"Mark's book is pitch-perfect on why the Maker Movement is so important for our collective future."
—BETH COMSTOCK, CMO AND SVP, GE

RULES FOR INNOVATION IN THE NEW WORLD OF CRAFTERS, HACKERS, AND TINKERERS

THE MAKER MOVEMENT MANIFESTO

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MAKE

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SHARE

Sharing what you have made and what you know about making with others is the method by which a maker's feeling of wholeness is achieved. You cannot make and not share.

GIVE

There are few things more selfless and satisfying than giving away something you have made. The act of making puts a small piece of you in the object. Giving that to someone else is like giving someone a small piece of yourself. Such things are often the most cherished items we possess.

LEARN

You must learn to make. You must always seek to learn more about your making. You may become a journeyman or master craftsman, but you will still learn, want to learn, and push yourself to learn new techniques, materials, and processes. Building a lifelong learning path ensures a rich and rewarding making life and, importantly, enables one to share.

TOOL UP

You must have access to the right tools for the project at hand. Invest in and develop local access to the tools you need to do the making you want to do. The tools of making have never been cheaper, easier to use, or more powerful.

PLAY

Be playful with what you are making, and you will be surprised, excited, and proud of what you discover.

PARTICIPATE

Join the Maker Movement and reach out to those around you who are discovering the joy of making. Hold seminars, parties, events, maker days, fairs, expos, classes, and dinners with and for the other makers in your community.

SUPPORT

This is a movement, and it requires emotional, intellectual, financial, political, and institutional support. The best hope for improving the world is us, and we are responsible for making a better future.

CHANGE

Embrace the change that will naturally occur as you go through your maker journey. Since making is fundamental to what it means to be human, you will become a more complete version of you as you make.

In the spirit of making, I strongly suggest that you take this manifesto, make changes to it, and make it your own. That is the point of making.

Introduction

Welcome to the next big thing, the Maker Movement and its revolution. We are still riding out the waves of the last big things, the computer revolution and the explosion of the Internet. But because the maker revolution is physical, it is destined to be bigger. We can't live in a computer or on the Internet, but we do live in houses, drive cars, wear clothes, use medical devices, play with toys, eat, grow, and live in the real world. I love the virtual world, but even its next big foray—the Internet of Things (where we connect physical objects up to sensors attached to the Internet)—will leverage and reside in its very physicalness. For the Internet of Things to work, there must be "things" to be attached to. What is happening and helping to drive the Maker Movement is that the nature of making things is changing. That is primarily what this book is about: the changing nature of making things and its tremendous impact on your life.

TECHSHOP, INC.

I'm the CEO of TechShop, a membership-based, do-it-yourself (DIY), open access, fabrication workspace. From my unique perch in the Maker community, I have had the opportunity over the last six years to see the emergence of

a movement, the Maker Movement. TechShop is an integral player in that movement. Started in October 2006 by Jim Newton and a group of diehard maker enthusiasts in Menlo Park, California, TechShop was the first open-access shop of its kind. With six locations open across the United States at the time of this writing, and many more in the works and aspirations to go international, TechShop is now the largest and most influential makerspace in the world.

Shop locations average 16,000 to 20,000 square feet in size, with every tool and piece of equipment needed to make just about anything . . . like the world's fastest motorcycle, the world's first desktop diamond-manufacturing device, the world's cheapest drip irrigation system, and award-winning start-ups, one of which is currently worth billions of dollars. It is the most creative hub of activity in every city where it opens. People move to be near one; others take extended vacations in them; and a number of venture-backed start-ups have temporarily relocated their engineering teams to work out of the space. TechShop is changing the nature of making things, who gets to make them, and how they are made. The platform is allowing anyone over 16 years old to make almost anything, in a space designed for them, with access to the world's most powerful and easy-to-use machines the world has ever seen.

A LITTLE ABOUT ME

Through my work at Avery Dennison in the 1990s as corporate director of global technology and business development, I developed an understanding of the importance of and barriers to manufacturing. As director of computer services at Kinko's at the beginning the 2000s, where I managed a $200-million product line of publically available, open access, computers systems (10,000+) along with powerful soft-

ware tied to large expensive high production machines, I saw firsthand the transformative power of open access to tools. We launched more design firms every year out of Kinko's than any school ever did.

As the former owner/operator of an auto body shop, I understand the importance of pride and craftsmanship, the local aversion to manufacturing, and the sometimes stifling effects of regulation. And now, as the CEO of TechShop, I have a unique opportunity to arm a Maker Movement army with the tools it needs to change itself and the world.

Along the way, I also picked up an MBA at the feet of the grandfather of management, Peter Drucker, and I am a trained revolutionary, thanks to the Special Forces training I received on my way to becoming a Green Beret. I use the dialectic of movements, manifestos, and revolutions explicitly.

MAKER MOVEMENT MOMENTUM

A number of trends are coming together to push the Maker Movement forward. Cheap, powerful, and easy-to-use tools play an important role. Easier access to knowledge, capital, and markets also help to push the revolution. A renewed focus on community and local resources and a desire for more authentic and quality things, along with a renewed interest in how to make things, also contribute to the movement. I'll cover each in its own way, but with a multiplicity of trends pushing along the Maker Movement, we have only begun to see an outline of its eventual power to remake the United States and the world.

The founders of this movement launched *Make Magazine*, the bible of the Maker Movement, in January 2005. Dale Dougherty, Sherry Huss, and Dan Woods, along with the support and encouragement from Tim O'Reilly, launched the

magazine and then the Maker Faire, an annual gathering of 50,000 to 125,000 in three major cities around the country,

Modeled after the old *Popular Mechanics* format, with a heavy emphasis on describing projects that could be made by the home enthusiast, *Make Magazine* has become the touchstone of the movement. The arrival of each magazine is like getting a new Christmas catalog of things you want . . . to make.

When the group launched the first Maker Faire in San Mateo, California, in April 2006, 25,000 people showed up, many from out of state, wanting to connect with other people like themselves. And just like that, with an eclectic mix of people, projects, and things, the twenty-first-century version of the state fair was born. Eight years later, with expansions to hundreds of Mini Maker Faires in other cities and states around the country, the San Mateo Maker Faire will likely top 125,000 visitors and participants in 2013. With its annual draw of tens of thousands of acolytes joining together to celebrate making things, Maker Faire is like Mecca to the Maker Movement.

At the first Faire, future TechShop founder Jim Newton sat with a table, a sign, and an idea. By October 2006, he, his partner, and a bunch of volunteers had opened the first full-blown makerspace.

Since then, the movement has begun, and TechShop has been joined by many other companies. We have partnered with Autodesk, the software company that owns AutoCAD, Inventor, 3ds Max, and Maya. Autodesk has jumped into the Maker Movement with both feet, releasing a slew of free software, making it possible for anyone eight to eighty to design and make. The company has also increased its pace of acquisitions with purchases like Instructables.com, an online free instructional website where one can learn and share how to make almost anything.

Ford Motor Company, DARPA, the Veterans Administration, General Electric, Lowe's Home Improvement, National Instruments, and a growing number of other large and small companies have recently joined with us and others in helping to drive the message, platforms, and impact of this movement.

New companies have emerged as a result of the Maker Movement. AdaFruit, Sparkfun, Inventibles, Quirky, and MakerBot Industries all come to mind. One of the keys to this movement is the democratizing impact of access to the tools one needs to make things.

I met Jim Newton, founder and now chairman of TechShop, at a software party in Palo Alto, California, in 2007. I overheard him describe the workshop as being "kind of like Kinko's for geeks." Since, at one point in my career, I had run the geekiest part of Kinko's (the computer services area across the United States), I was intrigued. I thought to myself, "I am Kinko's for geeks. What is this guy talking about?" Eventually, Jim got me to come and take a look at the first TechShop location in Menlo Park, and he introduced me to the beginning of the movement.

At one point on that first visit, I went from table to table in the store asking, "What are you making?" Three times in a row I talked to entrepreneurs who told me that they had saved 95–98 percent of their development costs by using TechShop to make their initial products and sometimes their first couple of production runs.

I had done plenty of business development, product development, new product, or service launches along with research and development in my career. A 98 percent reduction in the cost of launching a product or company means, for example, that what used to cost $100,000 now costs just $2,000. This is stunning. It moves something from being hard or impossible

to easily doable by anyone in the middle class. This platform democratizes hardware innovation in one fell swoop.

Jim showed me the class infrastructure and educational track that could be taken by anyone and that would move each person from not knowing how to make anything to helping him or her become a confident maker. And then I met the TechShop members. This was the most amazing group of artists, scientists, entrepreneurs, students, crafters, investors, and engineers I had ever encountered in one location. Some of them were already on a path to change the world. I was instantly hooked—and you will be too. You will meet many of these people in the following pages.

These have been six of the most amazing years of my life. I've met the most interesting, innovative, optimistic, energetic, and engaging men, women, and kids one can imagine. Many of my heroes have become friends, and many of my new friends have become heroes of the movement.

When I first started this journey, I believed that if this Maker Movement could scale up, it could actually impact the world in a positive manner. Six years later, I don't just believe this anymore . . . I know it. I have proof. Our members have changed the world in significant ways. Important companies have launched out of our space and the movement at large.

You will have to read the book to learn more, but what I know now is that we are at just the beginning of the largest explosion of creativity and innovation the world has ever seen. I know that these platforms revolutionize innovation in a way the world has never before seen. I know that the Maker way, thought, and movement will become a defining characteristic of at least the first half of this century, if not most of it. I know this because I see it play out every day in my role as the CEO of TechShop. I get to see people pursue their dreams of changing the world . . . and then watch them and others do it again and

again and again. I get to interact with our staff members, who tell me they have a hard time believing all the amazing things our members are doing and making. They tell me that being a part of this makerspace is the most interesting, fun, and meaningful work they have ever had.

I get to host dignitaries, futurists, consultants, and exploratory committees that come to the Silicon Valley to see the next big thing and try to understand how they might be able to take some of the great ideas home.

Please forgive me for talking about TechShop throughout the book. I use the generic "makerspace" wherever I can, where it makes sense, and where it doesn't detract from the facts. But we have the leading makerspace in the market with six locations spread across the United States today. We have become one of the leading brands in this emerging market. The point of this book is not to shill for TechShop. Rather, it is to shine a light on what will become one of the most important movements of a generation, and then to invite *you* to participate in it.

I became a Green Beret years ago and adopted the motto, "De Oppresso Liber." This translates as "to liberate the oppressed." Little did I know at the time that the real opportunity for me to help "liberate the oppressed" would come through helping TechShop achieve its goal of democratizing access to the tools of the next industrial revolution. It has been an amazing ride so far and promises to become even more amazing as the movement grows in the United States and then around the world. This movement will not stop at the U.S. borders. It is too fundamental. It will eventually wash over the entire world.

I was thrilled recently when Chris Anderson, formerly of *Wired* magazine (the preeminent chronicler of all things web-related), told an audience filled with his peers that, "If you thought the web was big, I think this is going to be bigger."

I couldn't agree more.

The real power of this revolution is its democratizing effects. Now, almost anyone can innovate. Now, almost anyone can make. Now, with the tools available at a makerspace, anyone can change the world.

Every revolution needs an army. That is the real purpose of this book. To use revolutionary language, my objective with this book is to *radicalize* you and get you to become a soldier in this army. Not so that we can destroy some nation, political party, or social movement, but so that we can *collectively use our creativity to attack the world's greatest problems and meet people's most urgent needs*. So that we can reduce the size of the dead-zone at the end of the Mississippi River, like one team has begun to do; or so that we can reduce the size of the carbon footprint of all the computer servers running the Internet, as another team did; or so that we can create the world's least expensive drip irrigation system and help with the global water crisis; or open up the merchant banking systems or literally save tens of thousands of babies' lives, like other teams have done. We need you to add your creativity, enthusiasm, experience, knowledge, and skill to the mix. We need millions of people to join this movement.

So please read on. You can't help but be inspired by the stories you will read. If you do take on the challenge of making, it will change you in exciting and surprising ways—and you might just change the world.

1

Maker Movement Manifesto

In the spirit of making, I strongly suggest you take this manifesto, make changes to it, and make it your own. That is the point of making.

MAKE

Making is fundamental to what it means to be human. We must make, create, and express ourselves to feel whole. There is something unique about making physical things. Things we make are like little pieces of us and seem to embody portions of our soul.

Make. Just make. This is the key. The world is a better place as a participatory sport. Being creative, the act of creating and

making, is actually fundamental to what it means to be human. Secular philosophers like Georg Wilhelm Friedrich Hegel, Carl Jung, and Abraham Maslow all came to the conclusion that creative acts are fundamental. Physical making is more personally fulfilling than virtual making. I think this has to do with its tangibility; you can touch it and sometimes smell and taste it. A great sentence or well-written blog is creative and makes you feel good about what you have accomplished, but it is not the same as the satisfaction that comes from the physical labor involved in making something physical.

If you come from a Judeo-Christian religious background, whether Jewish, Protestant, or Catholic, then you know that the first book of the Torah or Old Testament is the book of Genesis. Read Genesis Chapter 1 closely. Whether you believe in the literal interpretation of Creation or not, we can probably agree on two things coming out of this chapter. God is a maker, and he made us in his image. It is a very powerful introduction to God and who we are as humans. What do you know about humanity by the end of the chapter? It says, "God made" (or "let," or "created") some 15 times and ends with making people in his image. At the end of Genesis 1, we may not know much about God or humans, but we do know one thing for sure: we were made to make.

There is nothing that can replace making—philosophers, religious scholars, and personal experience make that clear. Wars have been fought when the common people thought they were going to lose access to ownership of their own productive tools. So the first thing we must do is make. The do-it-yourself (DIY) home improvement industry in the United States is worth over $700 billion. The hobbyist segment is worth over $25 billion. The most valuable segment of the $700 billion DIY is the perpetual remodeler, specifically those who have enough money to let business professionals do the work for them, but

don't. You might know or even be one of these people. In your heart of hearts, you know you don't really *need* to redo the bathroom, or certainly not the way you plan to do it, yourself. But you do it anyway. This is because there is more satisfaction in completing the remodel yourself.

A makerspace is a center or workspace where like-minded people get together to make things. Some makerspace members are designers, writers, practitioners of medicine or law, architects, and other white-collar types who come in and start making things for themselves, their families, and friends. They spend time in makerspaces because they just love to make things. They don't *need* to make Christmas presents; they *want* to.

Tina Albin-Lax had made a New Year's resolution for 2012. She was going to learn how to make something. She signed up for TechShop's basic laser cutter class and has never been the same since. For $60, she learned how to use a laser cutter. Then she booked it for the next day so she could practice what she had just learned, but she needed a project to practice on. As luck would have it, that evening Tina's sibling called and invited her to attend her nephew's birthday party that weekend. With a flash of brilliance, Tina asked for the names of all the children who would be at the party.

The next day Tina used her new training to make cupcake toppers for each of the party attendees. Using the laser cutter, Tina cut out the name of each child and etched in some nice patterns. She finished them with a nice glossy coat and that weekend put one on each child's cupcake. What child doesn't love to see his or her name emblazoned on something? Particularly something chocolaty and sweet? Not surprisingly, the parents wanted cupcake toppers for the rest of their children and then wanted them for their children's parties. It snowballed.

Soon Tina had an online store (www.etsy.com). Then she began teaching classes on how to launch a business and had a great mention in Martha Stewart's magazine, *Martha Stewart Living*. Her phone couldn't make it through the day from all the order notifications she was getting. Last I heard, she was working on a book.

This all came about from a simple desire to make something for the first time since sixth grade. An accidental entrepreneur was born. And what was Tina's background? She was a labor organizer.

I grew up playing neighborhood football with a kid named Ben Parks. His dad was a ceramic artist and had throwing wheels, clay, and amazing glazes around his house. One day his dad invited us all to come out and throw a pot. What a great afternoon. I attempted to make a large vase—and after what seemed like dozens of attempts and lots of help and encouragement—I ended up with a sad-looking, lopsided, very small coin holder. It will hold a couple of dollars' worth of quarters. I glazed it beautifully with help from Ben's dad. A couple of days later, after it had been fired, I got to take it home.

This thing is an ugly duckling that will never grow up, but guess what . . . I still have it. It's small enough that I've taken it everywhere I have moved. Its only value is that I made it and it is some kind of memento from my childhood. Looking back, I realize now that I was not the target of that day of making, though I still appreciate the gift it was. Ben eventually became a ceramic artist himself, following in his father's footsteps. There is something fundamental about making.

SHARE

Sharing what you have made and what you know about making with others is the method by

which a maker's feeling of wholeness
is achieved. You cannot make and not share.

We make to share. Each of us is wired to show off what we have made. We get a lot of satisfaction out of the making, but the real payoff is in sharing. Some people are coy about showing their work off. Others are just terrified. One of the reasons we may have stopped making is that what we set out to make and what we ended up with may not match very well. Or others may have ridiculed us for our attempts. "I'm not good at making anything," need never be said again. We were born to make. It may take some practice to get good at some kinds of making, but technology has begun to make creating easy enough that everyone can make.

My favorite question to ask at any makerspace is, "What are you making?"

People open up like flowers when asked that question and given any kind of positive encouragement. In this regard, we are all still five years old.

Interestingly, after six years of working in a creative space, I've been told, "I can't tell you everything, but . . ." probably hundreds of times, maybe thousands of times, but I've never been told, "I can't tell you."

Why? We want others to see what we have done.

When I worked at Avery Dennison, we used to let the newest junior product managers help work on the back panels of our product's packaging. They had to work off templates that had been approved and developed for the line, and they had to have all the appropriate approvals; nonetheless, the back panel was "theirs." The young managers would jump into this with gusto, argue over font choices, the kerning of apostrophes, the shade of loam green. I repeat, they cared about the kerning of an apostrophe—the space between a letter and

an apostrophe. Look at the space they had to work with here: *' s*. Can you see it? On a high-resolution computer screen, this is about the distance of two or three pixels, and they removed one! Yet, they would protect their design turf like a pit bull protects its bowl of food, growling when someone tried to mess with their back panel.

Let me put this into context. To be a junior product manager at any Fortune 500 packaged goods company, you have to graduate from a respected MBA program at the top of your class. You have to work between your bachelor's degree and your MBA at another major company with consumer facing interactions. You are among some of the "best and brightest" our schools and companies produce. You will almost always make senior director, VP, SVP, or CEO if you choose, or you will go out and start your own company. If you are a junior product manager at this level, you are a very intelligent, type A, hard-charging, competitive professional.

That said, once the aforementioned products were launched into the channel and we all went to an Office Depot or Staples to see what the final product packaging and shelf positioning looked like in the stores, the junior product managers would rush like little kids to the stacks of "their" products. They would stand in front of them, momentarily admiring the way the products looked on the shelf and then pull a package off the shelf, turn it over, and examine their handiwork. A sense of satisfaction visibly rolled over them as they saw that the typesetters had taken their ideas into final production and the *s* was just a little closer to the apostrophe because it had been manually kerned. Invariably, these talented, impressive, type A young professionals would turn and say something like, "I did this."

"I did *this*."

"See the space between the apostrophe and that *s*? I did that."

The glow on their faces was like a new mother's when holding her child for the first time. Complete satisfaction. The need to show others one's new, beautiful child is embedded in the human psyche.

What is going on here? First, while the contributions that these professionals were excited about might seem insignificant—after all, the difference, distance-wise, between the spacing of an apostrophe that has been automatically kerned and one that has been manually kerned is negligible—but the end product is something that can be bought, taken home, and shown to a significant other. Second, it is public. Hundreds of thousands of these packages are shipped all over the world. Third, it is often the first tangible and public representation of years, if not a decade, of work. It isn't the size of the impact that is significant; it is that there was impact and it was made tangible, and tens of thousands of people would "see" their work. That really is powerfully satisfying, even if it is only the amount of nothing between an apostrophe and an *s*.

If you make something and don't share it, was it made? If you make something, even something as small as a one-pixel space modification on the back of a package, and share it, you have made something, and it must be shared.

Another aspect of sharing is sharing knowledge and know-how. The best attribute of a well-run makerspace is the sharing of skills and knowledge. It starts with the formal instruction, but the best learning takes place while one person is building or designing and someone else with just a little (or sometimes a ton) more experience lends a helping hand and the project gets upgraded in the process. The sharing philosophy gives a makerspace its magic. People show off their creations knowing

criticism was left at the front door, and everyone feels comfortable asking for help, guidance, and input into projects as they go through the build process. Sharing makes a makerspace a community.

GIVE

There are few things more selfless and satisfying than giving away something you have made. The act of making puts a small piece of you into the object. Giving it to someone else is like giving that person a small piece of yourself. Such things are often the most cherished items we possess.

One of the most satisfying aspects of making is giving away what you have made. Wonderfully, most people still value gifts made by the giver more than gifts that were bought off the shelf. If you do nothing else this year, make one Christmas present to give away. And reflect on the level of satisfaction you get and the recipient receives in that act. It is immeasurable.

If your parents are still alive, they probably are still hanging onto craft projects you made for them when you were a child. Quilts are often handed down for generations. A well-made item, meeting a real need, made by and for a loved one, is among the greatest of gifts.

There is another type of giving, that of your creativity or intellectual property. Embrace Global is a wonderful nonprofit that used TechShop for some of its development work. Naganand Murty was one of the design engineers who came to our space, under Embrace cofounder and CEO Jane Chen's direction, to address the problem of infant thermoregulation in developing countries. Babies who are born even a few weeks prematurely are unable to thermo-regulate, or maintain their

body temperatures on their own, and consequently must be incubated within one hour of birth or risk death or serious permanent disabilities. For the hundreds of thousands of these babies who are born around the world every year without quick access to incubators (because they are born in rural areas where the nearest hospital with incubator equipment may be several hours, if not days, away), the problem is especially critical.

The question that Naganand Murty and his team had (you'll meet cofounder Jane Chen in Chapter 3) was fairly simple: Would it be possible to design a simple, affordable "blanket" that could maintain a baby's body temperature at a constant level for an extended period of time? And that was not dependent upon a continuous supply of electricity? Well, it turned out the answer was yes. The Embrace portable infant warmer, which looks like a mini sleeping bag and costs a fraction of the price of other baby warming devices, uses some fancy chemistry and design to make it work.

But here is the most amazing thing. Portions of Embrace's core technology were donated to the organization through interactions with other members of the TechShop community. These community members gave their ideas away freely. And as a result, General Electric has signed on to help distribute the blanket, and Embrace is on track to save the lives of 100,000 babies in the next five years. Jane has been recognized by the World Economic Council as one of the top social entrepreneurs in the world.

LEARN

You must learn to make. You must always seek to learn more about your making. You may become a journeyman or master artisan, but you will still learn, want to learn,

and push yourself to learn new techniques, materials, and processes. Building a lifelong learning path ensures a rich and rewarding making life and, importantly, enables one to share.

Making brings about a natural interest in learning. It brings out the natural four-year-old in all of us. "Why is the sky blue?" "Where does milk come from?" "How are babies made?" This natural inquisitiveness seems to be beaten out of most people in school or at home. I'll let the educators in this community help figure out why "project"-based learning seems to fit some learning styles better than others, but it certainly feels more natural. I always found the order we did things in physics class backward. Instead of being taught the formula for determining the ratio of the required output force to the input force and then trekking to the lab to see how a lever works, it makes more sense to first observe the lever in action and then learn the formula for it. This is how the principle was figured out in the first place, through observation. You observe an effect, then build a theory to fit the observation. It may be faster to memorize facts than to experience them, but then I would argue you don't really own that fact. "Hot" is a pretty abstract concept until you've burned yourself.

The world is such a fascinating place. How do you design and build a table? What kind of joints can be used to join the legs to the table? Which are the best ones for what I'm trying? What periods in history used different technics? What glues should I use, and when do I use a screw or a nail, or a brad, or a staple, or a rivet? What woods have which characteristics? What style do I want? What tools should I use? The options go on and on. They don't have to; you can jump in and just do it. Or you can plan and plan and plan. The key takeaway, though,

is that you are going to learn something. And no one can take it from you.

Learning is fundamental to making. The more time you spend familiarizing yourself with and practicing in a field, the better you will get in it. Very quickly, you will be able to share what you have learned with someone else who is newer to it than you are. There is a different kind of satisfaction that comes from teaching, but it is very real. Watching people you have been teaching become facile and expert in what you have taught them is extremely satisfying.

Learning is fundamental; it is why we have books, libraries, schools, the food channel, the DIY channel, and shows like *How It's Made*. These days, the DIY magazine rack at a local newsstand often constitutes 15 to 20 percent of the total space.

From an educational perspective, we live in a sad time for making. When I was growing up, woodshop and metal shop were required courses for middle schoolers. Every middle school I was aware of had a woodshop instructor. I still have the things I made in middle school woodshop, and many of you do too. Today, it can be hard to find a shop in an entire school district. This makes no sense at all. In our "race to the top," school systems tend to focus only on the students who are headed to college, ignoring the 50 percent of those who aren't, depriving all students of skills that they could use the rest of their lives.

Just as badly, right as we are on the cusp of the largest explosion of new products and development of physical goods through breakthroughs in materials science, 3D printing, bioengineering, nanotechnology, design, and engineering, American institutions are failing to graduate enough engineers, scientists, and production workers. Economically, this is insane. It is time to reengineer our schools and reintroduce

shop class. Oh, and by the way, through cheap and powerful design computers and 3D printers, we can make these courses exciting, engaging, and transformative.

With access to the right kind of tools, you can experience your own industrial revolution in a matter of weeks. It's possible. It really happens.

Let me give you an example. A couple of years ago, some of our TechShop staff members encouraged me to meet one of our newer members. He was the first I'd met who was taking an extended "maker vacation." This member had saved up his money for a couple of years working odd jobs as a security guard and janitor, and once he had accrued enough money, he quit his job and took the first vacation he had taken in years.

This man was committed. He had the bug. He wanted to learn how to make things. He was good with the hand tools, but he had never taken welding, machine shop, woodworking, textiles, 3D printing, computer-aided design, or any number of other classes.

To stretch his funds, he didn't stay at a hotel or rent an apartment. Instead, he used couchsurfing.org to find free places to stay every night. A few times, he couldn't find a couch, so he just slept in his car. Couch surfing turned out to be a great tool for him to help us find new members. He was so focused and excited that he would go "home" at night and tell his new couch surfing host all about what he was doing at the shop. We picked up half a dozen or so new members that month. We actually kicked around the idea of turning him into a sales representative by having him couch surf through the Bay Area for a couple of months.

But even better, he became a maker that month. He took every class he could schedule and went from hand tools to power tools to computer-controlled advanced manufacturing

tools. He could weld, lay out carbon fiber, CNC mill, lathe a bowl, and spin a lighting fixture. He even picked up a little electronics in that 30 days. His desire to learn was so powerful that he quit his job, stayed at strangers' houses, and created other new makers in his enthusiasm. What is holding you back?

TOOL UP

You must have access to the right tools for the project at hand. Invest in and develop local access to the tools you need to do the making you want to do. The tools of making have never been cheaper, easier to use, or more powerful.

I had to use a phrasal verb as a heading to this section so it would be consistent with all the other one-word headings in the manifesto. I like manifestos heavy with verbs.

You and I are living through the most amazing age in all of human history. Whenever someone asks me which time period I would like to be living in, I always say "right now." Tools are getting easier to use, they are more powerful, and they are cheaper to acquire than at any other time in history. Materials are becoming more accessible, more sophisticated, and more fun to work on and with.

Odds are, you cannot possibly afford all the tools you may want or need. So join a makerspace. What I have learned is that a community of makers does not fully emerge until a complete makerspace is provided. The advantage of a well-equipped makerspace is that it attracts people with a widely diverse selection of projects, creating a beehive of activity, passion, knowledge, and sharing. When a large and diverse set of tools is provided, a large and diverse group of makers comes out to live, work, and play. The following is a general list of