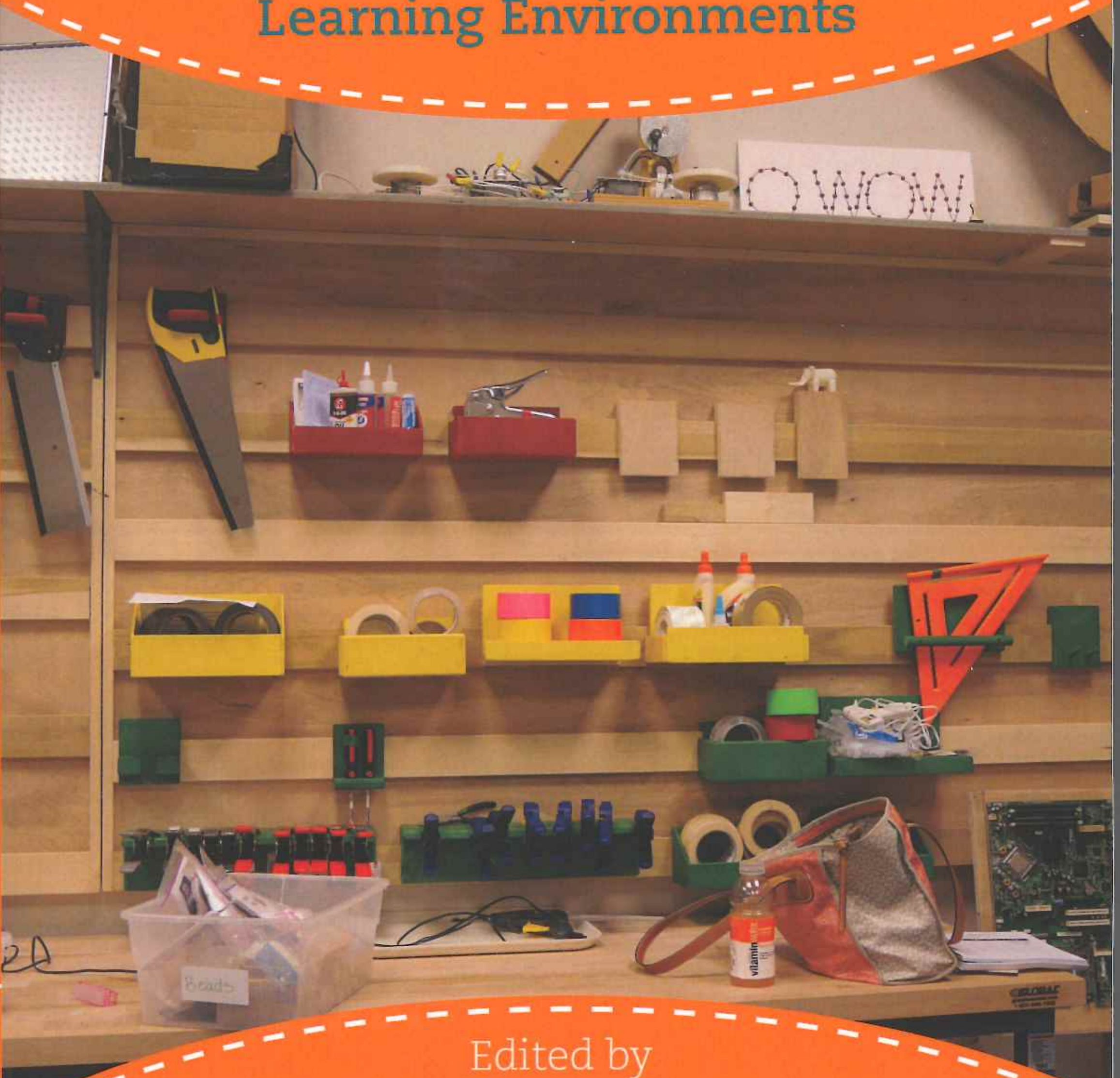
VOLUME 1

Makeology

Makerspaces as Learning Environments



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CHAPTER 10

The Make-to-Learn Youth Contest

Gaining Youth Perspectives on Learning Through Making

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Introduction

While we know from theory and prior research that making can be particularly beneficial in the learning process (e.g., Catterall, 2009), most of what we know in this area comes from studies within schools and afterschool programs (e.g., Kafai, Peppler, & Chapman, 2009), and less from makers and maker culture at large. In the interest of developing a grounded understanding of youths' own conceptions of learning from the process of making, the Make-to-Learn[1] steering committee, including Kylie Peppler, Mitchel Resnick, Mimi Ito, Lisa Regalla, and Elyse Eidman-Aadahl, launched an online competition for young makers (between the ages of 13 and 18) to share and discuss their "makes" for the chance to win prizes ranging from gift cards to mini iPads. The Make-to-Learn Youth Contest, part of a broader effort to leverage DIY culture, digital practices, and educational research for placing making at the core of educational practice, was hosted on the preeminent DIY portal, Instructables.com—an online community for makers of all ages to document their original work, connect with others, and gain inspiration. Contest entrants were tasked to post one or more images and a brief description of their make, which could be anything from a pinewood derby car, to a short movie, to science fair project.

In an effort to uncover (a) the range of locations where youths' making was taking place (e.g., at home, in school, in afterschool clubs, etc.), (b) the range of practices involved in youth's making (e.g., working independently or collaboratively, etc.), and—perhaps most importantly—(c) what learning took place in the process of making, entrants had to answer the following questions in their submissions: (1) What did you make? (2) How did you make it? (3) Where did you make it? (4) What did you learn? These questions helped to situate and contextualize the learning experiences of the youth makers. In addition, the questions served as a way to help youth reflect introspectively and synthesize their experiences as designers. The questions provided qualitative data on their conceptual and analytical processes as designers, providing insights for researchers on learner-centered principles of design. So often, when we think about designing for students, adult perspectives are privileged. Alternatively, the Make-to-Learn Youth Contest privileges the voices and experiences of youth participatory media culture, which we view as an opportunity to co-construct knowledge within a participatory frame.

Background

Papert (1980) postulated that making and designing is a particularly important activity, as it positions the learner as an active agent in the creation process, rather than as a passive recipient of materials designed for the learner. Designing an artifact, what Papert called an "object-to-think-with," involves externalizing one's mental model and iterating on it throughout the design process. This creates several conditions that are ideal for learning. First, having to explain in words or through an externalized artifact what you think you understand necessarily requires a reorganization of that idea into a different format. Second, the creation of an externalized representation and observations or reflections on that design create an opportunity to receive formative feedback. Trying to understand why designs fail and making changes so that it ultimately succeeds creates an important opportunity for the learner to refine their understanding of the concept being modeled (Kafai, 2006; Kolodner et al., 2003; Papert, 1980). Learners can be engaged in building any number of artifacts in this process, including creating a sculpture, composing a song, writing a poem, or programming a computer animation, but what's important is that learners are actively engaged in creating something that is meaningful to themselves and to others around them (Resnick, 2002).

Open competitions and design challenges occur for many research and educational purposes, including idea generation, youth engagement in STEM, and to openly display work to a broader public. To date, STEM fields have championed local and national competitions as efficacious avenues for learning and showcasing accomplishment (Kafai et al., 2014). With the first science fairs appearing over a century ago, public STEM competitions have been steadily on the rise in recent decades, fueled by a growing belief in the value of such events for K–16 students in math, science, engineering, and computing fields (e.g., Abernathy & Vineyard, 2001; Grote, 1995; Yasar & Baker, 2003) and for their correlation with positive STEM career outcomes (Forrester, 2010). Coding Wars, Hackfest, and the National STEM Video Game Design Challenge are but a few of these competitions, bringing together participants either in person or online. In response to the growing prevalence of these events, researchers are now beginning to leverage these contests to learn about youths' interests and motivations in the out-of-school hours (Abernathy & Vineyard, 2001; FIRST LEGO League, 2008–9; Forrester, 2010; Yasar & Baker, 2003). This chapter uses the Make-To-Learn Youth Contest as a way to inform what we know about youths' making and learning practices as part of our broader work in the Make-to-Learn initiative.

The Make-to-Learn Youth Contest

"Hands-on learning is great, but what do kids actually learn in the process of creating something?" Such was the opening question posed to the Instructables community in the Make-to-Learn Youth Contest (www.instructables.com/contest/maketolearn/), part of a broader effort of the Digital Media and Learning Hub at the University of California, Irvine, and funded by the MacArthur Foundation to develop a well-grounded understanding of the educational value of making. Recognizing that clearly articulating the learning potential of DIY culture is critical to integrating making into educational practice, the Make-to-Learn effort brought together makers, educators, and researchers to better understand the activities, tools, and environments for realizing the learning potential of making, as well as the kinds of DIY activities that appeal to learners across a range of backgrounds and interests.

The Make-to-Learn Youth Contest leveraged the prior successes of Instructables contests—monthly competitions around a particular theme where entrants upload Instructables (i.e., step-by-step descriptions of a project they've created) for a chance to win prizes. This act of documenting a project in order for others to recreate or modify the design, and share it back out with the community in turn, is a central facet of the DIY movement. The winners of Instructables-sponsored challenges are often determined by the number of votes from the online community and are rewarded with prizes that can range from T-shirts and stickers to more elaborate prizes, such as cameras, iPad Minis, and leatherworking tools, depending on sponsorship of the challenge. To enter the contest, participants had to post one or more images and brief description of their make, as well as answer the following questions:

1. What did you make? Tell us the story about what you made and how it works. What tools and materials did you use?

2. How did you make it? Tell us how you got the idea for the project. Did you work with anyone else? Did your plans and ideas change as you worked on the project?
3. Where did you make it? Did you work on it at home or at school or somewhere else—or some combination? How did the project connect to other activities in your life?
4. What did you learn? Describe your biggest challenges and any surprises that arose during the build. What are you proudest of? If you had to do it again, what would you do differently?

The Make-to-Learn Youth Contest went live on Instructables.com in February 2013, with the entrance period closing 9 weeks later. During this time, a total of 322 entries were submitted to the competition from a wide array of youth, primarily across the United States. Submissions ranged from a "'French' style" kitchen knife made using a homemade grinder, propane forge, and milling machine; to homemade bracelets; to an Arduino-powered Analog VU meter that doubles as a clock (see Figure 10.2 below). Given available data from self-reports and profile pages, the average age of the submissions was about 14.5 years; 46% were submitted by females and 54% by males.

For the purposes of this chapter, youth responses to the first, third, and fourth questions were further analyzed and assigned the following codes: (1) project type (i.e., arts and crafts, programming and electronics, shop projects, mechanics and engineering, fashion, digital media, cooking, or other); (2) where youths' making occurred (i.e., home, youth-serving organization, school, makerspaces, or other); and (3) what youth thought they learned in the process of making (i.e., subject-specific STEM content, techniques for using tools and materials, general habits of mind (Hetland, Winner, Veenema, & Sheridan, 2007) cultivated while making, observations of personal growth and social connections, and other). Because of the inherent interdisciplinary nature of most maker projects, multiple codes were applied to projects exhibiting more than one type of production (e.g., an e-textile dress is both "fashion" and "programming & electronics"). This is admittedly a first pass at a very rich dataset worthy of further exploration. Subject-specific STEM content included learning how to computer program, material science, engineering, physics, etc. The techniques for using tools and materials included how to use an X-ACTO knife, how to raise fire temperature for forging metal, and specific types of stitching techniques. The general habits of mind cultivated while making included perseverance, need for iteration, patience, setting reasonable goals, and so forth. Observations of personal growth

and social connections included statement like "I learned that I liked . . ." and "I learned that I could . . ." To illustrate each of these aforementioned coding categories, evocative examples were selected from the winning entries and other exemplary submissions to the contest and are further presented below.

What Youth Make on Their Own Terms

Submissions fell into the following categories of project types: Arts and Crafts (36.4%), Mechanics/Engineering (18.8%), Electronics and Programming (15.8%), Shop Projects (e.g., metal, wood, plastics, PVC, etc.) (9.9%), Fashion (5.1%), Digital Media (4.8%), Cooking (2.9%), and Other (6.4%) (see Figure 10.1). Based on the larger cultural discourse around making and the way that the media portrays the Maker Movement, there is often a conflation of making and STEM learning that sidelines the traditional arts and crafts aspects of the movement. As such, the predominance of the arts and crafts entries was unexpected. The diversity of work submitted reminds us of how important it is to make sure that we don't narrowly define making for youth as we think about the applications for school and society. Additionally, over three-quarters of the submitted projects were made at home (76.1%), with the remainder of projects being made within schools (14.1%), youth-serving organizations (4.7%), makerspaces (1.8%), and other settings (3.3%). This positions families as an important part of youths' learning ecology around making. The work that did take place at schools frequently happened during lunch periods or was an off-task activity (i.e., "I snuck this in a lunch" or "my teacher didn't know I was doing this during math class") with a minority of projects produced in school-based shop class or makerspaces.

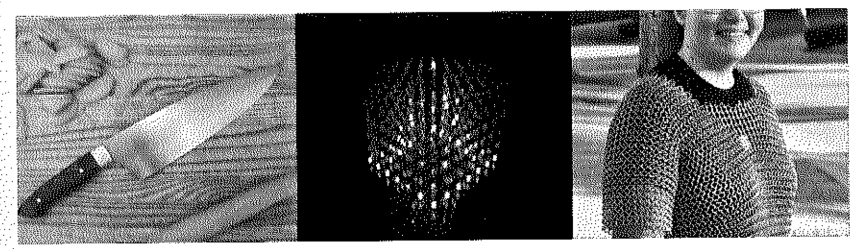

Figure 10.1 An array of projects submitted and reflected upon for the Make-to-Learn Youth Contest.

What Youth Think They Learn Through Making

Analysis of youths' written reflections revealed that youth were most likely to state that they improved some aspect of craftsmanship (i.e., techniques for using tools and materials) (33%) before they expressed discipline-specific learning in STEM (22%) or Art (6%). Other aspects of making, such as the development of beneficial habits of mind cultivated through making (20%), observations of personal growth and social connections (14%), and the development of entrepreneurial skills (2%), also surfaced in youths' entries. Three percent of entries cited learning outcomes that we were not able to categorize (see Figure 10.2). These are not mutually exclusive categories. If a youth cited multiple areas of learning in their reflection, these instances were coded for each area of learning present. Only learning self-reported by the youth was coded into these categories (i.e., what *they* felt they learned)—we resisted the urge to infer STEM content, for example, that might have been touched upon or tacitly engaged in the process of making. This was especially true of reflections that spoke to craftsmanship-level learning; while many techniques developed by these youth have clear theoretical explanations for why they improved their ability to create their project (e.g., silicone dampens the sound of an anvil strike because

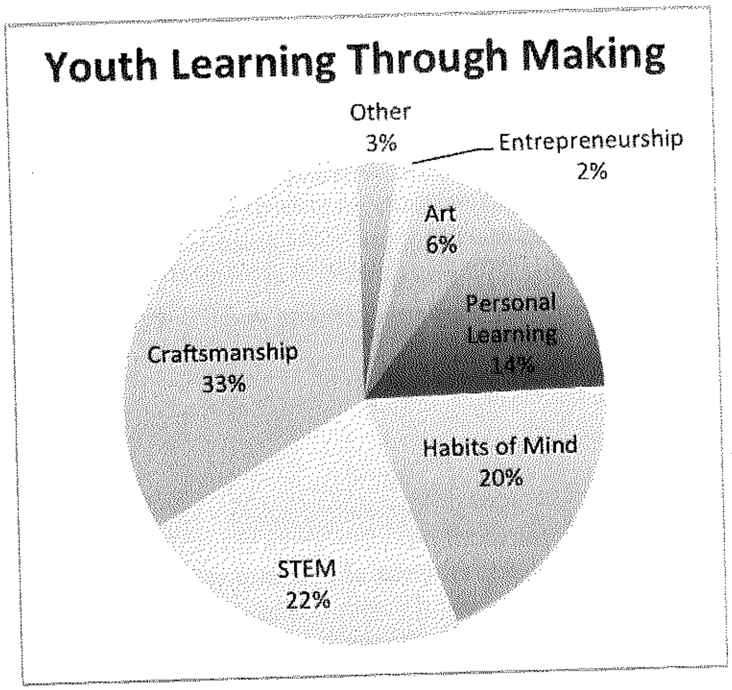

Figure 10.2 Youth's self-reported learning from the Make-To-Learn Challenge.

vibrational energy is being absorbed, otherwise known as the principle of acoustic quieting), these reflections were only coded as "craftsmanship" unless the maker named the connection to the domain in question. The quality of both the make and the reflections on learning impacted the committee's assessment of the project, though projects that cited more learning designations were not seen by the panel as "more successful" than an entry citing only one area of learning. Each of the top four areas of learning is investigated in further detail below due to space limitations.

Craftsmanship

The most prevalent form of learning that youth self-reported in their entries related to general insights about craftsmanship (33%) and the techniques for using tools and materials. Skills cited ranged from learning how to effectively use an X-ACTO knife, to uncovering how to raise the fire temperature for forging metal, to discovering different types of stitching.

For example, one entrant using the pseudonym *Badger the Bladesmith* uploaded an 8-step Instructable on making a "Stock Removal Chefs Knife" forged from ball bearing steel, Mexican Cocobolo, and salvaged copper stock. This submission was one of three Grand Prize Winners and has earned over 36,000 views since the initial posting. A lover of "hunt[ing], fish[ing], camp[ing], cook[ing], eat[ing], etc.," Badger reported making his knife in his dad's shop, where he had been creating knives since he was 11 years old. Badger developed his craft by reading books and watching demos from "Master Smiths," in addition to refining his techniques through experience. For this project, he utilized a "homemade 2X72 grinder, a homemade propane forge, and a milling machine that my dad and I bought as scrap and rewired." Despite this experience, Badger reported additional opportunities for developing his craft further in the process of creating his project:

> The knife turned out almost just as planned, despite the blade warping a bit during the heat treat. Next time I'm going to leave the edge thicker before the quench and that should solve the problem. Also I think if I dome the pins before putting the handle on, it might not chip around the pin holes. As far as what I'm the most proud of, I think the copper bolster with brass pins look awesome.

While there is implicit STEM content that could describe the learning he illustrates here, what Badger the Bladesmith is paying most attention to in his reflection is the subtle refinement of the tools and materials over time and honing his aesthetic sensibilities about the final product. Nearly a third of entries shared this focus on the tools and materials, observations of process, and skill development, as opposed to citing examples of learning taking place at a more conceptual or theoretical level explicit to STEM.

What is captured here is more or less an ongoing conversation with the tools and materials over time to further learn effective techniques for making.

Given that hands-on production is central to maker activities (and perhaps also an important prerequisite of learning in STEM or the arts), the attuning of learners to discoveries about process, construction, and method perhaps comes as little surprise. In the push for the emergence of development of conceptual academic learning, educators can build upon the learning that takes place in the thousands of small decisions, observations, and steps that occur in the production process. By emphasizing these moments, youth that cited the improvement of craft and technique are speaking to the value of knowing the tools and materials over time and honing their craftsmanship. Other instances of improving craftsmanship were self-described in projects ranging from visual arts to hardware design:

Project	*Description of improved craftsmanship*
Greek Lyre, by *NolanThompson*	". . . learned that veneers are annoying when you need to sand because they tend to get ripped off. I learned that fishing wire is much stretchier than the average violin string and is therefore harder to tune and needs more frequent tuning"
Model of a Building, by *jonathantellez*	"The hardest thing to do while making the model was gluing the walls together and putting them into the final model . . . [next time,] I would change my X-acto knife blade more often because it would give me cleaner cuts and make everything a lot easier."
Forging Tongs, by *bobfransisco46*	"[I learned that] good charcoal makes for a much hotter forge. I also learned that silicon [sic] under the anvil deadens the sound"

Subject-Specific STEM Connections

Though connections between the Maker Movement and STEM innovation are the most stressed by policy makers and the broader education community, such explicit learning outcomes only appeared in 22% of entries. Youth entries that reflected the more popular tech-driven trends of the broader Maker Movement engaged a number of STEM practices, ranging from programming to the use of cutting-edge technologies like laser cutters and 3D printers.

For example, a high school student using the username *Lopuz3* submitted a 26-step Instructable for a programmable, three-dimensional lattice of LED lights that he named a "Self-Contained 7x7x7 LED Cube" (see Figure 10.3). In a rich and complex description of his make and the circumstances surrounding its production, Lopuz3 reflected on what he learned ("a lot!") in the process of making his project:

> I learned how to used [*sic*] Adobe Illustrator to create things with the laser cutter. In terms of electronics, I came to really understand how transistors work while working on this project, and it was by far the largest and most complex circuit I have ever designed. On the programming side, I learned how to use pointers and memory management to write the C++ code that controls the cube. It was neat to see a real-world application of polymorphism and to learn about the virtual keyword in C++.
>
> More generally, this project taught me the value of building a smaller-scale prototype and the power of digital circuits coupled with a microprocessor.
>
> My cousin was with me while I was programming the cube. He had no programming experience, but I taught him enough that with some help he was able to write two of the eight routines that are displayed on the cube.

While Lopuz3 cites the acquisition of new tool-specific skills (e.g., capabilities in Adobe Illustrator for controlling a laser cutter; using pointers, memory management, and virtual keywords to code in C++), he also speaks to STEM learning taking place on a more conceptual level (e.g., that he "came to really understand how transistors work"). Strikingly, he

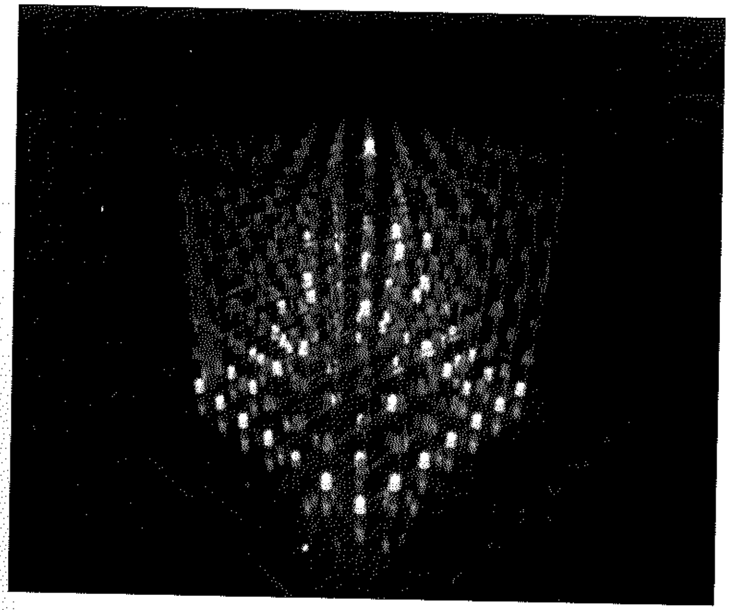

Figure 10.3 Lopuz3's "Self-Contained 7x7x7 LED Cube."

Reprinted from Instructables (n.d.). Retrieved October 15, 2015, from www.instructables.com/contest/maketolearn/

seems to acknowledge that the act of hands-on production lent a depth to learning concepts with which he was already familiar (e.g., "it was neat to see a real-world application of polymorphism"), and that his understanding of the production process—namely the importance of creating a prototype to initially test out complex interconnections—was enhanced in the process.

It is worth noting that the learning Lopuz3 speaks to in his contest entry also includes the act of teaching his cousin, a novice programmer, how to program the cube. Not only would this have given Lopuz3 an opportunity to test the effectiveness of his informational writing (i.e., the steps in his Instructable pertaining to programming), but it also underscores the emphasis in Instructables and other online DIY forums on disseminating ideas and processes throughout the broader DIY community. In this sense, the youth are participating in what Bakhtin (1981) refers to as a dialogical relationship between learning and teaching and, in the process, the act of teaching presents a form of learning in itself.

Other instances of youth reporting STEM learning outcomes through the act of making surfaced in projects ranging from the design of musical instruments to robots:

Project	*Description of STEM content learned*
ECG Machine, by *stive.cool*	"I learnt a lots of the things from this project, how the potential difference of our body changes along with change each heart beat. But then the heart is not the only source of radiation mobile phones, pc and lots of other things effect skin potenital so the pearson should sit still to get a accurate reading. This project doesnt cause any harm to the body as it has diodes attached with the electrodes which prevents high currents to leave the electrodes."
Build an Acoustic Guitar, by *Eat More Chicken*	"[this project] taught me about engineering as well as wave and music theory . . . this is a very creative project with multiple ways to get the steps done, so make the guitar in your own way."
Flashlight Air Gun (Can break Sound Barrier), by *CoolInventions*	I learned the basic principles of Penumatic Design, and methods of achieving supersonic velocities by using physics equations, and simulations. Using the equations for drag, and velocity I was able to estimated the pressure with about 9% error to the actual thing, which was measured by a chronograph to 850 feet per second."

While implicit STEM content could still be taking place in a number of projects that don't cite STEM learning as one of the outcomes of making, it's clear that a sole focus on making as a STEM endeavor eclipses an important part of the learning that is happening in these spaces and could neglect major genres of making important to preserving the broader maker ecology important to young makers. In other words, by forcing an explicit STEM focus (particularly with electronics and programming), we may be overlooking the important aspects of learning in the majority of young maker interests in the arts and crafts, fashion, cooking, and digital media.

Habits of Mind Cultivated Through Making

The act of making can be laborious and highly iterative, requiring participants to move at a slower, more focused pace than what they experience in other learning endeavors. Therefore it stands to reason that over a fifth of youth entrants (20%) would observe the development of new habits of mind, like patience, grit and perseverance, goal setting, and seeing and envisioning, etc., that were cultivated through making. For many, this concerned either a recognition of the importance of perseverance or careful iteration, or a more critical view of the way that prolonged, focused work engendered new ways of thinking or being (see chapter 17, this volume, and chapter 3 in volume 2 of this series for other perspectives on maker habits of mind).

Both of these manifestations of learning came to bear in the reflection of a 9th grader, *Ringer1633*, in her Instructable for a "historically correct" chainmail shirt (see Figure 10.4). Ringer1633, no stranger to "sit[ting] in front of the computer all day," reported that producing her chainmail shirt took 10 months of non-screen-based activity. She indicated that the perseverance and focus required for this task, much of it performed solitarily and "impact[ing]" her relationships with friends and family, produced what sounds like an almost meditative state of consciousness:

> I learned a lot from making the chainmail but the most important things would be patients and the meaning of silence. Patients is pretty self-explanatory because there are over 6000 links in my chainmail, all of which were connected by hand. The meaning of silence is more difficult to explain: what I mean by it is that in our society there is a constant flow of information and garbage being thrown at us from TV, billboards, and shopping mails. Basically I found that when I turned off my computer and just sat and did chainmail I rediscovered silence and it is a beautiful thing.

Through this work creating the chainmail shirt, the designer talks about achieving a Zen-like state of being through repeated action, cultivating a sense of presence and stillness. As of October 2015, Ringer1633's tutorial

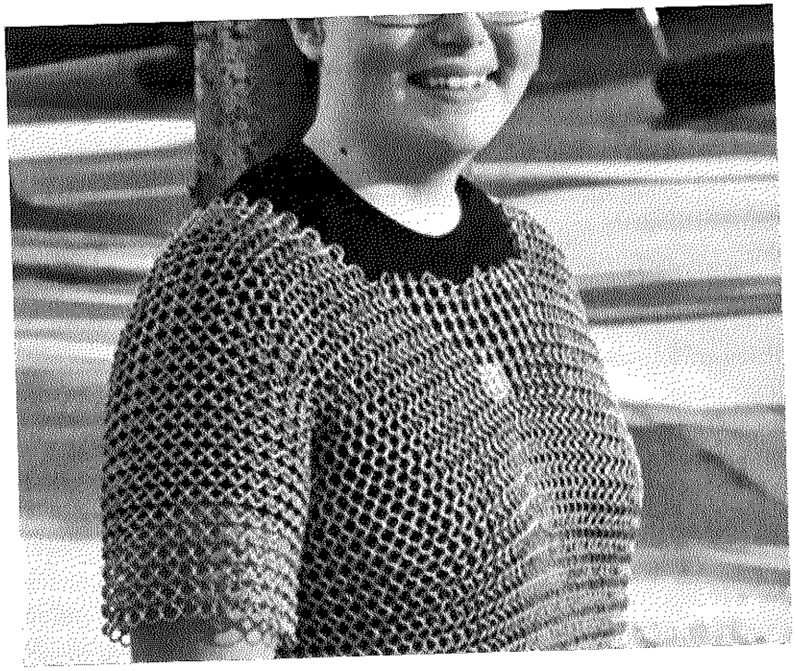

Figure 10.4 Ringer1633's Chainmail Shirt.

had received over 103,000 views (and over 530 "favorites") on Instructables.com, with over 100 enthusiastic responses from the field praising her craftsmanship, the clarity of her instructional writing, and celebrating her new perspective on the world.

In outcomes-based learning environments, youths' development of certain habits of mind is often superseded by emphasis on specific learning content knowledge and objectives. However, the open-endedness of most maker environments (especially those based in informal spaces or in the home) gives greater space for youths' meta-reflection on the way they learn and other environmental factors that play a role in what and how they make. In some cases, the development of specific habits of mind (e.g., persisting, less fear of failure, and testing unknown solutions) is an important aspect of lifelong learning. In 21st-century learning environments—which can be awash with information and possible connections—providing space to "rediscover silence" can be a prized effort.

Other instances of the development of new habits of mind were self-described in projects ranging from gardening to engineering:

Project	*Description of learning new habits of mind*
Color Visualizer, by *Qtechknow*	"I learned that nothing works the first time, and that you can fix your mistakes . . . I accidentally messed up on the copper traces on the PCB, but I still have prototypes that work, because I improvised."
Hand Puppets by Max Miller at the *LincolnStreetBGCB*	"I really like thinking up my own projects to do. I learned that sometimes if you have a good idea, and you plan it out your project can be easy to make."
Modern Airscrew!, by *Ã©clatement*	"not everything that can be very useful needs to be super complicated. helicopter and this vehicle both fly vertically while building a helicopter will take a month but this one only takes a day. The most important factor in inventing useful tools isn't how much calculus and electronic and physic one knows; it's just one's perspective that matters."

Personal Connections

The act of hands-on, interest-driven making became an opportunity for several youth (14% of entries) to reflect on things they learned about themselves through the act of making (e.g., youth learned that they were interested in becoming engineers or artists in the process of making). Whereas habits of mind pertain to learned behaviors for confronting problems or the unknown, observations of personal growth are seen as more or less permanent ways of interpreting the self with regard to one's likes or abilities. Such observations fuel the development and honing of interest-driven projects, which are central to the maker ethos.

For instance, a 16-year-old maker named *jill710* created an Instructable on the design and manufacturing of a Rube Goldberg machine, intricate 3D mazes of interconnections and chain reactions (see Figure 10.5). Her machine was created using household materials (e.g., paper towel rolls, tape, paper, yarn, film canisters, etc.), and featured a path for a marble to trace through a progression of simple machines before ultimately hitting a bell at the end of the path. For jill710, the creation of the Rube Goldberg machine was a test of her interest in and aptitude for engineering—her father's profession—as a potential career path:

> One of my biggest challenges was the pulley system. It always seemed to have some sort of problem, from the pulley twisting every which way, to the wheel not turning properly. However, after many alterations and attempts at fixing it, the pulley system began to work much more

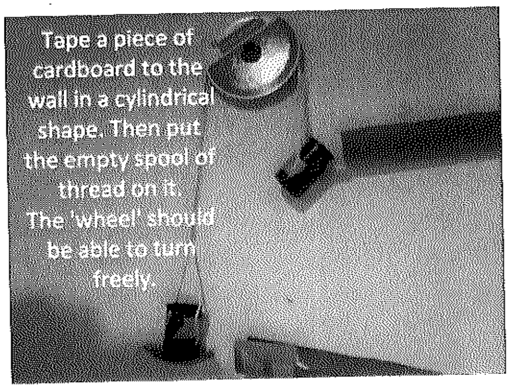

Figure 10.5 Still from jill710's video "Make a Rube Goldberg Machine!" Instructable.

Reprinted from Instructables (n.d.). Retrieved October 27, 2015, from www.instructables.com/id/Make-a-Rube-Goldberg-Machine/

> accurately. I would have to say the pulley is one of the machines I am most proud of. It was also very fun to watch the swing work as well as it did. I loved watching each of the pieces come and work together to accomplish the final task of ringing the bell! If I had to do this project again, I would not change a thing! The whole point of this project, for me, was encountering obstacles and finding new ways to fix or improve them. I enjoyed this project a lot, and I am definitely going to consider engineering in my career choices.

Notably, here jill710 says that she is "definitely going to consider engineering" as a career choice, connecting making to a potential future career. It is important to also note that, while iteratively designing, adding to, and troubleshooting her machine, jill710's self-assessment of her creativity and problem-solving skills underwent transformation (as well as her understanding of mechanics and engineering). She spoke to a number of behaviors that we associate as the development of efficacious habits of mind for engineering (e.g., thinking flexibly, long-term planning, tinkering, and innovating), though, in addition, she also illustrated how the act of production was a test that pointed inward, and was thus also an instance of personal growth. Given the flexibility of youth's learning trajectories to trace unexpected and uncharted paths in the rise of new industries and professional markets, the act of questioning and clarifying one's own abilities and interests is particularly significant.

Other instances of youth reporting personal growth—things they learned about themselves—through the act of making surfaced in projects

ranging from descriptions of unexpected self-reliance to overcoming past hurdles to success:

Project	*Description of personal growth*
The Obamas, by Emma Austin at the *LincolnStreetBGCB*	"I was really proud of myself because I worked on this all by myself . . . I learned that if I work on something for a long time I can make it look really good, and be proud of all of my hard work."
How To Make A Coroplast Boat, by *BATbuilder*	"I got really frustrated and wanted to quit the whole idea when I tipped over when I was testing whether or not the boat would leak . . . I am most proud of the fact that I was able to drive it around Lady Bird Lake because it made me feel like I really accomplished something and made a real boat."
How to Make a Mustache Face Cake, by *JordanRunnels*	"I tend to challenge myself too much and end up failing miserably. This cake taught me to take it slow and stay simple so I can do something easy but nice, instead of trying to go too big and getting to frustrated and giving up."

Discussion

The learning exemplified here describes more than a mere transfer of received knowledge, an inscription of a unified or a rigid pedagogy; it assumes that youth designers are moved by their passions and motivated, in part, by the identifications, range of experiences, and commitments they bring to the design process. In part, this suggests connecting what is taught in a learning context to the social worlds (Hall, 2011) and cultural capital (Bourdieu, 1990) that youth inhabit in their everyday lives.

There are some things that this data set cannot reveal to us, such as the extent to which this range of making is representative of nondominant youth. We also were not able to deem the ways in which gender may have influenced the types of design projects. Despite its promise, since most of this making occurs in homes and outside of any formalized context, how can we be sure that we are inviting youth from nondominant communities to participate? Moreover, most of these projects require access to specialized tools, materials, and social networks to support such making that may have been prohibitive for youth to participate. Indeed, the high level of access to resources was evident in descriptions of home makerspaces, which were, at times, similar to those described in community-based makerspaces.

However, these findings reveal how the Maker Movement can be inclusive of diverse trajectories for participation and leveraged to broaden STEM pathways. As we begin to think about leveraging maker culture in the learning landscape, gaining the perspective of youth makers can guide what aspects of broader maker ecology we must preserve in the drive to make potential connections to disciplinary learning more explicit. Furthermore, examining the modes of production in which youth engage can guide the types of projects we promote in our educational workshops so as not to mutate the maker culture to constrain and enable the authentic learning goals. Such information can prove essential for youth-serving organizations in the community that seek to leverage out-of-school making practices in order to connect learning across spaces. Submissions to the Make-To-Learn Youth Contest speak to the rich repertoire of maker practices in which today's youth engage, which should be built upon in order to forge more accurate academic and career pathways for youth. This is why we need more information on youth maker perspectives in the design process and what they are actually doing in the out-of-school hours. Youth maker perspectives' relationship to design tools is a fertile ground for future research, which has implications for teaching and learning in contemporary formal and informal spaces. In fact, it has already disrupted and redefined many traditional learning and teaching paradigms from the past.

Note

1 Make-to-Learn is a thematic initiative of the Digital Media and Learning Hub at the University of California, Irvine, supported by the MacArthur Foundation.

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"*Makeology* is the first broad and comprehensive examination of the Maker Movement as a catalytic force for young people's learning. Practitioners and scholars interested in implementing and studying making as a force for creative expression and student-centered learning will find in this two-volume collection a wealth of thoughtful and significant information."
—Margaret Honey, President & CEO, New York Hall of Science, USA

"Our goal should be helping children see themselves as good learners, as lifelong learners. The impact of what they create, design, shape, and build will be known in the future, but the time for making it happen is now. This book can increase the opportunities for making in educational settings by sharing the insights of many leading practitioners."
—Dale Dougherty, Founder & Executive Chairman, Maker Media, Inc., USA, from the foreword

"One thing we have in common is our commitment to putting more power in the hands of people from all backgrounds, enabling everyone to develop their voice and express themselves. There's a special opportunity right now. But that moment could also slip away, so it is all the more important to make connections and join forces with other communities with shared values, to make sure that all children have the opportunity to grow up as full and active participants in tomorrow's society."
—Mitchel Resnick, LEGO Papert Professor of Learning Research and head of the Lifelong Kindergarten group at the Media Laboratory at Massachusetts Institute of Technology, USA, from Volume 2

Makeology introduces the emerging landscape of the Maker Movement and its connection to interest-driven learning. While the movement is fueled in part by new tools, technologies, and online communities available to today's makers, its simultaneous emphasis on engaging the world through design and sharing with others harkens back to early educational predecessors including Froebel, Dewey, Montessori, and Papert. *Makerspaces as Learning Environments (Volume 1)* focuses on making in a variety of educational ecosystems, spanning nursery schools, K–12 environments, higher education, museums, and after-school spaces. Each chapter closes with a set of practical takeaways for educators, researchers, and parents.

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