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The value of a makerspace: cultural (re-)production and the making of a city

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ABSTRACT

Coming to prominence in the early 2000s, makerspaces have become a popular strategy for community development, neighborhood vitalization and education initiatives. However, challenges in defining and communicating the value of makerspaces limit their inclusion in policy and community development initiatives. This article fuses approaches from urban design, planning and cultural anthropology to outline a novel approach to understanding the value of a makerspace. We argue that makerspaces can help to (re) produce the unique culture and character of their host communities. This study surveyed 43 makerspaces in the Northeast of the United States, identifying four broad typologies categorizing how makerspaces relate to their socio-material contexts. We look to these typologies to identify commonalities and differences in the ways that makerspaces contribute to and are shaped by their host communities. Our study offers a community-centered approach to valorizing makerspaces. These findings have implications for future policy, social investment and community development initiatives.

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Introduction

The way that people and many communities relate to production is changing. Where the twentieth century witnessed a seemingly inexorable shift of industry from cities to suburbs (Rae 2003), the twenty-first century has seen the beginning of a reintegration of certain material production capacities, firms and activities back into urban environments and households. The growing prevalence of a "Makers Movement", digital and physical communities who make artifacts for pleasure, sharing their process and progress with others (Halverson and Sheridan 2014, 496), marks perhaps one of the larger shifts in contemporary relationships between people and production. Those within this movement – referred to as "Makers" - are said to redefine taken-for-granted relationships between production and consumption, becoming the designers, consumers and producers of things through the act of "making" (Tanenbaum et al. 2013). Making shares many similarities with other

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kinds of "productive leisure" (Gelber 1999) like hobbies and "Do-It-Yourself" (DIY)". In the past, DIY and hobbyist production have been predominantly framed as activities occurring within the household (Gelber 1999; Jackson 2006).[1] Making is relatively novel in terms of its rapid expansion beyond the household and into other kinds of built and social environments. Makers might be people who produce from home, but they are also likely to participate in an array of production spaces and physical and online communities.

Shared physical spaces and communities including Makerspaces, Hackerspaces and FabLabs play an important role within the contemporary Makers Movement. These spaces grant users access to a range of productive instruments and work-spaces (Richardson, Elliott, and Haylock 2013), as well as facilitating social networks and connections that enable their making. To some extent, the terms used to describe these spaces reflect the different kinds of making and production technologies encountered within them. Those spaces that self-designate as Makerspaces might facilitate any range of making activities. This is the broadest of the three categories. Hackerspaces, on the other hand can be expected to provide access to computers and the internet, as well as some limited workspace and tools. FabLabs are a "special kind" of makerspaces with a focus on (and minimum requirements relating to) digital fabrication tools (Anderson 2012). In practice, distinctions between Makerspaces, Hackerspaces, and FabLabs are subject to debate. For the purpose of this article, we use the term makerspace without capitalization to refer to this general category of facility.

Makerspaces have been celebrated for their potential to enhance educational outcomes among users (Dougherty 2016) and for enabling users to act innovatively and incubate business activity (Van Holm 2015, 2017). However, makerspace advocates and organizers encounter difficulties in articulating the value of these spaces in ways that are persuasive to policy and investment decision makers. This research departs from the above paradigms by embracing a community-centered, rather than user-oriented approach to valorizing makerspaces (Taylor, Hurley, and Connolly 2016).

We hypothesized that the social and spatial relationships between a makerspace and its host community would shape the role that a makerspace plays and its value within that community. To test this, we canvassed an array of makerspaces across the Northeast of the United States. We identified four distinct typologies of socio-spatial relations between makerspaces and their host communities. Within each typology, we found that makerspaces enabled users to, among other things, participate in and bolster the unique culture and character of a host community.

This paper is structured into the following sections. First, we review two dominant paradigms for valorizing makerspaces. We discuss some of these frameworks' key limitations and argue for greater attention towards culturally and community-oriented dynamics when qualifying the value of makerspaces. Second, we discuss the paper's aims, methodologies and limitations. Third, we discuss some common trends identified in the literature that help to understand the socio-material relationships between makerspaces and their host communities, and document how these trends were reflected in our own data. Fourth, we describe four socio-spatial typologies typifying the relationships between canvassed makerspaces and their host communities. Each typology is described in detail with the aid of a case study. The subsequent two sections discuss and summarize our findings regarding the socio-spatial relationships between makerspaces and their host communities. We conclude that our findings illustrate a novel cultural value to makerspaces; that they may offer a space and material outlet for communities to bolster and (re)produce their own locally unique character and culture.

Predominant and emerging approaches to valorizing makerspaces

The contemporary discourse on "making" was popularized by a handful of predominantly North American technologists, futurists and entrepreneurs in the mid 2000s (Anderson 2012; Dougherty 2012; Gershenfeld 2007; Hatch 2014). These early proponents shared a profound optimism regarding the ability for advances in fabrication technologies to transform the social and material nature of production: democratizing, in a sense, the means of digital production. Notions of a "Makers Movement" appeared to solidify around the launch of Make magazine (2005) and the associated Maker Faire (2006). Since this time, makerspaces have proliferated around the United States and globally, as have efforts to qualify the value associated with them.

Efforts to valorize makerspaces predominantly fall into one of two camps. The first of these identifies value in makerspaces' potential to facilitate user self-development, and to assist users in attaining educational outcomes. This approach emphasizes the value of experimentation associated with making and participating in the communities associated with makerspaces. The second highlights the entrepreneurial value of makerspaces, specifically their capacity to drive economic development by facilitating users' innovation and entrepreneurial activity.

Makerspaces have been celebrated by educators who stress the pedagogical value of "learning in the making" (Brady et al. 2014; Kurti, Kurti, and Fleming 2014). In a review of 150 research papers on makerspaces, Mersand (2021) reports that makerspaces have been associated with improved outcomes relating to students' affective, cognitive, psychomotor and behavioral outcomes. In addition to a focus on individual users, makerspaces have been acknowledged for supporting the development of "communities of practice". These form around a collective focus, open membership and the free sharing of knowledge and resources between members (Wenger 2008). These communities intertwine learning with sociality and collaboration (Forest et al. 2014; Halverson and Sheridan 2014; Sheridan et al. 2014).

A second dominant approach valorizes makerspaces in terms of their relationship with business, small-scale production and entrepreneurship. Makerspaces are seen to exemplify trends towards smaller and more agile models of urban manufacturing capable of driving economic growth, employment, innovation and market resilience (Grodach, O'Connor, and Gibson 2017; Muessig 2013; Wolf-Powers and Levers 2016). Makerspaces are envisaged to facilitate "micro-manufacturing" (Kim 2018) and the emergence of "micro-industries" (Granger 2018). They are said to lower barriers to entrepreneurship by lowering production costs and creating dense networks of people and producers (Van Holm 2015).

While efforts to qualify makerspaces in terms of their contribution to entrepreneurship and pedagogy are common within the literature, makerspaces rarely simply serve one purpose. Scholars have in fact conceptualized makerspaces as existing on something of a values-based continuum, locating them between commitments to experimentation and entrepreneurship (Capdevila 2017; Schmidt and Brinks 2017).

In recent years, researchers have problematized some of the core assumptions underpinning earlier thinking on the value of making and makerspaces. Early maker movement advocates suggested that technological developments, like the increasing accessibility of online communities for sharing knowledge and designs, would reduce the importance of geography in constraining and shaping the value of production. These developments were foreseen to create a future where “ideas trump geography” (Anderson 2012, 47). Recent works, however, reaffirm the importance of place in defining the value attributed to makerspaces (Budge 2019). Further, scholars show growing interest in how the perceived value of manufacturing and making is transformed through the subjective and sensory experience of host populations (Cima and Wasilewska 2023) in shaping the value attributed to production and makerspaces (Budge 2019). In spite of technological developments, the unique social and material characteristics of a host community continue to constrain and guide how, where and what value can be derived from production-based activities, including making.

Literature on makerspaces and urban manufacturing illustrates that the particularities of a community and its material surrounds can impose constraints on production activities. For example, certain landscapes and facilities are more conducive to urban manufacturing (Capdevila 2013; Gibson et al. 2017; Grodach, O’Connor, and Gibson 2017; Leigh and Hoelzel 2012; Miller 2017; Muessig 2013; Pollard 2004) and to “making” (Richardson, Elliott, and Haylock 2013; Wolf-Powers and Levers 2016) than others. Urban manufacturers require spaces that are both affordable, and suitable for certain kinds of material production while also preferring spaces that have a strong history of industrial use (Miller 2017). Suitability depends both on identifying facilities with the physical features necessary for production, as well as achieving a good social fit with surrounding tenants (Pollard 2004). Both the social and the material qualities of a host community can constrain how makerspaces, their administrators and users operate.

Beyond being constrained by the characteristics of their host communities, production activities can also derive specific values from these characteristics. For example, the term “cultural production” has been used to describe the production of goods “infused with cultural or semiotic meaning” (Grodach, O’Connor, and Gibson 2017, 1). This kind of production occurs, for instance, where producers “tap into [the] distinctive cultural legacies” of innovation and creativity associated with well-established industrial settings, contexts and entire communities (Gibson et al. 2017, 15). In makerspaces, users might create things that “tap into” the unique history, culture or characteristics of their host communities (Miller 2017, 2).

A limited number of publications have illustrated the need to delve deeper into how community characteristics and dynamics impact the values associated with makerspaces. Johns and Marie Hall (2020) for instance, suggest that the idea of “openness” that supposedly typifies how knowledge is shared within makerspaces is a simplification of more complex dynamics of exchange characterizing how users share time, expertise and labor. They argue for more comprehensive understandings of the systems of exchange within makerspaces. The idea that makerspaces are inherently innovative has also been questioned. Gantert, Fredrich, Bouncken and Kraus (2022) seek to identify the various factors that lead to innovation in makerspaces, while Farritor (2017) suggests that innovation is a characteristic that can be both cultivated and hampered through a makerspace's management and design. These critiques highlight the need for greater nuance and responsiveness to diversity in our understandings of how particular values and dynamics become embedded within makerspaces.

Efforts to evaluate makerspaces generally focus on the value derived by users, as in a makerspace's ability to facilitate user experimentation, or to lower barriers that users face in engaging in entrepreneurship. Wider benefits, such as enhancing overall educational outcomes for a community or enhancing economic participation are envisaged to flow on through these more direct benefits received by users. Taylor, Hurley and Connolly (2016) argue that this user-centric approach restricts our ability to recognize the value that makerspaces can contribute as a resource for their community. In this study, we sought to valorize makerspaces at this community-centered level. Our findings suggest that makerspaces might facilitate forms of production that manifest and enrich the unique qualities of a host-community.

Aims and methodology

This study sought to understand and categorize the types of social and spatial relationships occurring between makerspaces and their host communities. We aimed to create broad, descriptive portraits for each typology, illustrating how particular socio-spatial relations functioned and subsequently informed makerspaces' design, use and limitations. Drawing comparisons, and exploring similarities across these typologies, we sought to identify how makerspaces were shaped by and shape their surrounding communities. Subsequently, the study sought to explore how "the value of a makerspace" could be better understood via the socio-spatial relationships between makerspaces and their host communities.

Data for this study were collected through an iterative and mixed methods approach. The study canvassed makerspaces within the New England states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont, together with New York State. Initial research was conducted between June 2017 and March 2018. A subsequent analysis to identify longitudinal changes in participating spaces' building occupancy, financial status (e.g. their for-profit, or non-profit status) and operational status (i.e. whether they were defunct or still operating) was conducted in September through October of 2022.

The scope of this study was limited to those spaces that were open to public membership or use, and which reflected the ethics of openness and explorative tinkering conveyed within the literature. Several commercially-oriented spaces were excluded based on this definition and foci. Spaces exclusively used by commercial (for profit) firms, entrepreneurs or other professional producers such as co-working spaces and dedicated business incubators were excluded from the study. A number of these firms were initially identified for inclusion in this study but were ultimately excluded. During early scoping activities, researchers assessed that these spaces were qualitatively distinct from the community-oriented and accessible makerspaces we sought to review.

During the first research round, researchers conducted an online search to identify and collect data for 43 spaces within New England (six states) and New York state (NENY). We identified 33 makerspaces, five FabLabs and four hackerspaces from this initial investigation. Where data were available, we collated information on facility size, charitable status, membership base and costs, objectives, types of facilities, equipment, labor and management structure and sponsorship agreements of each space via their websites and related online material. Where the operational status of a makerspace was ambiguous, we referred to social media accounts to identify ongoing and recent activity.

42 selected makerspaces were mapped and analyzed for establishment and district scale qualities using satellite imagery. Researchers conducted a virtual tour of target facilities, and roughly 0.6 miles (1 km) surrounding these facilities via satellite images and Google Maps.

Visual cues were used to identify the types of buildings used to house makerspaces. Researchers drew on a combination of visual cues, online research regarding a building's date of construction and prior uses, and regional heritage listings to assess a building's historical significance.

Researchers looked for indicators or factors that might shape how a makerspace fitted within its surrounding socio-spatial fabric, such as visual cues indicating surrounding density, the level of commercial and residential activity, ages of surrounding facilities and proximity to infrastructure and other cultural facilities. Surrounding infrastructure such as roadways and rail, public facilities, businesses and geographical features were mapped. This secondary analysis entailed some margin for error. In addition to the possibility of facilities not being visible or identifiable via satellite imagery, some data may have been outdated while other data was not yet available. Notwithstanding these limitations, secondary analysis provided a strong qualitative base for examining district scale tendencies and features.

Four socio-spatial typologies were identified through a preliminary analysis of this data. Six makerspaces exemplifying characteristics of the various typologies were identified and contacted for further engagement. Researchers undertook one or two field visits to each of these sites, attending tours, undertaking participant observation and conducting interviews. Participant observation occurred either concurrently or separately from tours or interviews, depending on the accessibility of the facility. Researchers conducted semi-structured interviews with key personnel including managing directors and central organizers. These interviews targeted five topics of discussion relating to: 1) the space's history and origin, its production focus and mission or role within the community; 2) the space's user-base and demographic and how they used the facility, e.g. what they made, when they made it, and for what purpose (i.e. pleasure or for profit); 3) how facilities and their members interacted with their surrounding community and built environment, and in particular, what features of their physical facility were necessary, useful or desirable; 4) the space's relationship with the nearby community, probing for positive relationships and collaboration or for evidence of nuisance and complaints; and 5) each facility's organizational structures and oversight.

Limitations

The methodology employed for this study has several limitations. First, this study did not seek to produce and should not be read as a comprehensive census or inventory of makerspaces in the Northeast of the United States. Researchers used various sampling techniques to develop a broad, qualitative picture of regional makerspaces, the activities going on within them and their relationship to surrounding environments. The use of web pages to develop an initial inventory of tools and equipment in each makerspace would likely not reflect the dynamic shift of functions and foci that can occur over time. It is also possible that information available online was incorrect or out of date at the time of recording. In the time since data collection new makerspaces may have opened and some canvassed makerspaces may have closed.

A second key limitation was the use of satellite imagery to categorize makerspaces. These images can be several years old and limited in their capacity to illustrate the spaces and their surrounding environment. Satellite imagery was cross-referenced with online information to check that the images were current.

A final limitation regards the depth of qualitative engagement with makerspaces and host-communities. This study primarily collected qualitative data by engaging with makerspace administrators and not with end-users. Our findings are primarily based on our online survey of makerspaces, on interviews with space administrators and on participant observation and attendance at a select few makerspaces. Greater depth of understanding could have been achieved through more rigorous ethnographic engagement with targeted makerspaces (including more detailed work with makerspace users), as well as with their host communities. This was not possible given budgetary and time constraints.

Socio-spatial characteristics of makerspaces

This section describes some observed characteristics of makerspaces that shaped their social and material interactions with their host communities. This analysis extends the existing discussions commonly found in makerspace literature.

Tools and production foci

The types of tools and production foci encountered within makerspaces varied and was determined by a space's priorities and locale. Data regarding the kinds of tools available to users were available for 30 of the sampled spaces. Drawing on data obtained online and through the limited sampling of makerspaces, a wide array of tools and resources were evident. Most commonly, makerspace websites stated that they provided resources for electronics and robotics ($n = 22$), 3D printing ($n = 21$), woodwork ($n = 19$), metalwork ($n = 17$) and textiles ($n = 14$). Other common resources were related to software development ($n = 8$), automobile maintenance ($n = 4$), photo, videos and music production ($n = 4$), bicycle maintenance ($n = 3$) and jewelry production ($n = 3$).

Production elements were influenced by specific spatial, social and material considerations; more intensive production foci, for example, required substantial space (e.g. auto work), were noisy (e.g. metal fabrication), required significant ventilation (e.g. painting) or demanded large, fire resilient environments (e.g. welding and other hot tools). The kinds of environments that were conducive to these more intensive production practices were often associated with traditional manufacturing and industrial plants, and with primarily industrial land-use districts.

Other production activities entailed different socio-material concerns. High tech tools like laser-cutters, CNC mills and 3D printers, for instance, required dry, clean and secure environments but were also lower in nuisance and better suited to smaller spaces, including those with mixed occupancy. Such activities could be located in makerspaces within public institutions such as libraries, or in dense central business districts. These activities also possessed an element of spectacle, given their comparative novelty, which may have made them more appropriate for higher-pedestrian traffic areas such as libraries or coffee shops. The capacity of makerspaces to embrace particular production foci was therefore strongly related to their occupation of appropriate facilities and social environments.

Built environments

Makerspaces were identified in a range of neighborhood types: from well-serviced, wealthy neighborhoods to those with substantial issues of disinvestment and abandonment. Industrial buildings commonly used for makerspaces included pre-war industrial facilities ($n = 13$), warehouses ($n = 5$) and modern industrial precincts ($n = 3$). Commercial buildings, both pre-war ($n = 6$) and more modern ($n = 8$). Four makerspaces were established in retail spaces, three in public facilities or community centers and one in a residential property. Many of the examined spaces could be described as having limited frontage, public exposure or walking traffic. They were difficult to identify from the street, and were frequently located in low traffic areas, at the back of complexes or in spaces with limited signage.[2] Many of the facilities that makerspaces occupied were categorized by researchers as possessing evident and significant industrial ($n = 13$) or commercial ($n = 2$) heritage.

Industrial facilities and warehouses possessed a variety of qualities that made them well suited and popular with surveyed makerspaces. Participants emphasized the utility of high roofs, loading bays and open floorplans. Industrial access-ways were sometimes useful for large deliveries, although not always necessary given the desktop scale of many makers' projects. Open floor plans were easily adapted for makers' changing needs and preferences. Makerspaces used desks, rolling dividers or temporary constructions to partition out flexible, adaptive workspaces. More permanent fixtures like heavy plastic dividers or walls generally split "hot" tools from "cold" ones and created spaces conducive to meetings or quiet work. Administrators emphasized the importance of these generally large and open spaces having adequate heating (particularly relevant to New England's harsh winter climate).

Experimentation and entrepreneurial production

Our data suggested that a makerspace's objectives and foci could be situated on a continuum between emphasizing exploration (for education and self-fulfillment) and entrepreneurship (Capdevila 2017; Schmidt and Brinks 2017). Makerspaces generally prioritized leisure-oriented activities over entrepreneurial production. Makers were often more akin to hobbyists, builders and tinkerers than to budding industrialists. Every surveyed space facilitated educational activities, classes or programs. These included introductory safety, skill-specific classes (such as how to TIG weld), and project-specific classes (such as how to build an electric guitar). Surveyed spaces were primarily geared towards for-leisure and educational outcomes. Although all canvassed spaces appeared to facilitate some limited degree of entrepreneurship, none were equipped to support more intensive or commercial production. Space administrators stressed that their facilities could help entrepreneurs get started and could facilitate prototyping and product development. However, they also emphasized that full-time manufacturing entailed a different set of spatial demands, temporal rhythms and resource requirements to the leisure-oriented and non-commercial production activities primarily facilitated by makerspaces. A makerspace's position on the education/entrepreneurship continuum shaped the space's internal dynamics, the kinds of facilities that they occupied, their spatial demands, as well as the user base that they recruited from their host communities and further afield.

Business models

Reflecting a broader commitment to openness and accessibility, makerspaces often embraced business and membership models that enhanced accessibility to their community. They embraced member-driven organizational models and were generally non- or low-profit entities. All but two of the makerspaces surveyed in this study possessed some kind of membership-oriented organizational model. They charged between $30 and $190 per month for memberships, with the average membership around $50 USD. Spaces generally offered a range of membership options: single drop ins, family passes, discounts for multiple memberships, students, low-income and senior citizens. Some spaces divided their rates based on the time of day being used (cheaper from 9am-5 pm on weekdays, and more expensive for using the facility at night or on weekends). Others varied prices depending on the kinds of equipment used (particularly for equipment like laser cutters and 3D printers where filaments, lenses and other consumables incur extra costs). Private workspaces and storage could often be rented for additional cost. Spaces often encouraged a degree of volunteering, and sometimes this could offer a way to offset dues. Membership fees and payment structures were often highly variable and somewhat flexible. In some cases, administrators spoke of members purchasing specific equipment and gifting it to their makerspace in lieu of paying fees.

Makerspaces generally embraced not-for-profit or low profit business models. Data regarding the business status of makerspaces were available for 36 of those surveyed. Of those, 30 were already in the process of becoming, or were incorporated within, a registered 501(C)(3) non-profit entity. Three were connected to government entities. Two were attached to a for-profit company. Only one makerspace in the sample was a low-profit limited liability company. The owner of this space stated that he intended to one day convert the makerspace into a member-owned cooperative, or to a non-profit once he could recruit a board from within the membership pool. The low and not-for-profit business models common among makerspaces generally entail tight budgetary constraints for space administrators. These constraints influence the types of facilities and locales that makerspaces occupy. As discussed below, makerspaces rarely occupied "prime" land within their host communities.

Makerspaces business models influenced the kinds of connections that spaces, their users and administrators formed with the surrounding community, including relations with surrounding businesses and government organizations. All makerspaces appeared to be somewhat reliant on business and government sponsorships, direct funding from government agencies or large institutions, or the patronage and support of benevolent landlords. Surveyed websites listed a range of sponsorships from hardware stores and breweries to universities, technology companies and local authorities and councils. Makerspaces generally had positive relationships with surrounding tenants and businesses.

Value proposition

Research into the motivations underpinning the establishment of makerspaces suggests that they are guided by certain "value propositions" regarding what a city needs most, and the role that spaces of this kind play in shaping a community's future (Wolf-Powers and Levers 2016). Our canvasing of makerspace websites and publications, and our qualitative engagement with numerous sites supported these claims. We identified an array of value propositions. Among those observed within our survey, makerspaces commonly referenced facilitating access to technology, democratizing production and enhancing educational outcomes. The value propositions encountered within each makerspace framed a narrative that often situated a makerspace's self-identified purpose within the context of its particular social and built surrounds.

Socio-spatial typologies among makerspaces

This study identified four key typologies typifying the social and spatial relationships between makerspaces and their host communities. These typologies are discussed below and illustrated with the aid of a case study. The typologies demonstrate the diversity of building types, geographical settings, production foci and surrounding densities encountered across makerspaces. Although canvassed makerspaces differed widely in their production foci and the facilities that they occupied, nearly all spaces surveyed ($n = 42$ out of a possible 43) conformed to one of the four spatial typologies described below. One makerspace could not be classified. This space was located within a rural, single-family home and was considered an outlier to the data set. Table 1 offers a summative view of the trends found in our analysis, illustrating features typically found within each typology.

Typology I: makerspaces within dedicated production districts.

Nine of the surveyed spaces (all of which were self-designated makerspaces) were classified as existing within *production districts*. Production districts might be recently built industrial precincts and complexes, or historic industrial areas that were never intermingled with other land uses of the city. These districts are dedicated for commercial or industrial purposes and are differentiated from residential and retail tenants by clear geographic markers including rivers, freeways or rail lines. Today, they contain older historical facilities, or a mix of old and new, that have not (yet) been inhabited by residential or retail tenants.

Production districts in this study were typically sparse industrial or commercial landscapes located away from dense residential areas. They were located within the city, and

Table 1. Summary of the four typologies and their characteristics.

	Production Districts ($n = 9$)	Enclaved Industrial Facilities ($n = 11$)	Embedded Facilities ($n = 19$)	Publicly Administered Facilities ($n = 3$)
Composition	Makerspaces: 9	Hackerspaces: 2 Makerspaces: 9	FabLabs: 5 Hackerspaces: 2 Makerspaces: 12	Makerspaces: 3
Building Types	Commercial buildings, industrial facilities and warehouses	Historic mills, factories and more recently constructed business parks.	Pre and post-war low rise office or commercial buildings	Public cultural facilities including libraries and museums
Typical Features	High ceilings, open floor plans, loading docks, sufficient ventilation	High ceilings, open floor plans, loading docks, sufficient ventilation	Fixed floor plan, street frontage and limited footprint.	Makerspaces embedded within existing public and cultural facilities
Industrial Heritage	Significant industrial heritage: 2 Evident prior industrial use: 2	Significant industrial heritage: 7 Evident prior industrial use: 4	Significant industrial heritage: 4	–
Proximal features	Freeways and arterial roads. Industrial rail Parks and green space Rivers and waterways	Arterial roads Commuter rail and bus Rivers and waterways	Commuter rail and bus Mid-rise commercial and retail surrounds	Commuter rail and bus Parks, green space and playgrounds Schools
Proximal facilities	Low density, industrial and commercial facilities	Medium to high density residential and retail buildings	Office and commercial buildings, cultural spaces and public facilities	Cultural centers and Schools. Facilities are shared with and hosted by existing tenants
Appropriate Production Foci	Supports moderate to high nuisance and space requirements e.g. auto-work and metal fabrication	Low to moderate space and nuisance e.g. woodwork, welding, ceramics	Low space and nuisance e.g. craft activities, ceramics, digital production	Low nuisance: craft and digital production

(*Continued*)

Table 1. (Continued).

	Production Districts ($n = 9$)	Enclaved Industrial Facilities ($n = 11$)	Embedded Facilities ($n = 19$)	Publicly Administered Facilities ($n = 3$)
Key Benefits	Floor-plan adaptable to user needs. Availability of useable floor-space. Industrial building features assist makers Highly nuisance tolerant Good parking access. Established connection to production activity and history	Floor-plan adaptable to user needs. Availability of usable floor-space. Industrial building features assist makers Moderate foot-traffic Accessible for non-car commuters Industrial aesthetic of value to makers Proximity to neighboring community and businesses Established connection to production activity and history	High foot-traffic Highly accessible for non-car commuters Proximity to neighboring community and businesses	Floor-plan adaptable to user needs. Availability of usable floor-space. Moderate foot-traffic Accessible for non-car commuters Accessible parking Proximity to neighboring community and businesses
Key Constraints	Difficulties with heating facilities during winter. Limited foot traffic Difficult to access for non-car commuters. Facilities may require extensive upkeep and renovations to ensure usability.	Proximal residents limit nuisance tolerance. Makerspaces need to compete against other industries for these facilities Limited parking options.	Limited usable floor space Inflexible floor-plans High surrounding density limits production foci Need for additional ventilation Limited parking options	Proximity to other tenants limits nuisance tolerance

appeared urban, but did not manifest the type of mixed-use appearance favored by contemporary redevelopment planning.

Makerspaces within production districts occupied a mix of historic and more recent industrial facilities, all in relatively low-density areas. Two of the nine spaces were classified as occupying facilities with significant industrial heritage and two occupied spaces with evident prior industrial use. The remaining spaces occupied more recently built warehouses and commercial facilities. They were typically located close to freeways, arterial roads and industrial rail. Public transport access was limited, but road access and parking were almost always readily accessible due to the presence of open lots and city streets.

Production districts were the most nuisance and space tolerant spatial typology identified in this study, enabling more intensive forms of production that would not be appropriate within dense residential or retail areas. They offered greater tolerance for nuisance, noise, fumes and traffic congestion associated with more intensive production practices. Makerspaces within this typology were accordingly capable of facilitating making that took up more space and generated higher noise pollution, including auto work, metal fabrication and other "industrial arts". They were generally co-located with other manufacturing enterprises, including those with moderate levels of nuisance. As of August 2022, eight of the nine makerspaces within production districts appeared to still be operational.

Case study: The Steel Yard

The Steel Yard occupies a 170,000 square foot facility within a dedicated production district in Providence, Rhode Island. The Steel Yard's director Howie Sneider described it as "the makerspace that is not a makerspace". The project differentiates itself from many makerspaces in its explicit focus on "industrial arts".

Located in the former Providence Iron and Steel Company (PISC) compound, The Steel Yard both occupies and maintains an architectural legacy of Providence's industrial history. The Steel Yard's open courtyard, high roofed red-brick building, and exposed metal beams appear at home among the neighborhood's vacant lots and pre-war industrial building which house commercial wholesalers, auto body shops, bars and adult clubs as well as artists' residences, graphic designers, leatherworkers, jewelers and florists.

The Steel Yard promotes the continuing value of Providence's historically significant metalworking and jewelry industries through education, entrepreneurship and support for local artists. The Steel Yard predominantly accommodates artists through residencies, although studio access is available to the public once they have attended a course. The Steel Yard's "Weld to Work" program helps capitalize on local manufacturing histories to generate economic resources for low-income members of the community and is celebrated as a pathway to simultaneously bolster a historically important industry while training and preparing people with the skills they need to participate within it. Through partnerships with large local institutions and city governments, The Steel Yard's Weld to Work program is quite literally shaping Providence's landscape by producing things like trash cans, benches and public artwork. According to participants, the artifacts produced by The Steel Yard through this program have become an important part of the city's aesthetic, reinforcing the ongoing local importance of high-quality industrial arts.

The Steel Yard draws on Providence's industrial heritage to frame their contribution to the city's present-day development and the well-being of its community. Expressed via the organization's publication materials, stated objectives, production foci and in the language used by participants, The Steel Yard taps into and extends the city's historic relation with industrial arts to achieve wider community development objectives. The Steel Yard has recruited a variety of stakeholders to participate in the preservation of the region's material production heritage: notably including the Environmental Protection Authority via its cleanup funding as well as local institutions who have participated through their patronage of the Weld to Work program.

Typology II: enclaved industrial facilities

11 of the surveyed makerspaces (nine makerspaces and two hackerspaces) existed in what might be called *enclaved industrial facilities*. These facilities were predominantly historic industrial facilities or clusters of facilities in proximity to metropolitan centers. Enclaved industrial facilities sit within distinctly industrial, or post-industrial pockets that are generally surrounded by moderate-density residential and commercial buildings and tenants.

Buildings within this typology appear to be of both pre-war and post-war construction. Surrounding areas appear to have been centers of industrial production containing structures such as large mills, or more recently, industrial or business parks. Seven makerspaces in this typology occupied buildings with evident and significant industrial history. They included a historic dairy plant, four mill buildings, an envelope factory and a tube works. Four of the spaces in this category occupied more modern buildings with evident prior industrial use.

While retaining some industrial aesthetics and functions, these spaces were often relatively central and conveniently close to local residential and commercial tenants, due to their mixed-use surrounds. Enclaved industrial facilities were suited for low to moderate intensity uses, including material production. In addition to makerspaces, occupants within these kinds of facilities included gymnasiums, artists' studios, breweries, and small manufacturers of goods and food. Proximity to local businesses, homes and modes of transport improve user access to enclaved industrial facilities. However, these spaces were generally located in urban and suburban environments which limited access to dedicated parking spaces.

Enclaved industrial facilities generally had sufficient footprints and low enough surrounding density to facilitate a diverse range of production activities that might occur within makerspaces. Other design features that supported diverse forms of material production included high ceilings, concrete floors and significant ventilation. These features often enabled "hot" and loud activities such as metal fabrication and woodworking to occur concurrently with others, including digital fabrication and ceramics. Due to the density and often residential nature of the surrounding environment, higher nuisance activities and those requiring a substantial footprint like metal smithing or vehicle maintenance were generally not suited to enclaved industrial facilities.

Of the 11 makerspaces in enclaved industrial facilities that were canvassed in 2017, nine remained active in the 2022 survey. One makerspace, the Artisans Asylum, relocated to a more recently constructed enclaved industrial facility in the time between surveys.

Case study: Open Bench Project

The Open Bench Project (OBP) is a makerspace within an enclaved industrial pocket in Portland, Maine. The OBP is situated at the northern end of an industrial corridor that has been surrounded by mixed residential and commercial tenants. Jake, the owner of the OBP, notes that the location was ideal for the desired density, offering space for a larger facility footprint and proximity to certain types of "neighbors." These neighbors included a few artists spaces as well as hardware and paint stores. Jake sought to build relationships with these neighbors to develop the local community of artists, makers and potential suppliers. Other proximal facilities included fast food restaurants as well as a large regional medical center and the county jail.

Initially the OBP had occupied disused industrial facilities via informal tenancy agreements with benevolent property owners. The OBP built a strong community following during this time and "brought new life" to two dilapidated properties. Citing the need for greater formalization due to growing membership and renewed interest in the vitalized property by the landlord, Jake sought more stable tenancy arrangements.

At the time of writing, the OBP's facility housed a primary work area and three smaller rooms at the ground level. The smaller rooms were equipped for meetings or computer work, while the main workspace featured a number of large woodworking tools and select digital tools, including a CNC router. Jake explained the challenges of accommodating the various needs of the space's users. Woodworking and hot tools are incompatible in the same room at the same time, which had spurred Jake to undertake significant renovations to create distinct "hot" and "cold" workspaces. He also noted the need to have space for growth and adaptation.

Jake spoke extensively about embedding the values of nimbleness, courage, education and community within the OBP. He assured researchers that this emphasis reflected his community's "peninsula independence."

> "Maine is a peninsula and has a sense of independence. It provokes this feeling of 'we don't need someone to come solve the problem for us. We can solve it ourselves.' . . . Modeling that behavior here is important for me."

Jake emphasized that he was primarily interested in promoting experimentation and encouraging users to "learn to take risks". The OBP sought to facilitate entrepreneurship and the space had supported members to launch businesses in the past. However, Jake stressed that this facility was not equipped for commercial production. Budding entrepreneurs were encouraged to find new facilities once they had outgrown these constraints.

Typology III: embedded facilities

19 of the surveyed spaces (12 makerspaces, two hackerspaces and five FabLabs) occupied buildings in denser environments that were difficult to distinguish from other residential, retail or commercial purposes. These *embedded facilities* were located in areas with established cultural and commercial functions. Makerspaces within this typology were generally housed within medium to high-density office and commercial buildings near cultural spaces and public facilities (such as courthouses, non-profit agencies, performance and music venues, libraries and institutions such as YMCAs).

In some instances, buildings comprising these denser landscapes may have been low to medium rise industrial spaces, but over time became predominantly commercial and, to a lesser extent, residential properties. Surrounding buildings were often three or more stories high, abutting commercial and residential properties. While six makerspaces within this typology occupied buildings with evident and significant industrial ($n = 4$) or commercial ($n = 2$) history; the remaining 13 spaces occupied recently constructed commercial ($n = 9$), industrial ($n = 2$), or institutional ($n = 2$) facilities.

Embedded facilities were the least nuisance tolerant and most restrictive environments for making activities. Space came at a premium within these dense environments, leading makerspaces to favor production activities with a smaller footprint and lower levels of nuisance. These included traditional craft-like activities or more high-tech forms of additive and digital production. Space-intensive practices like metal fabrication and auto-maintenance were poorly suited to these kinds of environments and were not typical of these makerspaces. According to participants, these environments were often also associated with higher land use costs. As of the 2022 review, 15 spaces within this typology remained open. One canvassed space relocated to a different yet still embedded facility. Four of the 19 spaces in this typology had closed.

Case study: ab@CIC

From June 2015 until ceasing operations in mid 2022, Fab@CIC was a self-designated FabLab located in Boston's dense downtown area. Alongside the appropriately named Render Coffee, Fab@CIC occupied the ground floor and public face of the Cambridge Innovation Center (CIC), Boston.

Embedded in the CIC, Fab@CIC was located in downtown Boston's mix of high-rise commercial and historic sites. Globally reputed as a "biomedicine mega-center" (Cooke 2004) and a "start-up city" (Florida and Mellander 2016), much of the city's social and physical fabric was shaped by rapid growth in finance and high tech industries during the 1970s (Ganz 1985, 451), and then again by the migration of entrepreneurial activity (Guzman and Stern 2017) and venture capital (Florida and Mellander 2016) throughout the early 2000s (Best 2015).

The Cambridge Innovation Center taps into this local history, providing office and coworking space for start-ups and entrepreneurs. Fab@CIC was formed through a partnership between the CIC and the Fab Foundation. The Fab Foundation was a client of CIC's and expressed interest in supporting the establishment of a FabLab within their host facility. In forming Fab@CIC, the Fab Foundation provided much of the equipment and the CIC provided space and funding for two paid staff to operate and manage the space and maintain equipment.

Fab@CIC provided select digital fabrication tools including vinyl cutters, laser cutters and 3D printers. An extractor neutralized hazardous fumes produced by digital tools. Staff and volunteers maintained and scheduled equipment, facilitated public walk-in sessions, and equipment training for new users and members.

As described by Fab@CIC employees, the relationship between the Fab Foundation and the CIC informed Fab@CIC's foci and value proposition.

> "As a CIC sponsored endeavor, we want to provide value for our clients. We're dedicating a lot of our attention to making sure that clients working on professional projects have the resources they need."

While open to the public, Fab@CIC primarily functioned as a resource to enhance innovation and entrepreneurial activity among CIC members.

> "It feels like this is a way to accelerate their [clients] innovation."

Interviewed staff suggested that up to two thirds of Fab@CIC's making was of an entrepreneurial nature, particularly including prototyping for biomedical industry start-ups.

Typology IV: publicly administered facilities

Three makerspaces (all self-designated makerspaces) were encountered within publicly administered facilities. These facilities included public libraries, publicly-funded cultural facilities and museums.

One of the three facilities canvassed was located within a public library. Located in Duxbury, MA (population 15,000), the Duxbury Free Public Library (DFPL) makerspace was based out of the DFPL complex. This complex was surrounded by other significant, low-density public facilities including playgrounds, sports fields, a performing art center, museums, schooling facilities and a wildlife trust.

A second publicly administered makerspace, the Hatch makerspace, was associated with the Watertown Free Public Library (WFPL) but housed free of charge within the Residence at Watertown Square, an assisted-living community. Hatch was located in a low-density commercial pocket surrounded by residential properties, very similar to the DFPL space.

Lastly, the NYSCI makerspace was housed within the New York Hall of Science, within Flushing Meadows-Corona Park (FMCP) in Northern Queens. Established as the site of the 1939 and 1964 World Fair, FMCP is home to an array of cultural and sporting facilities.

Both the Hatch and the DFPL makerspaces appeared to operate on a membership-based "drop-in" style similar to many other makerspaces. The NYSCI makerspace catered specifically to school groups while hosting public workshops two days a week. The NYSCI makerspace leant heavily towards facilitating explorative making and learning and was not equipped to support any commercial-level production.

Makerspaces within these publicly administered facilities appeared to often draw on pools of users, public resources and support from enterprise already tied with their host facilities. Unlike many other makerspaces, those within this typology did not appear to need to compete for available building stock and benefitted from benevolent or institutionally endorsed tenancy arrangements. For these reasons, this typology of makerspaces was considered as largely distinct to the three typologies identified above.

Socio-spatial constraints on makerspace activity

This study found that makerspaces were both constrained by and largely modeled to fit within their surrounding environments and this finding was consistent across the four typologies.

The need for harmony between material producers and surrounding tenants has been noted by others. Specifically, creating sustainable relationships between material producers and surrounding tenants is understood to require significant effort and forethought (Pollard 2004). Makerspace organizers appeared to be largely cognizant of the social and pragmatic demands of their host environments. For example, dedicated production districts facilitated the most intensive forms of material production and were, generally speaking, the most tolerant of nuisance including production byproducts, user traffic and noise. Enclaved industrial facilities were less nuisance tolerant. These facilities were often located more closely to surrounding residential and commercial tenants, and generally appeared to have a more limited footprint for production-oriented activities.

Integrated production facilities and publicly administered makerspaces required greater sensitivity to their impact on surrounding tenants than both dedicated and enclaved production facilities. Integrated production facilities were generally surrounded by more dense neighboring tenants and their ability to accommodate nuisance and intensive production practices was limited. Publicly administered makerspaces were generally housed within multi-purpose public facilities, so these makerspaces existed near other tenants who used shared building space in markedly different ways. Productive space in makerspaces within these typologies tended to be scarcer than within dedicated or enclaved production facilities.

A makerspace's ability to engage in more intensive production activities was greatly increased through access to existing (and often historically significant) industrial building stock. However, cases such as Fab@CIC illustrate that non-industrial environments can be suited to certain limited production foci, particularly including high-tech and digital fabrication, provided that they conform to the social expectations and material constraints of their host environments.

Leveraging socio-spatial relationships to generate value

Our efforts to identify the value of makerspaces as community resources (Taylor, Hurley, and Connolly 2016) revealed a novel potential (and perhaps even a tendency) among some makerspaces towards perpetuating, bolstering and enhancing unique characteristics, industrial qualities and cultural nuances from their surrounding communities. Makers have been shown to, at times, engage in cultural production – producing things imbued with cultural and semiotic meaning (Grodach, O'Connor, and Gibson 2017, 1; Miller 2017, 2). Our study illustrates that the cultural and community-oriented value of a makerspace might extend beyond this cultural production and the specific value that makers attribute to their products.

Beyond facilitating cultural production, our data suggests that makerspaces can offer physical and social environments suited to cultural reproduction.[3] As used here, cultural reproduction refers to the efforts required to maintain a community's unique cultural qualities and characteristics. We use it here with cognizance of the important legacy of industrial and manufacturing heritage in shaping community culture and characteristics throughout much of the Northeast of the USA. Our data indicates that makerspaces have the potential to facilitate cultural reproduction by enabling people to participate in the contexts, cultures and histories of production that are characteristic to their surrounding communities.

Makerspaces served as a resource where people could go to manifest the unique qualities of their communities through material production. The Steel Yard, for instance, exemplifies the capacity for makerspaces to act as resources for the reproduction of Providence's unique industrial culture and history. Beyond simply producing "things" imbued with cultural and semiotic meaning, the production occurring within The Steel Yard also reproduced the unique industrial artforms and skills historically tied to the city. The Steel Yard provides users with an opportunity to engage with that history, participate within it and to manifest it through making. Many of the things produced within The Steel Yard went on to populate the surrounding landscape, bolstering the city's connection to its industrial heritage through an array of benches, trash cans and artifacts produced by the makerspace's Weld to Work program.

For other makerspaces, examples of cultural reproduction were less obvious but still apparent. Fab@CIC, for instance, reproduced a local culture of high-tech and knowledge-based innovation and entrepreneurship. Fab@CIC sought to perpetuate, bolster and enhance this entrepreneurial and innovative culture. The OBP sought to cultivate the "peninsula mentality" typifying Portland, Maine. The OBP sought to create opportunities for users to "take risks", "learn to be brave", "learn to fail" and to model a healthy and balanced relationship between entrepreneurship and exploration.

Evidently, not all production occurring in makerspaces could be classified as cultural reproduction. However, this study suggests that many makerspaces prided themselves on their ability to perpetuate distinctly local cultures and characteristics and that this is a unique proposition regarding the value that makerspaces can contribute to their surrounding communities.

Conclusion

Technological and logistical advancements are transforming how societies do production (Gershenfeld 2007). Makerspaces illustrate this trend, often housing a mix of conventional production practices as well as more technologically advanced forms of making. By exploring the socio-spatial relationships between makerspaces and their host communities, this study illustrates that despite significant changes, the social, cultural and material characteristics of a host-locale remain important determinants in defining how and where production can be done, and how it will be valued.

This study sought to contribute to community-oriented approaches for valorizing makerspaces. Canvassing makerspaces across the Northeast United States, we aimed to explore and typologize makerspaces based on the social and material relationships between them and their host communities. Identifying three major and one minor typology, we found that these socio-material relationships were important factors shaping how and where makerspaces operated and the value that they contributed to their communities. Makerspaces across all of the identified socio-material typologies were profoundly shaped and largely modeled to fit within their surrounding environments. Rather than understanding socio-material relations between makerspaces and their host communities as a set of constraints limiting what is possible within makerspaces, this study found that makerspaces often generated unique value by aligning their objectives and foci with these socio-material relations.

Our findings support a limited body of research exploring the capacity for small-scale production activities to enrich the unique qualities and characteristics of a community (i.e. Pratt 2008; Scott 2006). In prior literature, scholars have pointed to makerspace organizers who establish themselves within buildings with significant industrial history and argued that makerspaces might serve a purpose in preserving these buildings (Gibson et al. 2017). In this sense, makerspaces can potentially help to preserve and maintain a community's *built* production heritage. By facilitating cultural *re*production, makerspaces might also be seen to preserve a community's *living* production heritage.

As a resource for their host-communities, makerspaces create opportunities for users to manifest a community's unique cultural and productive character. This finding is relevant to the use of makerspaces within community development initiatives. Globally, activists and academics are increasingly interested in cultivating the uniqueness and autonomy of communities (Escobar 2011; 2018; Jiménez 2014:342). Evidence from this study suggests that makerspaces might provide an effective model for standalone initiatives that can build cultural vitality. Such initiatives might create environments where targeted cultural practices, skill sets or art forms can be explored, shared and perpetuated among users.

Our study suggests that makerspaces might serve a greater role within community and economic development efforts, helping to bolster locally resonant, historically and culturally important forms of production. We also hope that this paper will better equip future makerspace organizers, policy makers and funding bodies by enhancing knowledge of the socio-material relationships, constraints and opportunities shaping the future of these valuable community resources

Notes

1. The North-American fixation with hobbies, for example, was suggested to emerge from market and workplace values penetrating into people's free time during industrialization (Gelber 1999). Likewise, DIY is said to have emerged in Britain through a proliferation of leisure-time and a desire for productive activity within the household (Jackson 2006).

2. In contrast to this, almost all spaces canvassed in this study had well-developed and user-friendly web pages. This speaks to the internet-literate user-base of these spaces and potentially, to their geographically dispersed memberships.
3. Here we echo work by Suzanna Narotzky (2016, 86) who, building on Marx (1976, 719), sought to clarify the effort required to produce and maintain the family and community as a social unit. Social reproduction entails people's efforts to foster relations and conditions that are necessary and favorable for living.

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