

Tools & Materials

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

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

The Perfect List

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

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

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

Budgeting for Tools *and* Their Care

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

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

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

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

Reusable Tools List	<p>JOINING</p> <ul style="list-style-type: none"> • staple gun • hot glue gun • hot glue gun • pop riveter • box rivets • big sewing needles • paint brushes (1" and 3") • straight pins • splice set • tap and die (SAE + Metric) 	<p>MECHANICAL</p> <ul style="list-style-type: none"> • screwdriver set (precision) • screwdriver set (big) • allen (SAE + metric) • claw hammer • mallet • combination wrench • ratchet set • joint pliers (channel locks) • miter box • PVC pipe cutter • socket set • driver bits • hollow-shaft nut drivers 	<p>ELECTRONICS</p> <ul style="list-style-type: none"> • Arduino • LilyPad • soldering iron • soldering tips • crimping tool • wire cutter • wire stripper • diagonal cutter • solder sucker • digital multimeter • solder tip tinner • 1/2 size breadboard • third hand • tweezers • solder • heat gun 	
	<p>CUTTING</p> <ul style="list-style-type: none"> • hole saw • metal file(s) • file card • chisel/rasp set • tin snips • box knives • X-acto knife • scissors • drill bits 	<p>FIXTURING</p> <ul style="list-style-type: none"> • vise • C-clamps • bar clamps • needlenose • locking pliers • adjustable wrench • binder clips • locking pliers 	<p>BATTERIES / POWER</p> <ul style="list-style-type: none"> • AA NiMH and charger • AA NiMH • 9V battery clip • 4 AA battery holder • 3 AA battery holder • 2 AA battery holder • alligator clips 	<p>TEXTILE/SOFT CIRCUIT</p> <ul style="list-style-type: none"> • Fabric scissors • pinking shears • seam ripper • cloth tape measure • sewing needles • iron • embroidery needles • needle threader • snap setter • Serger
	<p>STORAGE TOOLS</p> <ul style="list-style-type: none"> • containers • labels • camera • broom • dust pan and broom • Shop Vac 	<p>POWER TOOLS</p> <ul style="list-style-type: none"> • sanding block • hacksaw • wood-saw • block plane • deburring tool • countersink • awl • cutting mat • hand-crank (rotary) craft drill 	<p>EXTENSION</p> <ul style="list-style-type: none"> • 3D printer • CNC mill • laser cutter • circular saw • orbital sander • table saw • hot wire foam cutter • plastic bender 	<p>ETC</p> <ul style="list-style-type: none"> • tool box • workbench • saw horses • CNC router

Strategies for Stocking Up

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

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

Third-party services can make up for a lack of some tools. Laser cutting, 3D printing, milling and other

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

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

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

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

Modular build-out and Makerspace "levels"

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

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

In the companion document *High School Makerspace Tools & Materials* we define several different modules, and each section contains checklists in two categories, and these constitute the bulk of each section.

Checklists include the common name of each tool, general pricing information, and when necessary, a more specific description and web link to an example.

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

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

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

Materials Inventory and Maintenance

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

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

Consumable Materials List		ADHESIVES	TAPE
ELECTRONICS		<ul style="list-style-type: none">wood gluewhite glueepoxyhot glue stickssuper glue (CA) medium + debondCA glue thinspray adhesivePVC cement	<ul style="list-style-type: none">packing tapepaper Kraft tape 2"electrical tapeduct tapemasking tapescotch tapeblue painter's tape
<ul style="list-style-type: none">conductive thread 2plyconductive thread 4plybreadboarding pinsbatteries AAbatteries 9V9V battery snapsbattery holdersheat shrink tubingbreadboardsresistors	<ul style="list-style-type: none">switchesbuzzersmotorsphotoresistorsjumper wireswirecrimpsbeeswaxLEDsbatteries	WOOD <ul style="list-style-type: none">2"x4"x96" wood4'x8' 1/4" plywoodbalsa wood FLUIDS <ul style="list-style-type: none">small plastic syringeplastic tubingLuer connectors1-way valveT-connector	HARDWARE <ul style="list-style-type: none">hack saw bladesjig saw bladesjewelers' saw blades + lubricantX-acto and utility knife bladeslubricantacid brushespopsicle stickspaper mixing cups (Solo)plastic mixing cups (medicine)toothpickscaliper battery
ABRASIVES		TEXTILES	FIRST AID KIT
<ul style="list-style-type: none">sandpaper (80/200/400/600)sandpaper (80/200/400/600)		<ul style="list-style-type: none">threadadhesive tapesewing machine needlesfeltfabricsewable battery holdersnapsbobbinsmetal beadsplastic beads	<ul style="list-style-type: none">glovesdust maskssafety glasses
FASTENERS			MISC
<ul style="list-style-type: none">fasteners (screws, nails, etc.)staple gun staplespop rivetsMr. McGroovy's Box Rivetszip tie assortmentbinder clips			<ul style="list-style-type: none">Shapelock (or Instamorph)Nichrome wirestringrope

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

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

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