special events)
- One-year subscription to Make: magazine
- Orientation to Makerspace by staff from Disney-PIXAR, the Exploratorium, and or Make Magazine / Maker Faire.
- Additional training as needed, available, and appropriate.
- A creative, supportive environment to explore one's own interests alongside the members.
- Opportunity to help young people build skills and confidence
- Volunteer experience
- The opportunity to network with program staff and mentors throughout the region

**Application Process**
To apply for this volunteer opportunity in a diverse & dynamic work environment, please submit your cover letter & resume by email to ___@____ and please include the position title "Makerspace Mentor" in the email subject line.

# Sample Project Match for Students

We'd like to understand who you are and what you like to make, so we can help you find the right mentors and resources.

Name Age Grade level
Address
Home Phone Mobile Phone Email address
Parent names(s), phone(s), and email(s)
Best way and time to reach you

1. On the back, please tell us what makes you a Young Maker. You can tell us about your interests or projects you've completed, or both. (Use the back!)

2. Are you able to attend Maker Faire on _______________? yes / no

3. Have you ever attended Maker Faire? yes / no If so, which ones?
   ... and have you ever exhibited at any of those events?

4. Take a look at the Maker Faire exhibits listed here: **makerfaire.com/search.csp** and name some you really like.

5. Some Makerspace start the program with an idea of what they want to make, and others just want to make something, and don't have a specific idea as they begin. Do you know now what you would like to make over the next several months, which you will then exhibit at Maker Faire? yes / no
   If yes, please describe it here and SKIP the next question.

---

6. These are some of the content areas for projects at previous Maker Faires. **Circle** the ones that you wouldn't mind incorporating in your project. (You may also draw an "X" through anything that you wouldn't want to do.)

Ex: I like this thing.
Ex: ~~This is boring.~~
Alternative Energy
Animation
Arduino & Kits
Art Cars
Architecture
Arts
Astronomy / Space
Bicycles
Biology
Chemistry
Circuit Boards
Construction Kits (LEGO, K'NEX, etc.)
Crafts
Dance
Electronics
Farming
Fashion
Fire Arts
Flight
Food / Cooking
Gaming
Gardening
GPS
Graphic Design
Hacking
Halloween / Horror
Humor
Kites
Knitting
Lights / Glowing
Mathematics
Mechanics
Microcontrollers
Music
Musical Instruments
Papercraft
Photography
Physics
Printmaking
Programming
Recycling
Robots
Rockets
Rube Goldberg Devices
Sewing
Social Media
Spying/Surveillance
Sustainable Living
Technology
Tesla Coils
Toys
Transportation
Vehicles
Video
Water
Weather
Wind
Wearables
Wireless
Woodworking

Everybody knows how busy kids and their families can be! About how much time do you hope to spend on your project? (You can estimate per week / per month / total time.)

Check the box in front of the statement that seems the **most** true:
[ ] I really enjoy working with several other people as part of a team.
[ ] I prefer to work on projects by myself.
[ ] Sometimes I like to work independently, other times with others. It depends.

Is there anything else you'd like to tell us about yourself or your projects, background or interests? *(Use the back!)*

# Sample Project Match for Mentors

This form is intended to help us understand who you are as a mentor and what kinds of skills and passions you would bring to the Makerspace, so that we can match you with the right kids.

Name
Address
Home Phone Mobile Phone Email address
Best way and time to reach you

In the space below, please tell us about why you'd like to mentor a Young Maker and your experience mentoring, if any.

Are you able to attend Maker Faire on ____________? yes / no

Have you ever attended Maker Faire? yes / no If so, which ones?

... and have you ever exhibited at any of those events?

Take a look at the Maker Faire exhibits listed here: **makerfaire.com/search.csp** and name a few that you really like.

---

What skills can you share with our Makerspace as an "expert" (or at least as someone very experienced)? What areas do you dabble in—that is, you are very interested in them, have some experience doing them, or are really motivated to learn more about them, enough that you can stay ahead of an equally motivated teenager? We've included a list of some of the kid-friendly content areas from projects at previous Maker Faires to help you brainstorm. Please be specific when appropriate (for example, if you list "Programming", you may want to list your favorite languages.)

| I can be an expert on... | I'd like to learn more about ... |
|---|---|
| | |

Alternative Energy
Animation
Arduino & Kits
Art Cars
Architecture
Arts
Astronomy / Space
Bicycles
Biology
Chemistry
Circuit Boards
Construction Kits (LEGO, K'NEX, etc.)
Crafts
Dance
Electronics
Farming
Fashion
Fire Arts
Flight
Food / Cooking
Gaming
Gardening
GPS
Graphic Design
Hacking
Halloween / Horror
Humor
Kites
Knitting
Lights / Glowing
Mathematics
Mechanics
Microcontrollers
Music
Musical Instruments
Papercraft
Photography
Physics
Printmaking
Programming
Recycling
Robots
Rockets
Rube Goldberg Devices
Sewing
Social Media
Spy/Surveillance
Sustainable Living
Technology
Tesla Coils
Toys
Transportation
Vehicles
Video
Water
Weather
Wind
Wearables
Wireless
Woodwork

Is there anything else you'd like to tell us about yourself, your projects, background or interests? *(Use the back!)*

# Sample Liability Waiver

**Assumption of Risk and Release**
You agree that you are voluntarily participating in Makerspace with knowledge of the risks of doing so, such as the risks of injury, property damage, or death resulting from the use of potentially dangerous tools or materials, and/or the active or passive negligence of Makerspace sponsors and suppliers, including ________________ and their respective officers, directors, employees, agents, and exhibitors (collectively, "we" or "us"). You release us from all liability, claims, damage, or demands arising from or related to your participation in the Makerspace.

**Recordings**
You acknowledge that Makerspace events may be recorded in audio, visual, and/or audiovisual media and you consent to the making and use of such recordings by _______________ and/or its licensees for any purpose. You release ______________ and its licensees from and waive any claims related to or arising by reason of the making and/or use of any such recordings. You grant to ___________ the right to use your name and likeness in connection with the use of the recordings.

**Acknowledgment**
You acknowledge that you have read this Agreement and understand that it includes an assumption of the risk and a release of liability. We are relying on this waiver to allow you to participate in the Makerspace.

**Participation**
You understand your goal is to define a project and work with other Makerspace and mentors to exhibit your completed project (or evidence of what you've accomplished to that point) at Maker Faire (dates: _________). You agree to use the facilities, tools, and materials in a safe way, and to alert fellow Makerspace, mentors, and/or program leaders when facilities, tools, and materials are being used in a way that could cause harm to themselves or others. You will do your best to come to all meetings. You will provide others with assistance or helpful feedback when you see a way their project could be improved, if such feedback is welcomed. You agree to tell program leaders changes you'd make to the program to improve future workshops. That is: I'll come. I'll make something. I'll help others and stay safe.

Name of Young Maker ( printed ) ______________________________________ Age ______

Signature of Young Maker ________________________________ Today's Date ___________

Name of Legal Parent or Guardian ( printed ) ________________________________________

Signature of Legal Parent / Guardian _________________________ Today's Date ___________

# Sample Mentor Request Form

This is an online form we've posted. you could do something similar for your Makerspace.

To look for a mentor to work with members in your Makerspace, there are two first steps: take a look at the list of people who have signed up (it's attached to our Google group) and also define what you need. This form outlines some of the most important points that mentors would need to know to determine if they are a good match for your Makerspace

* indicates a required question

1. Makerspace Name *
2. If your Makerspace doesn't have a name, tell us the city where you meet.
3. Where does the Makerspace meet?
4. When does the Makerspace meet?
5. What day and time and how often
6. What age or grade level are the Makerspace students?
7. How many Makerspace students are there?
8. How many Mentors do you think you need?
   If you have already recruited some, please just say how many you're still looking for.
9. Are there specific projects that the Makerspace students want to make? Or special skills you need the Mentors to have?
10. Is there anything else we should know about your Makerspace—-or the project(s) that need a Mentor?
11. Who is the Makerspace leader? *
12. How should Mentors contact you? *

# Sample Project Plan

We recommend shooting to complete the project a week before Maker Faire. That way you'll have a little cushion in case things take longer than you expect (and they almost always do!).

| **Project Name** | |
|---|---|
| **Student Name(s)** | **Roles** ***(if appropriate—ex: software coder, hardware hacker, photographer, videographer, etc.)*** |
| | |
| | |
| **Primary Mentor** | |
| **Other Mentors** | |
| **Project Description (a short paragraph of 10-30 words)** | |

**Setting Milestones**: Plan a timeline for your project. Feel free to adapt this chart as necessary to meet the needs of your project and team. This template is just a starting point. You may want to have one or two milestones each week, or every other week. For each milestone date (a) create sub-goals for each team member and (b) Include the amount of time you think this goal will take to reach.

| Date | | Milestone or Event | Who? | Time |
|---|---|---|---|---|
| | 1 | | | |
| | 2 | | | |
| | 1 | Complete Project Plan – Discuss with mentor. | | |
| | 2 | | | |
| | 1 | | | |
| | 2 | | | |
| | 1 | | | |
| | 2 | | | |
| | 1 | | | |
| | 2 | | | |
| | 1 | | | |
| | 2 | | | |
| | 1 | | | |
| | 2 | | | |
| | 1 | | | |
| | 2 | | | |
| | | Project complete | | |
| | | Maker Faire begins! | | |

# Sample Proposal Form

*(Note: this is similar to the online form)*

| **Your Name(s) / Project Team Name *** | |
|---|---|
| **Mentor(s)** | **Project Keywords** *(Ex: robotics "wireless sensor" knitting)* |
| | **Pick a category:** Arts Crafts Engineering Food Green Music Science |
| **Project Name** *(Provide a short, catchy name for your project.)* | |
| **Project Description** *(In 225 characters or less, describe your project and what it does. You can also add links to your project's website, a photo, and/or a video on your proposal form.)* | |
| **A little about who you are** *(In 50 words or less, describe who made this, whether an individual or the project team.)* | |

| X | **Special needs:** This project... | **Describe your Special Needs.** List any safety issues, & be sure to get a Safety Plan turned in by April 11th. Need > 5 amps? Tell us how much and what you will be plugging in. (You can find out how much power you need by looking at the back of the device you are plugging in. Most laptops use 2.5 amps.) Using radio frequencies, tell us which ones., etc..... |
|---|---|---|
| | must be outside. | |
| | makes a loud, repetitive or annoying sound. | |
| | requires Internet access. | |
| | makes or uses radio frequencies. | |
| | has to be plugged into an electrical socket. | |
| | needs more than 5 amps of power. | |
| | poses a danger to myself or others. | |
| | could hurt someone. | |

**Schedule Preference:** We'll give you a time slot to exhibit of at least 2 hours per team member. When are you available? **Circle slots when you'd like to exhibit** and mark a big "**X**" through any times you are **UN**available.

| Sat 10 – 2 | Sat 1 – 5 | Sat 4 – 8 | Sun 10 – 2 | Sun 2 – 6 |
|---|---|---|---|---|

[ ] I / We only want to exhibit on only one day, either Saturday or Sunday.
[ ] I / We would like to exhibit at a scheduled time both Saturday and Sunday, if possible.

**Be ready to provide basic info for each Project Team Member when you fill out your form online.**

| Name | Email | Phone | School | City | Previous Maker Faires attended or exhibited |
|---|---|---|---|---|---|
| | | | | | |

# Sample Safety Plan

| | |
|---|---|
| **Maker #** | |
| **Exhibit Name** | |
| **Description** | |
| **Placement** | |
| **Demonstration Summary** | |
| **Qualifications and Previous Experience** | |
| **Personnel** | |
| **General Safety Precautions and Plan** | |
| **Additional Comments** | |
| **Maker Name** | |
| **Contact number** | |
| **Signature** | |

# The Safe Workshop

## Rules to make by.

**By William Gurstelle**

Your workshop should be a welcoming and friendly place. The key lies in creating a safe and secure environment. Before embarking on a new project, it's a good idea to take a close look at the working conditions in your shop.

If your project area gives you a vaguely nervous feeling, now's the time to bring things up to date. Don't delay: inspect, review, and evaluate your space and make whatever changes seem necessary to keep you out of trouble.

Don't know where to start? Here are some ideas from the members of MAKE's Technical Advisory Board to get you started. Have at it!

**Wait 12 hours** between sketching the plans and starting the construction process. The times people get hurt are usually when they're excited and in a hurry. Slow down, and work deliberately.

The high-decibel noise generated by power tools such as table saws and circular saws can damage your hearing. **Protect your ears** by using full-sized, earmuff-style protectors.

**Wear a particle mask** when appropriate to avoid breathing dust and other particulate pollutants common in workshops. Sawdust from treated wood and some plastics have known health risks.

**Secure your work** when using hand or power tools.

**Avoid using a table saw** when you can. Statistically, it's easily the most dangerous piece of equipment in the shop.

**Obtain** a pair of well-fitting, cool polycarb **goggles**, leather work **gloves**, and a protective **lab coat**. Make them attractive and stylish so that wearing safety equipment is fun. **Pull back long hair.**

**Aim away from yourself.** When cutting with a utility knife, position yourself so that when you slip, the blade doesn't land in your flesh.

**Always use clamps,** not your hands, to hold a work piece on a drill press table. If the tool binds, the work will spin dangerously.

**Don't touch a bare wire, or cut any wire,** until you're sure where the other end goes. When in doubt, measure the potential. This will save you from a possible heart-stopping electrical shock.

Always keep a **first aid kit** in your workshop, and always know where it is. First aid kits can be purchased ready-made, or you can put one together yourself. Essential items include bandages, pads, gauze, scissors, tweezers, and tape.

If you work with heavy things — say, timbers or angle iron — or are prone to dropping tools, **steel-toed safety shoes** are a great investment in long-term foot appearance.

**Install a smoke detector** in your shop and place a fire extinguisher in an easy-to-reach spot. Make sure the extinguisher is rated for all types of fires.

# Recommended Suppliers

Here is a list of some good parts suppliers in various categories when looking for specialty items beyond the basic tools included in our Makerspace in a Box. Please tell us if you have your own recommendations of vendors to add.

## Electronics

- **Adafruit**: More open source hardware. Ships from NY. **adafruit.com**
- **Brown Dog Gadgets**: USB charging circuits. **browndoggadgets.com**
- **Cool Neon:** Electroluminescent wire (it glows!). **coolneon.com**
- **Digi-Key**: Excellent prices on coin cell batteries. Ships from Minnesota. **digikey.com**
- **Electronic Goldmine**: They specialize in inexpensive recycled parts. **goldmine-elec.com**
- **Evil Mad Science**: LEDs, open source hardware, and local. (Email for local pickup info in Sunnyvale.) **evilmadscience.com**
- **Hobby Engineering**: A supply store for people who want to build robots, electronic gadgets, kinetic art or anything else that moves, beeps or flashes. **hobbyengineering.com**
- **Jameco**: Located in Belmont, will-call availability. **jameco.com**
- **Maker Shed**: Lots of variety, not just electronics. **makershed.com**
- **Sparkfun**: Especially good for robotics parts like motors, controllers, etc. **sparkfun.com**
- **Weird Stuff**: Resellers of surplus computer hardware and software. **weirdstuff.com**

## Mechanical, pneumatic, industrial, fasteners, etc.

- **Grainger**: You need a company account to buy on-line, but they have stores around the Bay Area, including San Rafael and Berkeley. If you call a store and order by 9am you'll have your part by 3pm. **grainger.com**
- **McMaster-Carr**: Extensive and well organized online catalog, fast delivery. **mcmaster.com**
- **Olander**: Mostly fasteners. Located in Sunnyvale, they have will-call availability. **olander.com**

## R/C equipment

- **D&J Hobby**: San Jose, very good selection and not just R/C. **djhobby.com**
- **Tower Hobbies**: Extensive selection, good prices. **towerhobbies.com**

## Modeling, molding, casting

- **Douglas & Sturgess:** Just about everything you need to model in plaster, plastic, clay, fiberglass, etc. Located in Richmond, but they have an on-line store too. They also have classes. **artstuf.com**
- **J. Greer**: Carries a wide selection of plastic molding and casting materials. Fast delivery too. **aeromarineproducts.com**
- **Tap Plastic**: Stores throughout the Bay Area. They are best known for their selection of acrylic sheets, but they also have most molding and casting materials. Kind of pricey but very convenient with a knowledgeable staff. **tapplastics.com**

# Makerspace-in-a-Box: First Tool Purchases

| | | | |
|---|---|---|---|
| general workspace & safety | 2 | containers | 24-divider storage container |
| | 2 | containers | 24-container storage box (plastic) |
| | 3 | containers | shoe-box size |
| | 1 | dust pan and broom | BLASKA dust pan and broom |
| | 2 | power strips | |
| | 1 | extension cords | 25-ft 10 gauge tripe tap extension cord |
| | 1 | first aid kit | |
| | 5 | safety glasses | |
| | 5 | gloves | |
| | 1 | fire extinguisher | |
| | 5 | respirators/dust masks | |
| | 5 | aprons | |
| | 1 | camera | Canon PowerShot A2300 |
| cutting | 1 | tin snips | 12" power tin snips |
| | 2 | box knives | utility knife |
| | 2 | hobby knives | X-acto or similar |
| | 2 | scissors | multi-purpose scissors |
| | 1 | drill bits | 29-piece high speed steel drill bit set |
| | 1 | hacksaw | 12" hacksaw |
| | 1 | wood-saw | 10" flush cut pull saw |
| | 1 | cutting mat | |
| | 1 | hand-crank (rotary) craft drill | fiskars manual rotary craft drill |
| measuring | 1 | ruler or yardstick | 40" aluminum ruler |
| | 1 | caliper | 6" dial caliper |
| | 2 | angle square | aluminum rafter angle square |
| | 1 | compass | |
| | 3 | tape measure | 33-foot x 1" quikfind tape measure |
| fixturing | 1 | vise | 2.5" table swivel vise |
| | 4 | C-clamps | 4" |
| | 3 | bar clamps | |
| | 2 | needle nose pliers | 5.75" |
| | 1 | adjustable wrench | 4-piece steel adjustable wrench set (6", 8", 10", 12") |
| | 1 | locking pliers | 3-piece curve jaw locking pliers set (5", 7", 9") |

| | | | |
|---|---|---|---|
| joining | 1 | staple gun | three-way tacker staple gun |
| | 2 | hot glue gun | high temperature mini glue gun |
| | 2 | hot glue gun | professional/industrial glue gun |
| | 3 | big sewing needles | |
| power tools | 1 | jigsaw (electric) | |
| | 2 | sewing machine | |
| | 2 | cordless drill | |
| | | electronics tools | |
| | 2 | soldering iron | |
| | 2 | soldering stand | |
| | 2 | soldering tips | |
| | 2 | wire cutter | 7" wire stripper with cutter |
| | 2 | digital multimeter | 11-function ac/dc digital multimeter with audible continuity |
| | 1 | solder tip tinner | |
| | 2 | third hand | |
| | 4 | 9v battery clip | battery snap, 6-in |
| | 4 | 4 aa battery holder | battery holder,4-aa,wires,with cover & switch |
| | 1 | alligator clips | alligator clip test leads, 10-pack |
| mechanical | 1 | screwdriver set -- precision | 6-piece precision screwdriver set with molded handles |
| | 1 | screwdriver set -- big | 8-piece professional screwdriver set |
| | 1 | allen (sae and metric) | 36-piece sae/metric hex key set |
| | 1 | claw hammer | 16-oz fiberglass curve claw hammer |
| | 1 | mallet | 1-lb rubber mallet with fiberglass handle |
| | 1 | combination wrench | 9-piece sae highly polished combination wrench set |
| | 1 | socket set | 64-piece 1/4", 3/8", and 1/2" socket set |
| | 2 | driver bits | 10-piece 2" color-coded driver bit set |
| | 1 | miter box | |
| textiles | 1 | fabric scissors | |
| | 2 | seam ripper | |
| | 2 | cloth tape measure | |
| | 2 | knitting needles | |
| | 1 | sewing machine needles (pack) | |
| | 2 | bobbins | |
| | 1 | iron | |
| | 1 | sewing needles (pack) | |

# Makerspace-in-a-Box: First Consumables Purchases

| | | | |
|---|---|---|---|
| adhesives / tape | 2 | white glue | Elmer's All Multipurpose White Glue, 7 5/8 oz. (E379) |
| | 2 | hot glue sticks (regular size) | Stanley GS20DT Dual Temperature 4-Inch Glue Sticks, 24-Pack |
| | 2 | hot glue sticks mini size) | |
| | 2 | packing tape | |
| | 1 | electrical tape | |
| | 1 | duct tape | |
| | 1 | masking tape | |
| | 1 | blue painter's tape | |
| fasteners | 1 | pack of staple gun staples | Stanley TRA704T 1,000 Units 1/4-Inch Heavy Duty Staples |
| | 1 | pack of assorted zip ties | |
| | 1 | pack of binder clips | |
| cutting | 3 | hacksaw blades | |
| | 3 | jigsaw blades | |
| | 1 | pack of X-acto blades | |
| | 1 | pack of utility knife/box cutter blades | |
| electronics | 100 | LEDs | |
| | 10 | batteries coin cell 3v | |
| | 10 | batteries AA | |
| | 5 | batteries 9v | |
| | 5 | breadboards (solderless) | |
| | 100 | resistors | |
| | 2 | Arduino uno | |
| | 5 | buzzers | |
| | 5 | motors | |
| | 5 | photoresistors | |
| | 1 | jumper wires bundle | |
| | 1 | Arduino kit | |
| | 10ft | wire | |
| | | solder | |
| textiles | | thread | |
| | 250 | straight pins | |
| | 100 | safety pins | |
| general | | string | |
| | | cardstock, cardboard | |
| | | mailing labels | |
| | 5 | paintbrushes (1" and 3") | |
| | | trash bags | |
| | | pens, pencils, markers, chalk | |
| | 10 | acid brushes | |
| | 250 | popsicle/craft sticks | |
| | 1 | pack of sandpaper (80/200/400/600) | |

# Makerspace-in-a-Box: Next Tool Purchases

| | | | |
|---|---|---|---|
| electronics | 1 | crimper tool | 8" four-way crimping tool |
| | 1 | diagonal cutter | |
| | 2 | solder sucker | |
| | 4 | tweezers | |
| | 1 | heat gun | 12 interval heat gun with led temperature settings |
| | 8 | AA NiMH rechargeable batteries | |
| | 1 | AA NiMH charger | |
| | 2 | 9V rechargeable batteries | |
| cutting | 1 | hole saw | 10-piece carbon steel hole saw, 1" depth, 1" to 2.5" width |
| | 1 | metal file(s) | 12-piece file and rasp set |
| | 1 | file card | |
| | 1 | sanding block | |
| | 1 | countersink | |
| measure | 2 | adjustable square | 16" heavy-duty combination square |
| | 1 | level | 9" magnetic torpedo level |
| fixturing | 6 | bar clamps | 12" quick release bar clamp |
| | 2 | needle nose | 8" needle nose pliers |
| | 2 | needle nose locking pliers | 6" needle nose locking pliers |
| | 3 | curve jaw locking pliers | 3-piece curve jaw locking pliers set (5", 7", 9") |
| join | 1 | popriveter | heavy-duty 17.5" hand riveter |
| power tools | 1 | Dremel | Dremel 100-n/7 single speed rotary tool kit |
| | 1 | orbital sander | |
| | 1 | hot wire foam cutter | |
| mechanical | 1 set | ratchet set | 6-piece metric ratcheting wrench set |
| | 1 set | joint pliers | 4-piece tongue and groove joint pliers set |
| | 2 | miter box | |
| | 1 | PVC pipe cutter | |
| | 1 set | hollow-shaft nut drivers | |
| | 1 set | SAE nut drivers | |
| textiles | 1 | pinking shears | |
| | 1 set | embroidery needles | |
| | 2 | needle threader | |
| | 1 | snap setter | |
| | 1 | grommeter | |
| | 2 | rotary cutter | |

# Makerspace-in-a-Box: Next Consumables Purchases

| | | |
|---|---|---|
| adhesives / tape | 2 | wood glue |
| | 1 | epoxy |
| | 1 | glue thinner |
| | 1 | super glue (CA) medium |
| | 1 | super glue (CA) debond |
| | 1 | spray adhesive |
| | 1 | PVC cement |
| | 2 | paper kraft tape 2" |
| | 2 | scotch tape |
| fasteners | | box rivets |

| | | |
|---|---|---|
| cutting | | Dremel bits |
| electronics | | shrink tubing |
| | | conductive thread |
| | | capacitors |
| textiles | | grommets |
| | | sew-in snaps |
| general | | sandpaper for orbital sanders |
| | 10 | paper mixing cups (solo cups) |
| | 250 | toothpicks |
| | 1 | lubricant |

# Makerspace-in-a-Box: Additional Tool Purchases

| | | | |
|---|---|---|---|
| general | 1 | video camera | |
| | 1 | GoPro camera | |
| | 1 | tripod | |
| cutting | 1 | awl | |
| | 1 | deburring tool | |
| measure | 1 | center punch set | 3-piece nail punch set |
| | 1 | scribe | |
| join | 1 | splice set | |
| | 1 | tap and die (SAE and Metric) | |
| power tools | 1 | circular saw | |
| | 1 | table saw | |
| | 1 | drill press | |
| | 1 | 3D printer | PrintrBot Jr ($399)<br>Afinia H-Series ($1499)<br>Type A Machines ($1499)<br>MakerBot Replicator ($2199) |
| | 1 | laser cutter | Full Spectrum CO2 Basic Laser ($1850)<br>Epilog Zing 16 ($7995) |
| | 1 | CNC machine | Bluumaxx CNC & Dremel 4000 ($430)<br>Shopbot Desktop ($4995)<br>Shopbot PRStandard ($7595) |
| | 1 | vinyl cutter | Roland Desktop Vinyl Cutter ($1500)<br>US Cutter SC model kit ($500) |
| textiles | 1 | serger | |

Make:

makezine.com