6

Practices

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

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

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

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

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

Our Challenge

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

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

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

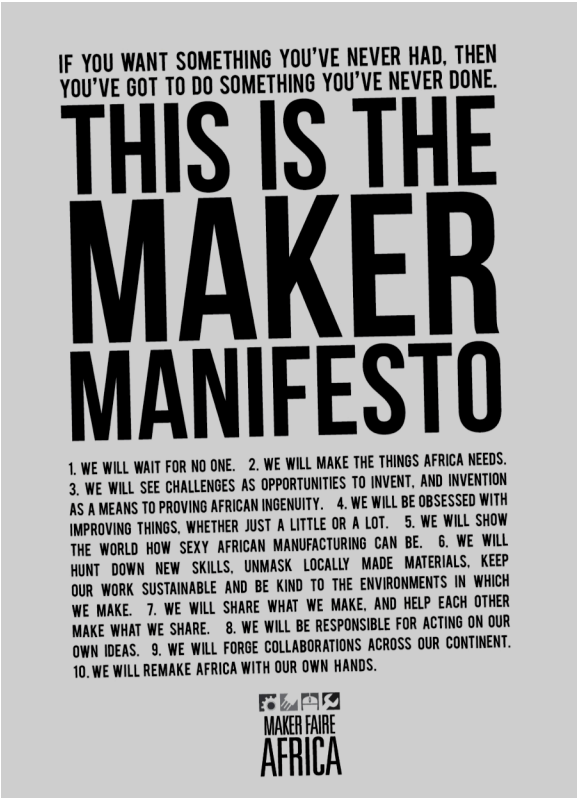
Our kids can be learning more efficiently—and as individuals. We imagine that schools can become places where students learn to identify their own challenges, solve new problems, motivate themselves to complete a project, engage in difficult tasks, work together, inspire others, and give advice and guidance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

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

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

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

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



A Makerspace Manifesto

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

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

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

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

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

From Personal to Social: DIY and DIT

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

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

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

Teacher tip:
Model muddling.

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

Community Initiation

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

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

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

Plussing as a Community

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

Plussing sessions provide...

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

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

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

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

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

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

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

Content: How to Cover a Lot of Ground

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

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

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

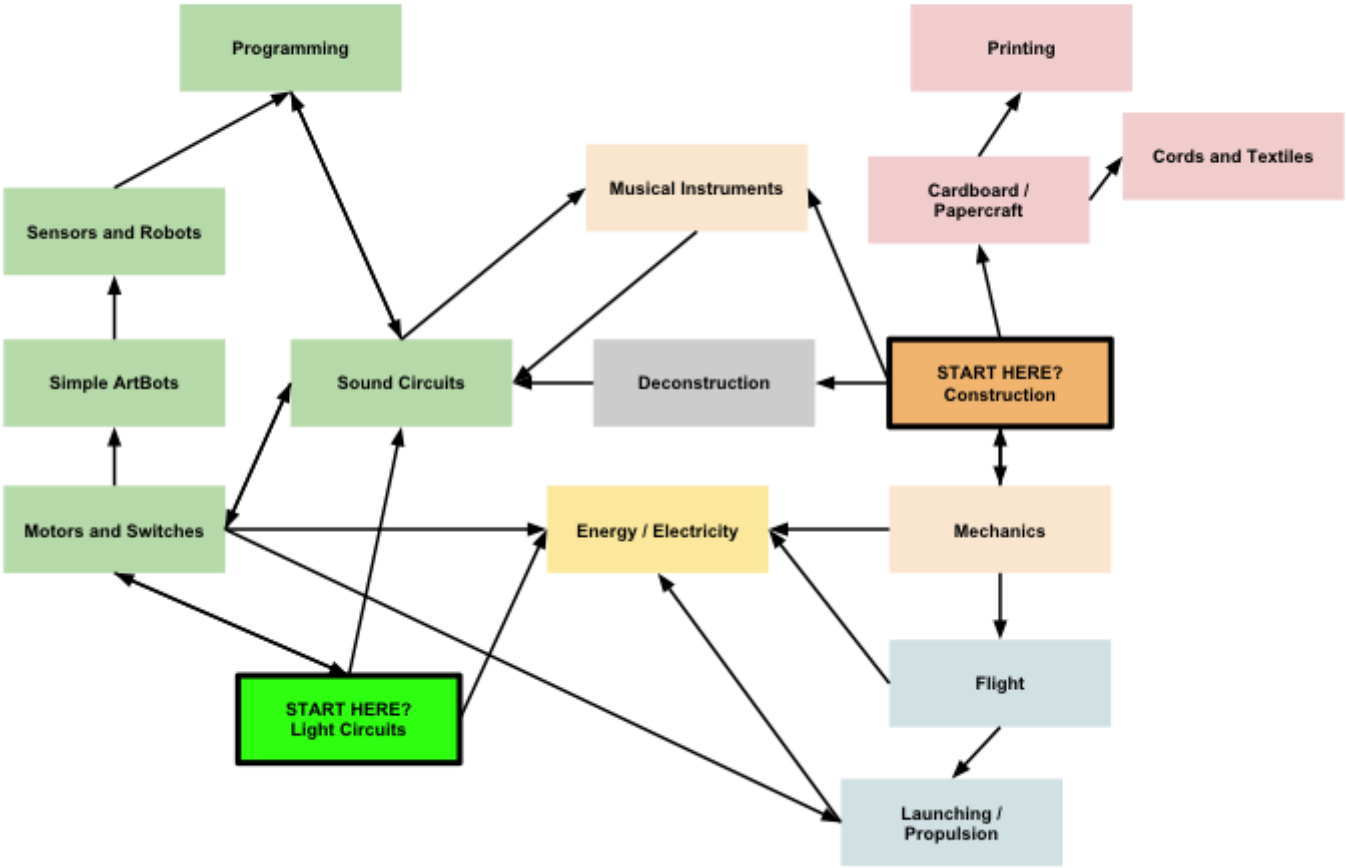
- **Exploratory**: Workshop project sets in skill building; a sampler of a few brief projects that expose students to some of the basics within a given domain.
- **Applied**: More involved, cross-disciplinary projects which may or may not cross domains and ask the students to extend the skills that they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

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

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

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

A Course in Making: Learning Paths



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

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

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

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