Makerspace

Makerspace Playbook

Working Draft
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Makerspace Playbook

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Welcome…

to a community of people who have a passion for making things and want to share that with others by making with young people. This playbook should help you—the founder of a local Makerspace —establish a great new community resource in your school, neighborhood, or wider local community. It shares the knowledge and experience from the Makerspace team as well as from Makerspace managers who have already established Makerspaces.

Through Makerspace, we encourage everyone to start making in your communities and schools to create something of your own imagination. We know that the thought of getting a Makerspace started can be daunting, whether it's finding a shop facility, engaging students, recruiting mentors, dealing with liability, etc. This playbook is designed to help you navigate through the issues. It is written for Makerspace managers who represent the Maker movement to the community at large and who coordinate a space used by young people who make.

We are invested in the success of your Makerspace. We want your Makerspace to succeed, to build Maker community, to share the DIY mentality, and to engage and stimulate your neighborhood, school, town or region. That is why we have spent the energy to write this Playbook, why we will help your Makerspace, and why we have "open-sourced" Makerspace and encouraged the Maker movement to flourish. We are constantly trying to refine and improve the material we provide. Please contact us if you have anything to add or share, and please report back on your experiences each season so we can enrich the book with new insights, advice, illustrations, and anecdotes. We have published this document so that it might 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 mentor@otherlab.com.

For more information and continuing updates, visit makerspace.com

The majority of this Makerspace Playbook was written by the Makerspace team, including Dale Dougherty, Saul Griffith, Michelle Hlubinka, Joel Rosenberg, Steve Hoefer, Stephanie Chang, with additional contributions from Aaron Vanderwerff. 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.

Makerspace is developed by Dale Dougherty of O'Reilly Media's Make division in partnership with Dr. Saul Griffith of Otherlab. This project is supported by an award from the Defense Advanced Research Projects Agency (DARPA) in support of its Manufacturing Experimentation and Outreach (MENTOR) program, an initiative aimed at introducing new design tools and collaborative practices of making to high school students.

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

Makerspace Overview

The Makerspace program integrates online tools for design and collaboration with low-cost options for physical workspaces where students may access educational support to gain practical hands-on experience with new technologies and innovative processes to design and build projects.

We aim to build literacy in design, science, technology, engineering, art, and mathematics, by combining what O'Reilly Media, MAKE magazine, and Otherlab have learned about the maker community. We wish to do this with as much engagement as possible with the broader maker community to leverage the fantastic energy and talents of everyone doing beautiful things.

Our emphasis is threefold:

1. Self-directed learning (building your own project as a better motivator to engage in engineering).
2. Lower the cost of building and realizing dream projects through lower cost tools (software and hardware.)
3. Making making more social and engaging.

We will establish the practices of making in high schools, reaching 1000 schools over four years. Those schools need not be limited to the United States. By creating makerspaces in an educational context, students can have access to tools and equipment that they might not have otherwise; they can collaborate on projects that are driven by their own interests, and by doing so, develop the capacity and confidence to innovate. We see making as a gateway to deeper engagement in science and engineering but also art and design.

As part of our work on this project, we are committed to…

- Develop teacher's guides for MAKE projects that will help educators integrate making into their own curriculum, which will be made available for free under a Creative Commons license.
- Define modular specifications for low-cost makerspaces in educational settings. We want to encourage schools to establish makerspaces, so we are providing some basic guidelines on the costs of getting started.
- Write an overall guide to teaching the practices of making for educators, mentors, and others who help coach students to become makers. This is similar to the guide we've written for the Young Makers program.
- Build a collaborative online platform that can be used by teachers and students to select projects, monitor progress, and generate student documentation for the work. This platform will allow students to work beyond their own classroom with other students and mentors.
- Integrate new design tools for CAD and CAM that help students become familiar with 3D design and personal fabrication.
- Prototype a low-cost, open-source CNC machine that can be affordable for schools to use.
- Over three years, build a network of up to 1000 participating high schools.
- Showcase the work of students at Maker Faires and bring students together to meet each other and other makers in the community.

All the software we develop as part of the program will be made open source. All material developed for the program will be made available online under Creative Commons. None of the organizations attached to the program is placing any claim on student work—not O'Reilly, not Otherlab, and not DARPA.

Creating models for makerspaces at schools is the heart of our approach. In some of our pilot work, we are seeing that having a place to make things creates new opportunities. We are re-thinking the shop class and re-inventing the computer lab, and combining both of them. The makerspace should be like a library, available for use by anyone in the school to make things for a variety of purposes.

Our approach to the Makerspace project covers three areas:

- **Places**: defining the aspects that make a space more conducive to a community that makes together, including the tools, materials, and layout
- **Projects**: highlighting how-tos that guide novice makers as they build their skill set; providing the infrastructure to share those projects
- **Practices**: seeking out the pedagogical approach that experienced makers can use to support emerging makers

Chapter 1 **Beginnings**

Through the Makerspace project, we have been focusing on the importance of creating a space where kids have the opportunity to make – a place where there are some tools, materials and enough expertise to get them started. Makerspaces share some aspects of the shop class, home economics class, the art studio and science labs. In effect, a makerspace is a physical mashup of these different places that allows projects to integrate these different kinds of skills.

Makerspace grew out of MAKE magazine and Maker Faire, a leading force in the Maker movement.

The Maker Movement

It's hard to describe just what the Maker movement is. Yet, there is a mindset that is shared by all Makers featured in the magazine and participants in a Maker Faire. We hope that you'll 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 typical project made by a Maker does not provide a platform for politics or religion.

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 hyper-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 O'Reilly and the Mini Maker Faires that are 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 <link> Make Magazine. Nowadays, over 700 Makers of all ages will convene for one fantastic weekend to show off a spectacular array of projects that combine arts, craft, engineering, food, health, music, performance, creative reuse, science, and technology. Rockets

to robots, felting to beekeeping, pedal-power to mobile muffin cars — you never know what you'll see at Maker Faire. In its simplest form, Maker Faire creates conversations with Makers. It is a show-and-tell format 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 this event special is that all these interesting projects and smart, creative people belong together. They are actively and openly creating a Maker culture. At their core, 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.

From the beginning, Maker Faire has been a perfect family event, with many attendees under age 18. Even at the first Maker Faire in 2006 in San Mateo, California, we had young people exhibiting as Makers alongside adults. Some Young Makers come on their own, sometimes they are part of a family team that created a project together, and still others exhibit as part of community organizations or schools.

Makerspace is our strongest effort to suffuse 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 well. Out of that process emerges new ideas, which may lead to real-world applications or new business ventures. Making is a source of innovation.

Dr. Stuart Brown, in his book, *Play: How it Shapes the Brain, Opens the Imagination and Invigorates the Soul*, tells the story about how the Jet Propulsion Laboratory realized that, although they were hiring the best and brightest college graduates, it was hiring the wrong kind of people. Something had changed in the kind of people that 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 this kind of magic into schools, hard as it may be. Formal education has become such a serious business, defined as success at 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.

The rigid academic system is short-changing all students, even though an elite few seem to do well by academic standards. However, there is increasing skepticism that even those who succeed academically are not the kind of creative, innovative thinkers and doers that we need.

Potential Impact on Education

Our biggest challenge—and the biggest opportunity for the Maker Movement—is 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. Students are seeking to direct their own education lives, looking to engage in creative and stimulating experiences. Many of them understand the difference between the *pain* of education and the *pleasure* of real learning. Unfortunately, they are forced to seek opportunities outside of school to express themselves and demonstrate what they can do.

The Makerspace project hopes to bring the Maker Movement to education in a few specific ways:

- Create the context that develops the maker mindset, a growth mindset that encourages us to believe that we can learn to do anything.
- Build a new body of practice in teaching making and develop a corps of practitioners.
- Design and develop makerspaces in a variety of community contexts that serve a diverse group of learners who may not share the access to the same resources.
- Identify, develop and share 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. To design and host online social platforms for collaboration among students, teachers, and the community.
- Develop programs especially for young people that allow them to take a leading role in creating more Makers.
- Create the community context for the exhibition and curation of student work in relationship with all makers and making sure that new opportunities are created for more people to participate.
- Allow 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.
- Develop 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.
- Develop in each student the full capacity, creativity and confidence to become agents of change in their personal lives and in their community.

As leaders in the resurgence of the do-it-yourself (DIY) 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.

Impact Areas
· *Inspiration* : to participate in the creative economy and direct their own future
· *Innovation* : a catalyst for grassroots invention
· *Education* : building a connection between the community and learners

We are particularly interested in how this approach might reach students who don't fit well into the existing system or who have already dropped out of it. As we've said, 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, Dept 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 inspires 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!

Chapter 2 **Places**

Makerspaces are a space 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 with the Makerspace project 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.

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

A Different Approach

Makerspaces borrow somewhat from the tradition of *technical and vocational education*, but they diverge by metaphorically, sometimes literally, tearing down the walls between the silos of home ec, automotive repair, woodshop, computer science, etc. in pursuit of a more interdisciplinary goal. Makerspaces also recognize that making enriches the educational experience of students who are motivated to different degrees in school. Unfortunately, technical education gained some stigma in education as the track where guidance counselors sent the failing students, and this is part of the reason that so many schools are getting rid of thousands of dollars worth of valuable equipment. 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, and 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. Although many hackers consider themselves Makers and vice versa, hackers have a sensibility that is not always very welcoming to kids. In part this is because hackerspaces often have an adult atmosphere, and there are safety issues when you open your door to minors, ones that many hackerspaces feel ill equipped to confront. Makerspaces also have learning and education as a primary focus, 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.

A Makerspace is like a *community FabLab*, in that it provides a wide variety of tools for fabrication to people who might not otherwise have access to such powerful tools. It differs 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, we also embrace a wider range of domains and types of projects.

The Multipurpose Space

A school could have a Makerspace that serves as 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. We imagine a variety of uses for a Makerspace: [will say more here]

- Classroom for physics and robotics classes (see the Spotlight on Lighthouse Charter School in Ch. 9)
- Specially designed elective classes (see the Spotlight on Analy HS in Ch. 9)
- An interdisciplinary resource center used by many different teachers and classes
- Fellow teachers (building teaching materials)
- Makerspace meetup space / Makerspace manages the space
- Community / neighborhood (after hours)

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. Partner with an existing, possibly underused or disused room yearning to be used as the 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 the fabrication tools your students need and want.
- The Library: This resource is already used by many departments at your school. Some public libraries have started fundraising to get Maker tools and hackerspaces into their libraries; school libraries may be close behind!
- Partner courses: think about teaming up with the Art teacher or the vocational ed department to share space and students. These match the Maker spirit well.
- Home Economics / Photography Darkroom: Some classes have fallen out of fashion in recent decades. These can have the right setup with sinks and large surfaces. We also enjoy the history that these kinds of spaces have, bringing together the
- 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 as well to build tools. One outdoor structure we like is the Shelter 2.0 project. It provides housing in areas that have been hit by a disaster, using a simple, digitally fabricated shelter that is in 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 who are interested in something upcycled, consider buying a used shipping container, as some art collectives have done to house their 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

Ideally, your Makerspace works should be conducive to inspiration, collaboration, and conversation. Make sure the tools and materials you have on hand give 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. So if you found 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.

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

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 students use the space.

Designing Safe Environments

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. Plan to easily and regularly remove trash and debris. The space needs to be well lit and ventilated.

Provide access to grounded outlets all along the perimeter of the room. Drop cords can quickly become a work and tripping hazard, so outlets need to be provided around the perimeter of the room and/or dropped from the ceiling for each workbench. Similarly the use of power strips is generally discouraged.

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.

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.

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. 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.

Logistical Issues

Typically the first limitation for what space to use is what you can afford to build or build-out. When budgeting be sure to include one-time expenses such as remodeling as well as ongoing expenses such as electricity, heating, permits, etc.

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 separated, such as woodworking, metalworking, electronics, craft, kitchen, and computer areas. Grouping these activities together brings together similar equipment and safety materials, and isolates noise and dust. It can also help to gather people working on similar projects to encourage skill sharing.

Account for space for people to gather and organize. Large workbenches allow makers to work comfortably while allowing them to build cooperatively. Ideally this area should be separate from other parts of the space that can be noisy or dirty and be isolated from the general traffic of the space.

In addition to supporting the members the space needs to support the equipment. Be sure 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. If the space supports larger projects a loading dock and/or a freight elevator is a great feature.

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 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. Ideally the Internet access is wireless.
- Projects and machinery with sensitive electronics need to be protected from moisture and sawdust.
- Some projects may require outdoor space with pavement, no overhead foliage and lots of room to test fire.
- Some projects need relative quiet, others are so noisy that they need to be acoustically isolated.

- Some special maker exhibits featuring electricity could ask for 220 volts or even three-phase power.

Furnishing the Space

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

[more about resources for DIY furniture here]

Chapter 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 need in order 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. In fact, sometimes an empty counter 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:

3. Make: magazine's special issue, the *2011 Ultimate Workshop and Tool Guide*
4. *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.

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.

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 worse 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. It's also possible to get pricing breaks if members or classes combine their orders. However the price of these tools are dropping and there's 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 (aka 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. See the Resources section for a sample proposal and budget to submit to a funder.
- 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 to need it.
- Wait for critical mass, and for prices to come down. There's nothing more lonely than a $3000 machine collecting dust, while its more powerful, smaller, cheaper cousins roll off the manufacturing floors. 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 which 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 fund-raise to buy one.

Modular buildout 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 and sculpt various materials.)

Materials

Tools aren't much use without something to build with them. Materials can come from everywhere from the nearest street corner to the local home center, from attics to eBay. It is up to you and your students to determine how many and what materials to have on hand. Many spaces have reserved space for scavenged, used, cast off, and contributed materials.

A retention policy, such as "first in, last out", or a 6-month expiration date is common to keep contributed materials from piling up. This space should also be kept separate from member and project storage to prevent the accidental dismantling of someone's project.

For things that aren't available at local suppliers, spaces will often consolidate online orders from members to get bulk discounts and save on shipping costs.

Safety and Training

Working safely is of prime importance in a making space. It doesn't take much of a very big tool 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 you hope the worst doesn't happen, you must be aware of the danger and prepare.

Students and members need to be trained in safely operating tools before using them. 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.

Well-stocked first-aid kits need to be visible and easily accessible in every part of your space and clear and visible warning signs should be posted where necessary.

The equipment itself needs to be 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.
Tools also need to have enough space to be operated safely and not endanger the operator or other people in the space. Work areas need to be well lit and clean. Ventilation and/or air filtering is required for many tools. Metalwork areas need welding screens or curtains to prevent eye damage in passers-by. Personal safety equipment such as goggles, earplugs, gloves, etc. should be provided for members that don't have their own.

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. *Say something here about who should operate the equipment—is there any reason not to let kids do it when possible?*

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. Use the lower heat glue guns when possible, and make sure there's cool running water nearby for burns. Enforce eye protection while members solder. Keep Band-Aids and a full first aid kit nearby.

William Gurstelle wrote a piece called "The Safe Workshop: Rules to make by" for our 2011 Ultimate Workshop and Tool Guide, and we're including this text below and the PDF of the original article in the Resources section.

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!

- 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.
- Secure your work when using hand or power tools. 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.
- 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.
- Avoid using a table saw when you can. Statistically, it's easily the most dangerous piece of equipment in the shop.
- 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.
- 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.
- 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.
- 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.

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.

More specific tips:

- *Tools are safe when used responsibly. Here are a few special precautions:*
- *Hand tools can give scrapes, small cuts and pinches. Hammers can crush.*
- *Safety glasses should be worn near power tools to protect eyes from flying debris. Hammers and power tools both can generate flying debris, so eye protection should be worn when using those as well.*
- *A heat gun and handheld torch can generate fires if used without proper attention to the work and surrounding areas.*
- *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.*
- *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.*
- *Respirators (masks) should also be worn when sanding with either a power sander or by hand.*
- *Electronics at this level are low power and safe, however the tip of a soldering iron heats to about 400°F, hot enough to cause burns and should be handled attentively. Under normal soldering conditions, solder containing lead posed 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. Any kind of soldering generates fumes from the rosin core of the solder so the area should be ventilated.*
- *Sewing is generally a safe activity with very little risk of more than a small prick from a needle. However steam irons*

do get hot enough to cause burns, sergers have blades that can cut a careless finger, and sewing machines and sergers both have enough power to put a needle through a finger when used carelessly.

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. Whether or not your showcase event will require a written Safety Plan, creating one is a wise habit to establish among your students.

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. By the way, there's usually a different process for people who plan to serve food, which involves getting a city permit. We've included a template for a Safety Plan in the Resources chapter.

At Maker Faire, safety plans are necessary 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 demo, 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.

Chapter 4 **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 different kinds of roles we have seen emerge in Makerspaces: what should be expected of the teacher, the students, mentors, and shop coordinator.

Nobody who uses the space is required to be an expert. 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 most common motivators for learning. Students and mentors can tap online resources, or access the expertise and know-how of the local community and other members. Skills can be brought, taught, or bought.

A New Kind of Teacher

When you have five to 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 that 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. It's time for a different brand of leadership. Here are some metaphors to use 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. *From wikipedia: "Key project management responsibilities include creating clear and attainable project objectives, building the project requirements, and managing … cost, time, scope, and quality."*

- 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 you and 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. ~~(need to insert a reference here: 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, adult mentors, and a shop coordinator (if it's not you).
- Assign or help match mentors to project teams.
- Schedule meetings and group build sessions.
- Engage with colleagues in the Makerspace network to ask and answer questions.
- Stay in touch with the Makerspace core team.
- Participate in surveys and other data collection to help improve the program.
- Sharing documentation you collect from your 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.
- Apply good time-management and project-planning skills (optional, but very helpful!)
- Come to meetings.
- Improve or "plus" projects with helpful feedback, tips, assistance when they see a way other students' projects could benefit from what they have to offer, while respecting their projects and only if such feedback is welcomed. Give others working on other projects feedback and help make their projects the best they can be, in a positive, creative, dynamic spirit.
- 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 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 initiation to your Makerspace. They could to write a short paragraph about why they want to be in the program, what kinds of things they made, 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 groups of students, 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. 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.
- [more here]

At Georgia Tech, the Makerspace is jointly operated by the students who use the space. [more here]

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 both models are fine as long as 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.

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.

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

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. You can learn more about facilitation on the Exploratorium's Tinkering Studio website: <link> tinkering.exploratorium.edu.

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 the Resources.

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.

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.

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 any young maker working on any project feedback and help make their 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

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.

Chapter 5 **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 over 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 Learning Approach

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 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 in this project 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 leverages the power of technology to provide personalized learning instead of a one-size-fits-all curriculum, pace of teaching, and instructional practices.

From Personal to Social

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. 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 I think we're interested in how personal engagement drives us and connects us to a community.

What you need (and don't need) to know

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 you don't need to be an expert in everything. [more tips for finding expertise here?]

Learning goals / "curriculum" guidelines
[talk about setting those here]

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 users and in continued participation from year to year. Start with some low-key initiations: 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.

Defining scope & schedules

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.

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. For students who won't see their mentor(s) on a more frequent basis, weekly phone chats or Skype check-ins might be useful for trying to build momentum early on so (hopefully) all 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. 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 that they can check in on progress with the team or with its individual members. We have included a template for a Project Plan 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 in your Makerspace. (It may help the teams think about their project in a new way!) Do something your Makerspace already enjoy doing, or take on a project that includes new talents the members want to add to their skill set. In the Bay Area, we've been introducing some new approaches and techniques during the <link> **Open MAKE sessions at the Exploratorium** including both "Skill Swaps" in the Tinkering Studio 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 earlier section on "Making" to get a sense of the kinds of projects you can do in a short time frame.

Don't forget to expose members 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 <link>**Exploratorium** website. <link> **Make magazine**, and the <link> **Make blog** provide great reading and some video links, as do <link> **TED talks** and <link> Instructables. Encourage your members 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, then working some more

Meetings set aside quality time for sharing progress on projects and getting helpful feedback, and unsticking those who are stuck, but in our experience they aren't a great time to get work done. For this, you'll need to plan time to work on the projects in your shop, and to help Makerspace 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 shop with their partner. One Makerspace met from 10am to 1pm on occasional Saturday mornings for the first few months, then weekly for a month or two in advance of Maker Faire, but this is just an example. Do whatever works for you and your Makerspace.

One thing to keep in mind is that in preparing for 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, your Makerspace may go over 100%!) For that final month, see our advice on scheduling intensive build sessions, below.

Early in the season you might meet only one or twice a month for build sessions. Then you might gradually meet more often as Maker Faire approaches. The number and duration of build sessions will depend on the progress and scope of the projects in your Makerspace. Between meetings, members might discuss their projects on social networks, chat rooms, email, and so forth. If you find an online discussion tool that works for your members, please let us know about it.

During the course of a project you may find that tools are needed for which you don't have access. When that happens, we hope to use the broader Makerspace community to help. Consider posting a request for the tool to the Young Makers Google Group. If that doesn't work, contact us and we'll see if we can help you find the tool.

In the final month before Maker Faire, project teams will be very busy finishing their projects and preparing to talk about them with visitors to the showcase event or Maker Faire. We set aside a Saturday or Sunday on the schedule when the Makerspace 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 if necessary.

Make the day into a work party. You will want to have some water and healthy drinks on hand, then maybe order some pizza once you see how many people show up.

Encouragement (without empty praise)

Encouragement takes a lot of work. You'll have to stay on top of all 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." is an effective way to foster confident learners, perhaps more than a thousand "Good job!" comments.

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 with your students about this. Most of them got 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. And all Makers, young and old, have to face down discouragement.

Some tips from Makers for getting over the slump include the following. They say the same thing in different ways, but one of them may speak to your Makerspace more than others:

- 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. It's a good time to 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 this year's Maker Faire, that's OK. Get done as much as you can 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 begin first, etc.

- Talk to others about your project. It can 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.

The interest and excitement members can expect from attendees at Maker Faire is worth it. Try to find out if there is anything you can do to help your members 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 members 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 members, 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.

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.

Here's another way to look at projects that are incomplete. MAKE and Maker Faire always sponsor the "Most Spectacular Failure" award at The Tech Challenge at The Tech Museum of Innovation in San Jose. Although 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 members will have done their best work, and that alone is something to be proud of. Encourage them to keep going, and if they hit some stumbling blocks along the way, 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) where your students will share their projects. Whether the project is a tangled heap of lots of great ideas that didn't pan out when they sit down to show it off—or it's a fabulously finished realization of their original design—we can assure you that it'll be great and attendees will be impressed, especially if they can tell their story in a compelling and interesting way.

Exhibition, not competition

Something that distinguishes the Maker movement's work in education is our emphasis on exhibition instead of competition. We feel that the pressure of a deadline and wanting to put your best work before thousands of visitors is adequately motivating 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 visitors to Maker Faire. Attendees vote with their feet and the time they spend interacting and asking questions. The interest that visitors pay to a project is all the evaluative feedback they need to get a sense of accomplishment. And we think that is very appropriate, because 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. (Note: We have several examples of how to tell the story behind the projects in the 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 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 them with people who ask, and share them with us too! Send links to mentor@otherlab.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.

Using your own down-time well

Your services may not be required every moment that you are working with your Young Maker. 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.

Connecting with other Makerspaces

[discuss our teaching community and tapping into the social network]

Chapter 6 **Projects**

Making things, and your love for making things with others, may be your main reason for starting a Maker Makerspace. That may be true, but 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 your Makerspace 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 could be one large group project or a simple project everyone can do. It can be customizable or not. Of course, your Makerspace students, may have very different levels of expertise. Here are some sources for simple workshops and starter projects you might consider as first projects.

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 <link>Wind Triggered Lantern, <link>Soda Bottle Rocket, or <link>Cigar Box Guitar provide easy starting points.
  http://makeprojects.com/Project/Wind-Triggered-Lantern/1271/1
  http://makeprojects.com/Project/Soda-Bottle-Rocket/446/1
  http://makeprojects.com/Project/Cigar-Box-Guitar/87/1
- The "Kids" topic page is a good place to start, too, but the projects are not all projects that young people would build; some are projects kids would enjoy playing with: **http://makeprojects.com/Topic/Kids**
- You might also want to check out the most popular projects: **http://makeprojects.com/?page=1&sort=popular&filter=all**

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 **http://tinkering.exploratorium.edu/activities/**

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.

Seek out simpler Instructables projects. The Crafts for kids link includes projects on how to make playdough, oobleck, seed bombs and much more.

Build Howtoons projects. This wonderful collection of highly visual materials also distributes a particularly helpful Guide to Visual Communication.

- ***Make It Go*****:** Take a dive with Das Bottle. Turn electricity into motion with your own mini-motor. Bring a Frankenmouse or a nocturnal robot to life.
- ***Make It Sing*****:** Turn a turkey baster into a flute. Transform a cup into a speaker and microphone. Strum a guitar you craft out of a cigar box.

- ***Make It Fly*****:** Shoot marshmallows in kids' all-time favorite Make project! Float your own blimp. Send a bird-like ornithopter flapping.
- ***Make It Stop*****:** Capture motion with a homemade strobe
- ***Make It Dance*****:** Make light bend.
- ***Make It Tall*****:** Construct a tower to the sky.
- ***Make It Tasty*****:** Shake up a batch of your own ice cream.
- More Howtoons

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. These are some activity design tips 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 (science, technology, engineering, mathematics) 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)
-

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.

See what's out there. To get your idea generator going, it helps to look at as many examples as possible 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. You can find both simple projects and deeper expertise when a member gets 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.)
- ***Maker Faires of the past.*** 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. <link>
- ***MAKE magazine***. Every edition, filled with detailed project ideas and plans, is a well-spring of ideas. Aaron Vanderwerff 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. The 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 window-shopping. Look at the wacky inventions in SkyMall magazine, found in the seat-back pocket of many airlines. If you know someone going on a flight, ask them to pick up some copies of SkyMall for your Makerspace. Your members may 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.

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. Point your members to the site IKEA Hackers <link> http://www.ikeahackers.net/ for ideas for repurposing materials.

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.

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.

Do what you love. Focus on things you like, such as music, video games, or holidays. Halloween and Christmas provide great opportunities for Makers. For Halloween you can make props for your yard or interesting costumes. 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 writeup on the seven rules.
<link> http://www.openideo.com/fieldnotes/openideo-team-notes/seven-tips-on-better-brainstorming

Choosing big projects

Students should aspire to choose projects that are ambitious, yet attainable. Attainable means reining in the idea just enough to acknowledge what expertise the Makerspace have and hope to gain, as well as the expertise of their current or potential mentors. And, 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 Makerspaces will work together all on one big project, like the <link> **Water Totter**. In our experience, though, most Makerspaces will have kids working 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 Making.)

Plussing

Pixar uses the term "plussing" to mean finding what's good about an idea and making it even better. In the Young Makers program, 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. We held plussing sessions at our regional meetings, but

you can hold them at a local level in your Makerspaces as well.

Plussing sessions provide…
- a monthly deadline so that project teams can pace themselves and aren't faced with one huge deadline (Maker Faire) months in the future.
- 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.

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 members know each other well. (Otherwise, everyone tends to be a little shy, and the adults end up talking too much!)

Here are a few of the kinds of questions members 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 them 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 the most to say during the 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 at the monthly meetings. 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.

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 be individuals or groups who 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 members 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 Makerspace members who ring 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.

Also, 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 members 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 up for workshops like "How to Make Jam" or "How to Prune a Bonsai Tree." Your members 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 members 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 (encourage attendees to bring with them on day-of event) get picked through and transformed with hand sewing, sewing machines, silkscreening, gluing, and other decorating stations.

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 are interacting with (e.g., one chair per user).
5. Provide a place for people to wait their turn.
6. Make sure to model safe use of tools and materials in your space (see Safety section, below.)

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 would 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 members. 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.

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-yo Makerspaces

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 Groups

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

Participating in a Maker Faire

To learn more about having your student participate in a Maker Faire, take a look at the Maker Club playbook which outlines a timeline for finishing a project to exhibit at Maker Faire.

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 information about creating a "Mini Maker Faire", contact Sabrina Merlo sabrina@makerfaire.com and ask for the Maker Faire Playbook.

Chapter 7 **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. **[describe several models here]**

Regardless of which model you implement in your school, you will need to take care of a few things as there are a few steps 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 a section called "Makerspace Directory" if you fill out the form for us there. Please write to mentor@otherlab.com if you don't see your Makerspace on this page.

Get connected

Join the Makerspace email list to hear announcements that are relevant to everyone in the network. Although the list currently posts announcements only, we will be rolling out discussion groups later, which you can opt to join.

The purpose of the Makerspace Managers' Google Group is to help each other, to generate discussion, and to share resources and ideas. If you haven't yet been added to our Google discussion group for Makerspace managers and would like to be, please write mentor@otherlab.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 to mentor@otherlab.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 kick off your Makerspace. As we've built support in the Bay Area, we've shared 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 Makerspace might grow.

You can get the word out by having a visible presence at community events. In this way you can diversify your member pool with people you don't know personally. For instance, one year, we reached out to girls through a gathering organized by Exploring Your Horizons, an educational non-profit that aims to nurture girls' interest in science and math. When you work a table, we recommend having a simple banner to hang, postcards and printed materials to distribute, sign-up sheets for volunteers and members, and a simple activity or object. An activity or object demonstrates what the Makerspace is 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 <link>LED throwies at events. If you don't have the energy to "table" an event like this, you can attach posters to poles and business windows just before a fair or other community event you think would attract the kinds of members or mentors you're seeking.

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. We've put together a <link>template presentation, and you are welcome to customize and re-use whatever is helpful.

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. The largest Makerspace we've seen so far were the twenty students in Aaron Vanderwerff's class at Lighthouse Charter School in Oakland.

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 Young Maker 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 you have an individual in your leadership team 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:

- <link> Wordpress.com. 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 <link>Affiliated Makerspaces page. A simple bare bones example of a site is the one for the <link> Central Marin Young Makers Makerspace.

If you'd like to register your domain name (URL), GoDaddy.com 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, "youngmakers.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 O'Reilly Media (see the Resources section for the wording.) Set up a page to show off the Makerspace ' projects, 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 the Makerspace, Maker Faire, Make, and O'Reilly 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?

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 word-smithing 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 money to fund your Makerspace and its projects

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.com and Indiegogo.com 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.

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 a Maker Faire near enough to where you are, <link> **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.

Chapter 8 **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. One team member on each project could take on the role of documentarian along with their other making duties.

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. 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 mentor@otherlab.com

Posters. After Maker Faire, Aaron Vanderwerff asked his 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.

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 <link> Ignite http://en.wikipedia.org/wiki/Ignite_(event) or <link> Pecha Kucha http://en.wikipedia.org/wiki/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. <link> 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:, our print 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 mentor@otherlab.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 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 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 in this
- 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 the Makerspace network

The network of all Makerspaces would *very much appreciate* your sharing some notes, writeups, 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.

- Participant Post-Season Survey Makerspace has developed an online survey for distribution to every Makerspace participant. We require that you email this survey to your attendees within two weeks after the end of our season (the Maker Faire or other event where you exhibit your projects.) Please Bcc: mentor@otherlab.com on the email in which you ask your participants to complete this survey.

- Maker List: We are building an international database of Makers and their projects with the ultimate goal of starting a Maker Guild. MAKE would also like to offer subscriptions to your Makers, as well as contact some for potential editorial coverage in MAKE or makezine.com. You can submit.csv or.xls files to mentor@otherlab.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

- Managers' Post Season Report / Survey: 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. To remain an affiliate of the Makerspace, you must fill out this <link> simple survey within 45 days of the end of your season. It asks questions about your event 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?

- Share best practices. Take a moment after your season to report back to the Makerspace core team as well as the Managers' Google Group. *Please* share what you learned.

- Contribute to this book! The Makerspace Playbook is intended to be a living document, evolving as the collective experience of the Makerspace network and its community of Makerspaces grows. Please email mentor@otherlab.com with comments, helpful anecdotes, or your own Makerspace snapshot.

- Share images and video of what you've accomplished: 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:

      http://www.youtube.com/watch?v=Usw4t7NVnt0
      http://www.youtube.com/watch?v=Cn9ST2ay6c4
      http://www.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 mentor@otherlab.com.

Chapter 9 **Snapshots**

[one now, more later]

Lighthouse Community Charter School

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 had learned basic programming and electronics 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.

Chapter 10 **Resources**

- Language
- Program Team
- Recommended Suppliers
- Design Guidelines and Assets
- Tips from Mentors of the Computer Clubhouse
- Samples and Templates
    - 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

Language

Throughout your Makerspace season, you will find yourself writing about and explaining Makerspace repeatedly. In an effort to help provide a baseline description of Maker Faire, MAKE Magazine, and O'Reilly Media, as well as the relationship between your Faire and Maker Faire, we have come up with the following language.

We also require that you use this language in an "About" page of your blog or website. This language can also come in handy for the end of press releases and in grant or funding proposals.

About Makerspace

[TEXT HERE]

About Maker Faire

Started in San Mateo, California in 2006, and now expanding to Detroit and New York, Maker Faire is the premier event for grassroots American innovation. Held annually in each of these locations, the event may expand elsewhere in the future. Maker Faire is supported by MAKE Magazine (makezine.com) and O'Reilly Media, the premier information source for leading-edge computer technologies. The company's books, conferences and web sites bring to light the knowledge of technology innovators. Community-driven, independently produced Mini Maker Faires inspired by Maker Faire are now being produced around the United States.

About MAKE magazine

MAKE is the first magazine devoted entirely to Do-It-Yourself (DIY) technology projects. MAKE unites, inspires, informs, and entertains a growing community of resourceful people who undertake amazing projects in their backyards, basements, and garages. MAKE celebrates your right to tweak, hack, and bend any technology to your will. MAKE is published quarterly by Maker Media, the division of O'Reilly Media, Inc., that also produces the wildly popular **Make: Online** (www.makezine.com), **CRAFT** (www.craftzine.com), the **Maker Shed** online store for DIY kits, books, and more (www.makershed.com), and the world's biggest DIY festival, **Maker Faire** (www.makerfaire.com

About O'Reilly Media

O'Reilly Media spreads the knowledge of innovators through its books, online services, magazines and conferences. Since 1978, O'Reilly Media has been a chronicler and catalyst of cutting-edge development, homing in on the technology trends that really matter and spurring their adoption by amplifying "faint signals" from the alpha geeks who are creating the future. An active participant in the technology community, the company has a long history of advocacy, meme-making and evangelism.

"The Maker movement has brought the pre-1970s world of basement workshops and amateur tinkering into the digital age." ***— The New York Times***

Program Team

Otherlab, located in San Francisco, California, is a Clean Tech Do-Tank and developer of next generation algorithmic design tools.

Saul Griffith, Ph.D. (co-Principal Investigator) is a serial entrepreneur. Saul has founded or co-founded: Squid Labs (Do-Tank Engineering Incubator), Instructables.com (shared open-source hardware and instruction), Potenco (human-powered energy devices), HOWTOONS.com (science and engineering education and inspiration), Optiopia.com (technical solutions for low-cost eye-care), and MakaniPower (high-altitude wind / utility scale renewable energy). Of particular relevance to this project was Saul's involvement at MIT (1999–2004) in founding "Thinkcycle.org," a platform for distributed engineering collaboration and education focused on engineering challenges of the developing world that became "DesignThatMatters." Saul sits on the advisory board for the X-Prize Foundation, Duke Energy, Popular Mechanics, Make Magazine, Pfizer, and HP Environment council. Saul has taught design engineering at MIT and lectured on design engineering and design tools for engineering and invention at MIT, Stanford, UC Berkeley, University of Arizona, Harvard, and others.

O'Reilly Media, located in Sebastopol, California, is a technical publisher and conference organizer known for its advocacy of Open Source, the Web and the Maker movement.

Dale Dougherty (co-Principal Investigator) 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.

Joel Rosenberg (Project Manager) is an engineering educator with a background in mechanical engineering and journalism. He has helped develop multiple high school curricula, including "Engineering the Future" from the Museum of Science, Boston. (www.mos.org/etf) He was the first project manager of SMILE (howtosmile.org), a digital library of informal activities for teaching science and math; an 11th-grade chemistry teacher in Boston Public Schools; a nanotechnology educator at the Museum of Science, Boston; and a toy designer at the Intel Smart Toy Lab.

Michelle Hlubinka (Curriculum Developer) 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.

Stephanie Chang (Curriculum Developer) is currently in the Learning, Design, and Technology (LDT) program at Stanford's School of Education. Prior to graduate school, she spent five years with Galileo Learning as the Director of the Tech Museum Summer Camps. She has also worked in other informal science and experiential education settings. When not studying or working, she enjoys photography, glassblowing, and galloping around in the sunny hills and waters of the Bay.

Recommended Suppliers

Here is a list of some good parts suppliers in various categories. Please add your own recommendations.

Electronics

- Sparkfun: Especially good for robotics parts like motors, controllers, etc. http://www.sparkfun.com/
- Electronic Goldmine: They specialize in inexpensive recycled parts. http://www.goldmine-elec.com/
- Maker Shed: Lots of variety, not just electronics. http://www.makershed.com/
- Evil Mad Science: LEDs, open source hardware, and local. (Email for local pickup info in Sunnyvale.) http://www.evilmadscience.com/
- Jameco: Located in Belmont, will-call availability. http://www.jameco.com
- Digi-Key: Excellent prices on coin cell batteries. Ships from Minnesota. http://www.digikey.com/
- Adafruit: More open source hardware. Ships from NY. http://www.adafruit.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. http://www.hobbyengineering.com/
- Weird Stuff: Resellers of surplus computer hardware and software. http://www.weirdstuff.com/
- Cool Neon: Electroluminescent wire (it glows!). http://www.coolneon.com/
- Brown Dog Gadgets: : USB charging circuits. http://www.browndoggadgets.com/

Mechanical, pneumatic, industrial, fasteners, etc.

- McMaster-Carr: Extensive and well organized online catalog, fast delivery. http://www.coolneon.com/
- 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. http://www.grainger.com
- Olander: Mostly fasteners. Located in Sunnyvale, they have will-call availability. http://www.olander.com/

R/C equipment

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

Modeling, molding, casting

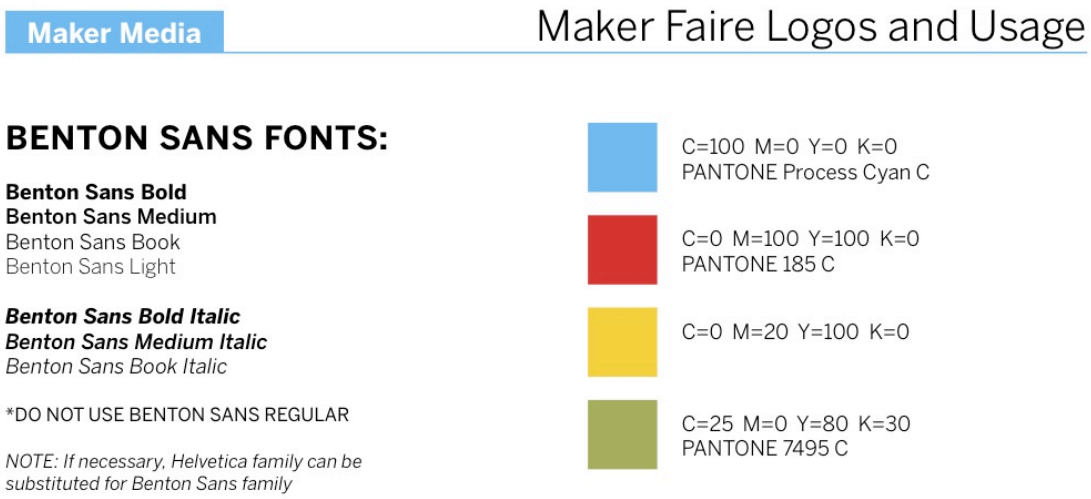
- J. Greer: Carries a wide selection of plastic molding and casting materials. Fast delivery too. http://www.aeromarineproducts.com/
- Douglas & Sturgess: Just about everything you need to model in plaster, plastic, clay, fiberglass, etc. Located in Richmond, but they have an on-line store too. They also have classes. http://www.artstuf.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. http://www.tapplastics.com/

Design Guidelines

Design aficionados may want to use the “official” Maker font and colors to build design assets for the Makerspace and the network. We have also created logos and some pre-designed postcards, posters, and T-shirts you are free to use, under certain conditions.

Font and Colors

MAKE magazine and Maker Faire use a font called Benton Sans. You can buy these fonts for about $40 each at http://new.myfonts.com/fonts/fontbureau/benton-sans/
If you’re only want to purchase one, purchase Benton Sans Bold. The far more common fonts of the Helvetica family closely resemble Benton Sans and serve as a reasonable substitute.



Logo

When you sign up as a Makerspace affiliate, you are agreeing to use the Makerspace and Maker Faire logos in particular ways:

- Use the logo only in conjunction with your Makerspace.
- The only thing you may alter about the logo is the size, and alteration in size must be proportional.
- Don’t combine or overlay the logo with other elements.
- Keep the logo separated by white space (the required rule of thumb is “empty space around the Marks must be X, where X equals ½ the height of the Mark.”)
- Don’t delete the ® symbol(s) or ™ mark in the logo.

Design Elements, Assets and Templates

Makerspace has provided a variety of branded design elements and assets you can use for design direction. This index of links gives you access to these files.

logos *postcards* *posters*
T-shirts *banners* *badges*
presentation

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.

Sample Proposal and Budget to Submit to a Funder

We propose creating a Makerspace. [*describe your 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 Student “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 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 in May 2011.

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.

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: http://makerfaire.com/search.csp Name some you really liked.

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.

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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

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1. 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.)

2. 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.

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

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: http://makerfaire.com/search.csp Name a few that you really liked.

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
Woodworking

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? *

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			
	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…
	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.

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….

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.

	10am – 2pm	**1pm – 5pm**	**4pm – 8pm**	**10am – 2pm**	**2pm – 6pm**

[ ] 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

Safety Plan Template

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