



HOT TOPIC II

Makerspaces

Supporting Creativity and Innovation by Design

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Key Take-Aways

- Makerspaces are sites for experimentation around ideas at the intersection of creative production and next-generation tools.
- The physical design of makerspaces encourages creativity by embracing key principles of mobility, diversity, and openness.
- Tinkering, a central practice cultivated in makerspaces, helps makers to better adapt to the needs of the 21st century by prizing creativity over optimization in the iterative design process.
- Making is a unique confluence of high- and low-tech tools and materials, resulting in new domains of creativity ripe for future study.
- Maker culture contains several examples of toolkits developed to expand creative maker possibilities, and of makerspaces used to create new economies of products and ideas.

Making and Makerspaces: What Are They, and Why Are They Popping Up?

Creative ideas, open experimentation, and interest-driven pursuits are but some of the core principles of today's Maker Movement. Made popular in the early 2000s through *Make* magazine, online communities like Instructables and Etsy, and public events like Maker Faires, this grassroots movement inspires do-it-yourself (DIY) production across a host of domains, ranging from advanced robotics to woodworking, and cooking to textile crafts (Dougherty, 2013). The popularity of the Maker Movement as a cultural phenomenon is fueled by its unique mixing of high- and low-tech tools and materials (e.g., cutting-edge technologies like 3D printers, laser cutters, and Arduino robotics, and traditional tools and materials), and the old and new (e.g., mid-century American DIY culture and future-forward creative products). These traits, alongside the rise of the internet making the sourcing of materials and sharing of ideas widespread, have created an expansive environment where peer-to-peer learning can turn DIY creative production into social connection, self-sufficiency, and future entrepreneurial opportunity.

Over the last decade, the Maker Movement has taken the education landscape by storm (Peppler & Bender, 2013). Makerspaces and FabLabs are cropping up in schools, universities, community centers, and libraries, with each of these spaces finding their own ways of incorporating making into curricula. As with any educational innovation, questions arise around the pedagogical benefits of making as a discipline, with many educators looking to research to provide answers about how makerspaces afford different learning possibilities from previous conceptions of hands-on learning and other similar lab-based experiences. While much of the discussion around the Maker Movement's potential for education concerns how it can be leveraged to inspire innovation and interest in STEM, there are reasons to further investigate the kinds of creative production that transpire in makerspaces to better understand making as a new domain unto itself and studied in its own right.

Current research on creativity and innovation within the Maker Movement can be classified into three categories: (1) understanding makerspaces as creative communities, both as physical spaces and online communities aimed to encourage creativity, (2) understanding making as a unique confluence of innovation between high- and low-tech tools and production, resulting in new domains of creativity, and (3) exploring entrepreneurship as part of the creative process in many communities of makers. This Hot Topic seeks to introduce the larger Maker Movement to readers interested in creativity, innovation, and entrepreneurship, and highlight areas for future research.

Makerspaces: Designing to Encourage Creativity and Innovation

Often situated in physical spaces such as schools, museums, libraries, community centers, and church basements, makerspaces provide users with professional-grade tools and community expertise for the purposes of pursuing interest-driven projects. Some makerspaces are free to use, while others require paid membership. While the notion of a makerspace may be new, the spaces themselves recall home economics or shop classes of the past, featuring workbenches, soldering irons, screwdrivers, and sewing machines. Situated among these traditional workspaces, however, are a range of cutting-edge technologies, such as 3D printers, computer numerical control (CNC) mills, Arduino electronics, and Raspberry Pi, that augment traditional work products in previously unimaginable ways. Makerspaces are designed to encourage exploration, invention, and whimsical experimentation. As such, users feel that a makerspace is an environment in which seemingly anything can be created. Through the combination of interest-driven exploration, just-in-time support, next-generation tools, and an emphasis on creativity and experimentation, makerspaces represent for many an opportunity to re-envision our learning environments, often seen as the sole domain of schools, in bold and future-forward ways.

The design of physical space (e.g., the designed aspects of makerspaces that lead to better creative outcomes, how people can seek to recreate these outcomes in their own spaces) plays a large role in the creative possibilities of each makerspace. A survey of makerspaces across the United States encourages us to think about how makerspaces are purposefully designed to inspire creativity (Peppler et al., 2018). At least three key principles for encouraging creativity in makerspaces have been identified, including openness, mobility, and diversity. Standing in stark contrast to the ways in which traditional science labs are created (e.g., the predominance of closed and locked cabinets to store potentially harmful tools and materials), makerspaces are designed to be open and to have nearly all tools and materials within view. Along these lines, open cupboards without doors, pegboards, and glass walls are frequently found in makerspaces. As many educators and makerspace administrators will attest, being able to see the full range of possible tools and materials leads to greater creativity and innovation in these spaces. In short, if you can't see it, how can you possibly imagine how to use it?

Second, makerspaces are designed to provide diversity in the tools and materials offered to users. In doing so, makerspaces invite individuals from a range of cultures, backgrounds, and demographics to design and innovate. Seeing tools, materials, and sample projects that reflect an individual's identity and background is a way to communicate belonging. This stands in contrast

to high-tech digital fabrication centers that focus solely on having access to cutting-edge industrial tools, which tacitly communicate upper-class, white males as the intended users of the space. Lastly, makerspaces embrace a spirit of mobility to encourage both the development of the space over time and accessibility for a wide range of makers with a variety of needs, including wheelchair access and standing desks. This is similarly important to embracing divergence of perspective and insight in the creative outcomes of the makerspaces.

Furthermore, it's not just how these spaces are designed that makes makerspaces ripe for encouraging creativity – the secret also lies in the unique processes for design encouraged in these spaces. Scholars and practitioners have centered on cultivating a process of “tinkering” as embodying work to illuminate unique processes for creativity that makerspaces seek to encourage. Tinkering is “characterized by a playful, experimental, iterative style of engagement, in which makers are continually reassessing their goals, exploring new paths, and imagining new possibilities” (Resnick & Rosenbaum, 2013, p. 164). While undervalued in traditional educational settings, tinkering stands in opposition to planning and other step-by-step approaches to design more commonly seen in approaches to planning writing, solving mathematical equations, or in engineering construction (e.g., in LEGO instructions or in design challenges that have an explicit goal, such as a bridge designed to hold 5 pounds). Instead, tinkering starts without a goal and is seen as a bottom-up and unplanned approach to experimenting with materials. Tinkerers explore and try new things, whereas planners are dependent on calculations and rules. In this way, tinkering prizes creativity over optimization in the design process that arguably helps makers to better adapt to the changing needs of the 21st century through iterative adaptation.

Making and Sharing in Online Communities

Making extends far beyond the boundaries of a physical space, given that making and sharing are integrally linked activities in the Maker Movement. Online communities of makers exist to share both their products and more frequently the processes used to make things. Popular online communities, like Instructables or Ravelry, serve both to showcase the work of exceptional makers around the world as well as extend their processes to others in the form of user-generated tutorials. Such online communities, centered around peer-to-peer learning and shared interests, provide new makers with the know-how to make practically anything.

Importantly for research on creativity, these online communities play a role in how new domains emerge and evolve, where novices and experts assess

creative works based on their previous experiences and preferences. While traditionally creative domains have been guarded by a select few (i.e., experts in the field, such as curators, publishers, or critics), the creation of a “sharing economy” (Shore, 2014) around making democratizes the curatorial aspects of creative domains by enabling any maker to be an active voice of the field, influencing the exposure of certain makes, innovations, and learning opportunities through comments, shares, and rating systems (Phonethibsavads et al., 2020). These online efforts focused on sharing assets or inspirations in order to enable production, rather than consumption, set apart online maker communities from other similar affinity spaces fueled by similar social media mechanisms.

In this way, assessing creativity in today’s Maker Movement can be understood using a sociocultural lens, where makers build upon culturally valued practices and designs to introduce variations into the domain (Csikszentmihalyi, 1988). Variations deemed valuable by the field then become part of the domain’s evolving conventions. As such, the mutual influence between creators and audiences (who are, in most cases, fellow makers) entails that colleagues and domain norms are essential to the realization of individual creativity. Such a view emphasizes the dialogue that transpires between makers and their audience (in the form of instructional writing, e.g., tutorials or the online “Instructables”) and the feedback they receive from fellow makers in order to communicate an appreciation of the constraints they are augmenting or violating while producing a creative contribution. Toward this end, as social media changes the landscape of how ideas spread and are appropriated within a field – a tricky concept in online maker communities, as much of the content online is designed for the audience to recreate what is being shown – what constitutes creativity is also in flux. The expansion of making from a solitary act of production completed within a discrete space to a more entwined interplay between tutorial creator, maker, online audience, and (if the project is in service of a larger entrepreneurial venture) customer fundamentally changes the nature of how we view and assess creativity, calling into question who constitutes the field, and expanding the methodologies we can use to investigate creativity.

E-Textiles and Making Other New Domains of Creativity

Another avenue in which to pursue new creative possibilities of making lies in the frequent cross-pollination between high- and low-tech tools and materials in maker culture. Makerspaces typically situate high-tech innovations

alongside traditional fabrication tools in addition to a varied collection of crafting supplies, including yarn, cotton balls, and fabrics. More than simply engendering hybridized practices through the fabrication of mixed-material projects, this assemblage of materials, and their histories of use, have been shown to have a tremendous impact on who feels invited to invent in today's makerspaces, thus opening the door to new types of projects, perspectives, and creative domains.

One prominent example of this intersection of high- and low-tech is e-textiles, programmable garments that employ wearable microcontrollers, conductive thread, and a range of sensors and actuators to create interactive garments, assistive devices embedded in clothing, health monitoring devices, and more (Buechley, 2006). E-textiles garnered attention within education research through the invention of the LilyPad Arduino, a powerful electronic microcontroller toolkit that made the making of e-textiles more accessible to a general audience (Buechley et al., 2008). Through this innovation and the entrepreneurial success of this toolkit via a popular online vendor of new materials, SparkFun, a new domain quickly arose. This domain is arguably the first high-tech domain to be dominated by female producers and designers (Buechley et al., 2013). Furthermore, research demonstrates that this engagement with this new domain reformulates a variety of learning outcomes, including conceptual understanding of basic circuitry concepts such as current flow, polarity, and connections, as well as artistic outcomes of expression and design, operating fundamentally differently from how technology-rich and crafting fields operate (Peppler, 2016). Thus, such new tools and materials created in makerspaces open up new creative domains with tremendous implications for creativity and society.

While e-textiles and the commercial success of the LilyPad Arduino represent just one avenue where the Maker Movement has led to new creative domains, there are a growing number of similar cycles of creativity, innovation, and entrepreneurship similar to what Dino describes in the larger Value-Adding Ecosystem model (2015). These examples include other commercial successes like Squishy Circuits (i.e., a circuitry toolkit that merges electronics and Play-Doh), Chibitronics (a paper and sticker-based circuitry kit), and LittleBits (a kit of modular electronics that snap together with magnets), among many other start-ups that have spun out of the Maker Movement, and in return supply maker culture with new tools and materials for creativity and innovation. In short, as we introduce materials, we introduce new creative domains. As new domains emerge, this raises questions around the nature of creativity in these domains, and subsequently, how such new creative domains compare to historic domains in the arts or other areas.

Making, Entrepreneurship and the Future of Work

There are many instances of making and entrepreneurship that extend beyond new start-ups to selling the creative products, whether it be on popular online marketplaces like Etsy or local marketplaces like farmers' markets. However, the most exciting examples show that when making is done right, it not only builds an object, it builds a community. One example from Madison, Wisconsin includes DreamBikes, which strengthens the local community by recycling bikes. DreamBikes serves the historically Black community on the north side by collecting used bicycles, refurbishing them, and reselling them. This nonprofit organization is staffed by teens, who get paid to learn essential small business skills (like sales and staff management) in addition to technical skills like bicycle construction and maintenance. DreamBikes teaches youth that building and engineering are not just decontextualized skills that one uses to work for someone else; rather, developing engineering skills enables them to give back to their community.

Given the ties between making and entrepreneurship, the field is ripe with opportunity for employers, researchers, and policymakers to leverage this potential as on-ramps into entrepreneurship, as well as a host of technology-focused careers, in which women and people of color remain underrepresented.

Conclusion

The introduction of makerspaces into schools and community settings a decade ago produced a number of promises about the future of creativity, innovation, and entrepreneurship. Makerspaces themselves serve as a model for the design of both creative spaces and creative communities with natural ties to innovation and entrepreneurship through their dedication to tinkering, making, sharing, and iterating upon creative products. The emphasis on having access to a wide array of physical tools and materials and a communal space for design seems to be a key driver of creativity in these spaces. Furthermore, these spaces move away from planned activities with specific design goals toward more open tinkering, experimentation with materials, that hints at new design processes that can be embraced to promote creativity in other settings as well. Researchers interested in creativity also have a dizzying array of new creative domains and stances toward entrepreneurship to explore in these settings. In sum, makerspaces serve as excellent incubators for teaching and learning. Along the way, they provide us with opportunities to form new

understandings of the creative process, as well as inspiring the designs of other innovation-rich settings, programs, and approaches to the workplace.

Recommendations for Additional Resources

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