Making Space in the Makerspace: Building a Mixed-Ability Maker Culture

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ABSTRACT

The Maker Movement, while heralded for popularizing DIY culture, has recently drawn some critiques for the ways in which the mass-marketing of maker culture partially obscures the social, cultural, and political implications of making. A number of educators, designers, and researchers are actively studying alternative approaches to maker culture, and specifically developing ways to broaden participation in DIY activities for socio-economically, racially, and ethnically diverse youth. To complement that initiative, this paper proposes the notion of a "mixed-ability maker culture" as one approach to realizing a more equitable, ethical, and sustainable culture of making that also encompasses youth with disabilities. As an illustration of how mixed-ability maker culture might shape interaction design for children with and without disabilities, this paper describes a modified formulation of Resnick and Silverman's popular metaphorical approach to designing children's creative thinking tools, and its application to DIY tools, activities, and pedagogy.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces; K.4.2: [**Computers and Society**]: Social Issues – *Assistive technologies for persons with disabilities*

General Terms

Design, Human Factors.

Keywords

Accessibility, children, disability, DIY, hacking, makerspaces.

1. INTRODUCTION

As a contemporary embodiment of the ethos of do-it-yourself (DIY) projects and the creative practices of hacking [1, 2], "making" involves the hands-on creation of material things that require of the maker a blend of both physical manufacturing and technical digital skills [3, 4]. "Maker culture," if it can be characterized as a single entity, is an important part of making [5]. Maker culture consists of the behaviors, values, and artifacts commonly shared among those who identify as makers. Online and offline peer production, resource sharing, and collectively organized makerspaces shape the social norms around making. Partly as a result of publications such as *Make* magazine (which effectively branded the term "make"), websites such as Instructables.com, and events such as Maker Faire, some have described the growing commercial popularity of making as a "Maker Movement" [6].

While credited for leading a popular renaissance of DIY culture, the Maker Movement has recently been criticized for the ways in which the mass-marketing of maker culture partially obscures the social, cultural, and political implications of making [7, 8]. *Make* and Intel recently commissioned a survey to determine the make-up of the Maker Movement. Taking a random sample drawn from Maker Faire exhibitors and *Make* magazine and newsletter subscribers, the survey found that 8 in 10 makers are male, their median household income is $106,000, and 80% have a post-graduate education [9]. While the Maker Movement may not characterize itself as political, there are clearly demographic disparities between those who self-identify as markers and the population at large.

The above survey also noted that 4 out of 10 respondents indicated having children under the age of 17 living in the household. There is a strong family- and child-friendly focus to the Maker Movement. This complements an emerging initiative to incorporate DIY practices into formal and informal education [10]. A number of educators, designers, and researchers are rightly concerned then with a possible "participation gap" that may exist for children with different backgrounds within maker culture. Jenkins et al. describe the participation gap as "the unequal access to the opportunities, experiences, skills, and knowledge that will prepare youth for full participation in the world of tomorrow" [11]. With the financial support of the MacArthur Foundation, various teams studying digital media and learning are actively developing ways to broaden participation in DIY activities for socio-economically, racially, and ethnically diverse youth [12]. To complement that initiative, this paper proposes the notion of a "mixed-ability maker culture."

2. MIXED-ABILITY MAKER CULTURE

By "mixed-ability maker culture," I mean a collaborative culture within which people with and without disabilities can co-exist and co-create as they work to maximize and develop their own skills. This includes making useful things *for* people with disabilities, as well as getting people with disabilities involved *in* making. The focus on "mixed-ability" draws on work from the interdisciplinary field of disability studies in education, which seeks to confront notions of diversity in learning that exclude disability, as well as call into question clear boundaries between disabled and non-disabled youth [13]. A mixed-ability maker culture is one that embraces the differences not only between people who do and do

IDC'13, June 24–27, 2013, New York, NY, USA.

not identify as having a disability, but also the wide range of differences that exist among people with disabilities.

Historically, there has been a great deal of hope around new technologies being an equalizer for youth with disabilities [14]. Maker culture, and specifically 3D printing, also has huge implications for development of new assistive technologies. Customized, lightweight, and easily replaceable systems open up new possibilities for mobility and expression [15]. At the same time, youth with disabilities are rarely portrayed as cultural producers within creative computing communities [16]. People with disabilities are also largely under-represented in science, technology, engineering, and math (STEM) fields [17]. Youth with disabilities potentially face an increasing divide in high-tech careers if also excluded from making and makerspaces, which are increasingly oriented towards STEM learning [10]. Disability also intersects with race, ethnicity, income, gender, and sexuality in various ways. Those complex intersections and the challenges they pose for young people and their participation in making merits more attention.

This participation gap is detrimental not just to children with disabilities, but also to the larger world potentially denied access to the things these young people know, the way they know them, and the things they may build. The irony is that the technological world as we know it has actually been fundamentally shaped by youth with disabilities who found their way around complex systems. For example, in the 1950s, blind youth were among the first to discover that they could hack the telephone system using perfect pitch to trigger automated switches, a phenomenon known as "phone phreaking" [18]. They became central figures in the history of hacking, and have been directly cited by Apple founder Steve Jobs and Steve Wozniak as highly influential [19].

Analyzing maker culture requires us not only to look closer at the materials, techniques, and activities that constitute making, but also the social context that surrounds participation in and exclusion from maker culture. By making space for diverse populations in mixed-ability maker culture, we also create room for new configurations of making and novel directions for the growing maker movement – one that respects the ways in which people with disabilities have historically expressed themselves and shaped the world through making and hacking.

Within the last decade, the field perhaps most active at the intersection of making, learning, and disability has been that of the area of interaction design and children [20, 21, 22]. The field itself draws upon research in engineering, human-computer interaction, computer science, learning sciences, developmental psychology, communication, and education. The next section of this paper serves as an illustration of how mixed-ability maker culture could shape inclusive principles that guide continued work in the area of interaction design for children with and without disabilities. It describes how a modified formulation [23] of Resnick and Silverman's popular metaphorical approach to designing children's creative computational tools [24] might apply specifically to DIY tools, activities, and pedagogy within mixed-ability maker culture.

3. FLOORS, CEILINGS, AND WALLS

Based on their experiences in designing computational construction kits (e.g. Scratch, Programmable LEGO Bricks), Resnick and Silverman describe an approach to diversifying children's range of possibilities with creative thinking tools. Designers should equip such technologies, they explain, with the following three specifications: 1) *low floors* (easy to start, short learning curve for novices); 2) *high ceilings* (can accommodate increasingly complex projects); and 3) *wide walls* (many paths for self-expression, depending on a child's interests and passions). In developing these design principles, Resnick and Silverman considered "diversity of outcomes as an indicator of success," which means that a successful system is one useful to diverse children from different backgrounds with various learning styles.

Considering the heterogeneous population of young people with disabilities (including mobility, sensory, cognitive, speech-language, and intellectual disabilities), Resnick and Silverman's framework is a particularly useful starting point for approaching the design of DIY tools and activities for a mixed-ability audience. Their framework emphasizes that children start projects having had different life experiences, grow up in unique contexts, and have a wide range of possible learning outcomes.

When employed as a framework for designing accessible maker tools, activities, strategies, and spaces, *low floors*, *high ceilings*, and *wide walls* take on nuanced meanings. When applied to the domain of youth with disabilities, Alper, Hourcade and Gilutz contend that specific dimensions need to be taken into consideration: low floors *with ramps* (for participation), high ceilings and *tall ladders* (for expression), and wide walls and *frames of interests* (for personalization) [23].

Besides offering an alternative take on those three dimensions, Alper et al. also suggest adding a fourth specification to Resnick and Silverman's framework: *reinforced corners*. By this, the authors mean supporting the creative pursuits of young people who may do best at the ground floor, the highest reaches of the ceiling, and/or the widest parts of the wall depending on the context. The following subsections describe this modified framework, and offer ways in which the utilization of this approach might support mixed-ability maker culture.

3.1 Low Floors with Ramps

For a fabrication tool to have a "low floor," children with relatively little experience should be able to learn the basics without extensive prior knowledge. Materials such as MaKey MaKey, which turns any object that conducts electricity into a computer controller, are powerful because they are easy to get started with and easy to continue to experiment with [25]. MaKey MaKey has in particular created new creative possibilities for children with disabilities. Due to an outpouring of posts from people using the kit to create custom assistive technology, the MaKey MaKey online forum administrators created a "Hackcess" board for parents, teachers, and caregivers to share ideas [26].

However low a "floor" may be though, without a "ramp" or other types of modifications, an entire system or kit may be out of reach for certain populations of children. For example, Bhargava adapted Cricket programmable bricks for use by children who are blind or visually impaired [27]. He integrated tactile- and auditory-based interactions into the BricketLOGO programming system, effectively building a "ramp" onto Cricket's "low floor." Low floors with ramps are a significant design consideration for maker tools that can be used by youth with disabilities.

Ramps are not solely about enabling physical access to simple maker tools. They are also about extending invitations for children with disabilities to participate alongside their peers, teachers, and families in mixed-ability makerspaces. Makerspaces, an outgrowth of the ethos of hackerspaces, are grassroots-oriented, face-to-face collectives for creative tinkering and production. They are akin to "Computer Clubhouses" [28] and "Fab Labs" [29], though often have more flexibility in terms of organization and programming. Examples of mixed-ability makerspaces include DIYAbility (http://www.diyability.org/) in New York, and the Assistive Design Center at the Perkins School for the Blind in Watertown, MA (http://www.perkins.org/inside-perkins/assistive-device-center/).

Mixed-ability makerspaces exemplify what Jenkins et al. describe as "participatory culture," defined as "a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices" [11]. The participation gap within maker culture concerns more than just tools, but also mentorship from those expert in fabrication, design, and engineering. In a mixed-ability maker culture, DIY tools, kits, and activities should not only be easy enough for a novice to start, but also the communal spaces for making (including makerspaces, Maker Faires, and online discussion boards) should also be welcoming towards youth with disabilities, as well as their family members, therapists, and aides.

3.2 High Ceilings and Tall Ladders

According to Resnick and Silverman, technologies with "high ceilings" enable a child to pursue increasingly sophisticated projects. Examples of creative maker tools with high ceilings include laser cutters and 3D printers. While these rapid prototyping tools often require the assistance of an adult, they allow young people (and the young at heart) to produce items such as the Free Universal Construction Kit (http://fffff.at/free-universal-construction-kit/), a set of toy adapters that allow for interoperability between popular construction toy sets such as LEGO, K'Nex, and Tinker Toys. Digital models for the Kit can be downloaded and reproduced on a 3D printer. The high ceilings of 3D printers make it possible for young people to digitally design gradually intricate objects, or in the case of the Kit, physically build increasingly complex projects out of their toys.

Tools with high ceilings, such as 3D printers, have their drawbacks though, particularly for young people with disabilities. To reach the highest ceilings of computational crafting, children with disabilities may require "tall ladders," or technical, physical, and social scaffolds that let every child progress at their own pace and excel to the best of their abilities. For example, while the automation of computer numeric controlled 3D printers means that there are little physical requirements for operation, designing 3D models is more complicated [15]. There are a growing number of computer programs such as Google's SketchUp that allow non-engineers to construct 3D models, the kind of "tall ladder" that might be necessary for youth of all abilities to pursue complex creative computing projects.

3.3 Wide Walls and Frames of Interest

"Wide walls" are key to personalization and individuality in using DIY tools. They allow for as broad a range of creative possibilities as children's interests and passions are varied. One example of a technological platform with wide walls is the Scratch programming environment. Scratch supports the creation of rich web-based media content, and a community site whereby users can download source code and modify existing content [30].

The design principle of wide walls applies to mixed-ability maker culture in two main ways. First, maker tools and activities with wide walls can encompass the vast range of variability within children with disabilities as a population or within specific disabilities. Scratch, for example, offers youth with cognitive disabilities unique opportunities for communication and artistic expression [16]. A child with a disability might also behave significantly differently based on the environment he or she is in (e.g., home, classroom, after school, therapy session) or the medications he or she is taking.

Second, there is the possibility that an individual child with a disability could grow frustrated with a project that emphasizes broad interests. For example, a young person with autism spectrum condition (ASC) might favor focusing in on a highly specific area, or *frame of interest*, instead of exploring the breadth of possibilities with a DIY project. Many children with ASC display an attraction to technology and some exhibit exceptional talent. They may have difficulty exploring the wide walls of creative interactive technologies though. Young people with pronounced ASC often favor repetitive play patterns with a few select devices or toys of the same theme. Mixed-ability maker culture supports children's individuality, even when that personalization might require educators to provide DIY tools and design activities that are highly routinized and singularly focused.

4. REINFORCED CORNERS

In addition to the three specifications above, Alper, Hourcade, and Gilutz propose adding a fourth component to Resnick and Silverman's framework: *reinforced corners*. At the points where the widest walls, lowest floors, or highest ceilings meet, exceptional children may need additional and unique types of support. For example, gifted students with disabilities are particularly at risk for growing frustrated or bored with DIY activities if their needs – intellectual, social, physical, and emotional – are not well understood or identified. Ample support and attention needs to be built into maker activities and programs for youth with disabilities with complex needs.

People with disabilities have the capacity to do sophisticated, highly technical and creative design work but may need specific adaptations. Increasing participation in DIY tools and activities requires not only making fabrication materials more accessible, but also widening societal perception of what "hands-on" making means, shifting perceptions to include people whose hands may make brilliant things in different ways. Mixed-ability maker culture recognizes that different bodies produce different types of knowledge. Reinforced corners support exceptional children who may thrive where the lowest floors, widest walls, and highest ceilings intersect.

5. CONCLUSION

Mixed-ability maker culture encourages people with and without disabilities to co-exist and co-create as they work to maximize and develop their own skills as makers. As an example of how mixed-ability maker culture might inform future work in interaction design for children with and without disabilities, this paper described how a modified formulation of Resnick and Silverman's "low floors, high ceilings, wide walls" approach to designing children's creative thinking tools can apply to mixed-ability DIY tools, activities, and pedagogy. A mixed-ability maker culture is one committed to an equitable, ethical, and sustainable democratic future. Looking at maker culture though the lens of mixed-ability requires us to look closer not only at the materiality of making, but also the social context that surrounds participation in and exclusion from maker culture.

6. ACKNOWLEDGMENTS

Thanks to Henry Jenkins and Andrew Schrock of the Annenberg School for Communication & Journalism at the University of Southern California for their thoughtful input and advice.

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