MAKER-CENTERED LEARNING AND THE DEVELOPMENT OF SELF: PRELIMINARY FINDINGS OF THE AGENCY *BY* DESIGN PROJECT

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In the past five years, hundreds of articles have appeared in magazines, journals and books extolling the virtues of the maker movement. Advocates praise the possibilities and potentials of making to ignite a new system of democratized manufacturing, to inspire a shift from a consumer to producer mentality, and to instill within the next generation of young people a renewed interest in the science, technology, engineering, and mathematics (STEM) professions. Communities are taking note: downtowns are developing makerspaces and fablabs; municipal libraries and churches are presenting opportunities to make, hack, tweak, iterate, and invent; and employers are wooing prospective employees by celebrating their company's practices of innovation, invention, and collaboration—the hallmarks of maker culture.

The educational sector is taking note as well. Schools are building out or repurposing spaces for maker-centered activities. Shop classes that were once de-commissioned and cut from curricula are being rebranded as makerspaces and tinkering labs. Tech Ed positions are replacing Ed Techs, as schools move to embed technology teachers into their programs. Across the country educators, policy-makers, and researchers alike are beginning to investigate the tools, tricks, and trends of the maker trade.

Through a generous three-year grant from the Abundance Foundation, the Agency *by* Design (A*b*D) initiative at Project Zero, a research organization at the Harvard Graduate School of Education, began to investigate the promises, practices, and pedagogies of maker-centered learning. Over the last two years we have simultaneously pursued three strands of work: 1) a review of pertinent literature; 2) interviews and site visits with leading maker educators; and 3) action research and concept development. We're now commencing our third year of work. Our

active data collection stage is over. We are well into an analysis of our results and are currently preparing several publications—including a book. However, in the put-it-out-there-and-tweak-as-you-go spirit of the maker movement, we offer this white paper as a preliminary glimpse at the emergent findings from our work, and as an open invitation to the maker educator community to continue to connect with us and share ideas.

In the pages ahead, we offer a strand-by-strand overview of our developing work, and conclude by presenting the "big take away" from our research and by making suggestions for policymakers, educators, and other stakeholders. Along the way, we identify what we consider to be the most salient benefits of maker-centered learning for young people and, introduce some of the key concepts and resources that have emerged from our work, including the concept of *maker empowerment*, the importance of developing a *sensitivity to design,* and the *three pathways* that lead to these desired outcomes.

Strand One: Literature Review

When we began our study, the Agency *by* Design research team was naturally curious to know more about the purported benefits and outcomes associated with maker-centered learning. To do so, our team embarked upon a review of the contemporary literature supporting maker-centered learning. We began by turning to the popular press, where hundreds of short articles had been printed over the past five years heralding the benefits of the maker movement. To increase our understanding of the promises being made around maker-centered experiences, we initially identified 200 popular press articles published between 2008 and 2013, eventually focusing our inquiry on 44 articles that more specifically addressed the effects of the maker movement (Ryan, under review). What we found was that, when maker-centered opportunities were discussed, they were largely being positioned as part of an economic conversation. The majority of the articles we reviewed placed making at the center of discussions around a future with a more democratized economy, industry, and manufacturing (*Economist*, 2011; Royte, 2013; Walker, 2012).

Innovation, invention, prosumerism and creativity have become the buzz words of the movement, with the economic driver extending beyond popular media, surfacing in trade publications such as the *Wall Street Journal* and books such as Chris Anderson's *Makers: The New Industrial Revolution:*

> What started as a cultural shift—a fascination with new digital prototyping tools and a desire to extend the online phenomenon into real-world impact—is now starting to become an economic shift, too. The Maker Movement is beginning to change the face of industry, as entrepreneurial instincts kick in and hobbies becomes small companies (Anderson, 2012, p.19)

Even president Obama jumped on board, noting the maker movement's potential for reinvigorating US manufacturing in his State of the Union Address (2014).

Some of the quintessential tools of the maker movement—such as 3-D printers and Arduino micro-processors—have become deeply associated with the future of manufacturing and the "new industrial revolution" (Anderson, 2012). In response, the call has gone out to train an emergent workforce to operate and innovate with these devices. Indeed, the idea that STEM education will be essential to the future success of the American economy is now a hallmark of the Obama administration's position on the top priorities for the future of American education (Obama, 2009a, 2009b). Perhaps adding urgency to this message were reports that U.S. students lag behind other countries on standardized tests of STEM subjects (Kalil, 2013; OECD, 2010), and that there is a lack of young people pursuing higher education degrees in STEM content areas (Committee on Conceptual Framework for the New K–12 Science Standards/National Research Council, 2012).

Increasingly, more academic literatures are looking beyond the economic implications of the movement. Some recent works have dug into more of the socio/intellectual potentials of making and maker-centered activities (Lang, 2013; Somerson & Hermano, 2013; Wilkinson & Petrich, 2014) and the individual and collective learning opportunities afforded through making (Gauntlett, 2011). And there are certainly authors writing from an education perspective who celebrate the more cognitive, character-building, and intellectual potentials of maker experiences (Dougherty, 2012, 2013; Honey & Kanter, 2013; Martinez & Stager, 2013; Quinn & Bell, 2013). Yet, while there is growing interest in scholarly and empirical research about the cognitive benefits of the maker movement—we share the maker-related research arena with colleagues from MIT, Stanford, Tufts, and Indiana University, to name just a few—the predominant advocacy points from the field continue to take cues from popular media, with a center of gravity being entrepreneurial and STEM skills.

Strand Two: Interviews and Site Visits

In addition to conducting a literature review, the Agency *by* Design team interviewed maker education practitioners and thought leaders working across a variety of contexts. Though we are still in the midst of fully analyzing these data, a clear picture has already begun to emerge. Overwhelmingly, the learning outcomes these educators describe have less to do with the development of skills, and more to do with the development of self and community. To be sure, our interviewees occasionally mention STEM skills, but they do so in the context of much larger outcomes.

Many of our interviewees talk about how maker experiences help students learn to pursue their own passions and become self-directed learners, proactively seeking out knowledge and resources on their own. They describe how students learn to problem solve, to iterate, to take

risks, to see failure as opportunity, and to make the most out of unexpected outcomes. They additionally talk about the distributed nature of maker-centered learning. Specifically, they talk about how students learn to build on each others' strengths and interests, to persist in difficult tasks, and to be confident of their capacity to learn new things. They talk about how students learn to learn together synchronously and asynchronously, in real as well as virtual environments, and from a wide variety of people, including their peers. Perhaps most strikingly, they talk about how students come to see themselves as capable of effecting positive change in their own lives and in their communities.

That is not to say that students don't develop technical skills along the way. But, for the educators we spoke with, technical skills and expertise are by-products in the service of the larger outcome of self-development. To focus on STEM skills and the like as the primary outcome of maker education would be to sadly miss the point—like saying that learning to cut your food with a knife and fork is the most important outcome of eating a nutritious meal. In contrast, what we have been hearing from maker practitioners on the ground is the power of maker-centered learning to help students develop a sense of personal agency, a sense of self-efficacy, and a sense of community.

Strand Three: Concept Development and Action Research

In an attempt to articulate our interviewees' best hopes about what young people might gain through maker-centered learning experiences, we developed a concept we call *maker empowerment*. This concept looks at agency through the lens of maker and aims to give a name to the self-making our interviewees described so eloquently: students' discovery of their own passions, their capacity to pursue them, and the confidence and resourcefulness developed as they learn with and from others. Maker empowerment is meant to encompass more than mere cognitive development; it includes character development. Accordingly, the concept aims to describe a kind of *disposition* that students develop—a way of being in the world—that is characterized by understanding oneself as a person of resourcefulness who can muster the wherewithal to change things through making.

From the standpoint of education, the goal of empowering students is nothing new: it is the deep rationale behind much of what we teach. We teach art, or history, or mathematics, not solely to the group of students who will go on to make their livings in these areas, but to *all* students, because we believe it is empowering for everyone to learn how to engage with the world through the lenses of these disciplines. The concept of maker empowerment aims for this same breadth. Not all students who are exposed to maker education will go on to become scientists, technology specialists, mathematicians, engineers, or carpenters. But perhaps, through high quality maker-centered learning experiences, they might all acquire a sense of maker empowerment.

Here is our working definition of maker empowerment:

> Maker empowerment: *a sensitivity to the designed dimension of objects and systems, along with the inclination and capacity to shape one's world through building, tinkering, re/designing, or hacking*.

Three distinct ideas come together to form this definition. *A sensitivity to the designed dimension of objects and systems*, a key principle of our study, points to the importance of simply noticing that many of the objects, ideas, and systems we encounter in the world—from desktops to democracy to driver education classes—are human-made designs. They are comprised of specific parts that fit together to serve a purpose (or multiple purposes), and they can be understood and analyzed from the standpoint of design. The second part of the sentence mentions both the inclination and the capacity to make (or remake) things. These two terms are separated intentionally: inclination has to do with motivation to do something; capacity has to do with skill or wherewithal to actually do it.

This three-part definition, with its emphasis on the triad of sensitivity, inclination, and capacity, extends a concept of dispositional behavior developed at Project Zero (Perkins, Jay, & Tishman, 1993; Perkins & Tishman, 2006; Perkins, Tishman, Ritchhart, Donis, Andrade, 2000; Tishman, 2001; Tishman, Jay, & Perkins, 1993) proposing that ability alone is not enough to ensure action. For example, to be called a cyclist you not only need to have the ability to ride a bicycle, but you have to be motivated to ride your bike on a regular basis, and you have to be alert to occasions to do so. Dispositional behavior occurs when these three things coalesce—the ability to do something, the motivation to do it, and the sensitivity to appropriate occasions to do it. Moreover, what the aforementioned research discovered is that the biggest bottleneck to behavior isn't a lack of motivation or skill, it's a lack of sensitivity. In other words, students often fail to develop the habits of mind we as educators aim to inculcate, not because they cannot do something, and not because they don't want to, but mainly because they do not notice opportunities to do so. In other words, they lack a *sensitivity* to notice opportunities to do things. This doesn't mean that young people's inner detection mechanisms are woefully flawed. Rather, sensitivity has everything to do with the saliency of cues in the environment.

An interest in the sensitivity dimension of maker empowerment provided a starting point for the action research strand of Agency *by* Design's work. Over the course of two years, we partnered with educators from six public, private, and charter schools in Oakland, California, who taught pre-K through twelfth grades, and were based in disciplines ranging from general education and literacy to art and technology. None was primarily a "maker educator," but all were willing to learn more about the possibilities of maker-centered learning within their curriculum. Working with these educators, we developed a conceptual framework that names three practices which help cultivate a sensitivity to the designed dimension of our world: *looking closely* (noticing

nuances and intricacies of object and system design), *exploring complexity* (considering the people, interactions, and motivations associated with objects and systems), and *finding opportunity* (noticing if and where there are opportunities for imagining how an object or system might be otherwise).

For an illustration of these practices, let's return to our cyclist. Initially motivated by the joy of riding, through ongoing observation and experience, our cyclist slowly builds an appreciation for the design of the object (her bike) as well as the associated systems connected to bike riding. She interacts with the numerous components of her bike and begins to consider it as a whole as well as a myriad of subsystems: gears, brakes, tires and wheels, and a variety of safety features. Complexity ramps up as she investigates the many external systems she interacts with each time she rides: bike lanes, traffic patterns, pedestrian crossings, etc. She makes informed observations about how her bike and biking systems are functioning, and finally begins to recognize opportunities for redesign—of the bike itself or the many internal or external systems within which her bike is situated. Our cyclist has exercised *sensitivity*: she recognizes the design cues in her environment, and notices opportunity for change.

How can we help students develop what we call a *sensitivity to design?* The practices of looking closely, exploring complexity, and finding opportunity provide a useful framework; however, simply naming these capacities isn't enough. They need to be accompanied by practices that weave attention to design into the daily fabric of learning. How can sensitivity to design become a "routine" practice in the classroom? To answer this question, we again look to a concept developed at Project Zero—the concept of *thinking routines*.

Thinking routines are short, widely-applicable, easy-to-use strategies that can be used by students across contexts and subject areas. Their purpose is to habituate and make visible certain kinds of thinking (Ritchhart, Palmer, Church, & Tishman, 2006).). To navigate through the practices of looking closely, exploring complexity, and finding opportunity, the Agency *by* Design team—with help from its action research partners—developed maker/design-focused thinking routines to provide teachers and learners with specific thinking moves they might make along the way. As just one example, a routine called Parts, Purposes, Complexities helps students enter the practices of looking closely and exploring complexity. The simple structure begins with the learner's observations and ideas about an object or system, as they are asked to respond to the prompt, "*what are the parts?"* Learners are next prompted to construct evidence based interpretations and explanations in order to respond to, *"what are its purposes? or what are the purposes of the parts?"* With the open ended final question, *"what are its complexities?"* learners are invited to ask questions, seek out problems, notice relationships, and challenge previously held assumptions. The language of these routines is accessible and their structure is spare in order to help learners notice and arrive at new understandings about the designed world. To learn more about the thinking routines connected to the three practices for developing a

sensitivity to design, and for classroom-friendly educator resources, please see the Agency by Design website.

The Big Takeaway

Students learn a tremendous amount through maker-centered learning experiences, whether these experiences take place inside or outside of makerspaces and tinkering studios. There is no doubt that students learn new skills and technologies as they build, tinker, re/design, and hack, especially when they do these things together. However, the most important benefits of maker education are neither STEM skills nor technical preparation for the next industrial revolution. Though these benefits may accrue along the way, the most salient benefits of maker-centered learning for young people have to do with developing a sense of self and a sense of community that empower them to engage with and shape the designed dimension of their world.

Implications for Policymakers, Funders, and other Stakeholders

The maker movement has energy and momentum. This is an important moment for policymakers, funders, and others interested in supporting an alternative narrative for education that focuses on deep and prolonged experiences of learning through making, and results in students developing a sense of agency, self-efficacy, and community. From the perspective of our work at the present moment, here are some things the Agency *by* design team believes policy makers, funders, and other education change-makers can do to help things along:

- Support efforts to document and assess maker-centered learning and teaching, through the development of frameworks and assessment practices that capture the most compelling benefits of maker education. These frameworks and practices will not only serve as assessment tools, they will also be tremendously useful to those interested in creating and supporting rich and meaningful maker-centered learning experiences in a variety of contexts, including maker spaces, tinkering labs, shop classes, libraries, museums, and everyday classrooms.

- A key tenet of the maker movement is the idea that making is enhanced by the contributions of individuals and groups who possess a variety of skills and experiences. Nonetheless, a quick glance at the maker community suggests that more needs to be done to bring greater racial, gender, and socio-economic diversity to this sector. We therefore suggest that policy-makers, educators, and other change makers support efforts to make maker-centered learning experiences more inclusive and accessible to a wider and more diverse array of young people and communities.

- Support professional development experiences for educators that help them learn about the real benefits of maker education *and* help them develop a sense of maker empowerment for themselves.

- Continue to support research that looks at maker experiences through a learning lens. The Agency *by* Design project has only scratched the surface: There is much more to learn about how young people can—and do—develop a sense of agency and a sense of community through maker-centered learning experiences.

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