

Makers

What is a “maker”? Quite simply, makers make things. Some makers build robots, some sew clothes, some prepare food, some design tools, some construct houses. “Maker” isn’t a title conveyed after passing some test or degree program; rather, it is a self-identification. It’s also not, by any stretch of the imagination, a new concept.

Humans have always been makers. Our survival is directly tied to our ability to create, or find, food and shelter, though we as a species shouldn’t allow ourselves to feel too special because of this. From birds weaving elaborate nests, to beavers building dams, and spiders creating traps for their food, we are just like every other species in our biological need to make. What does set us apart, perhaps, is that we’ve reached a point where many people grow up without the ability to personally create any of the things (food, clothing, shelter) that they need for survival. Similar to its poll of teenagers mentioned earlier, Nuts, Bolts & Thingamajigs surveyed 1,000 U.S. adults in 2009, and found that 58% have never made or built a toy, and 60% admit to avoiding handling major household repairs.¹

In the United States, the pride in creating things is such that President Barack Obama specifically mentioned makers in his 2009 [inaugural address](#):

Our journey has never been one of short-cuts or settling for less. It has not been the path for the faint-hearted, for those that prefer leisure over work, or seek only the pleasures of riches and fame. Rather, it has been the risk-takers, the doers, the makers of things—some celebrated, but more often men and women obscure in their labor—who have carried us up the long rugged path towards prosperity and freedom.

I was delighted to hear this characterization of makers. Rather than focus on “eureka!” moments and successes, the president honors the hard work, lack of

¹. The Foundation of the Fabricators & Manufacturers Association, International. “Americans Don’t Tinker Around with Hobbies, Home Repairs, Poll Shows,” November 16, 2009.

renown, and risk that is a more realistic portrayal of the road many makers follow. Yet for pride strong enough to make this something mentioned in a historic inaugural address, it seems worthwhile to reflect upon the apparent lack of knowledge among American citizens with regards to how things are made and why children should be taught to make things.

If humans have always been makers, why are makers and the Maker Movement garnering so much attention at this point in time? The story starts with a magazine. In 2005, O'Reilly Media launched a magazine titled *Make*: “*The urge to make things is primal and unstoppable. In service of that universal urge, humans grab the tools and materials at hand—while a previous generation picked up a saw and bullnose rabbet plane, today's makers are likely to reach for a soldering iron and Cat 5 cable. Make: a new magazine from O'Reilly Media, celebrates and inspires those who are driven to make cool and unusual things with technology, for the pure fun of it.*” From its start, *Make*: focused on showing the people behind projects, and the fun that could be had by jumping in and getting your hands dirty. The process of creating, not just the final outcomes, was as much of a focus as the technology.

The launch of *Make*: magazine happened while I was a doctoral student studying mechanical engineering and coming to the realization that my favorite things to do were teaching and designing/creating/tinkering. The week the magazine launched, I was at a conference also attended by Tim O'Reilly. He had left a few copies of the inaugural issue of *Make*: lying around and extended a generous offer for attendees to register for a subscription. The same day, I received a phone call from a department chair at the art school I taught at asking if I'd be interested in adding a robotics class to my teaching load. As I flew home from the conference, thinking of projects that would be fitting for a class of artists and designers, I was also flipping through the pages of *Make*: magazine.

When Issue 02 of *Make*: arrived, I was delighted to find instructions for Mousey the Junkbot.² I would go on to teach this project to many semesters' worth of Art Center College of Design students, and an intrepid group of 7- to 13-year-olds who took my robotics class at the Armory Center for the Arts. Here were projects that anybody with interest and access to some basic materials and tools could do. Watching my students building their Junkbots, personalizing them with everything from paint to custom shells, and then proudly showing them off to anybody who would look, I started to realize the power of what would very soon come to be referred to as “Making.”

^{2.} Gareth Branwyn, “Mousey the Junkbot,” *Make*: Vol. 02, May 2005

As I was finding in the classes and workshops that I was teaching, the final form of the artifacts, be they robots or clothing, wasn't where the power was coming from. Rather, it was through the community that was forming as people got together to make things, help each other, and then show off what they had made. For many makers, these endeavors were a hobby, not their main occupation. They'd spend their nights and weekends tinkering with technology, new and old, and taking to Internet forums and other outlets to get advice and show off what they were making. Typically, these forums were fairly specific and geared at certain skills or technologies. With the growth of *Make:* magazine and its related website, there was now a place where one article might be a profile of a "Live Steam enthusiast" who builds backyard steam locomotives, followed a few pages later by a description of an art installation involving "*500 stalks of chest-high, semi-flexible, fiber-optic strands arranged in a grid.*"³ By having an umbrella as wide as "people who make things," the magazine created opportunities to learn about a wide range of people and skills.

As readership of *Make:* grew, the concept of bringing the magazine to life, and providing an in-person way for makers to meet and share, arose. Founder **Dale Dougherty** recalls, "*Maker Faire started from the ideas in the magazine. We were covering lots of interesting people and I thought it would be interesting to bring them all together in one place. They did such different things, but they had a lot in common.*" In its first iteration, Maker Faire brought more than 300 makers and 22,000 attendees to the San Mateo, CA, fairgrounds for two days highlighting the sort of ingenuity and projects that were enticing people to read *Make:*. Attendees could wander the grounds and meet makers working on a dazzling array of projects. While this initial attendance was impressive, what has happened since shows how excited the world is about a return to the celebration of "the makers of things." In 2013, the Bay Area Maker Faire had more than 120,000 people together, and 100 Maker Faires were held worldwide.

Even more exciting than the attendance numbers for Maker Faires is the composition of the attendees. More and more, families and children are making up a large part of the audience. So much so that **the New York Times even asked "Is Maker Faire Made for Kids?"** after writer Amy O'Leary attended World Maker Faire in Queens, NY, and found that children played an integral role at the faire, both as attendees and as presenters. While the article went on to mention that some attendees thought this was a sign that it was a "less-edgy event," I see this as a sign that adults are realizing that this is something that they want their children to be

³. Arwen O'Reilly, "White Light/White Heat," *Make:* Vol. 01, January 2005

part of. So much so that in the comments to O’Leary’s post, attendees shared stories and videos about the positive experiences they had bringing their children to the faire.

As a parent, I brought my four-year-old daughter to a Maker Faire in 2012. (Her little sister got to attend her first Maker Faire at 10 weeks old, but I’m not sure it made much of an impression on her. My husband and I, on the other hand, learned that infants don’t seem to like the sound of jet-engine-powered carousels.) While I was excited for her to take in the amazing projects, it was the makers themselves that I most wanted her to see. I wonder whether, years from now, she’ll remember meeting the 11-year-old who creates her own maker how-to videos, or the man who painstakingly re-created landmarks out of toothpicks, and I hope that one day she is equally passionate about her own work and takes the time to share it with some other inquisitive little girl or boy.

Makers and This Book

The makers in this book were all born well before the launch of *Make:* magazine and long before “maker” was a word that regularly popped up in the press. None of them attended a Maker Faire as a toddler, or paged through *Make:* magazine as a high schooler. So how did they get started? What were they like as kids? That’s what I wanted to know, and so I set out asking makers to tell me what they were like as kids. Over the past few years, I’ve visited and spoken with what at times felt like every maker willing to talk to me. I was amazed by the generosity makers showed as they gave up time from their busy schedules to reminisce about their families, their schools, their mentors, their early experiments, and what it was that made them excited as a kid. I heard stories of basement shops, but also of playing baseball. Some talked about their love of school, some had the opposite take. Many of the makers I interviewed are also parents. I learned from them about how they, as people who value hands-on work, parent their own children, and some of their doubts and concerns and challenges in that regard.

As I reflected on the discussions I had with these makers, there were some attributes that kept appearing in multiple people. While this isn’t an exhaustive list, and while not every item on the list will apply to every maker, I do believe that the following attributes are ones that those of us who are interested in encouraging children in making should be thinking about (as you read the following chapters, I encourage you to draw your own conclusions as well, and make your own list of lessons you can draw from these stories):

- *Makers are curious. They are explorers. They pursue projects that they personally find interesting.*
- *Makers are playful. They often work on projects that show a sense of whimsy.*
- *Makers are willing to take on risk. They aren't afraid to try things that haven't been done before.*
- *Makers take on responsibility. They enjoy taking on projects that can help others.*
- *Makers are persistent. They don't give up easily.*
- *Makers are resourceful. They look for materials and inspiration in unlikely places.*
- *Makers share—their knowledge, their tools, and their support.*
- *Makers are optimistic. They believe that they can make a difference in the world.*

To close this chapter, I'd like to introduce you to a maker whose story, both past and present, captures many of these attributes. In the fall of 2013, Jane Werner ([Figure 1-1](#)) was flying to Birmingham to give a talk to the board of the Institute of Museum and Library Services about making in museums. As executive director of the Children's Museum of Pittsburgh and a founding board member of the Maker Education Initiative, Jane has spent a lot of time thinking about children and making, which makes her a perfect person to talk to this audience. On the flight to Alabama, thinking over what she was going to say at the meeting, she found herself thinking about the clothing she had packed for the trip. It is fairly likely that Jane was the only person attending the meeting in a dress she had sewn herself. To her, this dress represented the role that making, and the empowerment that comes with it, played in her childhood. “*When I really think back on it, sewing gave me confidence and when you have confidence you feel you can learn, you can change things. I believe [sewing] was one of the reasons I became a museum director. It's the psychology of making. It's not just learning STEM, and not just learning the arts. It's learning about yourself.*” Through sewing, “*this notion that I could change things in my world was driven home.*”

As a child growing up in the small town of Hellertown, Pennsylvania, Jane and her older brother spent a lot of time outdoors making things: forts (“*We were the fort king and queen*”) and little boats to float in their creek. Indoors, Jane was also an avid maker. Her mother sewed and encouraged a young Jane to make clothing. She became fascinated with fashion, and would peruse magazines at the library and then share the images with her mother who would say “*We can make that.*” In

this way, Jane began wearing clothes that were very much in fashion in big cities and magazines, but a bit less so in Hellertown. Her mother would help her find affordable fabrics at discount stores and in this way Jane became the first, and only, student in her high school to wear a midi skirt. *"They were big everywhere except for my town in Pennsylvania. I walked in and everyone looked at me like 'what are you doing?"* Even earlier, in middle school, Jane was hired by a friend's parents to make a dress for the girl's school concert.



Figure 1-1. A young Jane Werner, with her brother, wearing clothes made by their mother (photo courtesy of Jane Werner)

Jane has never stopped sewing. She started college as a fashion design major, but graduated with a synaesthetic art and education degree. After graduation, she moved to Pittsburgh, where she lived with her aunt who also sewed clothing. Her aunt, though, used really great fabrics and taught Jane that, in Jane's words, *"you really needed to invest some money and use Vogue patterns and look at things in a different way."* After her aunt moved away from Pittsburgh, at a time when Jane herself couldn't afford the nicer patterns and fabric, Aunt Judith would send patterns and fabric that she thought Jane would look great in.

Jane went on to work at science museums and launched her own exhibit design company. She later returned to Pittsburgh to become director of exhibits and programs at the Children's Museum of Pittsburgh. In 1999, she took over the executive

directorship of the museum, which became known for its hands-on, exploratory exhibits with an emphasis on “real stuff.”

In 2011, Jane attended her first Maker Faire at the urging of her friend, artist Ned Kahn. She remembers being amazed: *“I was blown away... This is everything that I’ve always loved. People doing whimsical, important, and playful things. Really interesting things.”* She returned to Pittsburgh and decided to turn part of the museum into a makerspace.

The Children’s Museum of Pittsburgh was, and is, created by the staff identifying things that were important in their own childhoods. MAKESHOP, the museum’s makerspace, reflects this. Staff members reflected on things like sewing and messing around in the basement with hammer and nails. There wasn’t a big budget for this project. Jane had \$5,000 that she could allocate to the makerspace creation, which is an almost impossibly low sum for most museum exhibit design projects. The Education Technology Center at Carnegie Mellon offered to send three interns to Jane for the summer. Over the course of one summer, four people (the interns plus a museum staff member) turned the empty space into a room with saws, nails, and electronic circuits, and *“just started to mess around.”* The space ended up so successful that it became a permanent exhibit. Jane and the other staff members realized that the MAKESHOP was a place where you could see interactions between generations, generating conversations and giving families an experience that they could build on at home. Families would return multiple times to the exhibit to work on multiday projects, and kids would spend hours at a time working on their creations. The day I was there, I watched a father and daughter working together on a colorful tank top using donated fabric scraps and a donated sewing machine.

While professionally Jane now spends more time creating situations in which her staff can be creative than in actually making things herself, she still sews. Laughingly, she tells me that when she’s *“having a day when I’m at loose ends about [things]”* it becomes a *“fabric day.”* She goes to her local fabric store and talks to Tammy, the owner, about fabric. *“I love the feel of fabric. I love that it drapes, and it’s really fun to take something two dimensional and make it three dimensional.”* While Jane no longer has to make her own clothes, she sees it as her creative outlet, as *“something that [she] can experiment with.”* So much so, that she can often be found wearing items that she made herself.

Jane tells me about a recent phone call she received. It was a father calling with a question. He had taken his eight-year-old daughter to the Children’s Museum of Pittsburgh and they’d had such a great time sewing together that when he went

home he went upstairs to their attic and took down the sewing machine that had belonged to his mother, who had died a few years earlier. Unfortunately, he realized that he and his daughter couldn't figure out how to thread the machine. He was calling to find out whether anyone could help. I suspect that he was a bit surprised when the executive director of the museum offered to teach them herself. Thus, this father and daughter returned to the museum where Jane taught them about thread tension and how to wind a bobbin. *"They were ecstatic,"* she recalls. The daughter immediately started thinking of the costume she wanted to create.

I love this story. An eight-year-old girl setting off to sew a Halloween costume of her own design, helped by her dad, using her grandmother's old sewing machine. She finds a mentor in a busy stranger, who was willing to share her time and knowledge (that she herself had put to use as a child to create clothes for herself and others). To me, that is the power of the Maker Movement.

Before leaving Jane to her busy day at the museum, I asked her what makers can learn from kids. I believe we adult makers can also learn a lot from watching children, as does Jane.

"The young kids don't care about failure. When they're 3 or 4, they just keep iterating and iterating. They just keep going. When we get them into schools, they start worrying about failing... you can watch kids... learn things quickly when they're making. You can see them making the connections. The joy in that... I think we sometimes forget about that joy in making things. It's so evident in kids."

My hope for all of us is that we begin to embrace this joy, and do our best to prevent our children from forgetting it!

Curiosity

Makers are curious.

They are explorers. They pursue projects that they personally find interesting.

When I was a child, I had an annoying habit of asking “why?” incessantly. It got so bad that once, at the end of a week-long camp, while the other kids were given titles like “best athlete” and “fastest swimmer” I was bestowed the name “Little Miss Why.” In retrospect, I don’t think it was meant as a compliment. As a parent, I’ll admit that I’ve occasionally gotten exasperated when my daughters ask me that same question countless times in a row. I’ve even resorted to the unsatisfactory answer “Because!”

Based on what I’ve learned of other makers’ childhoods, I definitely wasn’t alone in my inquiry-based approach to life. Perhaps more than any other unifying trait in this book, curiosity seems to come up when makers discuss their childhoods. Makers are curious. Their youthful curiosity took on many different forms, but the common interest in gaining knowledge, skills, and stories seems universal. They wanted, and still want, to know *why, how, when, and what if?*

We send mixed signals to children about curiosity. After all, it’s what killed the cat, so it can’t be a good thing, right? I believe this couldn’t be further from the truth. Curiosity, and self-driven pursuits, are behind all great innovations. Recently, I took a friend to her first Maker Faire. We walked around looking at projects and exhibits. She was impressed by what she saw, but wanted to know the motivation behind it. Why do makers make? Why would someone spend years building a city out of toothpicks? The projects that you find posted on Instructables, or in *Make:* magazine, aren’t typically part of someone’s job or a homework assignment. Rather, there is some internal motivation at work. Where does this come from? As someone who has seen amazing things come from these “just for fun” and “just because I’m curious” projects, my follow-up question is, “How do we nurture this in all children?”

Intrinsic Motivation

The makers in this book, now adults, still exhibit a childlike passion for learning. They find joy in doing new things and exploring new topics, skills, and places. Each of these are individuals who, even as grown-ups, see the world as full of wonder and possibility. They are driven by wanting to know, wanting to do. Few of them need to be incentivized to look outside of the proverbial box; it's something they're drawn to, regardless of what others around them are doing. Yet we, as a society, spend a lot of time focusing on external motivation for children.

Adults are very good at coming up with ideas for ways to motivate kids. Look at the proliferation of grades, badges, and awards. When it comes to teaching maker skills, I see this a lot: a competition to build the fastest car, or an assignment where your robot/windmill/circuit will be graded. I'm all for the existence of competitions and assignments that let students build and design, but I'm also interested in what inspires people to spend countless hours in the library, lab, garage, or computer room working on a project that no one has assigned to them. A project that, truth be told, may never work. A project with no due date, entry rules, or complete how-to instructions. Where does that passion come from and how do we encourage it?

As much as we might tell children to think outside of the box on a homework assignment, it takes a brave parent or mentor to let children go off script completely, to allow them to do something simply because they're curious. Doing so risks the possibility that the assignment won't be done on time or will be done in a way that might earn an unsatisfactory grade. Assignments are often created so that they can be completed in a certain amount of time and use a certain skill set. The world of open-ended, passion-driven projects is a bit harder to pin to a calendar or required parts list.

If we want to nurture intrinsic motivation, we need to demonstrate it. How often does a child meet a role model who is working on a project that he is truly passionate about? Who guides him on a project that he is doing because the process itself is enjoyable, maybe even more so than the finished product? My hope for my children is that they develop a spark that calls them to find their own interests, and to unselfconsciously throw themselves into projects that are meaningful to *them*. But, like any spark, these curiosities and passions are initially likely to be fragile and will need protection and kindling to grow.

Walt Disney once stated that "*[at Disney] we don't look backwards for very long. We keep moving forward, opening up new doors and doing new things, because we're curious... and curiosity keeps leading us down new paths.*" More than anything, curiosity is the fuel that propels all makers forward. As an educator and as a parent,

one of my greatest fears for today's children is that we are taking away opportunities for kids to get lost in their own curiosity.

Curious Kids

What does it mean for a maker child to be curious? When I ask this in the context of making makers, it seems to assume this means encouraging kids to take things apart. I'm a strong believer in the importance of letting kids take things apart, if they wish, but curiosity is about so much more than taking a screwdriver to your mom's iPhone. In fact, the first thing Dean Kamen, a prolific inventor, said to me during his interview was "*I wish I could tell you the myths about how as a three-year-old I was taking apart engines and electronics and televisions. Nothing could be further from the truth.*" I also naively assumed that engineer Allison Leonard, whose "Machines Project" is an online repository of step-by-step photographed dissections of technology ranging from a Super 8 video camera to an Xbox controller, was a "take apart kid." It turns out that the Machines Project was motivated by the fact that she was *not* very interested in taking things apart as a child. "*The reason I did that project,*" she admits, "*is because I didn't do that as a kid. I think I always felt really late getting into engineering, into tech. I didn't get into it until my mid-twenties.*" What she did do as a child was run around on the three acres of land her family had. That's where her interests, and curiosity, lay.

Dr. Lindsay Diamond ([Figure 2-1](#)), director of education at SparkFun Electronics, immediately answered yes when I asked her about this aspect of growing up. I began to imagine toasters and VCRs strewn about, but she quickly explained that, growing up in Florida they had "*an unbelievably large population of lizards. They were already deceased. I would take sticks and try to see what was inside.*" Lindsay's take-apart subjects included "*all things biological,*" both plant based and animal. Flashing forward 20 some years, Lindsay is now a champion of open source education, particularly as it relates to electronics. Whether it's lizards or flashlights, Lindsay is among those educators promoting the importance of letting kids follow their curiosity.



Figure 2-1. Lindsay Diamond in her first laboratory, the family's backyard (photo courtesy of Marsha Levkoff)

School Days

Makers, young and old, want to learn. Thus, it seems like school would have been a pretty fantastic place for them. While some makers found school easy, very few makers spoke to me about loving school. Many told me about favorite teachers and classes, but others looked back less than fondly on their days in formal schooling. Through my work with the Maker Education Initiative, and through my research lab's focus on Playful Learning, I have been fortunate to meet incredible teachers. Teaching, particularly in the early childhood and elementary/secondary years, is one of the most important, and often, underappreciated, careers. Every week I meet teachers who invest every bit of time and energy they have into making learning come alive for their students. Unfortunately, more and more, I meet teachers who are becoming frustrated by the ways they are being forced to do their job. Not a single maker I spoke to mentioned joyful experiences taking tests or reading textbooks. They did talk about teachers who let them do projects, or librarians who found intriguing books for them, or stories and field trips that their educators brought to life for them. What breaks my heart is knowing that so many of those experiences are becoming rarer and rarer in today's education system.

An eye-opening discussion on this topic was one that I had with Steve Jevning ([Figure 2-2](#)), founder of Leonardo's Basement, a youth makerspace with locations in both Minneapolis and St. Paul. I long knew Steve as an informal educator, having served on the Leonardo's Basement advisory board. What I didn't know was that Steve's original plan was to be an elementary school teacher. Steve was born in 1954 in a small town in Minnesota. Rather than playing with toys, Steve spent his days finding materials, natural and manmade, to create with. As he put it, "*you had to build stuff to make the environment more fun to play in.*" His maternal grandfather, a minister, had a woodshop in his basement and from the age of four or five, Steve was welcome down there. (He still remembers, though, that the lathe was off limits.)

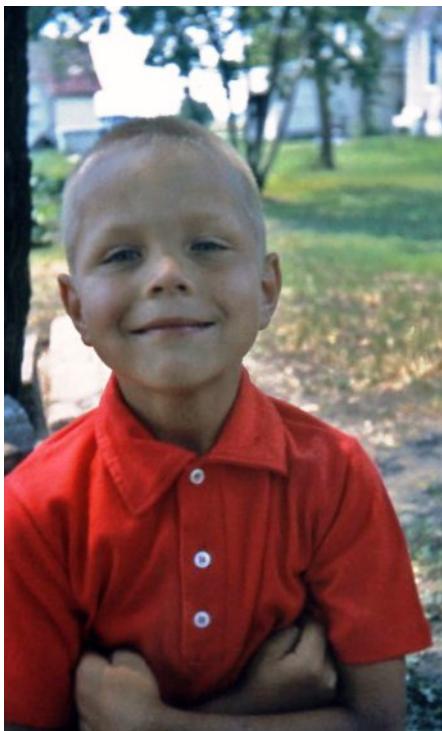


Figure 2-2. Steve Jevning as a child (photo courtesy of Steve Jevning)

Steve's other grandfather was a farmer, and Steve remembers his farm as being like "*a giant playpen with tools and machinery and haylofts and ropes to swing from.*" He would explore the neighborhood, borrowing equipment from construction

sites, and visiting the local blacksmith shop where he'd watch in awe as the workers would fix things using mechanical bellows that they had made themselves. In short, Steve was a kid who was thirsty for knowledge about how to make things. Through his fascination with building models, he taught himself things like scale and proportion. No one assigned this to him, or graded him on it.

One thing that bothered him then, and now, was the way that he and his friends were tracked based on grades, rather than interests. *"In that period of time you didn't really know what your friends' interests were because it was so predetermined by the adults. That's why Leonardo's Basement became a kid focused place because I so objected to those learning experiences where adults knew best and you were never asked what you wanted to do. I learned at an early age the value of motivation."* Steve found high school industrial arts classes intriguing, but was regularly questioned by others about "are you going to college or are you going to be just a shop guy?" Many of his friends, who had high grades in school, had to fight to be in shop class. They were pushed to stay away from those classes, and to take more "academic" classes instead. Steve considers it fortunate that he was a C student, because that meant he could go either way, taking more academic classes or taking industrial arts classes.

Steve had relatives who were teachers so he chose that field when he eventually went to college, after a few years of traveling around the country as a carpenter. As an education student in the '60s and '70s, there was lots of discussion about experiential learning, and Steve was hopeful that he could really make a difference in how things are taught. He spent most of his undergraduate time in student teaching and independent study classes, and gained a degree in elementary education. He reveled in writing curricula that he thought would be more engaging *"and not as lame"* as the textbooks they were using at the time. Exposed to science kits, he found himself thinking *"This is so dumb. There's nothing in this kit that you can't just get at the local grocery store or hardware store. Let's go to the grocery store, let's go to the hardware store, buy these things, and then use real stuff and do real experiments, rather than sit at little tables with plastic spoons."* Steve is quick to note that this was the era when you could still walk into a store in any city and buy a real chemistry set with real chemicals. That was his first *"inkling that real things had more educational value than pretend things. That making something yourself and finding an existing product made more sense than using someone's kit that was a representation of that."* Steve had become an education major thinking that he could change education, but became frustrated when he felt that the system fought against the sorts of methods he wanted to use. He valued exploration, and playing. *"I just knew that each kid was different and the goal of education should be to figure out how to help each individual find their own*

way." To him, individualized learning, and allowing kids to find their own interests, was critical. After two years of student teaching in a variety of school types, he decided he wasn't going to find a "place" for himself and left the world of formal education. He became a carpenter again and built houses.

When his son was born, Steve became a stay-at-home dad, who later would do construction work while his son was in school. At the end of the school day, his son and friends would go to the Jevning household to build things. Steve would eventually start a science club at the local elementary school. His belief was that "*instead of buying toys, you can open the cabinets [in] your kitchen and let [the kids] explore.*" Steve created a variety of opportunities for kids in his neighborhood from teaching school clubs and leading inventor's fairs. The growing interest in what he was doing led him to found Leonardo's Basement, a workshop where children, adults, and families can tinker and create with real tools and real materials. True to his educational philosophy, Leonardo's Basement is about relationships. Steve puts effort into making sure that Leonardo's Basement is a place where young and old learn and work together. "*Just because you are older doesn't mean that you can teach someone who is younger, or that you want to, or that you should.*" It may not be the way he originally planned it, but Steve was able to fulfill his vision of individualized, student-driven education, involving "*real stuff*" and "*real tools*."

The question more and more educators seem to be asking today is why they can't do more of that in their classrooms. It's a great question, and I believe that all of us should be supporting those teachers who are trying to bring this sort of learning back into the school day. We all need to ask whether we are giving today's children the skills and knowledge that they will need to accomplish those things that need to be accomplished in the decades ahead. Steve strongly feels that one of the keys to this is that "*Finding something that you give a hoot about is just a really big part of making it through the tough times, but also enjoying the good times.*" I agree with him, and hope that we're allowing all children to find just what it is that they give a hoot about! Steve proudly notes that 15 years after founding Leonardo's Basement, he is regularly being asked by schools to help them design resource rooms for designing and building projects.

Powerful Stories

For many of today's adult makers, books and reading played a critical role in helping them find the information they desired. Nearly every maker I spoke to could immediately list books and magazines that they read, sometimes more than three decades later. Some gathered up how-to books, while others read science fiction

novels. Some read classics, while others became enthralled by nonfiction. I did note, with some amusement, that not a single maker listed a book that had been assigned for school. Rather, the childhood books that they still recall fondly were the ones that they found, and chose, for themselves.

One of my favorite discussions about reading was with Dean Kamen. While many interviewees talked about school having been easy for them, that wasn't the case for Dean. He cared about learning, but didn't turn in the homework or do well on the tests. He found himself frustrated by textbooks and school because they spent too much time teaching things that were already known. He wanted to learn the things that weren't known. Reading was, and still is, something that Dean was slow at.

As he put it:

I'm a very, very slow reader, so reading long novels... I don't have the time. It's too much work for me. But once I realized that they called it Newton's law because of this guy Newton, he must have been a genius, he must have written a book. Oh! He did! Principia! Galileo wrote books too, Two New Sciences. Archimedes' principle: what did Archimedes write? So I figured, you come up with these great names, go and find out what they wrote. Instead of trying to learn what they did. A great genius spent his whole life writing Principia, and we're supposed to read one paragraph about it? I'm no genius, I'm no Isaac Newton, but somehow I'm supposed to learn and understand and appreciate his work, from one paragraph in an elementary school book that talks about Newton on one page, and the next page is how to put pins in frogs, and the next about what electricity is? No. I'll go get what that guy Newton wrote and if it's a whole book it'll take me a week or a month to read it, but when I'm done at least I think I'll understand it or I hope I'll understand it. I just decided I loved reading, very slowly, by myself, what these great people did and from it I developed an understanding of, and an appreciation for, the science, for the math, for the engineering that I think is just a beautiful piece of life that most people never get to see.

Sometimes those books loved in childhood offer hints to later projects. Chris Anderson ([Figure 2-3](#)), former Editor in Chief of *Wired* and founder of 3DRobotics (maker of aerial robots), regularly took books about aeronautics out of his school library. Growing up before the age of online shopping, Chris would also pore over mail order catalogs. Given his youthful lack of substantial spending money, most

of his catalog reading was aspirational. Occasionally he came across something in his price range. Often these potential purchases could be found in the back pages of magazines such as *Popular Mechanics*. Twelve-year-old Chris's big purchase was for what he thought was a submarine kit. Full of anticipation, he awaited his submarine kit, dreaming of adventures that could be undertaken when the vehicle was finished. In actuality, what he had ordered was a set of plans. Thus there was understandable disappointment when Chris opened the package to find a set of "*badly copied blueprints.*" Not only that, but the first step in the plans was to acquire a surplus U.S. Air Force P-51 external fuel tank. Not an easy task for a suburban high schooler. "*It was really kind of discouraging. Those were the days when dreams were shattered every time the packages arrived in the mail.*" Sadly, he was unable to find a spare fuel tank in his suburban neighborhood, and his hopes for having a personal submarine were dashed.



Figure 2-3. Chris Anderson machining with his grandfather, Fred Hauser (photo courtesy of Chris Anderson)

Chris went on to lament that he thinks he was born too early. He didn't get his first computer until he was 18, and still dreams of what he would have done had

he gotten one when he was 12. This raises an interesting point. Quite a few of the makers that I interviewed commented on how computers didn't play a large role in their early childhoods. Many wistfully discussed how great it would have been to have had one. I wonder if they would have grown up to be the makers that they are today had they had easy access to computers as a child. I pointed out to Anderson that had he had a computer, he might not have had his experiences with sitting in his room reading submarine construction plans. Sure enough, he remembered that "*The moment I saw a computer I pretty much gave up on anything mechanical on hardware entirely, and I just programmed for the next 20 years. And that's what happened, it's incredibly seductive and so maybe that kind of pre-computer period gave me an appreciation for the kind of mechanical side of the equation that's driven me to the makers world today.*"

Following Curiosity Wherever It May Lead

It was interesting to note that some of the makers that I assumed would have had highly computer-influenced childhoods often didn't. Nonetheless, *curiosity* continued to be an oft-mentioned thread in these stories. India, Noah, and Asa Hillis are the children of Danny Hillis (see Figures 2-4 and 2-5). Danny is a pioneer in the field of computer science, particularly parallel processing, and we'll look at his own youth in [Chapter 8](#). Given that Danny founded a computer technology company prior to the births of his children, I expected his children (all talented makers) to tell stories of a high-tech childhood. Instead, I was regaled with tales of rabbits, treehouses, hand tools, and low-tech mischief making. Also, lots and lots of exploring, of both places and of topics.

When I asked what drove them as children, all three Hillises explicitly mentioned "curiosity." Noah and Asa, twins now in their twenties, have fallen into the "take things apart" category for as long as they could remember. They recalled a time when they, as toddlers, managed to take apart their crib and, subsequently, their window's locks. Much to the horror of their mother and neighbors, this particular incident led to them ending up on the roof. Thankfully they were also fascinated by cameras and having their picture taken. When a frantic neighbor rang their house's doorbell and announced that the boys were on the roof, she was given a camera and was told to take the boys' picture. This caused the young explorers, who were also intrigued by photography, to freeze and pose while their mother ran upstairs and plucked them back into their bedroom.



Figure 2-4. India Hillis and an early woodworking project (photo courtesy of Danny Hillis)



Figure 2-5. Asa and Noah Hillis exploring (photo courtesy of Asa Hillis)

Introduced to a variety of tools as children, they have a long history of purposely seeking out ways to learn new things, and their parents were quick to encourage their interest. As Asa put it, “*If we were interested in something, [our parents] made it happen.*” Their mother, Pati Hillis, was trained as an artist, and passed her love of art onto her children. She also made sure that the children had roles in the design and construction of their family home—ranging from counting doorways to helping lay the tile in the courtyard. When they expressed a desire to learn something, Pati would find them tutors.



Figure 2-6. The Hillis family collaborating on a castle (photo courtesy of Danny Hillis)

Rather than simply dabble in a variety of topics, the Hillis kids immersed themselves in their interests. Prior to his college experiences in furniture design, Asa had already learned wood and metalworking, guitar building, and basic furniture upholstery, but knew little about electronics. His solution? Signing up for an entire year of electronics classes, despite it not being a required part of his major. The twins’ love of hands-on craft and artistry even foiled an early opportunity for them to pursue more digital topics. When he was 12, Asa briefly had an early iPod Video. He quickly sold it to one of his teachers, and used the money to buy a small wood lathe that he learned how to use, eventually becoming skilled at creating

wooden pens. To help find buyers for the pens, Pati Hillis would bring her son's creations to conferences and gatherings. This turned into a small company where he employed his twin and equally youthful neighbors, running a wooden pen making enterprise on the weekends.

The link between Noah and Asa's childhoods and their current furniture building seems rather logical. When I asked about topics they loved to study as a child, India answered for the trio by noting that they *"all loved math. We had really incredible math teachers."* Similarly, when I asked about toys, she noted that they didn't get toys, they got *"cedar blocks."* Woodworking, and related endeavors such as treehouse building, showed up in all three of their narratives. Noah summed it up like this: *"When we were kids we had freedom to run into the shop to build whatever."* These days, wood and mathematics are an omnipresent part of the boys' lives: *"[as a child, Math] was like a puzzle. There was a clear answer most of the time. It goes back to what I'm doing now, there's a lot of math in furniture design. Whether you know it or not, calculating an angle or how much stress will be on a certain joint, it's all problem solving."*

We don't get to pick what our children are curious about. We do, though, have the opportunity to guide them as they nurture this curiosity. I asked Chris Anderson, the young submarine builder turned aerial roboticist, whether he involves his five children in his making projects. His reply? *"Sure, I spend every weekend coming up with projects that they'll want to do, whether they're school projects or just fun things... Every weekend I push this, and every weekend it's like pulling teeth."* He admits that his desire is partly a *"selfish"* attempt to mold his children in his own image. And while he may not, as of yet, have been successful in his attempts to lure his children into the maker world as deeply as he is, I can't help but notice that he's doing something just as, if not more, important. The Anderson children are growing up watching their father tirelessly pursuing his curiosities, and his belief that science and technology are one of the pathways to making a positive impact in the world. Only time will tell which pathways they will choose to make their own marks.

More Tape!

Many parents, myself included, seem to have aspirations for what their children will find fascinating. Lisa Regalla, of the Maker Education Initiative, recounts a story of a father who came up to her after hearing her speak about the importance of making. He mentioned how despite his and his wife's efforts to get their sons interested in other materials and undertakings, the boys insisted on cutting paper and taping it together. It had reached the point where the parents were considering getting rid of the scissors and tape altogether. However, after listening to Lisa

speaking about young makers and ways to support them, he had a new idea. Rather than get rid of the tape and scissors, he was now heading home to get “*more paper, and different types of tape!*”

We don’t get to pick children’s interests, be it paper and tape or submarines. That’s the beauty of passion: it’s personal. Imagine the horror of a world where everyone wants to know the same things. Even more horrible, imagine a world where we are told what to care about and are only allowed to pursue those endeavors. One of the most exciting things about life is how different we all are. I can assign the same design challenge to 30 students and end up with 30 (or more) unique solutions that are colored by the life experiences those students have all had. Where one of them sees airplanes, another may see birds, and yet another is dreaming of acrobats. The greatest gift we can give today’s young makers is our support as they let their own curiosity take flight.