Making the Space

1

IN THIS CHAPTER

- Choosing the Location
- Designing the Space
- Safety

In a perfect world, the Makerspace is as common as a coffee shop. You become a member, whether it be paid or free, and when an idea hits you, you know where to go. As you enter the building into a well-lit, clean environment, you see Makers of all ages working tirelessly on their exciting projects. Around the perimeter of the room, you see people on computers with open source CAD software designing circuits and mechanisms, 3D printers extruding parts for more 3D printers, and soldering irons being used to mount components on custom Arduino shields. Near the windows you hear the hum of a squirrel-cage blower removing the smoke from a laser cutter that is meticulously outlining the frame of a quad-rotor helicopter. And in the center of the room, there is a group of students working on their robots for the next FIRST Lego League competition. Paradise.

This dream is quickly becoming reality. Makerspaces of all types are popping up around the world and are opening their doors to the future of Making. For these establishments to become successful at their missions, it is fundamentally important that they start with a good design. This chapter will discuss possible locations for your space, tools for laying it out, and ensuring its occupants have a safe environment to work (Figure 1-1).

Figure 1-1. *My project area.*

Choosing the Location

The first question asked when designing a Makerspace is "Where am I going to put it?" This decision sets the stage for determining the types of equipment, materials, and projects the space can support. It sheds light on just how many people can occupy the space as well as its potential for growth. Choosing the location is mainly dependent on the direction you want the space to go. What kind of projects do you want to support? Are they craft based or do they require sophisticated machinery? This section is designed to assist with this decision and will help develop an understanding of the proposed locale's benefits and drawbacks. Ultimately, choosing the optimal location ensures that its participants can function safely and effectively while they work.

Understanding the Constraints

Although each location possesses unique design constraints, there are common elements that are universal. In understanding each of these elements and the limitations they expose, you will be better able to choose, design, and ultimately construct your Makerspace. These constraints will also help to determine just what kind of equipment your Makerspace needs. Table 1-1 helps to illustrate different methods and tools required for completing common tasks. It might turn out that your space can get away with simple handheld power tools rather than the larger standing type. Or, that there are different ways for making a hole that doesn't involve a drill.

Table 1-1. Different tools for the same task

Task	Tech Level	Tool
Making a hole in <1/4″ Wood/ Plastic	Low	Mechanical drill or hole punch
	Medium	Hand Drill
	High	Laser Engraver
Making a hole in >1/4″ Wood/ Plastic	Low	Hand drill
	Medium	Drill Press
	High	CNC Router
Making a hole in sheet metal	Low	Sheet Metal Punch
	Medium	Hand drill w/ wood backing block
	High	Pneumatic punch
Making a hole in metal plate	Low	Hand drill w/ hole saw
	Medium	Plasma cutter
	High	CNC Mill
Cutting a profile in wood/ plastic	Low	Hand or coping saw
	Medium	Jig, scroll, or band saw
	High	Laser engraver
Cutting sheet metal	Low	Sheet metal hand shears
	Medium	Floor shear
	High	Pneumatic or electric hand shears
Cutting metal plate	Low	Hack saw
	Medium	Reciprocating saw
	High	Plasma cutter
Constructing a 3D object	Low	Hand model and cast
	Medium	3D Printer
	High	CNC Mill
Soldering a PCB	Low	Unadjustable soldering iron
	Medium	Adjustable soldering iron
	High	Reflow oven
Making circuit boards	Low	Toner transfer and hand etch
	Medium	Photo transfer and hand etch
	High	PCB Mill

Size

The size of your Makerspace is ultimately the biggest constraint. It dictates how many people can safely work at one time, the types and quantity of equipment you can support, and the size of the projects that can be worked on. A good rule of thumb for determining a number of occupants in your Makerspace is to allocate 50 sq. ft. of space per person: that's a roughly 7 ft × 7 ft area. This allotment allows for safe use of floor space, especially as the occupants will be working in a lab environment. You can find more information in the *BOCA National Building Code/1996*, Building Officials & Code Administrators International, Inc., 1996.

Equipment and technology take up space, require power, and often require some amount of ventilation for proper and safe operation. Table 1-2 is a list of common large equipment found in the Makerspace environment and their approximate size and power requirements.

Table 1-2. Common Makerspace equipment

Type	Size (ft)	Power (Watts)
3D Printer	1 × 1	100
Laser Cutter w/ Ventilation	3 × 5	1500
Standing Drill Press	2 × 3	350
Table-Top Drill Press	1 × 2	125
Standing Band Saw	2 × 3	350
Table-Top Band Saw	1 × 2	120
Soldering Iron	1 × 1	75
Heat Gun	1 × 1	1500
Hot Plate	1 × 1	750

Power

At the end of the day, someone has to pay the power bill. This constraint is important to understand as many of the pieces of equipment your Makerspace will use require a lot of power. Tools like heat guns and hot plates as well as equipment like laser cutters and their ventilation systems consume hundreds of watts of energy during use.

There are typically two types of outlets that will be available: NEMA 5-15 and NEMA 5-20 (Figure 1-2). Their design dictates how much energy that electrical branch can supply, specifically 15 amps and 20 amps. If you go over the available current, like you would if you used 4 heat guns on one outlet, you run the risk of tripping a circuit breaker, or in the worst case, starting a fire.

Figure 1-2. *NEMA 5-20 outlets feature a horizontal slot for a 20 amp plug.*

Whether you are creating a public or private Makerspace, it is imperative that you follow your local and state rules and regulations pertaining to fire-code and safety. A good place to locate this information is through the National Fire Protection Association at http://www.nfpa.org and the Occupational Safety & Health Administration at http://www.osha.gov. This book should not serve as the only source of information regarding outfitting and occupying a space, and it is your responsibility and discretion to ensure that your Makerspace follows the rules.

An alternative to calculating power consumption is to use an in-line or inductance type power meter (see Figure 1-3). These devices are designed to measure and display immediate power consumption, power consumption with respect to time, current draw, and voltage. They also have the ability to predict the cost in electricity to operate that piece of equipment, which could prove to be very beneficial for understanding the costs involved in operating your Makerspace.

Power Calculation

With DC circuits, we can simply calculate power using P = IV and, conversely, the current by using I = P/V. This equation holds true for instantaneous power in an AC circuit, yet the average power of an AC circuit is determined based on its power factor. You can calculate your equipment's potential current consumption prior to its use by using the following formula:

```
I = W / (PF × V)
```

I	Current in amps
W	Power in watts
PF	Power factor
V	Voltage in volts

The *power factor* describes the ratio between the power actually used by the circuit (*real power*) and the power supplied to the circuit (*total power*). This value ranges from 0 to 1 and can be difficult to pin down without a good understanding of the internal circuitry or through physical testing. Typically, resistive loads, like heaters and lamps, receive a 1.0 power factor. Equipment containing motors have a power factor less than 1, requiring more power than would be necessary if the circuit were purely resistive, and directly correlates to the efficiency of the system. For the most part, the equipment that you will be using in your Makerspace will not be drawing a large amount of power. Those that do will typically identify their power requirements either on a sticker or within the documentation.

Figure 1-3. *Digital watt meters can accurately display a piece of equipments' power consumption in real time.*

Ventilation

Nobody wants to work in a stinky room and the fumes emitted by Makerspace technology can quickly become a problem. The necessity for proper ventilation poses a serious design constraint if your Makerspace is going to support equipment that produces fumes. Technology like 3D printers, soldering irons, heat guns and plates, and most especially laser cutters are the primary contributors of potentially harmful fumes. Normal room ventilation systems (Figure 1-4) either recirculate the air after it passes through a series of filters or it is pumped in fresh. As the existing ventilation systems are something that cannot easily be changed, localized vapor removal methods need to be implemented.

Figure 1-4. *The ventilation system directs unwanted fumes outside of the building.*

Noise

The fact of the matter is this: tools make noise. On paper this might not seem like a very big issue, but the quantity of noise a machine generates can and will dramatically affect the layout of a Makerspace. This constraint is especially important to consider when implementing Makerspaces in schools and libraries. Even though these Makerspaces might be located in a room separated from the rest of the building, most commercial structures have drop ceilings and false walls. Sound also has the tendency to travel through duct work and will "broadcast" the Makerspace's activities throughout the rest of the building. Table 1-3 illustrates some of the more common, and noisy, Makerspace equipment and just how much noise you can expect them to produce while in operation.

Table 1-3. Equipment noise comparison

Reference	Tool/Equipment	Noise Level (dB) [a]
Rock band		110
	Hammer	100.4
Lawn mower		100
	Reciprocating saw	95.5
	Band saw	91.3
Blender		90
	Hand Drill	89.9
	Hack saw	89.7
City traffic		85
	Laser engraver w/ exhaust	82.2
Vacuum cleaner		75
	Drill press	72.3
Normal conversation		60

[a] Noise level readings were taken approximately 3 ft from the source using a TENMA 72-860 sound-level meter

If your equipment produces a lot of noise, you'll want to get some ear protection (Figure 1-5).

Figure 1-5. *Ear protection should always be worn when working in a loud environment.*

The Library Makerspace

The public establishment of a Makerspace is a marvelous idea. It acts as a common place for our youth to learn and explore engineering concepts, community members to organize and share designs, and it offers an extension to the classroom environment. Libraries happen to fit this bill perfectly. With their endless source of research materials, Internet access, and public atmosphere, what better place for a Makerspace. Wouldn't it be nice to have your public library support the basics for Making? Why shouldn't it?

Most libraries have allocated space that patrons can reserve for nonprofit events that consist of