CHAPTER 5

Children Are Not Hackers

Building a Culture of Powerful Ideas, Deep Learning, and Equity in the Maker Movement

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Introduction

The Maker Movement is one of the most exciting educational innovations in recent decades, but if it is indeed to transform schools, we need to quickly amplify and solidify its impact and avoid converting it into one more item in the long list of failed educational innovations of the last 50 years. In order to move forward, however, we need to understand where it came from. Since Émile (Rousseau, 1979), progressive educators and researchers have been questioning traditional schooling and prescribing constructivist, student-centered approaches based on authentic, meaningful experiences in the world (Dewey, 1902; Freudenthal, 1973; Fröbel & Hailmann, 1901; Montessori, 1964, 1965; von Glasersfeld, 1984). In the 1970s, critical pedagogy scholars (Freire, 1974; Illich, 1970) questioned the idea of curricular standardization and proposed that school curriculum should be based on students' values, practices, and local cultures. In the 1980s, Papert and his collaborators (1980) added their own contribution, highlighting the importance of externalizing one's knowledge into concrete, shareable objects—in other words, making things:

> Construction that takes place "in the head" often happens especially felicitously when it is supported by construction of a more public sort "in the world"—a sand castle or a cake, a LEGO house or a corporation, a computer program, a poem, or a theory of the universe. Part of what I mean by "in the world" is that the product can be shown, discussed, examined, probed, and admired.
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> (Papert, 1993, p. 142)

Taken together, these views prescribe a model in which students work on personally or community-meaningful interdisciplinary projects, often freed from a scripted curriculum, empowered to make choices about their own learning, and using technologies to externalize their ideas in sophisticated ways.

The Maker Movement is the newest and most prominent instance of this model—a century-old project that has not yet become mainstream outside of niche schools around the world (even though it has experienced greater success in afterschool and informal settings). The movement's roots in constructivism and constructionism have been explored elsewhere (Blikstein, 2013; Martinez & Stager, 2013), but it suffices to say that long before the label "maker" was coined, researchers had been busy building the theoretical foundations for it (constructivism, critical pedagogy, constructionism, project-based learning), and technologists had been creating the technologies that eventually made it possible (Logo, Scratch, LEGO robotics, open source physical computing, low-cost digital fabrication). By examining its origins and cultural roots, and thus understanding the underlying principles of the social protocols enabled by making, we might be able to determine the types of tools, spaces, and activities that have been successful, and find out under what circumstances they could be even more effective.

We believe that not only is the "Maker Movement" undertheorized (Gomez, 2012), but it's very undertheorization and anti-intellectualism (often dressed as a rebellious *enfant terrible* against traditional schooling) are part of its culture, which constitute a vicious circle that has engulfed promising educational innovation in the past—frenetically implementing new technologies in schools as if their efficacy was self-evident, without carefully demonstrating it. In this chapter, our goal is to step back, examine the cultural roots of the Maker Movement, make the case that these roots are a threat to its survival in schools, and propose a new set of principles that might allow the movement to achieve the goals dreamed by Dewey, Freire, Papert, and so many others.

The Four Cultural Roots of Making

The recent history of the Maker Movement—and how the name came to be—traces back to three main events: the invention of the first FabLab at MIT around 2001 by Neil Gershenfeld and Bakhtiar Mithak (Gershenfeld, 2005), the creation of the Maker Faire (and *MAKE* magazine) in 2005, and the growth of technology-rich informal education programs (in museums, afterschool settings, and student competitions). They emerged from well-established communities and cultures that had focused on innovation for many years. MIT and similar higher education institutions have been immersed in a culture of "hacking" for decades, so the establishment of FabLabs—essentially a high-tech "hacker's lab"—was a natural next step. Germinated within the O'Reilly publishing house, *MAKE* magazine and Maker Faire were heavily influenced by Silicon Valley culture. The growth of technology-inspired afterschool and museum programs was propelled mainly by the societal acceptance, mostly by middle-class families, of technology (computer programming, robotics, ICT), creativity, and problem-solving as marketable job-market skills beyond the traditional school curriculum—or simply worthwhile pursuits for children. Given the difficulties in implementing those activities in regular schools, these new afterschool spaces flourished. More recently, a fourth element appeared, following a widespread concern about the lack of engineers and computer scientists to keep up with other industrial powers such as China: the need for more STEM-focused workforce training starting at the K–12 level.

Yet, despite the predominant maker rhetoric, these four cultures—hackers, publishers, informal educators, and workforce—have fundamental incompatibilities with a culture of democratic, equitable, and deep learning. These incompatibilities might ultimately either annihilate the Maker Movement as a progressive force in educational reform or accomplish exactly the opposite of what its mission states by deepening educational inequality. This chapter thus proposes a conversation within the movement and the research community around it to better align its ideals, implementation, and future.

The Hacker Culture: Extreme Autodidacticism

Engineering schools, where the hacker movement was born, attract a population with extraordinarily high academic achievement. These places have their own values and social practices, notably, the idea of self-sufficiency, autodidacticism, individualism, and competition. The popular image of the hacker is that of a disheveled, unshaven White male in his twenties, doing all-nighters in a messy electronics lab, capable of learning anything by himself by scouring the Web or doing late-night runs to the library. Despite the incredible contributions of hackers to science and technology, this "sink-or-swim" culture only works for a small elite group of high-end students. The idea that "every child is a hacker" is, at its best, wishful thinking, and at its worst, an attempt to blindly impose a very specific mindset—generated in a very atypical environment—onto schools.

The Publishers' Culture: Product Before Process

As additional pillars of the Maker Movement, *MAKE* magazine and Maker Faire were born within the technological "counterculture" of Silicon Valley, demographically biased and male-centric. Thus it is no surprise that both started catering to a very specific population: college-educated, affluent, White men—as its own attendance surveys state, 97% of the adults attending the Maker Faire have a college degree, 70% have a graduate degree, and the average income is $103,000 (MakerMedia, 2014). This pattern is also reflected in the demographics represented within the pages of *MAKE* magazine (Brahms & Crowley, 2016, volume 2 of this series).

Having originated in a publishing house, the Faire and the magazine came from a culture in which product takes precedence over process: one needs shiny, "cool" objects and projects to sell magazines. Naturally, people walking in a fair will be attracted by the most spectacular projects, and students will generally talk about their products and not their process—an unfinished, "half-baked" project that does not yet work simply will not cut it. Having spectacular projects is the natural path of evolution for an exhibition, but not very inviting for novices.

Another component of this culture is its view of what technology is and what it is for: apps, electronics, mobile phones, rockets, cars—designed within an environment of affluence, where the range of real-world problems is quite limited: Water your lawn automatically? Turn on and off your home's lights while you are travelling? An electric skateboard to take you to school? Fly a quadrocopter? These types of projects designed to solve (often frivolous) "first-world" problems, despite their appeal to a particular population, could be quite foreign for children from a low-income family, with no lawn, travel budget, or money for expensive toys. This also downgrades and devalues projects such as traditional crafts, costumes, pottery, technology-augmented wearables and jewelry, among many others (Buechley, 2013). In some schools, art teachers feel pressure to have LEDs in their work to be part of the maker program (Flores, 2015).

The Culture of Informal Educational Spaces: The "Keychain Syndrome"

The third pillar of the maker universe is the numerous afterschool and museum programs focusing on STEM. Activities centered on robotics, physical computing, science, or math proliferated in recent years due to the availability of low-cost equipment (Arduino-like platforms), and the popular perception that these noncurricular STEM skills were becoming crucial for the job market. However, apart from the obvious issue of inequity of access to these often costly spaces and activities, there is another problem: science museums need to move visitors quickly, which creates an incentive for speed and standardization. This incentive leads to the proliferation of the "30-minute" workshop model: fast, scripted, perpetually "introductory" workshops. In previous work, we've called this the "keychain syndrome"—children keep doing keychains and other trivial objects but never move on to more complex projects, which require more complex facilitation, curriculum design, and equipment (Blikstein, 2013).

The "Job Market" Culture

Despite exaggerated claims of the shortage of new engineers and computer scientists to fill job openings (Stephan, 2012; Teitelbaum, 2014), a fear over the need to keep up technologically with China and other countries has taken a deep hold in the United States, especially in Silicon Valley. This led to several initiatives to solve the "STEM pipeline" problem. Despite the best of intentions, this Silicon Valley–inspired fixation on K–12 education as STEM job market training has influenced the tools, goals, and pedagogies incentivized (or allowed) in schools. For example, K–12 computer programming, which has been previously considered as an expressive tool and a foundational literacy for every child (diSessa, 1993; Papert, 1993), morphed into a gateway to "get more students into computer science." Many maker labs were made to adopt a similar discourse, claiming that their main goal was to get more students into engineering, and again backgrounding the goal of exposing students to powerful ideas and tools for self-expression.

These four cultural pillars of the Maker Movement were efficient in making it a worldwide phenomenon. However, for the movement to cease to be a novelty and really take hold in education, we need a new type of culture, one that promotes deep, plural, equitable learning. And the first step towards establishing it is to value *research*—not just academic research, but research done by teachers as well—not taking the efficacy of "making" for granted, and developing the practice of collecting and reflecting on data in order to improve our educational designs.

The Maker Movement, Research, and Assessment

Fun versus Hard Fun

Two of the main claims of early proponents of the Maker Movement in schools are that schools prioritize too much abstract thinking and leave no room for play and fun (Dougherty, 2013). In general, that is undoubtedly true, but educational researchers have already moved on from these relatively naïve and simplified conceptualizations in ways that are actually
AuQ3 useful for teachers to improve what students do in makerspaces. Freire, for example, was a strong advocate for discipline "with enjoyment," and Papert coined the term "hard fun" to explicitly contrast his vision with the traditional view of fun as "'touchy feely . . . make it fun make it easy' approaches to education" (Papert, 2002, p. 1). Both Papert and Freire and their disciples were advocating harnessing the passion of the learner to do the hard work

needed to master difficult material. In fact, early Constructionists were not interested in pitting serious against playful (Papert & Harel, 1991, p. 1), but instead finding ways to live at the intersection of the two. The lesson for educators is that the work in FabLabs and makerspaces can be enjoyable but should never be "easy" fun, devoid of frustration and difficulty.

Abstract versus Concrete Thinking

The naïve view of the concrete versus abstract dichotomy considers *concrete* as representing something that is physically tangible, and *abstract* as formulas, axioms, and esoteric "school" stuff. Papert is not opposed to students developing abstract thinking—the tools that his team and disciples developed were designed to bridge the concrete and the abstract, rather than negating one or the other (e.g., see "Gears of My Childhood" in Papert, 1980). The issue of abstract thinking has also been tackled by other researchers—Wilensky turns the issue on its head, proposing that abstractness is not a property of objects, but of a person's relationship with objects:

> Concepts that were hopelessly abstract can become concrete if we get into the "right relationship" with them; provided that we have multiple modes of engagement with them and a sufficiently rich collection of models to represent them. [. . .] What we would like to achieve in schools is not a restriction of children's knowledge to a smaller but more "concrete" domain, but rather an enrichment of the child's relationship to the whole panorama of human intellectual endeavor.
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> (Wilensky, 1991)

Following Wilensky's reflection, we should not think of makerspaces as places of "concreteness" where abstract math concepts, for example, have no place. The view that children should just be building physical things, and leaving the unexciting abstract "stuff" at the door, ignores the fact that the naïve concrete/abstract dichotomy is a category error. In fact, the richness of makerspaces comes not from the fact that the abstract is left out, but that it is brought in together with new ways to build relationships with and between objects and concepts. Supposedly abstract mathematical ideas suddenly become concrete when, for example, a student needs to design a laser-cut object using the least amount of material, or when a very "concrete" 3D printed object gives rise to a discussion about Boolean operations.

Research versus Gut Feeling

As a consequence of this view on "abstract thinking," many makerspaces take on a general ethos of more "doing" and less "thinking." In addition, mainstream Maker Movement advocates tend to take a dismissive stance towards the analysis of student learning. One example of how assessment is being dismissed can be found in the following excerpt from the book *Tinkering*:

> If you question how I know this learning took place in the course of that tinkering, I'll have to confide that I have no proof beyond the following: most kids have learned oodles and oodles of stuff, including talking and walking, texting, and skateboarding, with just this hit-and-miss, trial-and-success, seat-of-the-pants approach. I believe this is called "proof by inspection." [. . .] You can get a PhD trying to show that learning is happening [. . .] But [. . .] I'm comfortable with my gut instinct.
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> (Gabrielson, 2013, Preface)

This quote, more than a criticism to early proponents of making such as Gabrielson, is a manifestation of a culture which tends to trust "gut instinct" rather than research and, in so doing, implicitly encourages others to follow the same "gut feeling" process. Arguments that "doing is learning" were made for project-based learning, but several studies showed that students engaged in completing their projects were still not developing a conceptual understanding of what they were doing (e.g., Barron et al., 1998). Most people will not question the fact that nearly all types of learning experiences may result in fostering a tremendous change within a given student. The challenge, though, has been to know what those changes are, what fosters those changes, and when those changes are likely to take place.

The history of educational technologies and education reform (Collins & Halverson, 2009; Tyack & Cuban, 1995) has repeatedly demonstrated that the implementation of "revolutionary technologies" often leads to considering their benefits as self-evident. We see research (done *together* with teachers) as a tool for both measuring learning outcomes and as a way for teachers to reflect upon and optimize their own practice.

Four Elements of a Learning Culture in Makerspaces and FabLabs

From a Hacker Culture to a Learning Culture

A sign of the anti-intellectualism that prevails in the maker/FabLab movement is the bold slogans and claims: "every child should be a maker," "every child should hack," "making mistakes is good," "children should think as computer scientists/engineers," etc. Despite the fact that many of these slogans might be true in some limited way (e.g., productive failure: Kapur, 2006), they stem from the four aforementioned sets of beliefs rather than knowledge about how children learn and develop. To encourage students to take on an externally imposed identity, rather than to support them in building their own, is not really what progressive education proposes (Susanna Tesconi, personal communication, March 10, 2015).

The "sink-or-swim," hacker-inspired culture of work with minimal facilitation is problematic in a number of ways. In this view, if students are engaged in making, teachers can remove themselves from the equation—as opposed to the teacher as a coach, facilitator, and the one who holds the year-long vision for a particular area of study (Aaron Vanderwerff, personal communication, March 11, 2015). In our own research (Blikstein, 2013; Davis, Bumbacher, Bel, Sipitakiat, & Blikstein, 2015), novices coming into a maker lab need a considerable amount of onboarding and facilitation before they can start "hacking" and learning by themselves. When such facilitation was absent, these students (who are disproportionately females and minorities) felt lost and frustrated, and reported an even lower self-esteem than before coming into the lab. Seeing other students (who have had previous engineering experience, have been to STEM summer camps, etc.) comfortably learning by themselves, hacking away, and getting their projects done with minimal help was actually a disempowering experience for those newcomers. They would then offer to do the least technical parts of the projects, and learn very little STEM-related content. The opposite happened when those novice students were gracefully introduced to the space and the tools and exposed to activities and technological instruments appropriate for their expertise level and age range. We also found that the social engineering of the teams is critical to success. In another study, we paired high- and low-achieving students to accomplish a task, in three configurations: low-achieving pairs, high-achieving pairs, and mixed pairs. In half of the mixed pairs, the low-achieving student was mandated to be the "driver" of the activity (having control over the computer mouse and keyboard, etc.). In those groups, the learning outcomes were almost the same as the groups with two high-achieving students, and dramatically higher than mixed groups in which the high-achieving student was the "driver" instead (Schneider & Blikstein, in press).

The potential damage of the "hacker culture" is even greater considering the extensive research on stereotype threat (Cohen, Garcia, Apfel, & Master, 2006), which shows how individuals can perform below their ability level when they suspect that they belong to a group that historically does not do well at a particular activity. We know that women, African Americans, and Latinos have been historically excluded from technical professions, so bringing them into a makerspace without the proper facilitation and onboarding will likely result in the confirmation of any initial suspicions they might have had that they are "not technology people."

A learning culture, therefore, should make sure that the following elements are present:

- Going beyond the "hacker" myth and actually designing activities and projects that can include all students in a meaningful way, without exposing them to excessive levels of frustration.
- Avoiding the "glorification of failure" and understanding how much of it is productive: Surely making mistakes can be a powerful learning experience, but simply assuming that students will learn from their own mistakes is an oversimplification. There is an optimal amount of frustration and trial-and-error for every learning environment and age range.
- Making sure that students do not self-assign to activities only within their comfort zone, since this will increase the disparity (e.g., high-achieving students doing programming, while low-ability students cut and paste cardstock—see Abrahamson, Blikstein, & Wilensky, 2007).
- Being aware that historically marginalized groups come to the lab with preconceptions about their own ability with technology, but those can be deconstructed through authentic experiences of success.

From a "Jobs" Culture to a Literacy Culture

The idea of a "leaking STEM pipeline" became mainstream in the last 15 years, propelled by widely publicized claims about the lack of engineers and computers scientists. Nonprofits promoted campaigns to raise awareness of this issue and attract more students into STEM careers. These campaigns miss the point of STEM as a literacy—a lens through which to interpret the world and act upon it ("consciousness of the possible," Freire, 1970). First, it seems unlikely that a 5th grader would decide to take a computer programming class because it would increase his or her chances of getting a job 10 years later. Educational choices in children are aspirational and not driven by future financial gains. Research suggests that the best predictor of STEM career choice is not a student's K–12 math or science performance, but their self-reported love for science and if they see themselves as scientists in the future (Maltese & Tai, 2011).

Therefore, job market concerns should not be the main justification to introduce makerspaces in schools—otherwise, should we stop investing in those spaces when the shortage of engineers is solved? In the same way that we do not teach music, sports, or arts in schools because there is a shortage of artists, athletes, or musicians, "making" should be taken as a crucial set of skills, abilities, and heuristics for children to express themselves in a medium that is increasingly important in daily life. Thus, the move from a "jobs culture" to a culture of literacy should pay attention to the following issues:

- The materials that children use (robotics kits, electronics kits, etc.) should be specifically designed for children. We have shown in other research (Blikstein, 2013; Sadler, Aquino Shluzas, & Blikstein, 2016; Sadler, Durfee, Aquino Shluzas, & Blikstein, 2015) that "professional" platforms such as Arduino are not appropriate for novices because they introduce a plethora of technical details that are foreign to the main learning goal and end up unnecessarily frustrating students even before they can accomplish the simplest of projects. The same goes for programming languages: we should not teach Java as an introduction to computer science just because it is a language useful in the workplace—we should use the language that offers the highest probability of success, engagement, and motivation. Once engaged, children can explore more complex professional tools.
- There is a deep cultural abyss separating the corporate world and K–12 schools. While CEOs talk about their workers as "human resources," teachers and parents think of children as individuals, each with their own histories, needs, and talents. When corporations enter the debate, they should be careful to understand what schools and teachers actually do, being mindful of the differences between the two agendas. More often than not, to have access to corporate or government funding, schools and teachers find themselves obliged to "agree" with a political and ideological agenda they do not espouse (Aaron Vanderwerff, personal communication, March 11, 2015).

From a Keychain Culture to a Culture of Deep Projects

Digital fabrication enables students to create impressive objects in a short period of time, which generates an unintended consequence: It is easy to create an object that is impressive to the outside world even if said object is quite trivial. This generated a widespread practice in makerspaces of "too-simple" projects and workshops. For example, children would just download and print 3D objects from the Web without ever designing them, or laser cut simple designs like keychains and nametags. These "30-minute" workshops are excellent as a first contact with digital fabrication, but many institutions simply stop at them (we termed this the "keychain syndrome"; Blikstein, 2013). A real engineering project takes several cycles of redesign which are hard to fit into a one-size-fits-all 30-minute format—however, the digital fabrication lab provides a safe and productive space for long-term projects. A culture of deep projects can be fostered if:

- Teachers from multiple disciplines work together to create digital fabrication units and make them available as open educational resources. We have seen very successful curricular units in schools—but their success was due to a deep commitment from the school leadership to build a critical mass of curricular materials and invest resources in it. Teachers and lab managers were paid tens of hours a year to create these units, and then given the opportunity to implement, document, evaluate, and redesign them many times. If teachers and lab administrators do not have time to create these new and complex curricular units, the goal of integrating the lab with the rest of the school day becomes impossible.

- We think outside of the "STEM box": We have seen students creating fascinating musical instruments, clothes, costumes, and visual arts projects, working with and augmenting traditional crafts, and creating interactive art. We have also seen teachers from non-STEM areas create very compelling units, combining history and math, biology and engineering, language arts and physics. Allowing teachers to "pair up" and design curricula together, even if they are from different areas, greatly expands the range of activities that can be done in the labs and makes it possible to attract students with a variety of different interests.
- Project ideas and themes should be connected to students' lives, interests, passions, and their communities. Sometimes that connection manifests itself as a project to solve a real-world problem, but other times students engage in meaningful experiences that might not have a practical application (such as a math project on fractals)—both are valid pursuits that teachers should bring to their labs.

From a Product Culture to a Process Culture

Describing student learning in constructionist learning environments can be quite difficult. Students are likely to gain proficiency in a wide variety of areas based on their projects, which can be unique and make use of different resources. As such, there appears to be a dearth of metrics and content areas that one would expect to be applicable to all students. However, despite the significant variance in the types of students, projects, and tools, there are commonalities in how they approach the design and implementation of a task.

Using the commonalities as a means to characterize student learning is one way to establish process-based assessments that can be useful to both teachers and researchers. In prior work, we identified that one way to examine student learning is by studying changes in how students describe the origins of their design ideas (Worsley & Blikstein, 2014). We also found that properly designing the learning environment and materials, by encouraging students to leverage their prior knowledge in ways that emphasized examining engineering and science principles related to their projects, resulted in improved learning outcomes and better projects. Imagine, for example, that a student is building a model bridge. The "example-based" group would simply use as inspiration objects from everyday life—a chair, a desk, a tower—to build a strong bridge. The principle-based group would be prompted by specially designed educational materials to think instead of strong shapes such as triangles. When we compared the efficacy of example-based and principle-based reasoning, we found that students consistently performed better when primed to use principles instead of just using examples from the real world. We also utilized multimodal data analysis to compare the two groups, using a combination of sensors for dialogue, skin conductance, and gesture. We found students in the principle-based reasoning condition remained in a state that is typified by focused concentration, whereas students in the example-based reasoning condition tended to frequently deviate away from that state of focused concentration. These studies suggest that:

- Assessing the work that takes place in makerspaces is possible, but it requires a new set of approaches and tools. Teachers and practitioners need to be aware that the metrics of success will not necessarily be test scores but very different types of assessments—it is a common and dangerous trap to promise that students' math scores will automatically improve as a result of a maker class.
- Meaningfully examining students' work in those spaces requires a different mindset about the milestones and methods for evaluation. Instead of a "product culture," in which success is determined by the quality of the product shown at the school science fair or the Maker Faire, students' learning throughout the process should take precedence. Learners should be aware that they will be evaluated not only by the quality of the final product, but also about their process—including, for example, how they collaborated with colleagues, how they managed the work, and how much they went outside of their intellectual comfort zone. In other words, assessments have to measure what matters in makerspaces (Aaron Vanderwerff, personal communication, March 11, 2015), and signal to students how they should work, collaborate, and distribute their efforts.

Conclusion: The Making of the Future

Every few decades, one idea, practice, or place captures the hearts and minds of progressive educators: Maria Montessori's method, John Dewey's school at the University of Chicago, Paulo Freire's experiment in Angicos, or Seymour Papert's Logo programming language. To claim that education "never changes" and that all of those innovations were passing fads or failures is inaccurate. The influence of these scholars and ideas is quite present in today's schools. Montessori schools exist in dozens of countries; Dewey and Freire are avidly read all over the world and even have research institutes devoted to their work. Papert's Logo was the origin of Scratch, the most popular programming language for children, and the inspiration of one of the most popular robotics toys on the market—the LEGO Mindstorms kit—used by thousands of schools. If it is acceptable to think today that children should be protagonists in their own learning, pursue their intellectual interests, and not spend hours memorizing facts, it is because generations of educational researchers have studied and advocated for these new practices.

However, the implementation of those innovations has been the real obstacle: How do we make it happen at scale, in both public and private systems, with their wide variety of budgets and legislation? One reason for this difficulty is that the technological tools, ideas, and social relevance have never been completely aligned. In Dewey's time, for example, the technologies to make his vision possible were not available yet. In Papert's time, there was considerable skepticism against children programming or creating robots. The wide acceptance of the Maker Movement in educational and policy circles might be a signal of a rare and timely alignment. We are living in a time when the technological tools are inexpensive, the progressive ideas and research have been well developed and established for years, and society has finally embraced student-centered pedagogies.

Perhaps, not by coincidence, the vast majority of makerspaces and FabLabs were created spontaneously in schools by practitioners, rather than concocted in academic, government, or corporate offices—it is an organic movement that grows from the bottom up, and depends much less on centralized efforts than previous attempts to change schools did.

Yet the tide can abruptly turn if the different communities involved in the Maker Movement do not prioritize research, equity, pluralism, and powerful ideas. While hundreds of schools have makerspaces today, they are concentrated in affluent schools and suburban areas. Those schools possess the most valuable currency in times of educational change: flexibility. Rather than more equipment funding, what is increasingly setting those affluent schools apart is their freedom to experiment with more advanced, project-based pedagogies, rethink the curriculum, sometimes deviate from it, promote interdisciplinary projects, and provide proper facilitation and support. To truly make a difference, these opportunities need to be present in *all* schools rather than just the most affluent ones.

We have the once-in-a-generation opportunity to establish something truly new in schools, make it sustainable, and deeply integrate it into the school day. We have the opportunity to give to millions of children a new entry point into the world of knowledge and science, and give them a much richer palette of expressive media for their ideas to come true, creating much more sophisticated "objects to think with."

Getting to this point—where something as progressive as the Maker Movement is bound to be massively present in educational systems worldwide—took the work of several generations of scholars, practitioners, and students. By a fortunate turn of chance, hackers, engineers, publishers, entrepreneurs, and technology visionaries took those ideas to the next level and made them a worldwide phenomenon. However, now, it is time for educators to take back the driver seat. The Maker Movement will only survive and fulfill its educational goals if the decisions are being made by teachers, education researchers, and education policy makers—professionals that really understand schools, teaching, and learning. This does not mean that we will sever our connections with all the other stakeholders and partners in the movement, but it means that we need to reclaim our role as the intellectual compass of the movement.

Let's not wait another generation for such an opportunity.

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