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Garagecraft: Tinkering In The American Garage

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GARAGECRAFT: TINKERING IN THE AMERICAN GARAGE

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ABSTRACT

The American garage, whether in the home or larger, communal ventures, has been a site of technological crafting for a variety of people across the twentieth and twenty-first centuries. The garage has been a space in which to both reaffirm the status quo of masculinity, and to discover feminist modes of self sufficiency. It has provided a place to play, experiment, commercialize technology, while also providing a space to create new identities and communal standards. What we make and how we make it is, in the end, more about crafting ourselves than crafting objects.

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INTRODUCTION

The garage is a mainstay of the suburban American home. Less iconic than the white picket fence, the two car garage is still a signifier of the American dream and the motor vehicles it relies on. While the garage still means cars for most Americans, the garage has become a flexible space in the American home, open to uses ranging from car storage to long term junk storage to home workshops. While the most prevalent use of the garage in 2013 was as extra storage space, it is the garage workshop and its communal offspring, a feature of half of all American garages, on which I will focus in this dissertation.¹

While technology is prevalent in other areas of the family home, the garage workshop is unique in that it is a space wherein technology is often tinkered with, repaired, maintained, and experimented with instead of merely used. Using Richard Sennet's definition of craftwork, work that uses the imagination of technical processes and skill born of bodily process to create something for its own sake; many of those who tinker in America's garages are craftspeople, whether they are building a Mission style arm chair in the style of Gustav Stickley or creating a robot run garden powered with a Raspberry Pi.²

¹ Ed Hudson, "To Park or Not To Park: The Real Value of Garages (part 2)", *Home Innovation Research Labs*, 25 April 2013, http://www.homeinnovation.com/about/blog/20130425-eh-garage-data-part_2.

² Richard Sennet, *The Craftsman* (Yale University, 2009), 9.

1.1 HISTORIOGRAPHY

The most direct work on the space which shapes these works, the garage, done by J. B. Jackson, underscores the garage as a flexible space in the family home. Initially demanded by the needs of car owners, the garage served to protect the family's investment in their automobile. For most middle class families in the 1910s and 20s, this took the form of a utilitarian outbuilding. As changing patterns of front and back yard use in the inter-war years made outbuildings less desirable, and as cars became less of a fire hazard, garages moved to the front and eventually connected with the house. Jackson adroitly explains the changing form and placement of the garage, but leaves its use to other scholars.

By WWII, most suburban garages were connected to the family home. Negotiating what type of domestic space the garage would fill, however, had begun earlier, as the 10- and 8-hour work day became standard in America, and men had to carve out a space for themselves in the domestic sphere. The garage, often unfinished and less well suited to meeting the cleanliness and décor standards as the rest of the domestic home became a haven for men. At the same time, Steven Gelber argues, the garage would be put to use for the tasks these men had claimed for themselves, especially home repairs and the various tools and workspaces needs to undertake such activities. Masculinized leisure activities, such as ham radio and woodworking, also found a space in the garage.³ In this dissertation I look beyond the limitations of space individual hobbies put on their practitioners to put the garage in the center of the narrative as a space and an idea.

³ Kristen Haring, "The "Freer Men" of Ham Radio: How a Technical Hobby Provided Social and Spatial Distance," *Technology and Culture* 44. no. 4 (October 2003), 752.

Perhaps the most common myth told about the American garage is its role in the early days of Apple Computing. Placing Steve Jobs and Steve Wozniak in the role of lone geniuses so disproven by Thomas Hughes, the myth tells a story of how the garage sheltered and nurtured their brilliance and the infant personal computing revolution until it was ready to make commercial waves.⁴ While the actual story is less exciting, Apple only tested already assembled computers in the garage, and little to no design or prototyping work ever took place there, it is tenacious. Less than one percent of start-up business founded in 2005 started in a garage, but the general public estimated those numbers at thirty percent or more.⁵ Asserting the garage as a flexible use, masculine space appropriate for tools and other work, makes it the perfect setting for start-up technology companies. This narrative sense of rightness lends credence to the idea that the garage is the place where technological brilliance is turned into entrepreneurial success.

For many people, the idea that in America there is some special combination of individualism, talent, and mindset that allows for more and better technological innovation than in other countries is the mainstay of their identity as Americans. This technological exceptionalism has a long and varied history. Michael Adas demonstrates that Americans have understood technological superiority as a sign of the superiority of their own civilization since the Early Republic. Indeed, technological exceptionalism has been part and parcel of American exceptionalism and its impact on the world, and an

⁴ Robert Cringley, *Accidental Empires: How the Boys of Silicon Valley Make Their Millions, Battle Foreign Competition and Still Can't Get a Date* (New York: Harper Business, 1996), 5.

⁵ Pino G. Audia and Christopher I. Rider, "A Garage and an Idea: What More Does an Entrepreneur Need?" *California Management Review* 48, no. 1 (Fall 2005), 6.

excuse for intervention, civilizing missions, and modernization efforts. It is the impetus for many American actions, ranging from the settling of the frontier to the opening of Japan to the Vietnam War.⁶

While the beginnings of technological exceptionalism find their roots in the colonial period, Philip Scranton argues that the “Civil War confirmed... the larger faith that technical advances at farm and factory undergirded the defense and elaboration of American liberty,” and that “...technical progress arguably emerged as the symbolic engine propelling American eminence, then preeminence.”⁷ For Scranton, while the idea of America’s technology exceptionalism has been present since the founding, it found its heights during WWII and the early Cold War.⁸

Beyond technological exceptionalism, however, is the idea that people who can make their own things can be self sufficient, an idea just as important to the stereotypical American character. Pioneers settling the west not only had to farm crops, but fix wagon wheels, maintain grain mills and plows, and generally have at least a modicum of mechanical skill. Even as Americas farmers moved away from the isolated self sufficiency of pioneers, farms became more mechanized, and mechanical skill more necessary. Thus the self sufficiency so prized in yeoman farmers by Thomas Jefferson had a technological edge.

⁶ Michael Adas, *Dominance by Design: Technological Imperatives and America’s Civilizing Mission* (Cambridge, MA: Belknap Press, 2006), 3.

⁷ Phillip Scranton, “Determinism and Indeterminacy in the History of Technology,” *Technology and Culture* 36, no. 2 (30 October - 3 November 1995): S32, <https://www.jstor.org/stable/3106689>.

⁸ *Ibid.*, S33.

In the consensus narrative of American history, typified by Daniel Boorstein, individual effort and self sufficiency, along with exceptionalism, have been driving forces in the American character even before its founding. These ideals, often combined with limited federal government control over the individual, fomented into a strong strain of the American political scene starting with Thomas Jefferson and the Democratic Republicans, who saw the self sufficient yeoman farmer as the true expression of American life, rather than business people or merchants. This libertarian spirit has endured in the contemporary period and the garage workshop has often been framed by twentieth century advice writers in such or similar terms: a place to create freedom, especially from corporate control, through individual effort and individual skill.

While the idea that yeoman framers were both self sufficient and that self sufficiency was their goal were part and parcel of the ideology of Jeffersonian Republicanism, Richard Hofstader argues that, “Writers like Thomas Jefferson and Hector St. John de Crèveceur admired the yeoman farmer not for his capacity to exploit opportunities and make money but for his honest industry, his independence, his frank spirit of equality, his ability to produce and enjoy a simple abundance. The farmer himself, in most cases, was in fact inspired to make money, and such self sufficiency as he actually had was usually forced upon him by a lack of transportation or markets, or by the necessity to save cash to expand his operations.”⁹ Hofstader suggests that while this agrarian myth originated among the intellectual elite, by the American Revolution it had been adopted as “political folklore and its nationalist ideology,” and that it found its

⁹ Richard Hofstader, “The Myth of the Happy Yeoman,” *American Heritage* 7, no. 3 (April 1956). <https://www.americanheritage.com/content/myth-happy-yeoman>.

strength in the fact the early American farmer was both literate and politically enfranchised.¹⁰ In fact, Hofstadter argues the agrarian myth gained strength in America in an inverse to its truthfulness. The more yeoman farmers and family farms were replaced by factory farms, commercial enterprises, and land speculation, the more strongly Americans clung to the idea that farmers were self sufficient and the self sufficiency was American.¹¹

The home based hobbyist doing amateur craftwork in their own garage benefits from the interchange of these narratives. Doing work with one's own hands in one's own space allows the crafter to see themselves as engaging in an act of self-sufficiency. When that act is technologically orientated, whether directly working with electronics or through the use of power tools or in some other way, this craftwork also reinforces the idea that there is a special, technical nature to the American people, one that can be carried out in any home garage.

Modern craftspeople, both amateurs at work in their garages and professionals in large workshops, are a part of the national narrative of technology competency. Many of these craftspeople see themselves as rescuers of dying arts, preserving fields as varied as craft beer brewing to accordion repair. This work, however, is too often overshadowed by the idea that any interaction with technology in the garage is at its heart an attempt at innovation with the goal of entrepreneurial success.

But this myth of the American garage leaves unnoticed the actual technological work and play that takes place in such spaces, and thus ignores a great deal of what

¹⁰ Ibid.

¹¹ Hofstadter, "The Myth of the Happy Yeoman."

Americans actually do in their garages. While the start-up bound for glory is perhaps more eye catching than storing that broken down lawn mower you have been meaning to repair for the last five years, the second is a much more common phenomena. In between technological revolution and private junkyard, are the workshop and its hobbyists.

In the America garage, the object which craftspeople are producing and the ways in which they are crafting them connect then to a larger history of hobbyism in the United States. In doing so, domestic craftwork is linked to a national narrative of technological exceptionalism that requires imagining that America's technological superiority comes from individual effort and ability.

What then is craft? Colin Campbell, a sociologist, argues that the definition of craft has changed dramatically over the 20th century, ranging from the traditional view elucidated by Karl Marx and Thorstein Veblen of craft as the labor of human expression, which had been dehumanized through automation and machines, to design historian, Tanya Harrod's more encompassing, modern definition of it as an object "made and designed by the same person."¹²

For Campbell, the contrast between craft and machine production is not the machines, but, "between a production system in which the worker is in control of the machine and one in which the machine is in control of the worker."¹³ Susan Luckman, a cultural studies scholar, argues, perhaps more romantically, that it is the touch of human hands that create authenticity, whereas the coldness of machine production leads to

¹² Colin Campbell, "The Craft Consumer: Culture, Craft and Consumption in a Postmodern Society," *Journal of Consumer Culture* 5, no. 1 (2005): 24-27, <http://journals.sagepub.com/doi/abs/10.1177/1469540505049843>.

¹³ *Ibid.*, 28.

inauthenticity.¹⁴ Even more romantically, scholars of marketing, Christop Fuchs, Martin Schreier and Stijn van Osselaer argue that handmade objects might be considered to “contain (and perhaps even transmit) the artisan’s ‘essence’ in the form of his or her love for a product.”¹⁵ Sarah Kettley, design researcher, links craft work to the utopian ideal.¹⁶ David Pye, design scholar, points out that “‘*Handicraft*’ and ‘*Hand-made*’ are historical or social terms, not technical ones,” and therefore it is not whether or not a machine of any type was used in the production of an object, but instead a type of work that harkens back to the Middle Age.¹⁷

Hannah Arendt argues that “any maker of material things is not master of his own house; politics, standing above the physical labor, has to provide guidance.”¹⁸ Much like Morris, politics were at the heart of craftsmanship, whether the craftsperson knew or wanted them there. For Arendt, making was an amoral task, one in which the maker was absorbed in the question of how, separated from the discussion of how those things that humankind creates should be used.¹⁹ Her student, Richard Sennet, disagrees, arguing that making is not an amoral task, and instead a process through which humanity comes to understand itself. There is no separation of the how and the why of making things that Arendt proposed. For Sennet, craftsmanship is a “basic human impulse, the desire to do a

¹⁴ Susan Luckman, *Craft and the Creative Economy* (New York: Palgrave Macmillan, 2015), 6.

¹⁵ Christoph Fuchs, Martin Schreier, and Stijn M.J. van Osselaer, “The Handmade Effect: What’s Love Got to Do with It?” *Journal of Marketing* 79, no. 2 (March 2015): 99, <http://journals.ama.org/doi/pdf/10.1509/jm.14.0018>.

¹⁶ Sarah Kettley, “Fluidity in Craft and Authenticity,” *Proceedings of the ACM on Human-Computer Interactions* 17, no. 5 (September + October 2010): 13, <https://dl.acm.org/citation.cfm?id=1836219>.

¹⁷ David Pye, *The Nature and Art of Workmanship* (New York: Herbert Press, 1968), 4.

¹⁸ Sennet, *The Craftsman*, 1.

¹⁹ *Ibid.*, 7.

job well for its own sake” and that at the root of craftsmanship is imagination of technical processes and skill born of bodily process.²⁰ This craftsmanship is a broad one, encompassing both the woodworker and the doctor, the computer programmer and the craft brewer.²¹ While focused on the technological wonders of the twenty-first century, most of these garage-based tinkerers are recognizably craftspeople. Arguably they conform to Richard Sennet’s definition of craftsmen as those people “dedicated to good work for its own sake.”²²

The idea that handmade is the most human form of production is not then an invention of the 21st century. Sennet links this ideal to the ancient Greeks, but the modern expression was first fully articulated in the Arts and Crafts movement.²³ The Arts and Crafts movement was one of the first philosophically driven craft movements. Kettley argues that “Pugin, Ruskin, and Morris and their followers explicitly combined lifestyle with aesthetic choices that championed the medieval as ideal” and that the tenets of this lifestyle were that “craft sits in opposition to industrialization; craft centers on the experience of handmaking; all beauty derives from nature; and the worker must be free for the work to be good.”²⁴ This focus, not just on labor but also on labor practices, would become an important part of craft practice from then on. Making labor central, rather than profit, helped craft become an acceptable leisure activity according to scholar of

²⁰ Ibid., 9.

²¹ Ibid., 9.

²² Ibid., 20.

²³ Ibid., 22.

²⁴ Kettley, “Fluidity in Craft and Authenticity,” 13.

American studies, Michele Krugh.²⁵ This was not all a positive, however, as in doing so craftwork mostly ceased being a productive way to earn a living. It also created a situation in which the products produced by Arts and Crafts workshop were limited to elites as the cost of manufacture was significantly greater than industrial production methods.²⁶

For the Arts and Crafts movement, authenticity involved not only the process of making, but the type of material and the design as well.²⁷ For John Ruskin and William Morris, the Medieval Period exemplified what humanity's labor should look like. They imagined the craftsman in that period as both artist and worker, dependent upon themselves for design and production. As these two aspects split, conditions worsened until the machines of the Industrial revolution had enslaved the worker and divorced the artist from labor.²⁸ Many in the Arts and Crafts movement embraced socialism and especially Marx's critique that the worker had become alienated from his work. For many, the Arts and Crafts movement and its imagined Medieval Period was a solution to this alienation.

This led the Arts and Crafts movement to herald the workshop as the ideal location for labor. This idealized workshop was a place in which multiple craftspeople labored, able to not only create objects, but to create a community where ideas could be exchanged, and skills could be learned, creating an even larger sense of social solidarity

²⁵ Michele Krugh, "Joy in Labour: The Politicization Craft from the Art and Crafts Movement to Etsy," *Canadian Review of American Studies* 44, no. 2 (2014): 282, <https://www.utpjournals.press/doi/abs/10.3138/CRAS.2014.S06>.

²⁶ *Ibid.*, 288.

²⁷ Kettley, "Fluidity in Craft and Authenticity," 13.

²⁸ Krugh, "Joy in Labour," 283.

among craftspeople in the world at large.²⁹ This description might be applied to both the Women’s Cooperative Garages of Chapter 1 and the Makerspaces discussed in this chapter. Some proponents of the Arts and Crafts movement, like Morris, believed that machines had no place in production, whereas others such as Gustav Stickley felt that “the worker should master the machine as a useful tool,” an argument that later movements, like the Bauhaus School, would also embrace.³⁰ For Morris it was, “impossible to exclude socio-political questions from the consideration of aesthetics,” and so machines were anathema.³¹ While small workshops and guilds did appear, the Arts and Crafts movement did not accomplish much change in larger industrial production processes, and instead became niche production for wealthy clients.

The link between craftwork and the idea of an “authentic” past led to craft traditions being co-opted by fascists in Germany and Italy during the mid-20th Century, as a reaction against previous liberal policies.³² Oddly enough, American soldiers returning home from fighting in Germany and Italy also embraced craftwork, both in its DIY aspect of home repair as discussed in Chapter 1, but also through the Studio Craft movement whose ideas dominated the 1960s and beyond. The G.I. Bill opened university education to middle class men and women who would not have normally attended. In response to the huge influx of students, universities created new classes and departments to serve these veterans. Studio Crafts, in particular, grew exponentially because of this. For some veterans, the G. I. Bill allowed them to pursue education in fields that they

²⁹ Ibid., 284.

³⁰ Ibid., 287.

³¹ William Morris, “The Revival of Handicraft,” (1888), <https://www.marxists.org/archive/morris/works/1888/handcrft.htm>.

³² Krugh, “Joy in Labour,” 289.

would not have considered if they had been using their own money. Rob Barnard, a G. I. Bill recipient, was one such student: “By the end of spring semester and my second ceramics class. I had decided that I wanted to be a potter— whatever that meant. I was well aware that it was a culturally marginal activity, and that the possibility of making any kind of living from it was questionable, but my G. I. Bill stipend kept me in school and allowed me to pursue my investigations.”³³ This flexibility not only increased the amount of students in Studio Crafts, but also diversified the field, and spawned new philosophical stand points.

For the New Craft movement of the 1960s that many of the G. I. Bill students became a part of, craft was not separate from the fine arts but simply another expression of them. Kettley argues that it was the New Craft movement that shifted away from the Arts and Crafts’ user-centered utility to “expressions of individuality” that defined their authenticity through the lens of fine arts. He described what resulted as “the purity of the conceptual untainted by worldly bodies or material, and the artlessness of spontaneous expression.”³⁴ Modern craft practice, though, fit neither within the user-utility centered Arts and Crafts tradition, nor the art-gallery isolation of the New Craft movement. Instead Kettley argues, modern craft practices actually focus on the “dismantling of old dichotomies,” moving between the two ends of the craft spectrum to create objects that are both useful and open to new processes of manufacture, experience, and meaning.³⁵

³³ “The G. I. Bill and the American Studio Craft Movement,” *American Craft* 67, no. 4 (August/September 2007): 62.

³⁴ Kettley, “Fluidity in Craft and Authenticity,” 13.

³⁵ *Ibid.*, 15.

This, then, is the heart of garagecraft, creating, repairing, and experimenting with physical objects and ways of manufacturing to create communities and build identities.

By the 1980s, the post-WWII DIY boom had died off, and the height of throwaway convenience did not predispose consumers towards DIY activities. *Popular Science* moved away from DIY type projects to focus on Big Science, government-focused experimentation taking place in university labs that often required multi-million dollar equipment. RadioShack eventually stopped selling its line of DIY project oriented books and moved into the commercial cell phone market. It seemed like the era of high-tech DIY was at a close by the 1990s. Sleek, organic, mass-produced gadgets that would not look out of place in the home of George Jetson and were more disposable than upgradable seemed to be the future of technology. Gadgets such as MP3 players, smartphones, and tablets could not be physically repaired or modified by their users, and in many cases the ability to change or upgrade the software on these devices was limited. The cutting edge of consumer technology had locked the user out, denying them an active, creative role in their daily technological use.

As early as the 1980s, home-center stores such as Lowes and Home Depot moved away from the traditional Mom-and-Pop model of consumerism. These home centers were squarely aimed at the DIY consumer, and stocked a vast array of products from paint to plants. By the late 1980s, they also turned to grocery stores for inspiration in attracting and keeping female customers: wide aisles, shopping carts, and attentive sales people. These stores hoped to diversify their consumer base, and especially hoped to entice women to shop. These changes were very successful. While tinkering with electronics seemed to be on the decline in the 1990s, DIY home repair was once again

becoming popular. HGTV, which specialized in home renovation shows, went to the air in 1994 and has been successful ever since.³⁶ From 2001 to 2013 the DIY market share doubled, and the largest demographic of DIYers shifted from over 50 to under 35.³⁷

The late-90s also saw the Internet become an everyday tool of most middle class Americans. These digital connections formed the foundation for what would become the Maker Movement. The Internet allowed affiliative groups to form across great geographical distances. It did not matter if the person who shared your interest in making circuit boards lived next door or across the world, with the Internet people could meet and discuss even the most arcane of technical interests, show off their own projects, and learn from others.

Hobby stores such as Hobby Lobby, Michael's and A.C. Moore also became big business. Emily Matchar argues, that at least in part, that the success of such stores is due New Domesticity. Women, especially during the Great Recession, saw fewer opportunities for career advancement and fulfillment, coupled with rising costs of childcare, and feeling that “you can't do it all,” returned home.³⁸ They were not alone, many men also felt unfulfilled and betrayed by corporate life. These men often joined the homesteading movement, and along with wives who kept home and homeschooled the children, removed their entire families from the corporate rat race.³⁹

³⁶ Carolyn M. Goldstein, *Do It Yourself: Home Improvement in 20th century America* (National Building Museum and Princeton Architectural Press, 1998), 49, 87.

³⁷ Ashish Arora, “The Millennial Marriage of Tech & DIY,” *Gigaom*, 2 November 2013, <https://gigaom.com/2013/11/02/the-millennial-marriage-of-tech-diy/>.

³⁸ Emily Matchar, *Homeward Bound: Why Women Are Embracing the New Domesticity* (New York: Simon & Schuster, 2013), 182.

³⁹ *Ibid.*, 200.

Unlike their grandmothers, who may have spent the 1950s and 60s unfulfilled by their domestic duties and in a cloud of tranquilizers, the women who returned home to make house in the 2000s, created ways to make more work for themselves, but also to receive praise and acknowledgement for their labor. For them, the thesis of Ruth Schwartz Cowan's *More Work For Mother*, that labor saving devices really just made more work, was a good thing.⁴⁰ Women in the domestic sphere returned to home canning, knitting, and other older craftwork traditions to keep their meals organic, children clothed, and homes in order authentically, while creating labor that women could hold up to their internet audiences on the blogs they also maintained.⁴¹

This movement back to the home, and the craftwork it required helped fuel financial gains for hobby stores. In 2008, after the Great Recession began, Michaels, a chain hobby store, had sales higher than the previous non-recession year.⁴² The hobby market is profitable enough that Hobby Lobby was able to finance looting and grave robbing in the Middle East to the tune of 1.6 million dollars after the Iraq war.⁴³ They also financed a lengthy legal battle that ended up in the Supreme Court in order to deny

⁴⁰ Ruth Schwartz Cowan, *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave* (New York: Basic Books, 1985).

⁴¹ Matchar, *Homeward Bound*, 52.

⁴² Claire Cain Miller, "For Craft Sales, the Recession Is a Help," *The New York Times*, 22 December 2008, <https://www.nytimes.com/2008/12/23/business/23craft.html>.

⁴³ Jane Arraf, "Hobby Lobby's Illegal Antiquities Shed Light on a Lost, Looted Ancient City in Iraq," *NPR*, 28 June 2018, <https://www.npr.org/2018/06/28/623537440/hobby-lobbys-illegal-antiquities-shed-light-on-a-lost-looted-ancient-city-in-ira>.

female employees several types of birth control.⁴⁴ In 2017, \$36.2 billion was spent on craft and art materials.⁴⁵

Luckman argues the digital media was an important ingredient in shifting how we value craft work.⁴⁶ “Contemporary making cultures tap into the desire to bring together the affordances of digital technology and the information sharing of the internet alongside the making, not just the buying of things.”⁴⁷ Like Beard and other advice writers at the turn of the 20th century, Makers argue that handmade, even the type of handmade that includes a garage-based CNC machine, is the most authentic form of production. This argument is implicit, embedded in their work.⁴⁸ For Eakin, “D.I.Y.’—do-it-yourself—has become a synonym for virtue. This sensibility glorifies farming, a concept now flexible enough to encompass rooftop herb plots in Brooklyn and heritage-breed cattle ranches upstate.”⁴⁹ In an age where authenticity, or at least the appearance of it, is lauded as a virtue, the ability to group Maker made products with other authentic craft producers such as craft brewing, or artisanal food production, gives Makers legitimacy that the DIY movement lacked for most of the 20th century.

⁴⁴ Eliana Dockterman, “5 Things Women Need to Know About the Hobby Lobby Ruling,” *Time*, 1 July 2014, <http://time.com/2941323/supreme-court-contraception-ruling-hobby-lobby/>.

⁴⁵ Roberta Wax, “Creativation 2018 Show Report,” *Craft Industry Alliance*, 30 Jan 2018, <https://craftindustryalliance.org/creativation-2018-show-report/>.

⁴⁶ Luckman, *Craft and the Creative Economy*, 20.

⁴⁷ *Ibid.*, 21.

⁴⁸ Steve Mann, “Maktivists: Authentic Making for Technology in the Service of Humanity,” *DIY Citizenship: Critical Making and Social Media*, ed. Matt Ratto and Megan Boler (MIT Press, 2014): 38.

⁴⁹ Emily Eakin, “The Civilization Kit,” *The New Yorker*, 23 & 30 December 2013, <https://www.newyorker.com/magazine/2013/12/23/the-civilization-kit>.

Campbell's "craft consumer" is "a person who typically takes any number of mass-produced products and employs these as the 'raw materials' for the creation of a new 'product,' one that is typically intended for self-consumption."⁵⁰ For Campbell this craft consumption includes home repair and modification, cooking, gardening, and the creation of a clothing wardrobe, however, is it also descriptive of many of the activities of the Maker Movement.⁵¹ Ratto and Boler argue that "DIY citizenships, therefore, sits at the intersection of a series of tensions: between consumers and citizens, between experts and novices, between individuals and communities, and between politics as performed by governments and politics and DIY grassroots democracy."⁵² This tension between consuming and creating is a hallmark of the Maker movement.

For many, the term craft and craftwork are terms describe a different age, one before a computer could be found insides objects ranging from stuffed bears to watches to refrigerators. Craft conjures up a bucolic age, where agriculture ruled, mass production and industrialization were nonexistent, and talented artisans made everything from scythes to shoes by hand. This imagined Middle Ages, to which craft has been delegated, often has not much at all to do with the actual way goods were produced at the time. Instead, it is an artifact of the Industrial Revolution and the works of John Ruskin and William Morris.

John Ruskin rejected mass production and especially the use of machines to unskill workers, and the underlying principles of the assembly line. His socialism, like

⁵⁰ Campbell, "The Craft Consumer," 28.

⁵¹ Ibid.,36.

⁵² Matt Ratto and Megan Boler, "Introduction," *DIY Citizenship: Critical Making and Social Media*, ed. Matt Ratto and Megan Boler (MIT Press, 2014): 76.

that of William Morris, rejected technology and industrialism, unlike Marx. For Ruskin, man cannot be human and produce identical objects, precisely and repeatedly, to “make their fingers measure degrees like cog-wheels, and their arms strike curves like compasses, you must unhumanize them.”⁵³ In order to combat such practices, Ruskin called for people to recognize and reject practices of mass production in the objects they purchased and used, and instead only use such products that were created by the hands of an artisan undertaking his labor to create a whole object in a healthy and well compensating environment.⁵⁴

Indeed for Morris, much like Ruskin, cheapness was often the main indicator that a product was created through unhealthy labor, in fact Morris argues that “cheapness is necessary to the system of exploiting on which modern manufacture rests.”⁵⁵ Morris clearly articulates the differences in the types of labor that Ruskin outlines. Morris argues that unlike the popular perception of his time that not all work is the same, and that some work, which Morris classifies as toil, is harmful even if it employs a worker and provides them with pay. Even as his society (and ours as well) cheered a, “happy worker with congratulations and praises, if he is only ‘industrious’ enough and deprives himself of all pleasure and holidays in the sacred cause of labour,” the work that the worker did was actually oppressive and harmful not only to the worker but society as a whole.⁵⁶ There is,

⁵³ John Ruskin, *The Stones of Venice, Volume II* (New York: National Library Association, 1853), 162.

⁵⁴ Ruskin, *The Stones of Venice*, 165.

⁵⁵ William Morris, *Useful Work versus Useless Toil*, <https://www.marxists.org/archive/morris/works/1884/useful.htm>

⁵⁶ Ibid.

for Morris, another type of work, a productive, hopeful, and pleasurable work which creates a useful, worthwhile product, and provides the means for rest from this work.⁵⁷

While John Ruskin and William Morris, both English, believed in a socialist future, their socialism did not always translate to an American setting. Devotes of the Arts & Crafts style that Ruskin and Morris advocated, like Elbert Hubbard of the Roycroft movement, adopted the style and many of the ideas about how people should work, while discarding the socialist rhetoric surrounding these practices.⁵⁸ Indeed, Hubbard was a proponent of capitalism and self sufficiency, though not, it should be said, of copyright laws, which he and his publishing arm broke with abandon. After meeting William Morris and touring his Kelmscott Press, Hubbard set up the Roycroft artists cooperative which endeavored to sell beautiful things, most by focusing on books, but also leather and copper work and furniture. And, unlike many of the businesses and communes inspired by Morris and Ruskin, Hubbard and his artisans actually made money. He disdained the socialism of the Arts and Crafts movement, and in his capitalistic enthusiasm probably sold more advertisement than arm chairs.⁵⁹

Ruskin's message of socialism also spread outside the Arts and Crafts movement, and without being accompanied by his stylists design hallmarks. Mohandas Gandhi read John Ruskin's *Unto This Last* on a train in South Africa and decided to live by the ideals that Ruskin had laid out in the book:

⁵⁷ Ibid.

⁵⁸ Donald Drew Egbert, "Socialism and American Art," in *Socialism and American Life, Volume I*, edited by Donald Drew Egbert and Stow Persons (Princeton University Press, 1952): 707, <http://www.jstor.org/pallas2.tcl.sc.edu/stable/j.ctt183pqkf.18>.

⁵⁹ Tom Post, "Utopian Capitalist," *Forbes*, 10 Oct 2005. <https://www.forbes.com/forbes/2005/1010/327.html>

- “1. That the good of the individual is contained in the good of all.
2. That a lawyer’s work has the same value as the barber’s inasmuch as all have the same right of earning their livelihood from their work.
3. That a life of labour, i.e. the life of the tiller of the soil and the handicraftsman is the life worth living.”⁶⁰

In a few cases, both Ruskin’s style and his socialism were adopted most famously by Gustav Stickley, who, only one hundred and fifty miles away from Elbert Hubbard, produced both furniture and *The Craftsman*, a magazine which promoted both the Arts and Crafts movement and gave a voice to artisan minded anarchists and socialists.⁶¹

Thorstein Veblen critiques both Ruskin and Morris, arguing that their championship of craftwork is actually an ideology of waste and imperfection. For Veblen, to choose the “clumsy” and imperfect object over the perfection of the machine made object was at best irrational. Why should the irregularity of an object be the hallmark of its authenticity, he asks, “The product, if it is beautiful, must also at the same time be costly and ill adapted to its ostensible use,” and Veblen argues it is wasteful of labor.⁶² Veblen argues that Morris and Ruskin preclude innovation by creating a philosophy that looks solely to the past.

The place of craftwork and mass production in human life are expounded upon theoretically at length by both John Ruskin and Thorstein Veblen, and this dissertation

⁶⁰ Mahatma Gandhi, *The Story of My Life*, (Educa Books, 1955) , 62.

⁶¹ Allan Antliff, *Anarchist Modernism: Art, Politics, and the First American Avant-Garde*, (University of Chicago Press, 2001), 22.

⁶² Thorstein Veblen, *The Theory of the Leisure Class* (New York: Houghton Mifflin School, 1972), 76.

uses those theoretical constructs to consider what happens when Americans undertake craftwork in their home or community garage spaces. While men like William Morris attempted to create the workshops and guilds that Ruskin theorized, these institutions fell short of their goals. Within the structures of the capitalism of the early twentieth century, handmade products could only be sold to those who both wanted such products and who could afford them, limiting the audience of the products of Arts and Crafts workshops. For people engaged in amateur craftwork, however, profit can often be ignored or inconsequential. These people have many motivations, from pleasure to independence to curiosity, that are not as reliant on the capitalist market place as craftspeople doing craftwork as a livelihood.

Some of the amateur craft workers discussed in this dissertation will quickly leave the realm of amateur and become entrepreneurial, but while they continue to remain affiliated with the movements that bore them, for the most part, they stop working within the spaces that nurtured them as start-ups. The American tinkerers discussed in this dissertation have a variety of motives from fun to self fulfillment, to curiosity.

Not all craftspeople want their work to be on a professional level. The ethos of open source access which allows for both those engaged in profit motivated activities and those not to work with the same source knowledge and materials create conditions that allow for the creation of new, more physically based movements. The mindset that knowledge exists to be shared, a hall mark of the open source movement and its hacker predecessors, is most often found among people who are producing intangible goods. Both the women of the co-op garages of Chapter 2 and the Makers of Chapter 4 are exchanging knowledge, more often than actual physical goods. This type of sharing

economy is not unique among modern people, and in fact is very similar to the digital sharing economies of other affiliative groups, such as fan culture, in that knowledge is gifted to the group at large in a way to strengthen social bonds.⁶³

1.2 SOURCES

In 1972, when Julie Coryell wrote: “The reason I am a self-appointed archivist is that we have lost the history of women—or large pieces of it... So I keep a spare of everything—both for us, should we need it—and with an eye to future writers. Who knows, someday we may be a beautiful women’s cooperative shop and school. Our organization is quite a tale!”⁶⁴ she was unaware of the longer history of female mechanics and drivers, such as Martin Van Buren’s motorcycle riding granddaughters. Successive generations engaged in encouraging women towards jobs and hobbies in car mechanics would be unaware not only of the Van Burens, but of Julie Coryell’s efforts as well. These sources have in common a similar awareness of writing for an audience, often a future audience. The Mechanica Committee, of which Julie Coryell was a part, specifically kept archival records for future readers, and implicitly for a future academic audience that would be tasked with telling their “herstory.”

Advice books and magazine form another significant source of information. Both modern publications aimed at hobbyists and potential hobbyists, and older sources aimed at young men and boys have paid attention to the garage as a potential site of character

⁶³ Tisha Turk, “Fan Work: Labor, Worth, and Participation in Fandom’s Gift Economy,” in “Fandom and/as Labor,” edited by Mel Stanfill and Megan Condis, special issue, *Transformative Works and Cultures*, no. 15, <http://dx.doi.org/10.3983/twc.2014.0518>.

⁶⁴ “Suggested Procedure on Minutes,” Julie Coryell, 5 December 1972, box 29, folder 9, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

formation thorough amateur craft work. Many Makers and publications aimed at them describe Making as a lifestyle, a way of life that is different and superior to ways that normal people live their lives. These publications not only outline how to set up garage workshops and review the best tools for them, they also subtly encourage the community standards of the Maker Movement and champion these ways as the best way to live a human life. This echoes, minus the microprocessors and CNC routers, the advice giving manuals such as *American Boy* and *Boy's Life*. Advice books and magazines, however, advocate for an ideal, and give us little sense of whether or not people actually follow their prescriptions.

As some of the movements I speak of in this dissertation are currently extant, much of the academic work on them has come from the fields of sociology and cultural anthropology, as well as art and design scholars. Approaching these sources along with historical methodologies, allows me to place these sources in a historical continuum with more conventional historical records. Often, the different approaches have given insight into facets of these movements that were inaccessible through the archival documents and other published historical source that I have utilized in this dissertation.

Many Makers have published their own thoughts on the movement, as well as more academically oriented articles on their own projects. Project documentation in more informal modes, such as blog posts and forum posts, have been used in this dissertation as these are perhaps a closer reflection than cleaned up, peer-reviewed articles of what Makers are actually doing.

Oral histories allowed me to use the words of participants in these spaces to create a deep picture of the day to day practicalities and experiences of members. It also allowed

me access to information that was not present in archival or printed sources, the more ephemeral experiences of work in garage spaces. Also used are published interviews and recorded conference talks where a wider range of participants have discussed their involvement in such movements. These pieces range in formality and perceived audience from very informal to formal talks at major international conferences.

Some of these are clearly evangelical attempts, such as Dale Dougherty's desire to convince the world that everyone is a Maker. Others are more focused on advocacy such as Blaze Starkey's, a teacher at the Mní Wičhóni Nakíčižij Owáyawa (Defenders of the Sacred Water School) in the Sacred Stone Camp at the site of the Standing Rock protests, discussion of the role Making plays in indigenous education. Finally, several of the published interviews, such as Laura Moore's talk with Jeanette Sanchez, were done with the full knowledge that the interview would be a historical document, created for and by an archive.⁶⁵

1.3 CHAPTER SUMMARIES

In Chapter One, there is a discussion of the formation of the garage as a building type associated with the American home. As the car moved from a luxury item to a staple of the middle class, garages evolved in both form and use. The change in both architecture and location of the garage reflects changing patterns of residential use, especially in the suburbs, becoming not only a signifier of car ownership, but also of conforming to new social patterns of front and back yard use in the 1940s and 1950s. I argue that the garage, while originally intended to be a space for storage and maintenance

⁶⁵ Laura Ann Moore, interviewed by Jeanette Sanchez, 25 September 2001. Transcription by Jim Andris, 15 April 2015.

of motor vehicles, became a center of home based technological tinkering and innovation due to its flexibility and its masculinized segregation from the rest of the household spaces. I describe how these spaces are first formed by their original function of car storage and maintenance, and how the usage of these spaces expanded to encompass both a broader category of storage and use. Homeowners quickly used the space both as a workshop for home repair tasks as well as a space for more masculinized hobby pursuits. These hobbies were encouraged not only by boy's advice manuals, but also corporations hoping to create employees with backgrounds in science and technology. While women also participated in hobby work, this work most often happened inside the kitchen or living areas of the home. I also discuss how these factors led to a mythologized American garage, where a glamorized story of the titans of technological industry were created, and how that distortion has affected both public and governmental perceptions of technology startups and the role of the garage

In Chapter Two, I argue that women were a technologically competent component of motorists in the late nineteenth and early twentieth centuries, that they gained and used the knowledge and skills to maintain and repair their own vehicles, and that both their technological competence and their driving abilities were undermined by changing family patterns and male motoring journalists. This then erased these motorists from the common narrative of women and cars which helped to deny women in the inter-War years the chance to gain such technological skill. In response to these obstacles to self sufficiency, radical feminist and lesbians opened cooperative garages in the 1970s. I argue that these groups leveraged the garage as a space to acquire masculine knowledge, both to increase female independence, but also to fairly deal with male mechanics and car

dealers. As much as anti-rape and pro-choice advocacy are a hallmark of the radical feminist movement, so too was the ability of women to be self sufficient. Several radical feminist groups argued that in order to hold down a job; most women were dependent on their cars, cars that they often knew very little about. Thus, along with more well known activities, several groups undertook to form garages that would both teach women the technical knowledge they needed to maintain and repair their cars, as well as a place to do so without male interference. This knowledge also allowed them to fairly deal with male mechanics since they understood what type of repairs their cars would need and the work involved in those repairs. These efforts to create and acknowledge women's technological competence in the field of automobiles did not enter into mainstream consciousness, so much so that even at the turn of the twenty first century car advertisement aimed at straight and lesbian women relied on stereotypes of their technological incompetence in the field of motor vehicles. At the same time, a third wave of women once again was trying to create a pool of female mechanics without being conscious of those women who had previously done the same.

In Chapter Three, I argue that the Maker Movement, a group of people who creatively engage with technology, has become not just a hobby, but a way of creating, prototyping, and manufacturing that both government and industrial bodies see as changing the way we invent and produce goods in America. While some of these views are wildly optimistic, there is evidence that Making and the wider Do It Yourself community has changed both how the prototyping stage of inventing works and the consumer view of how labor impacts the value of products. In this chapter, I argue that the Maker Movement rests on access to open-source hardware and tools that were

previously the providence of industrial corporations. The open source software movement paved the way for these industrial tools to be recreated and modified by hobbyists for hobbyists who were experienced with both computer programming and machine shop tools. People who bridged these two skills helped bring previously unreachable tools to the hobbyist and garage workshop communities. 3D printing, Arduino, and CNC machines now available for hobbyist level tinkering, , all began as prohibitively expensive machines used (or researched for use in) industrial production and through hobbyist interest, and through the shifting culture of the open source software movement and its application to hardware, these machines have been modified and then commercialized in ways that make them available to hobbyists with garage workshops.

Chapter Four investigates the Maker Movement, and their own cooperative garage environments: the Makerspace. Makers are people who experiment or tinker with technology, most often modern electronics and computer adjacent technologies. As a group; creation, innovation, and problem solving are often at the heart of their individual projects. They reject the culture of disposability that has grown exponentially since WWII, and instead focus on innovation, reuse, repair, and self sufficiency. These threads did not start with the Maker Movement; they adopted them from their predecessors starting with Mechanical Institutes of the nineteenth century through the many incarnations of the Do It Yourself movement in the twentieth and the twenty first centuries. Makerspaces, then, are the cooperative garages of the Makers. These spaces are places where communally held tools can be used by members for their own projects. Moreover, Makerspaces are the physical location in which Maker communities form.

While there is copious Maker presence on the internet and the wide reaching communication it allows is necessary to the exchange of information and ideas within the movement, it is in these physical locations that the ideals of Making are played out.

CHAPTER 1

THE MYTH OF THE AMERICAN GARAGE

In 2014, Americans gathered around their television to watch the high holy day of American civic religion, the Super Bowl. Many gathered for the game, but others were just as interested in the cultural phenomenon that is the Super Bowl commercial. These commercials are the most expensive advertising time on American broadcast television, and not only reach a record audience, but are replayed and analyzed on late night shows, talk radio, and the evening news as signposts of America culture. “You never know what kind of greatness can come out of an American garage,” claimed the voiceover in a Cadillac advertisement entitled “Garages” shown during Super Bowl XLVII in 2014.⁶⁶ The commercial opens on a standalone garage in the middle of a field, followed in quick succession by several other garages as the voiceover links each to a paragon of American innovation: the Wright Brothers, Amazon, Hewlett Packard, Disney, Mattel, and the Ramones. It was seen by 111.5 million viewers.⁶⁷

This advertisement placed the home garage at the center of American innovation, not only in automobile manufacture, maintenance, or repair, but all sectors of the

⁶⁶ 2014 Cadillac CTS Sedan TV Commercial, “Garages”, Video, 00:300.
<https://www.ispot.tv/ad/76nQ/2014-cadillac-cts-sedan-garages>.

⁶⁷ “SUPER BOWL XLVIII DRAWS 111.5 MILLION VIEWERS, 25.3 MILLION TWEETS,” *Nielsen*, 2 March 2014.
<http://www.nielsen.com/us/en/insights/news/2014/super-bowl-xlvihi-draws-111-5-million-viewers-25-3-million-tweets.html>.

American economy. The garage, it implies, is a spatial residence of American exceptionalism. An exceptionalism which echoes in a modern retelling of Jeffersonian Republicanism, where the little guy, with only a few tools and a space carved out of the family home, is able to take an idea from paper to production and become an entrepreneurial giant. This advertisement is a prominent, recent example of the myth of the American Garage. It is an example of how pervasive and wide spread the phenomenon of the myth of the garage is that Cadillac could rely on the viewer to interpret the garage as a center for innovation in order to sell their product.

In this chapter, I will argue that the garage serves as a flexible space within the home that developed over time from a space solely for the storage and maintenance of vehicles to a part of the domestic home. I will show how the uses of garage spaces helped fuel this change, along with a broader cultural change in how Americans related to and used their homes and yards. As a flexible and often unfinished space in the home, the garage was often ceded to “the man of the house” as an area where his hobby pursuits would not disturb the good order of the rest of the family’s domestic space. The garage and its workshop were not only masculinized by homeowners, but also in advice books which argued for men and boys to have a space in the home to practice being or becoming producers (and not feminized consumers). Engineering and technology corporations also saw the masculinized garage workshop as a positive good. These companies often encouraged this type of hobby work as good practice and training for future employees Other companies legendarily got their start in a garage, and I will argue that this led to a mythologization of the American garage as a place of entrepreneurial

technological innovation that is both over played, over exaggerated, and over shadowing other locations of innovation both within the home and outside of it.

This narrative is deeply ingrained in the American mind. It is told and retold for both popular and academic audiences, so much so that Andrew Russell and Lee Vinsel argue, “The stalest innovation stories focus on well-to-do white guys sitting in garages in a small region of California.”⁶⁸ Why is innovation so linked to the garage in America that it has become passé and what is actually going on in this space? In this chapter I will argue that the garage became a site of innovation first through its identification with car repair, and then in its growing role as a workshop space as middle class American men embraced home repair as their role in the domestic sphere of the family home. This workshop, I argue, became a flexible space that men used to bolster their masculine identities with the mastery of tools and technology, a practice that was reinforced by both governmental policy and corporate action that sought to create future employees literate in scientific and engineering related skills and ideas.

The garage came into use as a structure to house automobiles. Walk through any middle class, suburban neighborhood on a sunny Saturday afternoon, however, and you will find that almost none of those garages house automobiles. Many homeowners have displaced cars and trucks so that the garage can be used for some other purpose. Most frequently, this space is used for storage and extra living space. Intriguingly, the garage often also serves as a home’s workshop, the main place for storing and using home repair tools, hobby equipment, and crafting implements. Whether the home owner is repairing a

⁶⁸ Andy Russell and Lee Vinsel, “Hail the Maintainers,” *Aeon*, 7 April 2016. <https://aeon.co/essays/innovation-is-overvalued-maintenance-often-matters-more>.

squeaky ceiling fan, crafting a small sailboat, or engineering the next advancement in robotics, the garage has become the central location of technological production and maintenance in the American home.

For many Americans, 93% of whom use their garages for extra storage space, the idea of the garage is still the one presented by Cadillac: a place where ideas are born and turned into commercial success.⁶⁹ Neither of these uses is the original or stated architectural purpose of the garage; that is to house and maintain an automobile. In fact by 2013, 30% of homeowners surveyed for the *Wall Street Journal*, did not have enough available space in their garages to park a car, 50% used the garage for a work space, and only 25% had ever used their garage for the simplest of car maintenance. The same survey found that homeowners, however, still view their own garage mainly as a place to park cars.⁷⁰

Of course not all Americans own or have access to garages. The Office of Energy Efficiency and Renewable Energy reports that there are garages or carports in 63% of housing units in the United States.⁷¹ There is racial disparity in who has a garage: 66% of Caucasian versus 42% of African American respondents lived in housing units with a garage, as well as an income disparity: of those making more than \$120,000 a year 84% had access to their own garage, whereas that drops to 50% at the federal poverty for a

⁶⁹ Ed Hudson, “To Park or Not To Park: The Real Value of Garages (part 2)”, *Home Innovation Research Labs*, 25 April 2013, http://www.homeinnovation.com/about/blog/20130425-eh-garage-data-part_2.

⁷⁰ Ibid.

⁷¹ “Fact #958: January 2, 2017 Sixty-three percent of all Housing Units have a Garage or Carport,” Office of Energy Efficiency & Renewable Energy, United States Government, 2 January 2017. <https://www.energy.gov/eere/vehicles/fact-958-january-2-2017-sixty-three-percent-all-housing-units-have-garage-or-carport>.

family of four (\$20,000-\$29,000). Because the 2015 American Housing Survey did not differentiate between garages and carports, all of these percentages are in actuality lower when carports are taken out of the equation.⁷²

Garages were not always centers of production, and the process through which they became such centers is poorly understood, or worse, misrepresented as an inevitable consequence of technological progress. In a scenario that has been replicated in millions of houses across America, the garage started as a place to store and maintain vehicles but over the course of the first half of the twentieth century, evolved into the main site of masculine-marked hobbies and crafts (often entirely unrelated to auto care) in the home. In a particularly illustrative example of this change, garage workbenches initially used exclusively for car work had, by the 1950s, transformed to contain not only car maintenance equipment, but also hand and power tools for woodworking, furniture building, and home repair. This trend accelerated, and today garage workshops are more likely to contain a computer driven tool like Computer Numerical Control (CNC) machines and 3D printers for use in activities ranging from robot building to space exploration as they are an engine hoist for car repair. Yet, the displacement of the car from the garage was anything but inevitable; rather, it was contingent on a surprisingly wide variety of historical developments in the United States, ranging from the proliferation of power tools to the decline of skilled manual labor to a yearning among middle-class Americans to express themselves creatively through amateur science and engineering, to government policy initiatives.

⁷² “2015 American Housing Survey,” United States Census Bureau.
<https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html>.

The transformation of the garage into a small-scale workspace for hobbies, electronics, computing or even general tasks either in the home or in larger, more communal settings has received scant attention from professional scholars. However, my work is informed by J.B. Jackson's examination of the evolution of the garage from outbuilding to a living-space. Jackson argues that from its inception to the 1910s, the American home garage underwent a three-stage evolution. The first stage, or the Romantic Garages, were built by the wealthy, often attached to the stables that housed these owner's other modes of transportation. These garages were located far from the house, both to avoid disturbing the inhabitants, and because early automobiles needed large spaces – these cars could not reverse and their engines often could only be accessed from under the car. There were few commercial garages and thus automobile owners or their employees undertook most auto repair and maintenance. The garage, then, had to not only serve as a storage space for the vehicle, but also as a repair and maintenance facility. The second stage, or the Practical Garages, consisted of a garage situated in the backyard serving as an outbuilding. It was often portable or made from a prefabricated kit and it served the needs of a more middle class car owner. In the third stage, the Family Garage, the post-WWII garage moved to the front of the home, and was often attached to it. The garage also expanded its purpose and moved from simply storing cars to storing all sorts of household debris. These developments were not as smooth and discrete as Jackson's scheme makes them out to be, but overall they follow his trajectory closely.

2.1 THE ROMANTIC GARAGE

From their invention to the first decade of the twentieth century, automobiles and garages were the domain of the elite enthusiast. *Scientific America* praised Richard

Dudgeon's automobile wagon of 1866 as the first truly working automobile, and by the 1890s, a plethora of steam, electric, and gasoline powered automobiles were on the market.⁷³ These automobiles were temperamental: they were sensitive to weather, needed their steam boilers stoked or their engines cranked before they would drive, could not reverse, and needed daily labor from a trained individual. Indeed, on a cross country journey from New York to San Francisco in 1911, Mrs. W.T. Warren packed a "blocks and tackle, pick, shovel, axe, chains, two extra castings, six inner tubes, 150 feet of rope, and extra spring, tool box..." for the gasoline powered Renault automobile.⁷⁴ Even small excursions could cause wear and tear. To keep these automobiles in pristine working conditions, most owners needed two things: a space to store the vehicle—the garage—and a person to care for it—the chauffeur. Thus in many elite car owning households, not only the automobile, but also the chauffeur needed to be housed.⁷⁵

Initially, car storage was makeshift. Outbuildings previously used as utility sheds or stables were retrofitted to house automobiles, and commercial garages also provided parking for owners. Neither solution was particularly effective. Cars, which could not reverse, needed a way of exiting a storage building they entered. Turntables, which rotated the car 180 degrees, were expensive and require almost as much upkeep as the car itself. Buildings large enough for a car to turn around usually needed to be purpose built and required a large foot print.⁷⁶

⁷³ "Some Early American Automobiles," *Scientific America* 96, no. 2 (12 January 1907): 23.

⁷⁴ Mrs. W.T. Warren, "From the Atlantic to the Pacific in a Renault," *Automobile Topics* 21 (January 1911), 891.

⁷⁵ John A. Jackle and Keith A. Sculle, *The Garage: Automobility and Building Innovation in America's Early Auto Age* (University of Tennessee, 2013), 119.

⁷⁶ *Ibid.*, 119.

These buildings also had to be heated, as many automobile systems such as the battery or radiator had adverse reactions to cold.⁷⁷ Another difficulty was the extreme flammability of gasoline, kerosene and other fuels. Jackle and Sculle point out that fire insurance requirements helped shape the early garage, keeping to a distance from the main house, and requiring the use of fire-resistant materials such as concrete floors and metal walls.⁷⁸ Barns, stables, and carriage houses were often adapted to meet these requirements, instead of purpose built garages. These structures were fitted with “hoists, workbenches, repair pits, storage cabinets, washbasins, pumps, gas-tanks, turntables to eliminate backing up, and overhead hoses suspended from the ceiling for washing cars.”⁷⁹ Chauffeurs then were installed above the car, to live with the machine they drove, repaired, and maintained.⁸⁰

Garages were linked with masculinity almost immediately after their inception, a place where the man of the house could invite his male guests to view the great machine under his mastership. This, added to the (male) chauffeur’s residence on the second floor, made the early garage male territory.⁸¹ Jackle and Sculle argue that “given the early automobile’s role as a novelty, one of the chief intangible benefits was for the owner to demonstrate his mastery of modern technology by fixing his own car when possible.”⁸² In

⁷⁷ Jonathan Sager, “The Garage: Its History and Preservation,” Master’s Thesis, University of Georgia, 2002, 7,

https://getd.libs.uga.edu/pdfs/sager_jonathan_e_200205_mhp.pdf.

⁷⁸ Jackle and Sculle, *The Garage*, 119.

⁷⁹ Sager, “The Garage: Its History and Preservation,” 7-8.

⁸⁰ *Ibid.*, 12.

⁸¹ Jackle and Sculle, *The Garage*, 120.

⁸² *Ibid.*, 121.

order to undertake such a demonstration, owners needed to create the garage as a stage to show their peers their mastery over the automobile.

2.2 THE PRACTICAL GARAGE

The middle class quickly aspired to car ownership, and many manufacturers leapt to the demands, most famously Ford with its model T in 1908. These middle class car owners also wanted to show off their own status and mastery over the automobile, but fancy garage parties in large garage complexes with turntables and hoists did not become part of the middle class experience. Instead, middle class car owners demanded that their vehicles require less maintenance, as they did not have the facilities or the money to keep mechanic-chauffeurs around to deal with their vehicles. In January of 1911, *Automotive Topics* predicted that the 1911 car lines would see a split between high end luxury vehicles that would require considerable time and money to keep up, and more compact runabouts which would require less maintenance and be more reliable.⁸³

Garages also adapted to these new middle class consumers who did not have stables and carriage house to transform into car storage. The first garages in middle class homes were barely more than outbuildings in the backyard. Many garages were portable and built from kits ordered from the Sears Catalogue or other stores. They were small structures, just large enough to hold a car, and were usually built in the owner's backyard. In cities, this often meant that the garage was accessed through the service alley, and the garage was out of sight.⁸⁴

⁸³ Warren, "From the Atlantic to the Pacific in a Renault," 891.

⁸⁴ John Brinckerhoff Jackson, *Landscape In Sight: Looking at America* (Yale University, 1997): 124.

In 1912, architect Charles E. White argued that whether the home was modest or pretentious, “nothing is more unattractive than a place where the house is of one style and garage another.”⁸⁵ For an automobile owner of modest means, White suggested the portable garage kit. For “a more pretentious garage,” however, White called for a purpose built scheme, and if the garage was to share a building with the stable that the cars be kept in one wing and the horses the other so that the ammonia produced by horse waste did not tarnish the cars.⁸⁶ Either way, a garage was a convenience every homeowner, no matter their station, needed.⁸⁷ Sager argues that the garage became an architectural feature for home designers, giving them a space with which to balance a sunroom or side porch, as well as create a rambling Colonial Revival style New England farmhouse.⁸⁸

The garage as an architecturally consistent part of the home, started appearing as early as 1900 among the wealthy, but the trend quickly caught on with the middle class as well and was firmly entrenched by 1930. Sears kit homes, a standard to which many middle class Americans aspired, included the Hillrose model (No. C189), which appeared in the 1916 Modern Homes catalog. The model home was situated to the left on a bucolic plain and centered on a roundabout drive was a Model T Touring.⁸⁹ Most Sears plans did not include a garage, as Sears kit garages could be purchased separately. Sears was one of the earliest producers of kit style mail order garages, and devoted an entire catalog to them. Some houses, such as the Franklin (No. 3405) and the Elmhurst (No.

⁸⁵ Charles E. White, *Successful Houses and How to Build Them* (New York: Macmillan Company, 1912), 498.

⁸⁶ *Ibid.*, 498.

⁸⁷ *Ibid.*, 497.

⁸⁸ Sager, “The Garage,” 9.

⁸⁹ “Sears Homes 1915-1920,” *Sears Archives*. <http://searsarchives.com/homes/1915-1920.htm>.

3300), began to be pictured with garages in advertisements between 1927 and 1932, and the Pennsgrove (No. 3348) plans included a two car attached garage in 1932.⁹⁰ The car, and the garage to house it, was now part of the ideal American home.

Even as Sears embraced the suburban kit house as a profitable venture, Americans themselves were unsure of the suburbs. In the inter-war period, most suburbs did not have the amenities and services city dwellers saw as hallmarks of civilized living, such as walkable markets and public transportation. Trading these for a lot of one's own was a gamble. A yard allowed suburban homeowners to indulge in the new trend of outdoor living spaces which was appealing but the longer commute to work from the suburbs necessitated transportation. Those people who moved to the suburbs often solved this problem with an automobile, one housed in a garage that did not impinge on backyard space. New and improved roads, and the smoother ride they provided also helped make the suburban commuter lifestyle palatable to Americans.⁹¹

In the wake of the post WWI commercial boom, developers changed how suburbs were built aiming home ownership at the working class instead of just middle class families. Due to the large investment in home ownership, many business people argued that workers would be less likely to quit their jobs or to strike, and that they would also increase their consumption of other commercial goods needed to outfit their homes.⁹² Henry Ford boasted that his workers used their wages to build their own homes, and Rose

⁹⁰ "Sears Homes 1927-1932," *Sears Archives*. <http://searsarchives.com/homes/1927-1932.htm>.

⁹¹ Arnold and Lang, "Changing American Home Life," 30.

⁹² *Ibid.*, 25.

Feld, an early sociologist, found that steelworkers in 1924 used their increased leisure time due to the new 8-hour work day to build garages for their family homes.⁹³

Even in the 1920s, garages were not single use spaces. Becky Nicolaides demonstrates that garages often served as the first foothold into suburbanization for many families. She uses the example of the Smiths, who moved west to Los Angeles from Nashville in 1925 via two Model Ts. The first things they built when they reached their new land in an aspiring L.A. suburb was a garage, a garage that they would live in until they were able to complete the construction of the rest of their new suburban home.⁹⁴ Nor were they the only family to do so, in 1920, thirty-six other families in their new neighborhood were doing the same thing.⁹⁵ These working class families often built on lots that did not have utilities or other infrastructure, and just as often spent a considerable time living in a garage or basement before building a home.⁹⁶

The 1920s also saw the dawn of convenient service stations across large parts of the United States. The Standard Oil Company of New York took out a full page advertisement in the New York Tribune listing the hundreds of stations which carried its gasoline in the New York City metropolitan area alone.⁹⁷ No longer did car owners have to be as mechanically inclined as the early pioneers of driving, instead they could rely on a helpful gas station attendant or mechanic for most of their needs.⁹⁸

⁹³ Gelber, "Do-It-Yourself: Constructing, Repairing and Maintaining Domestic Masculinity," 82.

⁹⁴ Becky M. Nicolaides, *My Blue Heaven: Life and Politics in the Working-Class Suburbs of Los Angeles* (University of Chicago, 2002), 11.

⁹⁵ *Ibid.*, 30.

⁹⁶ Dolores Hayden, *Building Suburbia: Green Fields and Urban Growth: 1820-2000* (New York: Pantheon Books, 2003), 115.

⁹⁷ "The Sign of Service: Socony Motor Gasoline," *New York Tribune*, 11 May 1920, 11.

⁹⁸ Sager, "The Garage," 16.

Even as garages became an accepted part of the America home, that middle class home was changing. Arnold and Lang argue that front and back yards shifted from being sites of household production to sites of leisure starting in the 1900s. The typical outbuilding found in a home's backyard in 1900—the outhouse, carriage house, the coal, wood, and even cow shed—were slowly being replaced. Outhouses moved into the home as plumbing and sanitation improved, coal and wood shed were replaced by electricity, and most livestock moved out of cities and suburbs.⁹⁹ This shift began the process by which the garage would eventually leave the backyard as well. Suburbanization and the privatization of the backyard, Jackson argues, along with a shift of the center of leisure to the home, would change the garage to its current larger form and shift its location to the front of the home.¹⁰⁰

2.3 THE FAMILY GARAGE

In the 1930s and 40s, the shape of home lots changed from rectangles with the narrow edge facing the street to rectangles with the broader edge facing the street.¹⁰¹ Even as more of the lot faced the street, less time was spent on front porches and in front lawns as traffic, especially automobile traffic began to dominate even suburban streets.¹⁰² The 1940s, saw a huge surge in consumption and the advent of the two-car family, as public transportation and home delivery of consumer goods declined.¹⁰³

⁹⁹ Jeanna E. Arnold and Ursula A. Lang, “Changing American Home Life: Trends in Domestic Leisure and Storage Among Middle-Class Families,” *Journal of Family Economic Issues* 28 (2007), 28. <http://dx.doi.org/10.1007/s10834-006-9052-5>.

¹⁰⁰ Jackson, *Landscape In Sight*, 124.

¹⁰¹ Arnold and Lang, “Changing American Home Life,” 28.

¹⁰² *Ibid.*, 28.

¹⁰³ *Ibid.*, 34.

This larger, more home-centered garage served not only as a flexible storage space, but as a multivalent creative space as well. Crucially, for my efforts to determine agency in the transformation of the garage into a crafting space, Jackson demonstrates that the shift to the attached garage used as an area that is both in- and outdoors and for work and play, was not an innovation of homebuilders, but rather of homeowners. According to Folke T. Kihlstedt, this shift first had to overcome the obstacles of city building codes and zoning regulations, which architects like Frank Lloyd Wright did by placing the garage in the basement of his Edwin H. Cheney house in 1904. She credits Le Corbusier in the 1930s and his new style of industrialism with wide spread acceptance of the garage door as an architectural feature of the home, instead of a nuisance to be camouflaged.¹⁰⁴

With the backyard now clear of production and car storage, leisure became the central purpose of the backyard. It was a space for hosting guests, and its maintenance became a hobby of its own. With the ascendancy of the backyard, especially in the post-War period, also came the popularity of the barbeque and lawn game such as croquet and badminton. Lang shows that the fence itself became a symbol of American freedom, a demarcation of the private sphere wherein a man was king of his castle, which many Americans felt that the boogie man of the 1950s—communism—was out to destroy.¹⁰⁵ Privacy was not only a symbol of freedom, but one of status, a status that working Americans hoped to achieve. The development of the model suburban homes at

¹⁰⁴ Folke T. Kihlstedt, “The Automobile and the Transformation of the American House, 1910-1935,” in *The Automobile and American Culture*, edited by David L. Lewis and Laurence Goldstein (University of Michigan Press, 1980), 166, 169.

¹⁰⁵ Arnold and Lang, “Changing American Home Life,” 30.

Levittown, with their picket fences and perfect yards, reflected this desire, and many returning veterans flocked to similar suburban neighborhoods.¹⁰⁶

The single family home, marked by a father who fixed leaky faucets and barbequed, a mother who created a comfortable home and a honey-do list, and children playing safely in the well-maintained backyard became a vision, if not a reality, of the American Dream in the 1950s. For homes built without garages, like those in Levittown, one of the first improvements many American did with their new suburban homes was to add a garage to complete this dream. While the houses at Levittown did not have garages, many of the new suburban homes did. These single family homes allowed huge swaths of Americans to become home owners for the first time. Men not only took on home maintenance duties, but as the suburban design provided a lawn, yard maintenance also became the arena of men. Having a perfectly manicured front yard, one full of close cropped grass that is not native to North America, shaped bushes and ornamental plants, was an aesthetic ideal handed down from wealthy manor houses.¹⁰⁷ J.B. Jackson argues that in America, the front yard is a front yard, whether suburban or rural, wealthy or middle class, most front yards in America look about the same.¹⁰⁸

Even as whites flocked to the suburbs, middle class African Americans in the 1950s and 60s attempted to capture as much of the American dream as they could under Jim Crow and the racial animus of the time. Margaret Ruth Little argues that middle class African Americans were drawn to modernist styles in suburban houses, and rejected

¹⁰⁶ Ibid., 30.

¹⁰⁷ Ibid., 31.

¹⁰⁸ Jackson, *Landscape In Sight*, 124.

“styles that evoke a certain type of past or exclusion,” such as Colonial or Revival style homes.¹⁰⁹ They desired their homes to have modern conveniences, such as garage door openers, that announced that while they might live in segregated neighborhoods, the African American middle class were as modern and technologically advanced as other middle class people. The garage and its technologically advanced garage door opener were signifiers that African Americans were members of the middle class and, at least outwardly, adhered to those same values of male home repair and maintenance as did other members of the middle class.

2.4 THE GARAGE WORKSHOP

As the white middle class moved to the suburbs in the inter War period, they saw the home as a place for both men and women, unlike the previous generation, which reserved the home as part of the domestic, feminine sphere. The garage, along with the basement in locales where they could be dug, was often used as the site of a home workshop for the man of the house. These workshops were separated from family life, unfinished, and unlikely to be damaged. They gave men a place of their own in the female sphere of the domestic home.

Work is a central part of most people’s lives. It is the subject of a significant part of people’s daily conversation, and for many people, work is at the heart of the ways in which they define their own identities, as well as mobilizing political ideology. While mass-production is the main economic production system in a capitalist economy and is often used as an indicator of both economic and social health of the nation, this

¹⁰⁹ Margaret Ruth Little, “Getting the American Dream for Themselves,” *Buildings & Landscapes: Journal of the Vernacular Architecture Forum* 19, no. 1 (Spring 2012), 73-86, <http://www.jstor.org/stable/10.5749/buildland.19.1.0073>.

dissertation focuses on work outside of mass-production. Ruth Schwartz Cowan argues that unpaid labor is often not considered work by Americans. While she is specifically talking about housework, this argument can also be applied to labor, such as hobbies, which is seen not as work but as play.¹¹⁰ Historians such as Steven Gelber label this kind of play as productive leisure.¹¹¹ Whether for pay or play, examining non-normative modes of labor shines a new light on work, one of the central activities of industrial life. While craft activities were fit for leisure time in the twentieth century, they were not seen as the same activities as professionals undertook. Several factors including professionalization, producer control, and “user friendliness” have worked to separate amateur or lay-persons from professional scientists and engineers and even older ideals of craftspeople. Lay people did not simply lose interest in these areas because they either could not or chose not to become professionals.

Through the 1950s, home-based hobbies including home repair, and the associated woodwork and mechanical innovation were ingrained as standard skills of white, suburban, middle-class American men through education programs and advice books. While they were not expected to be as skilled as professional craftspeople, these men were expected to understand and appreciate the basics of craft and trade work as appropriate leisure activities. American participation in craft derived hobby work as leisure activity was firmly in place by 1950 and the site of this craft activity was predominantly the home garage.

¹¹⁰ Cowan, *More Work For Mother*, 73.

¹¹¹ Gelber, “Do-It-Yourself: Constructing, Repairing and Maintaining Domestic Masculinity,” 68.

Women's hobbies could most often be performed in the finished, domestic parts of the home, such as living rooms or kitchens. Needlework and most other feminized hobbies were not often known for being messy or requiring a specific type of space to store their tools. Men's hobbies, however, often required space that would not be damaged by their work. They also often included tools and equipment that took up large amounts of space, and could not be seamlessly woven in with the rest of the home's décor.

Rachel Maines argues that British and American women had already embraced the democratization of previously aristocratic feminine-coded crafts such as needlework and home decorating as leisure activities in the nineteenth century, and Steven Gelber shows that men followed with masculine coded crafts—first home repair, and then woodwork and mechanical tinkering—at the turn of the twentieth century.¹¹² First the basement and then the garage became the home workshop of many men. As the home was generally considered the sphere of women, middle class men sought to create a domestic role for themselves that bolstered their masculinity as work days grew shorter, and the weekend became a time for leisure. Home repair and improvement of the single family home, often based out of a home workshop created in the garage or basement, allowed these men to assert control over their domestic environments with their own hands. As this process required a single-family home owned by the residents, do-it-yourself home repair and the masculinized woodworking and mechanical hobbies that developed in its wake became linked with suburbanization in America.¹¹³

¹¹² *Ibid.*, 68.

¹¹³ *Ibid.*, 68.

Hand-work and craft became linked with both working and middle class white men's leisure time at the turn of the century, and that this increased until the 1950s it was an integral part of white suburban men's identities. This transition from a Victorian world wherein men hired professional labor for home repair or other do-it-yourself tasks, to a suburban landscape where every garage was expected to host a workshop, if not a skilled worker, created a ripple effect. For the first time, power tools were manufactured and advertised for a home user. These tools, and the man who owned them, needed a space in the home; one that, in many suburban homes built without basements or garages in the 1930s-50s, was difficult to find.

Some home designers suggested that the best place for tools would be the same place as the rest of the household appliances: the kitchen, but both men and women objected to sharing this space and the garage quickly became central to home hand work.¹¹⁴ In the garage, men built furniture and tinkered with cars, continually engaging in creative hand work. Vocational education became an important part of high school curricula as the demographics of the student body changed to include student who previously would not have attended, and in the earlier half of the twentieth century was considered a necessity for both working and middle class boys. Vocational education was also central to some advocates' plans for African American educational goals. Some women argued that girls, too, should be taught "domestic engineering." Still, women's crafting tools did not move into the garage nor men's power tools the kitchen.

In 1954, *Popular Mechanics* surveyed its readers in order to create a dream home that would be within the budget of its audience. The three-bedroom ranch style home

¹¹⁴ Ibid., 80.

featured a workbench in the two-car garage as well as an extended workshop in the basement. These brightly lit work areas are pictured with a table saw, drill press, vice and assorted hand tools.¹¹⁵ A workshop's setup depended both on the space which it inhabited, and also on the type of work to be done. Woodworking tools were perhaps the most popular tools in the home, but a range of equipment from chemistry labs to ham radios to engine hoists could be found in American garages in the 1950s. By 1923, power tools were available for purchase by home users, and as garages expanded in size and moved to the front of the home, they became the preferred location for power tool use and storage.¹¹⁶

Popular mechanics began printing "Shop Notes," small write ups of their reader's garage based hacks and adventures. In 1919, Kenneth M. Bard from Manawa, WI, suggested warming a workshop with a blowtorch and a section of stovepipe.¹¹⁷ Nor were workshops segregated from home laboratories. Popular Mechanics published just as many tips and tricks for chemistry applications as they did woodwork, including George Yaste's tips on making tools such as microscope slide clamps and spring clamps for holding work to be soldered out of wire.¹¹⁸ The construction of what a workshop could and should be was formed just as much in reaction to what these readers suggested, as from actual advice given in the magazine itself.

¹¹⁵ Wayne Whittaker, "The House You Asked For," *Popular Mechanics* (Oct 1954): 145-7.

¹¹⁶ W.B & J.E. Boice, "Spare Time Worth \$1.00 an Hour," Advertisement, *Popular Mechanics* (April 1930): 155.

¹¹⁷ "Popular Mechanics Shop Notes for 1919: Easy Ways to Do Hard Things," *Popular Mechanics*, (Chicago, 1919), 3056.

¹¹⁸ *Ibid.*, 3070.

Ham radio, a hobby that became popular in the wake of WWI, also demanded a secluded and solitary space for the hobby practitioner, 95% of whom were male.¹¹⁹ These areas, located in garages, attics, basements and sheds, were known as “shacks,” and needed to be far away from televisions and other radios.¹²⁰ The location of this space, Haring argues, was a negotiation between the male hobbyist and his wife, whom often controlled the allocation of family space in the domestic sphere of the home. Many women gave up the basement and garage, unfinished and rugged, to their sons and husbands, while retaining the furnished and respectable areas of the home for themselves. Haring shows that just like in Gelber’s example of woodworking, ham radio operators also saw their hobby as a way to bond with their sons, though their operations often caused a rift between them and their wives.¹²¹

Just like their fathers, boys too were encouraged to have workshop space in the pages of boy’s magazines and parenting advice books. Alcorn argues that advice books, such as Daniel Beard’s *American Boy’s Handy Book* in 1882, called for boys to be given tools instead of toys, not so much so that they could take up the mantle of adulthood and go to work, but instead so that they build their technical knowledge and independence by making their own toys. The tension between the feminized consumption and the masculinized construction was apparent in Beard’s elevation of the handmade, especially that which would be handmade and then used outdoors, as the pinnacle of what boys

¹¹⁹ Haring, “The ‘Freer Men’ of Ham Radio,” 735, 738.

¹²⁰ *Ibid.*, 752.

¹²¹ *Ibid.*, 754.

should be doing. This “moral benefit of making,” is apparent in Beard’s greatest undertaking, co-founding the Boy Scouts.¹²²

Where Beard saw tools as a means to get boys outside, many others saw them as a good in and of themselves. Stout argues that “With the right encouragement, and using only simple tools and cast-off resources (most notably wooden spools and empty cigar boxes), the modern, inventive boy ‘will make everything from a submarine to a flying machine.’ Inspired by the potential of inexpensive tinkering, Stout concluded [in 1917]: “give the real boy some tools and a workshop, and half the problem of bringing up the next generation is solved.”¹²³

Boy’s Life encouraged boys to build their own work areas in 1963. “Home workshops are great father-and-son activities,” the magazine claimed, and encouraged boys to work together to make a workspace for boys.¹²⁴ In 1951, the magazine suggested that a boy’s workshop should contain both drafting and marking tools, such as squares, dividers, rules, compasses and marking gauges, as well as standard wood working hand tools, like planes, saws, clamps files, a brace and hand drill, hammers and screw drivers.¹²⁵ In a 1954 article, the same author encourages boys and their fathers to try power tools in their workshops.¹²⁶

¹²² Aaron L. Alcorn, “Modeling Behavior: Boyhood, Engineering, and the Model Airplane in American Culture,” PhD diss., Case Western Reserve University, Cleveland, 2009, 92-93.

¹²³ *Ibid.*, 178.

¹²⁴ Glen Wagner, “For a Creative and Enjoyable Hobby, Start a Home Workshop,” *Boy’s Life*, Aug 1963, 46.

¹²⁵ Glen Wagner, “Your Home Workshop,” *Boy’s Life*, Aug 1951, 16-17.

¹²⁶ Glen Wagner, “Dad and I Start a Power Tool Workshop,” *Boy’s Life*, Feb 1954, 67.

A boy could use these tools to make a work bench, or if they had indulgent parents and a large budget, could create their own workshop shed in the back yard, as the Army's Engineering Corps' Captain Gray suggested in the pages of *American Boy*.¹²⁷ He conceded that some boys might have to settle for a basement or an attic, but that the best workshop for a boy was one he built with his own two hands.¹²⁸ Alcorn argues that the dedicated and separate workshop that Gray advocated for was in keeping with "traditions of solitude and social withdrawal for creating knowledge."¹²⁹ For boys who could not build their own separate workshop, a workbench in a garage or basement would do. A workbench was "not only a great aid in constructing things, but it is a standing invitation to work."¹³⁰

The construction and maintenance of a male technical domain created by these publications and the fathers and sons who headed their advice left women and girls to fill the roles of passive consumers. Ruth Oldenziel argues that the separation of a technical, creating man and a consumer woman happened as a part of the same process, creating an opposition between the things men actively made and those same things that women passively used.¹³¹

This division was actively exploited by corporations which created a male, technical world that would produce male employees needed as managers and engineers in

¹²⁷ Alcorn, "Modeling Behavior," 95-96.

¹²⁸ *Ibid.*, 95-96.

¹²⁹ *Ibid.*, 97.

¹³⁰ Clarence Budington Kelland, *The American Boy's Workshop* (Philadelphia: McKay, 1914), 193.

¹³¹ Ruth Oldenziel, "Boys and Their Toys: The Fisher Body Craftsman's Guild, 1930-1968, and the Making of the Male Technical Domain," *Technology and Culture* 38, no. 1 (Jan., 1997), 62.

those institutions.¹³² GM and their subsidiary, Fisher Body Craftsman's Guild, "combined the appeal of toys and the model-making tradition with corporate needs for training new personnel while crafting consumers' tastes."¹³³ The Guild hosted a model building competition of a Napoleonic Coach for boys with a prize of a \$5,000 scholarship to an engineering college. In 2017, that would be approximately \$70,000, and in 1930, when the prize was first given out, a young man would be off to a good start in life with such a prize. Enough so that the competition attracted over 8 million boys between 1931 and 1960 and by the end of that period 55% of GM's design staff had been involved in the competition as children.¹³⁴ GM recruited judges from the elite of engineering education at both the university and high school level, not only allowing them to have a competent judging staff, but also to be in constant communication with educators on what GM wanted in an employee. In order to compete, the boys had to have access to tools and workspaces. The model Napoleonic coaches had to have working windows, moving axels and working leaf-spring suspension, all of which required time, dedication and specialized model building tools.¹³⁵ So in the workshops where these boys built, often with the help of their fathers, their technical skills were shaped by the demands of corporate America, advice books, and cultural dictates that saw boys as makers of things.

2.5 THE MYTH OF THE AMERICAN GARAGE

In a culture that sees boys of makers of things, and the garage as the appropriate location of such activity, it is easy for the garage's importance as a space to be over emphasized in narratives of entrepreneurial success. These narratives, which Russel and

¹³² Ibid., 65.

¹³³ Ibid., 66.

¹³⁴ Ibid., 66, 75.

¹³⁵ Ibid., 79.

Vinsel point to as being overplayed, place young white men in garages and through some alchemy of genius and location create the tech companies that help power the American economy. The garage, however flexible a space in the family home, has no special power to create commercial success. Then why is the garage such a prominent part of the foundational narratives of such companies as Apple computing?

Pino Audia and Christopher Rider argue that the garage is a symbol, one that “conjures up some common images of entrepreneurship, including the inspirational generation of innovation ideas, old-fashioned hard work and American ingenuity, bootstrapping resources to chase a dream, a rejection of the status quo, and the freedom of working for oneself.”¹³⁶ The garage then, for many Americans, is a symbol of the modern impulse towards Jeffersonian Republicanism, taking the place of the family farm as a locus for turning hard work into freedom. As Audia and Rider argue, “The garage entrepreneur is a contemporary legend that obtains its staying power not from its accuracy but, rather, from its ability to tap common emotions... While the legend of the garage entrepreneur evokes the image of the lone individual who relies primarily on his or her extraordinary efforts and talent to overcome the difficulties inherent in creating a new business...”¹³⁷

The first famous garage innovator are the founders of Hewlett-Packard. William Hewlett and David Packard created an audio oscillator, the first product of Hewlett Packard in their garage in 1939. Hewlett and Packard, it seems, did much of their work in the garage of the Packard’s apartment (Hewlett lived in a shed on the same site.) They

¹³⁶ Audia and Rider, “A Garage and an Idea,” 6.

¹³⁷ *Ibid.*, 7.

worked out of the garage for two years before moving off site.¹³⁸ In 1987, California chose to place the garage on the California Historic Landmark registry, and placed a plaque there declaring the space the “birthplace of Silicon Valley” and the garage was added the National Register of Historic Places in 2007.

Perhaps most famous of the mythical garage based innovator is Steve Jobs. In legend, Steve Jobs and Steve Wozniak entered a garage with an idea and ended up revolutionizing the world. In fact, they started their computer assembly in a bedroom, and were joined by a third friend, Ronald Wayne. While Wozniak and Jobs actually did work out of Job’s parent’s garage for a short period of time, it is hard to argue that the garage was an integral part of their company as it is in legend. Steve Wozniak himself said that “the garage is a bit of a myth, it’s overblown.”¹³⁹ While the Apple garage is a historic site for its role in the assembly of the first 50 Apple Computers, Wozniak claims that the garage was mainly used to test fully assembled computers before delivery. No computer were designed or assembled in the garage.¹⁴⁰ Apple Computing’s legacy in the arena of personal computers cannot be denied, nor can its’ creation story be separated from the American garage.

In Audia and Rider’s study, 89% of business students and 87% of American adults surveyed could name a company that started in a garage. The students estimated

¹³⁸ “A Home For Innovation: The HP Garage – The Birthplace of Silicon Valley,” HP brochure,

<http://www.hp.com/hpinfo/abouthp/histnfacts/publications/garage/innovation.pdf>.

¹³⁹ Alejandro Alba, “Steve Wozniak, Apple’s co-founder, reveals that Apple did not start in garage,” *New York Daily News*, 7 December 2014.

<http://www.nydailynews.com/news/national/steve-wozniak-reveals-apple-not-start-garage-article-1.2037003>

¹⁴⁰ Ibid.

that almost half of all businesses started in a garage, where as the general public put the number at 30%.¹⁴¹ They went on to survey start-ups which received venture capital in 2004, and found that only 25% of them had been started in a “garage, basement, dorm room, or a room in one of the founders’ residences” and only one in a garage.¹⁴² The myth of the American garage has a much bigger impact on how people think about technological innovation than on actual innovation itself.

Audia and Rider go on to argue that the myth of the garage is actually harmful, both to would-be entrepreneurs who prioritize individual genius over pre-existing experience and organizational and social ties, as well as to the economy as the whole, when the government makes policy decisions on the basis of this myth.¹⁴³ They argue that, “This legend resonates with many Americans because of the garage’s association with ideas of the U.S. as the land of opportunity, a meritocracy where people get their due, and as a place where all are created equal. These associations enable the legend to persist, absent extensive scrutiny of the details underlying the stories that contribute most to the legend.”¹⁴⁴

All of this innovation in the garage dependent on the shrinking size and increasing power of the computer is either powered or predicted, depending on your point of view, by a single article Gordon E. Moore wrote in 1975 arguing the component density (transistors, resistors, diodes, and capacitors) of integrated circuits would double every

¹⁴¹ Audia and Rider, “A Garage and an Idea,” 9.

¹⁴² *Ibid.*, 10.

¹⁴³ *Ibid.*, 21.

¹⁴⁴ *Ibid.*, 19.

two years.¹⁴⁵ Ten years before he had predicted that component density would double every year for ten years and it had. From 1975 to 2012, his law held true and component density doubled every two years, though in the last five years, companies such as Intel have seen a slow down to doubling every two and a half or three years. Moore himself predicts that the law will break down around 2025. But in the half a century during which Moore's Law held sway, computers shrunk from the building wide mammoths operated by an arcane priesthood of scientists and engineers to the pocket sized gizmos that are continuously in the hands of every teenager you know.¹⁴⁶

It is this process, the shrinking size and increasing speed and power of computers, that is hidden behind many of the events of this dissertation. Computers shrunk to fit on a desk to be tinkered with by both engineers at work and kids in their rooms at home, they became small enough to fit inside a car, which eventually made car repair the realm of a specialist, and then to control a tool on a garage workbench, allowing industrial tools to slip into the domestic home. These ever faster, ever smaller computers allowed for the Internet to connect people in affiliative groups unhindered by geography, and finally became small enough that Makers can buy a micro computer, a sew it into a piece of clothing in order to make it blink. While this dissertation focuses on people and how and where they choose to make things, underneath it all are computers which are getting smaller and faster every two years.

¹⁴⁵ Gordon E. Moore, "Progress in Digital Integrated Electronics." International Electron Devices Meeting, *IEEE*, (1975), 2-3.
http://www.eng.auburn.edu/~agrawvd/COURSE/E7770_Spr07/READ/Gordon_Moore_1975_Speech.pdf.

¹⁴⁶ Tim Cross, "After Moore's Law: Double, double, toil and trouble," *The Economist*, 12 March 2016. <https://www.economist.com/technology-quarterly/2016-03-12/after-moores-law>.

2.6 THE MODERN GARAGE

Even if the myth of the American garage is largely a myth, the suburban home, with its white picket fence and its two car garage is still a keystone of the American dream. While most Americans envision the garage as a place to park automobiles, most Americans actually use their garages as storage space. In Lang's study, almost all of the families had converted their garages, either formally into more living spaces, or informally into a storage area. None of these families routinely use any of the goods stored in their garages.¹⁴⁷ The study commissioned by the *Wall Street Journal* also found that in 2013, the garage was still considered by most homeowners to be a male domain. 70% of all activities based in the garage, including parking, storage, use as a workshop, and use as a social gathering space, were done by men.¹⁴⁸

Lifhacker, a popular internet advice website, declared the garage “a natural place to store tools and equipment.”¹⁴⁹ In their vision of the ultimate garage workshop, Lifhacker suggests that the first step is finding a different storage area for the household detritus that ends up in the garage. They also suggest wiring the garage with extra electrical outlets for your, “CNC machines, 3D printers, and computers.”¹⁵⁰ As I will talk about in Chapter 3, from 1950 to 2010, the tools used in the garage workshop expanded dramatically, bring digital fabrication tools into the hands of lay users.

The garage, itself, is also changing. Greg Dickinson argues that the trend of further pushing the front attached garage of the contemporary home forward is not only a

¹⁴⁷ Arnold and Lang, “Changing American Home Life,” 25.

¹⁴⁸ Hudson, “To Park or Not To Park: The Real Value of Garages (part 2).”

¹⁴⁹ Timothy Dahl, “How to Transform Your Garage Into the Ultimate DIY Workshop,” *Lifhacker*, 22 July 2015, <https://lifhacker.com/how-to-transform-your-garage-into-the-ultimate-diy-work-1719480723>.

¹⁵⁰ Dahl, “How to Transform Your Garage Into the Ultimate DIY Workshop.”

status symbol, but also often creates a front door that is set back and partially hidden. In doing so, he suggests, the garage becomes a symbol of safety and a demarcation between public and private space, as well as a sign of the increasing anxiety about safety and security in American culture.¹⁵¹ He also notes that new architectural movements, such as New Urbanism, are combating this prominent garage, and instead are returning the garage to the rear of the home connected to alleys or rear lanes.¹⁵² This tension between safety and a renewed emphasis on walkable cities highlights mirrors other tensions in American life.

These shifts in use have not changed how Americans think about garages, however. Tom Brokaw even brought the issue up in the 2008 presidential debates, asking “whether serious challenges such as climate change could be met by big Manhattan-style projects like the one that developed the atom bomb, or by people working in 100,000 garages...”¹⁵³ For many Americans, inside and outside of government, the myth of the American garage is strong. The garage-based innovator has become the Maker. A person whose individual drive to tinker with electronics and digital production technology is seen as the catalyst of innovation. These people have come together to create a community of people and communal workshops focused on tinkering with technology.

¹⁵¹ Greg Dickinson, *Suburban Dreams: Imagining and Building the Good Life*, (University of Alabama Press, 2015), 91.

¹⁵² “Principles of New Urbanism,” *New Urbanism*, <http://www.newurbanism.org/newurbanism/principles.html>.

¹⁵³ Dale Dougherty, “What’s In Your Garage?” *Makezine*, 8 May 2009, <https://makezine.com/2009/05/08/whats-in-your-garage/>.

CHAPTER 2

A GARAGE OF THEIR OWN

In 1965, Julie Coryell climbed into a 1965 Peugeot 403 with her new husband, Seeley, and drove cross-country from Massachusetts. By the time they arrived in Seattle, she knew two things, that she did not know enough about cars and that she wanted to learn.¹⁵⁴ How exactly, she was going to acquire that knowledge, was a quandary. Women, especially married middle class white women like Coryell, were not often welcomed in the masculinized garages that had developed in the first half of the twentieth century. For Coryell, the opportunity to learn hands on about car maintenance and repair from other women seemed revolutionary, but even in 1965 there was a long, if little-remembered, history of women's automobile work both in home garages and in larger, public and commercial settings.

Women's technical competency and their reputation for technical competency among the public, were never the same things, especially when it came to the automobile. In this chapter, I will first discuss how women established their technical competency in the arena of automobile driving, maintenance, and repair at the dawn of the motor car, and then consider how the perception of this competency was undermined by male motoring journalists and changing family structures. Using oral histories, published interviews and records from Women's Cooperative Garages in the 1970s, I will argue that these women were attempting to establish technical competency among women

¹⁵⁴ Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

drivers, without an awareness of the previous generation of female drivers and their struggles to obtain competency and the reputation technical competency in this field. I will then consider the ramifications of these cooperative garages on women and especially lesbian drivers and car owners in the 1990s to the present.

Kathleen Franz argues that early female motorists were equally or more mechanically knowledgeable about car maintenance and repair than their male peers. In the 1910s, women motorists were celebrated as mechanical heroines who broke with social conventions to travel alone or in groups of women. These women gained the technical skill needed to run and customize early automobiles which were notoriously finicky and often not optimized for user needs. Their ability to be competent drivers and mechanics was bolstered by male and female journalists writing for interest based periodicals, as well as fictionalized accounts of female drivers that portrayed women as good drivers and competent mechanics.¹⁵⁵

Women not only took to driving their own cars, but also sought employment as chauffeurs and taxi cab drivers. Georgine Clarsen tells the story of one such chauffeur, Miss Eva Mudge, whose skill at driving and repairing both steam and gasoline powered cars was heralded in a New York motoring magazine in 1900. Miss Mudge could fix a faulty connection or a short circuit, and drove skillfully according to the reporter. Female chauffeurs and taxi cab drivers advertised their services and were often interviewed by motoring journalists. Some, like Katherine Lockwood of St. Louis, aimed their appeal towards other women, arguing that many ladies would find a female chauffer both more

¹⁵⁵ Kathleen Franz, *Tinkering: Consumers Reinvent the Early Automobile* (University of Pennsylvania, 2005), 56.

palatable and skilled than a man. In 1912, twenty women took the taxi license exam in Chicago, several women in New York advertised as chauffeurs, and a few even found work as mechanics.

By 1916, the Girl Scouts of America added an “automobiling” badge, one of only 36 badges at the time.¹⁵⁶ To earn this award, a girl had to acquire her driver’s license, as well as be able to start a car on her own (a much more difficult task before keyed ignitions replaced cranks), and be able to deal with safety concerns related to automobiles such as fuel fires.¹⁵⁷

Not all women were as enamored with the automobile as Franz’s mechanical heroines. Ronald Kline and Trevor Pinch point to a 1915 Department of Agriculture survey, in which many of the wives of crop correspondents noted that automobiles made roads hazardous for women driving horse-pulled vehicles. Horses often reared or bolted at the approach of an automobile, sending buggies and their occupants into danger. Cars on country roads also killed livestock, and threatened the well-worn networks of rural life. Many rural farmers went so far as to sabotage roads, often ones that they had previously personally maintained in order to keep cars out of the countryside, arguing it was necessary for the safety of both women and livestock.¹⁵⁸

¹⁵⁶ Juliette Gordon Low, Agnes Smyth Baden-Powell, Robert Smyth Bade-Powell, *How Girls Can Help Their Country* (Savannah, GA: Press of M.S. & D.A. Byck, 1916), 33.

¹⁵⁷ Lauren Tedesco, “Making a Girl into a Scout,” *Delinquents and Debutantes: Twentieth-Century American Girls’ Cultures*, ed. Sherrie A. Inness, (NYU, 1998), 33.

¹⁵⁸ Ronald Kline and Trevor Pinch, “Users as Agents of Technological Change: The Social Construction of the Automobile,” *Technology and Culture* 37, no. 4 (October 1996), 772.

Cars, however, did not stay confined to the city. As more automobiles were marketed to a rural audience, farmers and their wives found new uses for the car. In fact, when not being driven, Kline and Pinch note, the car could be rigged to provide power for jobs like churning butter, separating cream, washing clothing, and pumping water, tasks that would have normally fallen to the woman of the house. The tinkering with the car, however, was mainly undertaken by the male farmer. Rural women showed their mechanical abilities during WWI, when farm women drove and maintained tractors for the American Woman's Land army, an organization which helped make sure crops were harvested even when male farmers were at war.¹⁵⁹

This was not the only place where women and the war effort intersected: Augusta and Adeline Van Buren, Martin Van Buren's granddaughters, promoted a pro-war "Preparedness Movement" from atop motorcycles on a cross country tour in 1916. This fete earned them a place in the American Motorcyclist Association's Motorcycle Hall of Fame. Their goal was to prove that women could be dispatch riders in the oncoming war, leaving more men for combat. They drove across the country on Indian Power Plus motorcycles, over ill-repaired and often unpaved roads, battling miserable driving conditions, unpredictable weather, and arrests for wearing men's clothing while riding their motorcycles.¹⁶⁰ Their cross country ride, including their ascent up Pike's Peak, (14,000 feet high) was celebrated by modern female motorcyclists following the Van Buren sisters' path across the country.¹⁶¹ Other American women aided the war effort by

¹⁵⁹ Ibid., 776-783.

¹⁶⁰ Robert Van Buren, "Adeline and Augusta Van Buren," *AMA Motorcycle Hall of Fame*, <http://www.motorcyclemuseum.org/halloffame/detail.aspx?RacerID=285>.

¹⁶¹ 100th Anniversary Ride, *The Van Buren Sisters*, <http://www.vanburensisters.com/100th-anniversary-ride-1/>.

becoming ambulance drivers in France, ferrying wounded soldiers to medical attention, and a few women served as mechanics and drivers.

On the home front, women made their living driving and dealing with automobiles. In 1915, *Motor Age* ran a two page spread on Mrs. E. M. Self, who, after being hired as a bookkeeper, quickly took over the Delco Garage in St. Louis, rescued it from bankruptcy, and turned it into the “largest, cleanest and best-managed garage in St. Louis.”¹⁶² She emphasized both physical and moral cleanliness, embraced new technologies, and kept accurate books. Louis Renick of *Motor Age* proclaimed that “Among the legacies which Mrs. Self inherited from the man-manager who proceeded her was a crowd of seventeen swearing, smoking and tobacco-spitting chauffeurs... Within a month she had converted the crowd into seventeen gentlemen.”¹⁶³ She also replaced hand-cranked garage doors with motorized sliding doors that she could operate from her office, so that employees would not need to constantly open and close the doors. She incorporated a book keeping system to make sure gasoline and oil did not go unaccounted for (previously up to 31 gallons of gasoline a week had disappeared unpaid). This cleanliness and accuracy helped fill all 75 parking spaces at the garage, even at the highest prices in St. Louis, as well as win accolades from motoring journalists.¹⁶⁴

For both fictional heroines, such as those found in *Motoring Girls*, as well as female farmers and cross country travelers who documented their experiences in articles and diaries, mechanical ability was a necessary part of driving. Not only might male

¹⁶² Louis Resnik, “The Female of the Species is More Efficient Than the Male,” *Motor Age* 28 (21 October 1915): 26-27.

¹⁶³ *Ibid.*, 26-27.

¹⁶⁴ *Ibid.*, 26-27.

mechanics be dishonest, they might not be present at all if the automobile broke down far from a town. If a driver of any gender did not want to end up stuck far from home, intimate knowledge of how their car worked and how to fix it was required. Even in the face of this technical competence, female drivers of the 1910s could not hold on to their strides in the face of changing domestic patterns and changing tone in automobile publications.¹⁶⁵

The shift toward increased male presence and power in the domestic sphere not only created the home garage as a masculinized space, but also changed the ideal template of behavior in marriage. With the advent of the weekend and the 10 hour work day, husbands and wives spent more time with one another. Instead of spending all their leisure time separately, men were encouraged to see their wives as companions. This, Franz argues, ultimately changed motoring from a sex segregated activity into one which men and women undertook together as a family. Thus, the familiar patterns of socially acceptable male and female behavior asserted themselves, with a male driver in control of the driving and his wife relegated to camp chores such as cooking. Motoring journalists no longer trumpeted the mechanical competence of female drivers, and went so far as to suggest that women were inferior to men in areas such as cooking when it came to these domestic tasks on the road.¹⁶⁶

Clarsen argues that the emphasis on “the first woman to” type journalism prevalent at the turn of the century also hampered women’s reputation as drivers and mechanics. The repetitive nature of these claims combined with the aura of

¹⁶⁵ Franz, *Tinkering*, 66.

¹⁶⁶ *Ibid.*, 67.

exceptionalism, she shows, was “based on the assumption that women’s technological competence had no past.”¹⁶⁷ Without a past, there can be no continuity, and without continuity, the narrative of women’s technological competency was easy to set aside and eventually forget.

By the 1920s, as women increasingly were the primary driver of the family car, they were routinely derided by motoring journalists as not only incapable of repairing their automobiles, but also of driving them. In trade journals, some writers advocated creating “fool-proof” cars for women.¹⁶⁸ For the next fifty years, the narrative that women were unsafe drivers, unable to do the most basic of repairs would become standard though erroneous, and is not unknown even in the twenty-first century. Cars, and the systems of technology that support their manufacture, use, and maintenance, might sometimes be driven by women, but they were not intended for women. In fact, this gendering of automotive technology had so much power that the women who came to form garages in the name of feminism and female empowerment in the 1970s appear to be totally disconnected from early female motorists. They did not consider the daring and mechanical heroines of the 1910s their foremothers. Instead they saw themselves as something new, a radical departure from a status quo of male mechanical skill that to them was not created in the 1920s, but seemed to be a truth embedded in the car itself.

Women of all walks of life found themselves renegotiating the appropriateness of gendered technical skills in the 1970s. Groups of both radical feminists and lesbian separatists engaged in making previously deviant technical behaviors—from car repair to

¹⁶⁷ Georgine Clarsen, *Eat My Dust: Early Women Motorists* (John Hopkins University, 2008), 69.

¹⁶⁸ Franz, *Tinkering*, 70.

trade work—women’s work. These efforts not only involved women associated with these causes, but also women who were simply interested in the technical skills being taught. This rift between women interested in technical work for the work’s sake and those primarily interested in technical work for the sake of feminism, however, was difficult for many groups to reconcile. Additionally, the very nature of learning worked against these groups, as women often did not stay affiliated after they achieved their educational goals. Lastly, the evolution of the car itself hindered their longevity, for it was during this period that the “tune-up,” a necessity of early car maintenance that could be learned by a relative novice, was phased out by new car design.

Historians Lee Vinsel and Andrew Russell argue that for many Americans, and indeed many historians of America, innovation is a proxy for progress, without the messiness of social or moral improvement. Innovation with its perceived link to economic growth and better living became the buzzword of the business world, and a focus of academic research. As Vinsel and Russell point out, innovation is a tiny sliver of the story of technology, and often not the most interesting part. The women’s cooperative garages of the 1970s were places of maintenance; no new piece of technology was invented, repurposed, or sold. In fact, maintenance was harnessed as a route to actual social improvement by many radical feminist in these garages, not just a shiny stand-in.¹⁶⁹

Radical feminism came early to Seattle. Radical feminists placed the root of women’s oppression in patriarchal society, and sought to change the social system in

¹⁶⁹ Andy Russell and Lee Vinsel, “Hail the Maintainers,” *Aeon*, 7 April 2016, <https://aeon.co/essays/innovation-is-overvalued-maintenance-often-matters-more>.

which they lived, in contrast with later moderate feminists, who attempted to improve women's lives by working within the current social system. For radical feminists, establishing their own systems and networks to meet the needs of female equality was a top priority. The University of Washington's YWCA opened an Abortion Referral Service in 1970, a Lesbian Resource Center in 1971, and a rape crisis hotline in 1972. While these three projects fit the traditional model of radical feminist efforts, in 1972, the YWCA also partnered with a group of radical feminists to open a cooperative garage for women. The YWCA was not alone. The Women's Action Collective of Columbus, Ohio, also opened a women's cooperative garage in 1972 after organizing efforts along more traditional radical feminist lines. In St. Louis, a lesbian cooperative garage opened as well, headed by a lesbian separatist. The car and its maintenance was an important, if historiographically overlooked, part of the women's movement. How then, did auto repair and maintenance fit in the radical agenda of feminists and lesbians in the 1970s, and what impact did these garages have on these communities?

Once in Washington, Coryell became involved in the YWCA's racism consciousness raising program. She became friends with many of the women who were involved with the YWCA's advocacy programs as well as the United Way, some of whom would be lifelong friends. There she was introduced to Robin Morgan's *Sisterhood is Powerful*, a book she remembers galvanizing her understanding that men have knowledge that they did not share with women, and that this knowledge gap helped oppress women. Boys had access to this knowledge both from their fathers and through vocational classes, but because of social constructions of appropriateness and gender

roles neither vector of knowledge transmission was usually open for girls to take part in.¹⁷⁰

With this in mind, Coryell attended many consciousness raising and radical feminist events. The idea of *Mechanica* developed during the November 1970 Survival Revival organized by the Anna Louise Strong Brigade where Brenda Spencer taught an auto mechanics class. Attendees including Coryell, learned the basic steps of tuning up a car, and some felt that these skills were necessary for all women. Cars, after all, were necessary for reliable transportation to and from jobs outside the home. They also had long been a symbol of freedom to Americans, a technological declaration of independence, and one which these women hoped would lend their cause power. The women that would come to form *Mechanica* believed that this symbolic freedom, coupled with technological competence in a masculinized field would not only allow them to help women achieve their practical goals, but also help change how women viewed themselves in relation to technology. Slowly, the group began to form a plan to create a cooperative garage where women could learn to repair their cars from other women. It would also provide a space for women without home garages or the appropriate tools to work on their own cars.¹⁷¹

Along with the other founders of *Mechanica*, Coryell felt that a space where tools and expenses could be shared was vital to helping women gain automobile maintenance knowledge for themselves. The women organized the garage around the Rochdale Principles, a set of ideas on running collectives. The members were very interested in

¹⁷⁰ Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

¹⁷¹ *Ibid.*

creating a working cooperative as an alternative to capitalist society. They were inspired by the Puget Sound Consumers Co-op and the Group Health Cooperative.¹⁷²

Problematically, the collective ownership of tools often meant that they were not well taken care of, or were cared for by women who had not used them, and this resulted in tensions in the garage.¹⁷³

Brenda Spencer was interested in cars and their maintenance as early as high school. The caption of her senior picture in her high school yearbook even devoted a line to how much she enjoyed taking care of her car. Spencer continued to teach classes through 1971 and 1972 with the University of Washington's Women's Commission, while a group of women began the search for garage space to expand the classes and offer a work space to the students outside of class.¹⁷⁴ The classes were well attended; more than one hundred women participated in 1971 alone. These women created a demand for the garage space as they honed their new skills. Women who had obtained car maintenance skills often did not have a place to perform them or the tools necessary, and many women wanted to continue their auto maintenance education.¹⁷⁵ Being knowledgeable in car maintenance helped women keep their cars running and offered them entry into masculine-aligned skills that had previously been unavailable to most

¹⁷² Ibid.

¹⁷³ Ibid.

¹⁷⁴ Julie Lee, "Women invade the grease pit," *The Seattle Times*, 12 May 1973, box 29, folder 7, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁷⁵ Letter to Members, Mechanica Committee, 24 February 1972, box 29, folder 7, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

women. This also allowed them to be knowledgeable while dealing with professional male mechanics for larger repair jobs on their vehicles.

On 2 Feb 1972, the group decided to call itself the Mechanica Committee.¹⁷⁶ They chose the name looking toward a future that they hoped would not only include teaching car repair, but a whole range of technical skills. In order to obtain the appropriate liability insurance, the group needed to partner with a larger, more established organization, so 1972 “these women approached the University of Washington YWCA and became a program of this organization. This relationship enabled Mechanica to obtain liability insurance for the small workshop, to open an office, and to receive tax-deductible contributions through the non-profit YWCA.”¹⁷⁷ In the early 1970s, the YWCA had become the home for many radical feminist efforts, so much so when the Y offered Mechanica desk space it was in the Abortion and Birth Control Referral room. This allowed the group to obtain a phone number and official address, and with these steps completed, Mechanica began to solicit funds.¹⁷⁸

In order to raise capital, the group first held a film benefit where they showed three short films: “ABC’s of the Combustion Engine,” “Power Train,” and “The ABC’s of the Automobile.” They attracted a small audience, mostly of women who were already committed to the project, but gained a few new audience members as well. The group

¹⁷⁶ Minutes for meeting of 2 February 1972, Mechanica Committee, undated, box 29, folder 4, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁷⁷ Herstory of Mechanica committee, Julie Coryell, 17 January 1973 box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁷⁸ Minutes for meeting of February 1972. Julie Coryell, box 29, folder 9, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

pitched car repair as a practical skill, and many women responded with interest. After the movies night, they also entered an agreement to sell Dayton and Snap-On tools to students who had previously taken auto mechanics classes with Spencer.¹⁷⁹ The committee also negotiated a discount on parts and tools from a local NAPA store. These efforts raised startup funds, but also got tools in the hands of the women who would be the operation's base users. In fact, these fund raising projects went well enough that they were able to rent a garage in short order.

The garage opened on 17 April 1972, and was initially available only to students who had previously taken classes with the University of Washington's Women's Commission or who could demonstrate their skill with auto maintenance. It cost \$3.00 to join the organization per quarter and \$0.50 per hour to use the garage to do jobs such as "oil changes and lub [sic] job, packing wheel bearings, relining brakes, tune-ups and installation of shock absorbers."¹⁸⁰ Members could rent the garage out for simple car repairs, and provided their own supplies (Mechanica did sell lube grease for a \$0.50 donation.)¹⁸¹

At the rental garage on Atlantic and Dearborn, Mechanica started with a single class of four or five women. Over the course of the garage's lifetime, class size rose to a high of 12, but the size limitations capped the number of women who could work at the garage at any one time. Coryell noted that she enjoyed the camaraderie of physical work

¹⁷⁹ Letter to Members, Mechanica Committee, 24 February 1972, Young Women's Christian Association (University of Washington) Records.

¹⁸⁰ Opening Announcement, Mechanica Committee, undated, box 29, folder 7, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁸¹ Minutes for meeting of February 1972. Julie Coryell, Young Women's Christian Association (University of Washington) Records.

with other women, and noted that many of the women became very strong. The garage, she said, “was a place to be ourselves and wear clothes to get dirty.”¹⁸² Coryell spent two to three days a week at the garage.¹⁸³

Mechanica’s goal was to provide women with the tools and skills needed to repair their own vehicles. While middle class American women often drove the family car to take care of errands such as shopping and taking the children to and from school, many performed few or no maintenance tasks on the cars they drove. Those tasks that they did undertake more often had to do with the cleanliness of the interior of the vehicle than anything under the hood. More often gas station attendants, almost all male, pumped gas and cleaned windshields, and tune ups and oil changes were performed either by mechanics, or husbands or sons who had learned to maintain vehicles either from their own fathers, or through school vocational classes.

Spencer offered a range of classes at the garage, but the introductory classes proved most popular. This led to a problem of providing garage supervisors for more complicated repairs such as “exhaust systems, head jobs, carburetors, clutches,” as many of the women who volunteered were not yet comfortable with those types of repairs even a year after the garage had opened. On 9 Dec 1972, the committee held a workshop for supervisors (who would soon be renamed attendants in accordance with the garage’s collectivist goals). Brenda Spencer taught, covering safety procedures as well as the basic procedures involved in tuning up a car, until there was a cadre of women who felt comfortable helping women who were using the garage for such procedures. Attendants

¹⁸² Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

¹⁸³ Ibid.

could also help women check their car batteries, top off brake fluid, adjust lights, and perform other basic tasks related to car maintenance.¹⁸⁴ Brenda Spencer continued to teach classes through the Women's Commission at the garage in the evenings, but the group began to recruit new teachers as well.¹⁸⁵

Women enrolled in the Beginning VW auto mechanics class held by Betty Richardson filled out surveys both about the course itself and what types of services they would like to be offered in the future.¹⁸⁶ Skills these women were interested in learning included: plumbing, electrical repairs, household repairs.¹⁸⁷ When asked why they wanted to work on cars, one woman wrote in "sexism of professional mechanics."¹⁸⁸ Another said, "feelings of accomplishment and self-respect and competence."¹⁸⁹ For many women, the car maintenance classes were not just about repairing their own cars, but having the knowledge that let women deal with often sexist commercial auto mechanics. One woman commented on a feedback form that *Mechanica* provided, "The

¹⁸⁴ *Mechanica* Attendant's Tune-Up and General Information Workshop, *Mechanica* Committee, 9 December 1972, box 29, folder 4, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁸⁵ *Feminist Cooperative Garage Statement of Principles and Vision*, *Mechanica* Committee, November 1971, box 29, folder 8, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁸⁶ *Ibid.*

¹⁸⁷ *Evaluation of Beginning Volkswagen Class*, Nikki Josel[?], undated, box 29, folder 8, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁸⁸ Questionnaire, Joni Foster, undated, box 29, folder 8, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁸⁹ Questionnaire, anonymous, undated, box 29, folder 8, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

more work one can do oneself, the cheaper the cost and more confident one becomes in negotiating for commercial mechanical work.”¹⁹⁰

The group had high hopes for its impact on women and the community at large. Julie Coryell wrote: “The reason I am a self-appointed archivist is that we have lost the history of women—or large pieces of it. Records of the YWCA are going into the Northwest Collection of the University of Washington. So, I keep a spare of everything—both for us, should we need it, and with an eye to future writers. Who knows, someday we may be a beautiful women’s cooperative shop and school. Our organization is quite a tale!”¹⁹¹ With an eye on their future, the group outlined their goals. One of the goals of the garage was “the breaking down of social stigma attached to women doing mechanical work. There will be increasing number of training schools graduating women as certified auto mechanics.”¹⁹² For the core group of women involved in *Mechanica*, the future was bright in 1972. They planned on expanding into a school, or possibly a full service gas station where women could both repair their own cars, and perhaps those of others for a living wage.

In the early 70s, Coryell was holding down three-part time jobs, including her work through the YWCA on the *Mechanica* Committee and the Arcadia Abortion Clinic,

¹⁹⁰ *Mechanica* Committee towards a Cooperative Garage, *Mechanica* Committee, undated box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁹¹ Suggested Procedure on Minutes, Julie Coryell, 5 December 1972, box 29, folder 9, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁹² Goals, *Mechanica* Committee, undated, box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

and work with the University of Washington's Women's Studies department. Working with a friendly social worker, she applied for and received a grant to teach auto repair to girls in the foster care system who were living in a group home in Seattle. The ultimate goal was to educate these girls so that they could hold jobs as gas station attendants. Gas station attendants were well paid for blue collar workers, but the job was traditionally male.¹⁹³ Coryell also did outreach to local progressive middle school, the Open Environment School, in 1972 and 73, using a plastic model of an internal combustion engine.

Kate Hunter, who would go on to be the director of the UW YWCA, met Coryell through the Y. They became friends, and when Hunter needed someone to look after her foster daughter, Coryell became a certified foster parent and took the teen in. As she turned eighteen and aged out of the foster care system, Coryell and the women of Mechanica tried find a way to help her, as she had severe reading delays. This girl became the first woman to apply for an apprenticeship, and be hired, with the Howard S. Wright Construction Company, Other women involved in Mechanica also sought out apprenticeships in the trades. Tudi Hasaal, an active participant in the garage, apprenticed with City Lights.¹⁹⁴

In a letter to a high school student who expressed interest in a starting an auto repair class for girls at her high school, Julie Coryell wrote, "In brief, Mechanica exists because women own and drive cars, but rarely have mechanical skill or confidence to use

¹⁹³ Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

¹⁹⁴ Ibid.

the skills, privately or professionally.¹⁹⁵ *Mechanica*'s reach was not, however, limited to technical education. They supported an end to police harassment of the gay community, free access to abortion, and other issues dear to the radical feminist movement.¹⁹⁶ The group also compiled a list of local mechanics known to overcharge or harass women, as well as those who had a good reputation.¹⁹⁷ In a letter to the YWCA board of directors the *Mechanica* Committee wrote, "We exist so that women may have access to knowledge generally denied them in this society. We wish to insure that women grow in skills, experience and confidence. Although we are in contact with and affected by other issues within the women's movement, we are not confronted with the moral hassles so beleaguering other programs of the 'Y.'"¹⁹⁸ In fact, the garage did not receive the same vitriol from people opposing feminism as did either the abortion referral service or the women's clinic that the YWCA ran. However, they also did not inflame as much passion among feminists either, and funding was a constant problem.

¹⁹⁵ Letter to Shirley Dunphy and Francina Noordhoek, Julie Coryell, 7 April 1973, box 29, folder 9, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁹⁶ Letter to N. Holder and *Mechanica* Committee, Mayor Wes Uhlman, 7 February 1973, box 29, folder 9, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington, and *Mechanica* Minutes, *Mechanica* Committee, 2 December 1972, box 29, folder 4, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁹⁷ Minutes of Garage Attendants Meeting, *Mechanica* Committee, 6 February 1973, box 29, folder 4, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

¹⁹⁸ Open Letter to YWCA Board Members, [?], 7 November 1975, box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

There were division in the garage, between the radical feminists and the non-politically inclined suburban women who just wanted to repair cars, between heterosexual and homosexual women, and between women who had to work and those who did not. There were also conflicts with Spencer, who chafed at her expertise being diminished by the cooperative, non hierarchical structure of organizing the radical feminists of the group pursued, especially after Mechanica moved into Spencer's garage.¹⁹⁹

While the initial funding allowed Mechanica to open in Brenda Spencer's garage, this created tensions. Initially, "To help Mechanica get on its feet financially, the Women's Commission (WC) and Brenda agreed to raise the tuition of these [auto mechanic] classes from \$10 to \$15 for the express purpose of giving this extra \$5 to Mechanica. With the money provided by the WC classes, Mechanica was able to take over the rent and utilities on Brenda's garage and to buy numerous tools."²⁰⁰ This arrangement broke down; Spencer decided to keep all \$15 paid for her classes, and there was increasing conflict between Spencer's classes and Mechanica garage users over space.

During a meeting called to correct these problems, Spencer resigned her membership in Mechanica and walked out. In response, Mechanica canceled their lease on the garage and put their tools in storage while reorganizing. They planned to shift their focus from being a cooperative garage to auto mechanic classes, as the income from

¹⁹⁹ Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

²⁰⁰ Letter to Mechanica Supporters, Mechanica Committee, undated, box 29, folder 7, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

membership dues to the garage were simply not enough to keep it running. They argued, “We feel there will be sufficient demand and support for a garage as soon as more women have enough confidence in doing their own car repairs. This confidence can only be gained through actually working on cars in a good learning situation—thus the need for education.”²⁰¹

In June of 1973, *Mechanica* began reorganizing after Brenda Spencer left the group. Betty Richardson suggested she could teach very basic classes using the garage at Stuart Hall, a school for delinquent girls. Other topics of concern include whether or not to set up a lending library for the group’s tools while the group was without a garage of their own.²⁰² The 1973 gasoline crises, however, had affected *Mechanica* in multiple ways. Many families had less disposable income, and many women went to work for the first time. Women who recently joined the workforce had less disposable time than previously, and many members left the group to work full time in order to support their families in the faltering economy of the 1970s.²⁰³ The reorganization sadly stalled out, and many original members left the group. Still, some members continued to be interested in the spirit of *Mechanica*.

Just after this, Coryell had major surgery and redirected her efforts to educational advocacy. She was burned out from “the emotional intensity of the women’s movement,”

²⁰¹ Letter to *Mechanica* Supporters, *Mechanica* Committee, undated, box 29, folder 7, Young Women's Christian Association (University of Washington) Records.

²⁰² *Mechanica* Committee Minutes of June 4, 1973, *Mechanica* Committee, box 29, folder 4, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

²⁰³ Julie Coryell (*Mechanica* Member), interviewed by author via telephone, 26 Oct 2017.

and without a Ph.D. felt she could not advance in academia. She and her husband turned their energy into having and raising children and his academic career.²⁰⁴

In 1974 the women still involved in the Mechanica Committee wrote a grant proposal for \$292,052 to the YWCA in order to create a women's skilled trades education and referral center, a project very much in the spirit of the original group's goals. They argued that women entered the workplace out of economic necessity, and skilled trade jobs paid well. However, women were underrepresented in skilled trades, with less than 4% of all skilled trade jobs being filled by women.²⁰⁵ The committee pointed to WWII as an example of women excelling at skilled trade jobs traditionally held by men. They also argued that while employers were unwilling to hire women as skilled labor because "women are 'incapable of' or 'dislike' doing labor in which they might get dirty, have to lift heavy loads, handle dangerous tools or materials, or have to think for themselves", many women worked in the same facilities as unskilled labor, which seemed to undermine the argument.²⁰⁶

The Mechanica Committee hoped the center would be able to provide carpentry, electrical work, plumbing, and auto mechanics classes to women, both for women seeking careers in these fields and those simply interested in obtaining these skills.²⁰⁷ The classes would be limited to women in order to provide a supportive environment where women could quickly gain confidence in these traditionally male skills, as well as receive

²⁰⁴ Ibid.

²⁰⁵ Project Proposal and Request for Funding, Mechanica Committee, undated, box 29, folder 10, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

²⁰⁶ Ibid.

²⁰⁷ Ibid.

an introduction to tools and techniques that young men would have been exposed to as children or teenagers.²⁰⁸ They hoped that the “center will have a catalytic function in sparking changes in the community’s attitudes on what is ‘appropriate’ work for women.” By helping women enter the skilled trades, and making these women visible to the larger community, the center would create role models that would encourage other women to follow in their footsteps.²⁰⁹

By 1975, *Mechanica* had expanded from a cooperative auto garage to a “skilled trade information service for women.”²¹⁰ This new direction allowed the group to help women earn the skills needed to find skilled trade jobs, to lobby for affirmative action programs for women, and to work with employers on job placement for women. In a brochure about the program, *Mechanica* claimed that most women take underpaid clerical jobs out of desperation not vocation, and that their goal was to assist women in gaining the skills to find better paying and more fulfilling jobs.²¹¹ The center was supposed to encourage minority and economically disadvantaged women to apply, as well as those women with prior felony convictions who were attempting to rebuild their lives after serving time in prison.²¹² *Mechanica*’s application was successful and on February 1, 1975, was awarded a grant that would allow them to fund two full time staff members.

²⁰⁸ *Ibid.*

²⁰⁹ *Ibid.*

²¹⁰ *Mechanica* Apprenticeship Brochure, University of Washington YWCA, box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

²¹¹ *Mechanica* Brochure, *Mechanica* Committee, box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

²¹² Project Proposal and Request for Funding, *Mechanica* Committee, undated, box 29, folder 10, Young Women's Christian Association (University of Washington) Records.

This allowed the group to hire Ann Emigh, who had previously been a volunteer, as their new project director. Emigh had been involved with Mechanica since it was a garage, and stayed on with the project even as it morphed into a different approach.

In a list of their achievements in 1976, Mechanica boasted placing 47 women in skilled trades jobs, up from the 27 they placed in their first year of operation. These women were specifically selected because almost all were previously unemployed, impoverished, or both. Mechanica's advocacy of affirmative action for women in skilled trades convinced the University of Washington to adopt a 12% goal for women workers on its construction projects.²¹³ Mechanica closed its doors in the summer of 1980 after losing its CETA funds. An anonymous donation allowed them to pay off their remaining debts and convert the program to a women's employment service under the YWCA. Kate Hunter, who had also been involved in Mechanica while it was a garage, served as the executive coordinator.²¹⁴ One of the organizations that spun off of Mechanica, Women in Trades, founded the Women in Trades career fair, which is still ongoing in Seattle today.

While Mechanica's time as a women's collective garage was short lived, it touched hundreds of women's lives. More than 300 women received the Mechanica newsletter, participated in auto maintenance classes, or worked on their own vehicles in the Mechanica garage. It inspired its members to continue pushing for women's access to

²¹³ Mechanica Description of Program, Mechanica, undated, box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

²¹⁴ Mechanica Ends Scrap Note, Kate Hunter, January 1971, box 13, folder 15, Coll. 1930, Young Women's Christian Association (University of Washington) Records. Special Collections, University of Washington Libraries, Seattle, Washington.

masculinized skills even after the garage closed, even as it had helped them to acquire these skills for themselves.

Julie Coryell started taking her car to a mechanic in 1973 and had completely stopped working on her car by 1986. She cited a decrease in free time both because of work demands and because she and her husband had two children. She also purchased a 1986 Volvo 240, which contained several computerized parts, unlike her previous Peugeot 403. She did note, however, that her experience with Mechanica had given her the expertise to be comfortable talking with mechanics, a skill she still employs at 73 years of age.²¹⁵

In Ohio, a similar story played out. The Women's Action Collective organized in the fall of 1972 in Columbus, Ohio. These women stated that: "The goals of the collective have been threefold: 1) to create services for women that are responsive to women's expressed needs, 2) to create alternate jobs and new ways for women to support themselves, and 3) to experiment in applying concepts of organization that we as feminists are interested in, such as small group organizing, sharing skills, work sharing, money sharing, and cooperative community development."²¹⁶ The collective ran ten task groups including the women's garage, a creative art's cooperative, and a share-a-job program.²¹⁷ Unlike Mechanica, the Women's Cooperative Garage was part of the initial larger plan for the Women's Action Collective.

²¹⁵ Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

²¹⁶ Bylaws, WAC, Box 1, folder 1, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²¹⁷ Philosophy, WAC, Box 1, folder 1, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

In 1972, eleven women enrolled in an auto mechanics course given by the Columbus Public schools in order to have knowledgeable women trained to run classes at the garage.²¹⁸ The women “focused on training so that we would not be trying to offer services before being able to follow through. We want women to feel they can rely [sic] on themselves and other women since so often in the past this has not been true.”²¹⁹ This was in line with the group’s adherence to non-hierarchical, collectivist organization.

The Women’s Action Collective provided an umbrella organization for its various groups to operate under, and noted that “The groups cooperate to keep certain central services operational. These are primarily information sharing about group activities, a telephone referral service giving women access to services, bookkeeping, and long-range planning. We have carefully tried to create functional leadership positions that are tied directly to each group’s experience of what they need.”²²⁰ The larger group decided that while they were currently incapable of self-funding, they were also uninterested at obtaining grants from other community agencies. Unlike *Mechanica*’s relationship with the YWCA, the Women’s Action Committee explicitly rejected relationships with larger organizations. Most members were either students or low income, many of whom did not have money beyond subsistence, and so membership funding was not a lucrative option. They did take money from “Columbus/OSU Women’s Liberation, Columbus Community Food Co-op, and a private donor.”²²¹

²¹⁸ Women’s Action Collective Newsletter, WAC, March 1972, Box 11, folder 1, Coll. MSS 530, Women’s Action Collective Records, Ohio History Connection.

²¹⁹ Organization Proposal, WAC, Box 1, folder 1, Coll. MSS 530, Women’s Action Collective Records, Ohio History Connection.

²²⁰ *Ibid.*

²²¹ *Ibid.*

Being a part of the WAC also gave the garage members access to the WAC house, a building which served as a meeting space, bookstore, and rape crisis center. In an oral history, Bat Ami Bar On argued that the house served, not only as a physical space to do the work of the WAC, but also a psychological space that lent permanence and power to WAC's mission.²²² The organization chose a space among other left-leaning activist groups, in order to participate in the progressive community.²²³

In her dissertation, Ardith Allen lays out some of the tensions of identity in the WAC and its subgroup Women Against Rape. As there was a large membership overlap between WAC's subgroups, it is very likely that these same tensions played out in the Women's Co-op Garage, with the added dimension of women who did not subscribe to radical feminism, but still became members of the garage. For many members of WAC, radical feminism encouraged women to be in relationships with other women. Being heterosexual in this context was to be in the minority, and heterosexual women were sometimes pushed to consider if they truly wanted to live a traditional and "male-identified life" which placed men and the society that they constructed at the center of women's lives.²²⁴ The tensions may have played a larger role in the Women's Co-op Garage because of the large presence of women who were not involved in radical or moderate feminism, though Bat Ami Bar On noted that within WAC itself

²²² Anna Richey, "Troublemakers: Feminist Anti-Rape Activism in Columbus, Ohio," Honors thesis, Ohio State University, 2016, 29.

²²³ *Ibid.*, 30.

²²⁴ Ardith Allen, "The Deradicalization of Columbus, Ohio's Antirape Movement, 1972-202," PhD diss., Ohio State University, 2008, 105.

heterosexuality was not a serious contention in comparison to other radical feminist organizations, though some judgment occurred.²²⁵

The women's Cooperative Garage got off the ground almost immediately. The women rented a garage, and those that had taken auto mechanic class began to teach and supervise car maintenance done by other women. The women's cooperative garage offered classes covering "tire changing, tune-up procedures, maintenance of points, plugs, and mufflers, oil change, and other procedures. The course is taught by a professional woman mechanic, and classes work on their own cars with tools owned by the Co-op Garage."²²⁶ The Co-op Garage raised funds through these classes (the introductory class fee of \$15 included the \$5 membership fee to the garage), membership fees, and instructional handbook and t-shirt sales.²²⁷

The women saw the garage as "a member-controlled ownership of auto mechanics tools and a mechanism for the sharing of skills and experience among the women members."²²⁸ Women started by learning the basics of car maintenance through a curriculum that the initial members of the garage had created. While some women stayed to work on their own cars and learn more advanced auto maintenance, one member noted that "We had strong support from local women—we must have taught well over 1000

²²⁵ Richey, "Troublemakers," 31.

²²⁶ Meeting Minutes, WAC, September 1976, Box 1, folder 7, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²²⁷ *Ibid.*

²²⁸ Nonprofit IRS application, WAC, box 1, folder 3, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

women basic mechanics but women tended to learn and leave. Women don't come back to join, they most only want to know enough to speak to a mechanic."²²⁹

The first skill all women wanted to learn upon joining was that of basic automobile maintenance. Using a curriculum designed by garage members, teams of teachers offered basic auto maintenance courses, geared to individual instruction while working on the women's own cars. The fundamentals of the internal combustion engine, the use of mechanics' tools, and basic procedures such as oil changes, tune ups, and changing tires are learned during the eight-session course."²³⁰ A member noted that, "Women have been denied access to the traditional sources of training open to men: high school shop classes, weekend jobs in gas stations, or working with older brothers and fathers on the family car."²³¹

In 1973, the group could not heat the garage they were renting, and were forced to close down for five months; this prompted the formation of a search committee to find a garage with heating. The group hoped to be able to buy new tools, fund the lease of a heated garage, and provide scholarships for women who wished to continue their education in auto mechanics beyond what the Garage could offer.²³² The group moved to a new garage on July 15th, and held a celebration of the new space. The garage had room

²²⁹ Draft of note, WAC, box 1, folder 4, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²³⁰ Nonprofit IRS application, WAC, box 1, folder 3, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²³¹ Draft of note, WAC, box 1, folder 4, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²³² Nonprofit IRS application, WAC, box 1, folder 3, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

for five cars and, even more importantly, was heated. The group signed a six month lease.²³³

In early 1974, the garage was becoming successful. They appeared on the Phil Donahue Show on January 24, 1974, and were interviewed by the Columbus Citizen-Journal, the Columbus Dispatch, and the WOSU radio station.²³⁴ Things were so good that the garage began a search for more teachers in order to increase their future class load. In January of 1974, the garage was running three sections of beginning auto maintenance under the supervision of six teachers: Ann Miller, Chris Matuska, Carol Huston, Pam Buidema, Caroline Sparks, and Jane Dailey.²³⁵

Money, however, was always an issue, and the pay for the teachers was delayed in order to pay rent on the garage multiple times.²³⁶ The group decided to rent out garage space to nonmembers for a fee. This was controversial, because some women who were more aligned with radical feminism did not want to share the garage with men, while other women who were more focused on auto maintenance felt that the garage should be rented to whomever could pay. Men were allowed to rent, and by December of 1974 the group was on sounder financial footing, money owed to teachers was repaid, and the group decided to work on paying teachers immediately in the future.²³⁷

²³³ Minutes 1973, WAC, box 1, folder 7, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²³⁴ Minutes, January 1974, box 1, folder 7, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²³⁵ Ibid.

²³⁶ Minutes, undated, box 1, folder 7, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

²³⁷ Notes, WAC, undated, box 1, folder 4, Coll. MSS 530, Women's Action Collective Records, Ohio History Connection.

The group hoped to acquire a commercial service station by 1975, so that profits from pumping gasoline and offering car repair could be used to help subsidize the garage and perhaps offer salaries for women to work full time teaching auto mechanic classes to other women.²³⁸ In 1975 the garage was able to hire a part time mechanic, but there was not enough work to support her and this only lasted for a few months.

Eventually there was “a split between members who were feminist and those who just wanted to work on cars.”²³⁹ The March 15, 1977 WAC minutes note the garage was on the “brink of disaster.”²⁴⁰ By July of 1977, the lease on the garage space was terminated and the tools and teaching materials stored. The WAC hoped that there might be a way to reanimate the garage, but that was not to be.²⁴¹ As the 1980s dawned, conservative ascendancy and a faltering women’s movement made projects such as the Women’s Co-op Garage financially and ideologically difficult.

Other organizations under the WAC umbrella fared better when it came to funding. Women Against Rape, arguably the most successful part of the WAC, eventually decided to take grant money from governmental organizations, and won a \$425, 000 grant from the NIH to research rape prevention strategies. The 1980’s were not easy for WAR. As radical feminism began to wane, WAR relied on lesbian members who could not integrate as completely with mainstream America as other white women.

²³⁸ Notes, WAC, undated box 5, folder 5, Coll. MSS 530, Women’s Action Collective Records, Ohio History Connection.

²³⁹ Letter to Laurie James and Kathy Gallagher, Caroline Sparks, 3 February 1977, box 1, folder 4, Coll. MSS 530, Women’s Action Collective Records, Ohio History Connection.

²⁴⁰ Minutes, WAC, 15 March 1977, box 1, folder 7, Coll. MSS 530, Women’s Action Collective Records, Ohio History Connection.

²⁴¹ Newsletter, July 1977, box 11, folder 5, Coll. MSS 530, Women’s Action Collective Records, Ohio History Connection.

Nancy Whittier argues that this was the main reason that WAR continued to function throughout the 1980s. This, however, led to increasing tension between lesbian and heterosexual members who had sided with NOW's rhetoric of a "lavender menace" which cited lesbians as a stumbling block for achieving mainstream feminist goals.²⁴² The longest surviving branch of the WAC, WAR persisted until 1995, outliving the rest of the WAC's subgroups, the WAC house, and eventually its affiliation with WAC.²⁴³

In St. Louis, the local women's cooperative garage sprung from a different source. Instead of the radical feminist community, the local lesbian community provided the impetus for the garage. Laura Moore, a cornerstone of the St. Louis lesbian community, organized and ran a women's garage for four years. Moore was raised in orphanages and the foster system, and at eighteen found herself on her own. She worked odd jobs and eventually enrolled in Ranken Tech in 1973 for electronics training. She and her friend, Peggy Miller, were the first women admitted to the school after a protracted battle. Indeed, while Miller was the first to express interest, it was Moore who located a lawyer and pushed to attack the college's federal funding on the basis of discrimination. Miller graduated in a single year. Moore took two years of classes through the night school, but did not graduate.²⁴⁴

Moore was open about her sexuality as a lesbian, and was well known in the community. She spent the 1960s working with various Civil Rights groups and helping

²⁴² Nancy Whittier, *Feminist Generations: The Persistence of the Radical Women's Movement* (Temple University, 1995), 205-206.

²⁴³ *Ibid.*, 37.

²⁴⁴ Laura Ann Moore, interviewed by Jeanette Sanchez, 25 September 2001. Transcription by Jim Andris, 15 April 2015.

women find doctors who would perform then-illegal abortions.²⁴⁵ Moore was also involved in the Midwest Women's Musical Festival. She would take her tools with her to the woods where the festival was held so that she could teach women how to repair their own cars. The festival was open to spontaneous workshops, and Moore's automobile maintenance series always drew a crowd.

Eventually Moore opened a cooperative garage of her own. Moore remarked, "That's what it was called, A Women's Garage. I ran it for four fuckin' years. Tell me about it. My body remembers. We didn't have hydraulic lifts, so ... Yeah. Jack it up, baby."²⁴⁶ Moore rejected capitalism and insisted that the projects she was involved with operate on a collectivist basis. She was originally apart of the Michigan Women's Festival, but left after the leadership structure changed, and she felt it became a capitalistic, monetized venture.²⁴⁷

Moore stayed in the Midwest for almost her entire life (she spent several months in California as a young adult before quickly returning to St. Louis.). While there were bigger and more organized gay and lesbian communities on the coast, she, "figured if you couldn't win in the Midwest, you couldn't win the revolution anywhere."²⁴⁸ Moore worked hard to "win the revolution" including mentoring younger lesbians. She taught Kris Kleindist how to repair her car when Kleindist was just out of high school and newly identified as a lesbian.

²⁴⁵ Nan Sweet, "Herstory: Finding the Lesbian Heritage," *The Lesbian and Gay News-Telegraph*, November 1988, 18.

²⁴⁶ Laura Ann Moore, interviewed by Jeanette Sanchez, 25 September 2001. Transcription by Jim Andris, 15 April 2015.

²⁴⁷ Ibid.

²⁴⁸ Ibid.

Kleindist remarked:

“I don’t exactly remember how, but I do remember getting involved with this, learning car repair, like this was one of these things women should know, how to fix their own car. Well everybody doing it was a lesbian. The two women who were teaching it were lesbians, and then all of us were lesbians, and kinda like one thing led to another.”²⁴⁹

“But most of the organizing for many years, you know, for like the first decade and a half after my high school, had to do with community building. It wasn’t directed at government or other kinds of non-governmental discrimination; it was directed at community building. Well, you know, space, sports, different kinds of ways just to identify ourselves and give ourselves some kind of space to be who we are.”²⁵⁰

While the garage was a short-lived venture, Moore’s impact on the lesbian community in St. Louis was not. Kleindist went on to open a lesbian feminist bookstore that is still in operation in St. Louis. Moore worked to expand rights for lesbians and transgendered persons, especially those of color, arguing that they were “interconnected, because how can you move in the world and not understand the human suffering that all of us face on some level, no matter who you are, what class, race or whatever, but some people will have more piled on them than others, you know, and not want to address it.”²⁵¹ She was involved in other collectivist pursuits, including one to help properly roof houses of impoverished people and one to create safe spaces for lesbians. She went on to become a building inspector and rose to the rank of building commissioner of Vinita Park, a position that put her in conflict with multiple parties, including contractors who routinely violated the Americans with Disabilities Act (ADA), and the Housing

²⁴⁹ Kris Kleindienst, interviewed by Monietta Slay, 3 August 1994. Transcription by Jim Andris.

²⁵⁰ Ibid.

²⁵¹ Laura Ann Moore, interviewed by Jeanette Sanchez, 25 September 2001. Transcription by Jim Andris, 15 April 2015.

Authority. The Mayor of St. Louis, Freeman Bosley, appointed her as the Civil Rights commissioner, a position she was fired from for being a lesbian.²⁵² Moore continued to advocate for the rights of oppressed people until her death in 2015.

As the 1970s came to a close, all three garages closed, too. *Mechanica* attempted to transform itself; the Columbus Women's Cooperative Garage stumbled financially as radical feminists and car enthusiasts clashed, and the St. Louis Women's Garage faded away as Moore's advocacy shifted focus to housing equality. Nan Sweet, writing a review of the lesbian community in St. Louis in 1988, decried the era as the "apolitical eighties."²⁵³ While some members of the Lesbian community were involved in advocacy, she said, "others never see anything written about Lesbianism that isn't sold as pornography."²⁵⁴ For many radical feminists, the 1980s were equally difficult with the defeat of the ERA, a rising backlash of conservative coalitions, and a declining membership in radical feminist causes. Lesbian and heterosexual feminists also found themselves at odds, as mainstream feminist groups such as NOW, decried lesbians as the "lavender menace" and an obstacle to achieving NOW's goals.

Some lesbian identified garages survived the 1970s. A garage that scholars dubbed "Amazon Auto Repair," was founded in San Francisco in 1978. This garage, unlike the others, was purely a business venture, though it was lesbian identified and created, for a time, a safe space for lesbian employees and their families to be out. Internal conflict over business practices led to a strike in 1981. Weston and Rofel argue

²⁵² Ibid.

²⁵³ Nan Sweet, "Herstory: Finding the Lesbian Heritage," *The Lesbian and Gay News-Telegraph*, November 1988, 18.

²⁵⁴ Ibid.

that “The measure of what made Amazon a specifically lesbian workplace was not the sexuality of individual employees or the women’s music played on the shop floor but the extent to which sexual identity received public affirmation in a place where being a lesbian was the rule rather than the exception.”²⁵⁵ Unlike the cooperative garages, this was not a lesbian or feminist space because of intentional pre-planning. Many of the mechanics who worked for Amazon attested that they did not take the job for a different work environment from previous employment in traditional straight garages, but because they needed a job. They joined Amazon to provide for themselves and their family and then their interactions with one another created a lesbian space.²⁵⁶ The conflict here was not one of lesbians and feminists against outsiders, but with each other, as disputes over wages and business policy led the workers to strike and eventually all leave Amazon.

Nor were these political problems the only force at play when it came to garages closing. A technological change was also at hand. Car companies began experimenting with computer chips as early as 1968, when Volkswagen added a computer controlled electronic fuel injection system to the VW bus.²⁵⁷ In the 1970s, computer chips were still large, though shrinking fast, and most cars did not have room for them. Early experiments were often unsuccessful, using microchips to “meter the rate of fuel mixture and advancement of timing,” in the carburetor,²⁵⁸ for spark plug timing. In 1978 the

²⁵⁵ Kathleen M. Weston and Lisa B. Rofel, “Sexuality, Class, and Conflict in a Lesbian Workplace,” *Signs* 9, No. 4, The Lesbian Issue (Summer 1984), 626.

²⁵⁶ *Ibid.*, 627.

²⁵⁷ Aaron Gold, “When Did Cars Get Computerized?” *Autotrader*, April 2017, <https://www.autotrader.com/car-news/when-did-cars-get-computerized-264028>.

²⁵⁸ “The Evolution of Car Computers,” *Computers and Cars*, <http://compandcarscomp1220uwi.weebly.com/history.html>

Cadillac Seville even included an “optional trip computer that used a Motorola chip.”²⁵⁹ These computer chips would not become widespread until the 1980s, when fuel injection systems replaced carburetors in most cars. Fuel injection systems, however, were both more efficient than carburetors and easier to integrate with microchips. Anti-lock brakes would also bring more computer chips into the car. By the 1990s, the computer controlled most of the electrical parts of the car. *The Telegraph* proclaimed in 2015 that, “The car of the future will be the most powerful computer you will ever own.”²⁶⁰ All of these changes made it more difficult for any car owner to repair or maintain a car. New specialty tools were needed to work with car’s onboard computers which were cost prohibitive. As the computer controlled more and more of the car, less and less of it was intended for repair outside a specialized auto shop. The switch from carburetor to fuel injection systems was in itself a blow to the owner-done tune-up, as the system became more difficult for an owner to maintain themselves.

As gas stations stopped offering full-service and became places to purchase gasoline and junk food, quick-change oil shops stepped into the niche. Between 1972 and 1989, approximately 136,500 fewer gas stations offered oil changes across America, creating a rather large niche. Quick-change oil shops such as Jiffy Lube, also led to a decrease in owner oil changes. These shops had single task, promised to accomplish it quickly and cleanly, and did so for a flat, upfront fee. Since there was no negotiation and

²⁵⁹ Jim Motavalli, “The Dozens of Computers the Maker Modern Cars Go (and Stop),” *The New York Times*, 4 February 2010, <http://www.nytimes.com/2010/02/05/technology/05electronics.html>

²⁶⁰ Sophie Curtis, “The car of the future is ‘the most powerful computer you will ever own,’” *The Telegraph*, 17 May 2015, <http://www.telegraph.co.uk/technology/news/11609406/The-car-of-the-future-is-the-most-powerful-computer-you-will-ever-own.html>

no way for mechanics to charge women more on the assumption that they would not know better, these quick-change oil shops attracted many female customers.²⁶¹

For all the strides made by these women, on the surface little has changed. In 2016, only 1.7% of auto service technicians and mechanics were women and more than half of women felt that they are being taken advantage of by mechanics.²⁶² Nor has the image of the female driver as mechanically incompetent and a poor operator of her vehicle faded. So rare are female mechanics, that the mere fact they exist is still news in many newspapers. Articles detailing the classes held at Mechanica in 1972 and at Becca Ziobro's garage in 2016 are practically identical.²⁶³ A 2014 article in the Laker-Lutz News quotes a high school auto shop student, "People always think boys know more about cars than girls, Proctor said. With what she is learning, however, she thinks she may be able to work on her own car one day."²⁶⁴

The failure of the women's cooperative garages did not signal the end of feminist and lesbian involvement in the world of motor vehicles. In the 1990's, Subarus, especially their Outback and Forester models, became known as cars for lesbians. Unlike Saturn's car for women, Subaru did not initially set out to create a car to appeal to lesbians. In fact, the company was in a sales slump and looking for a way to regain

²⁶¹ Joe Ames, "Quick Oil-change Industry Draws a Crowd," *Chicago Tribune*, 21 May 1989, http://articles.chicagotribune.com/1989-05-21/travel/8902020845_1_jiffy-lube-international-quick-oil-change-quick-lube

²⁶² Labor Force Statistics from the Current Population Survey, Bureau of Labor Statistics, US Dept. of Labor, <https://www.bls.gov/cps/cpsaat11.pdf>.

²⁶³ Kara Yoro, "Former mechanic teacher car repair basics to North Jersey women," *North Jersey Record*, 2 July 2016, <https://www.northjersey.com/story/life/community/2016/07/02/former-mechanic-teaches-car-repair-basics-to-north-jersey-women/94879378/>.

²⁶⁴ B.C. Manion, "Auto mechanics class for girls only proves popular," *The Laker/Lutz News*, 13 November 2014, <http://lakerlutznews.com/lln/?p=23139>.

market share by targeting the consumer groups most likely to buy their cars. Along with doctors and outdoor enthusiasts, Subaru was surprised to find that lesbians were one of their largest niche consumer bases. This was not a straight forward thing to find out in the 1990s, only after marketers noticed bubbles of Subaru ownership among female headed households in Oregon and Massachusetts and actually talked with the women did they realize that they were lesbians.²⁶⁵

Once identified, the marketing department struggled both to convince the company to market to lesbians and then what exactly marketing to lesbians looked like. Marketing to LGBT groups in the 1990s had caused backlash for companies like Ikea who had previous ventured into the field. Subaru decided to go subtle, using vague cultural clues that straight audiences might not even notice to entice lesbians to buy their cars. This sort of advertising included the slogan “Get out. And stay out,” and license plates that alluded to *Xena: Warrior Princess*, a television show popular among lesbians.²⁶⁶

Subaru even created an advertising campaign that linked their cars’ technical capabilities to sexuality. The “It’s Not a Choice,” campaign focused on the Subaru’s All-Wheel drive in all of their vehicles.²⁶⁷ They did not only create marketing for the LGBT community, but also changed internal company policies. The company began offering

²⁶⁵ Alex Mayyasi, “How Subarus Came to Be Seen as Cars for Lesbians,” *The Atlantic*, 22 June 2016, <https://www.theatlantic.com/business/archive/2016/06/how-subarus-came-to-be-seen-as-cars-for-lesbians/488042/>.

²⁶⁶ Ibid.

²⁶⁷ Kimberly Shearer Palmer, “Gay Consumers in the Driver’s Seat,” *The Washington Post*, 4 July 2000, https://www.washingtonpost.com/archive/lifestyle/2000/07/04/gay-consumers-in-the-drivers-seat/a5770b47-f5ab-4579-b3de-fe5334448d0a/?utm_term=.b90f56c3485a.

domestic partnership benefits, and started donating to AIDS/HIV causes. They partnered with Rainbow Card, a gay-friendly credit card, and hired Martina Navratilova, ousted tennis star, as their spokesperson.²⁶⁸

It worked. Subaru's sales went up, and kept growing. Advertising to LGBT groups did have an effect beyond increasing sales to LBGT people, it also inextricably linked Subaru with the gay community. Dan Neil, a motoring journalist for the *LA Times* called it "a brand for literature professors at the University of New Hampshire... for women's studies majors at Cornell, and their girlfriends... Smart people. Interesting people. People who can see their breath in the air. And Canadians."²⁶⁹ Kim Mills, the education director of the Human Rights Council, simply called them, "Lesbarus."²⁷⁰

With all this, Subaru still adhered to old stereotypes in their advertising to LGBT groups. Tim Bennett, the director of marketing programs at Subaru, "suggested that Subaru's reliability was ideal for women "who don't have a man around the house who fixes cars,"" making it lesbian friendly.²⁷¹ This stereotype, that women are not mechanically equipped to deal with the maintenance of their own cars, while at odds with the idea of the lesbian mechanic, was still pervasive enough in 2000 to play a role in the marketing of cars to lesbians. Without a historic consciousness of women's mechanical work on cars, progressive advertising easily fell back on old ideas.

²⁶⁸ Ibid.

²⁶⁹ Dan Neil, "The Subaru Forester: For Sunbelt Drivers too," *Los Angeles Times*, 4 June 2008, <http://www.latimes.com/news/la-hy-neil4-2008jun04-story.html>.

²⁷⁰ Palmer, "Gay Consumers in the Driver's Seat."

²⁷¹ Ibid.

In 2015, Patrice Banks, created Girls Auto Clinic, an organization devoted to “educating and empowering women through their cars.”²⁷² A female engineer turned car mechanic, Banks believed that women should understand how their cars work, be able to do simple repairs, and negotiate to buy their own cars. Banks and many other women who currently advocate for female mechanical skill see their fight as a new challenge, seemingly unaware of previous efforts. Banks argues that women are now the largest consumer of cars, the most likely population to have their car repaired, and the largest percentage of drivers on the road, and yet still are virtually ignored by the auto industry, and are still seen as largely ignorant of the care of their cars.²⁷³ This argument has been substantively similar since early female motorists were discredited by motoring journalists in the inter War period.

Coryell passionately noted that, “I have a relationship with my car.” At 73, she no longer uses her garage as an area to work on her car, but she does still uses the knowledge she learned from her experiences at Mechanica. She credits the experience with teaching her to talk with mechanics, being able to diagnose problems, and an increase in confidence in all areas of hands on work.²⁷⁴

²⁷² “Patrice Banks: How One Savvy Mechanic Tuned Up An Industry,” YouTube Video, 2:15. Posted at <http://girlsautoclinic.com/aboutgac/>, <https://www.youtube.com/watch?v=QmFRUi8DqgA>

²⁷³ “An Auto Clinic Busting Myths about Women and Cars,” YouTube Video, 12:20. Posted at <http://girlsautoclinic.com/about-us/>, <https://www.youtube.com/watch?v=FwFqvOFefqg>

²⁷⁴ Julie Coryell (Mechanica Member), interviewed by author via telephone, 26 Oct 2017.

CHAPTER 3

From Factory Floor to Garage Workbench

On 18 June 2014, President Barack Obama opened the first White House Maker Faire. After viewing such inventions as a 3D pancake printer and a robotic giraffe, the President declared the day a “National Day of Making,” and declared Making a “revolution that’s taking place in American manufacturing -- a revolution that can help us create new jobs and industries for decades to come.”²⁷⁵ While Makers had been tinkering with electronics in their garages for decades—many before the term Maker had even been coined—this is was the first large scale government recognition of their work, one which suggested that their hobby was not only a positive way for people to spend their leisure time, but also one that might have an impact on the way the entire country produced goods as well as on its economic system.

In this chapter, I argue that the Maker Movement is grappling with how prototyping and production are undertaken. These shifts in the possibilities of production have attracted the interest of the government and large corporations, as well a public policy makers who argue that a third Industrial Revolution is a possible consequence of these new production methods. I argue that these production methods are actually

²⁷⁵ Becky Fried and Katie Wetson, “President Obama at the White House Maker Faire: “Today’s D.I.Y. Is Tomorrow’s ‘Made in America’”” *The White House Blog*, 18 June 2014, <http://www.whitehouse.gov/blog/2014/06/18/president-obama-white-house-maker-faire-today-s-diy-tomorrow-s-made-america>

outgrowth of earlier industrial technologies that in the wake of the open source software movement were successfully transformed into home garage based tools by people interested in expanding the open source movement into hardware.

The White House Maker Faire was modeled on the World Maker Faire and its forerunner, the Maker Faire Bay Area started in 2006, the largest gatherings of Makers — contemporary people who embrace science, technology, and engineering with the goal of creating both interesting and useful things, whether they are Arduino-powered fire breathing dragons, three dimensional printers or bioluminescent yogurt. Makers are defined by their hands-on approach, their desire for creative control over cutting-edge technology and science, and their cooperative approach to creating and disseminating their experimentation with contemporary technology. For some, Making was a way to move towards a start-up company and a way of making an impact on science, technology, engineer and mathematics (STEM) fields. For most, Making was an amateur activity, one they might not have expected to be declared a revolution when they were tinkering in their garage.

Manufacturing, the traditional cornerstone of the economy, took place in factories during the 20th century in industrialized countries. Most industrial tools were large, expensive and designed to do a single task, repeatedly. The 21st century, however, has seen many challengers to this idea, especially as manufacturing is automatized and outsourced. Makers have utilized many industrial tools retrofitted or redesigned to be used in the garage workshop. In this chapter, I will discuss the three main tools of the movement: the 3D printer, the CNC machine, and the microprocessor, how they moved

from their role as industrial tools to residing on the garage workbench, and what impact they have on the creative processes of Makers and non-Makers alike.

Crafters, Makers, Steampunks, BioHackers, and many other affinity groups have formed around this act of creating new things through a hands-on process of production. Some of these people express hope for future financial success while others avowedly undertake these tasks for the pleasure of a job well done. All appeared in their current form in the early 2000s. While the line between Makers and Crafters can be nebulous at best, Makers are defined by their hands-on approach, their desire for creative control over cutting-edge technology and science, and their cooperative approach to creating and disseminating their experimentation with contemporary technology. While some Makers are professional scientists or engineers, or have turned their inventions into successful businesses, many Makers work out of their home garages, basements, or communal makerspaces and consider Making a leisure activity.

Stacey Kuznesov and Eric Paulos place the root of current DIY cultures in the Ham Radio movement of the 1920s, and argue that together with the punk music scene and computer hacking culture, formed a culture with “anticonsumerism, rebelliousness, and creativity” at its heart.²⁷⁶ A culture where “people can create rather than buy the things they want.”²⁷⁷ They argue that DIY culture was waiting for a system in which knowledge was accessible, easily transmittable, and decentralized, and that the internet

²⁷⁶ Stacey Kuznezov and Eric Paulos, “Rise of the expert amateur: DIY projects, communities and cultures,” *NordiCHI 2010: Extending Boundaries - Proceedings of the 6th Nordic Conference on Human-Computer Interaction*, October 2010, 296, <https://dl.acm.org/citation.cfm?doid=1868914.1868950>

²⁷⁷ *Ibid.*, 300.

provided the platform for DIY knowledge and culture to grow with it.²⁷⁸ The Maker Movement, with its emphasis on creative hands-on work with technology is a distinct subset of the broader DIY movement which can encompass a huge swath of hobby work. It is true that the Maker movement came of age with the widespread use of the Internet, and that the Internet provided a platform for them to disseminate their ideas, learn new skills, and collaborate with other makers.

While Kuznezov and Paulos focused broadly on DIY communities, including both technology focused groups like Makers and groups reviving centuries old technologies like knitters, their survey results help illuminate the Maker subculture. Kuznezov and Paulos' survey found that most people involved in one DIY community also participated in other DIY communities—knitters rarely just knitted, they also quilted, or did woodworking, or were into electronic fashion design. The DIYer participated in these communities to get new ideas and learn new concepts, most of which were transmitted via Internet based mediums such as YouTube, Instructables, or Ravelry. Most DIYers watched video tutorials, used text and picture based instructions, or asked and answered hobby related questions on these forums. Kuznezov and Paulos argue that, “DIY communities represent early adopters of new cultural practices that reform and repurpose technologies.”²⁷⁹

Zach Kaplan described being a Maker as something he had been his whole life. An outlook that, fed by “LEGOs, Duplos, Construx, Tinker Toys, and Cardboard Red

²⁷⁸ Ibid., 301.

²⁷⁹ Ibid., “Rise of the expert amateur,” 299.

Bricks,” called him to create.²⁸⁰ For Kaplan, however, the late 90s and early 2000s were dominated by the digital world and the open source software movement. A movement with, perhaps, similar values to the later Maker movement, but significantly less hands-on engagement with actual material. It would take the 2000s for the Maker movement to pick up steam, and become the movement which President Obama credited for positively impacting the American economy.

Many of the sources used are the publications of members of the Maker movement, whether in official magazines, or more ad-hoc online and offline spaces. *Make* and *Wired*, are perhaps the two most closely affiliated magazines with the movement and give space for both leaders and organizers of the movement, as well as devoted followers, in their pages. I have also used on line blogs, ranging from the online arms of such professional publications to the personal spaces of Makers as the internet is perhaps where many Makers feel most comfortable speaking about their work. I have also used industrial and academic papers which outline the creation of the tools in this chapter in their original industrial settings, as well as critiquing and improving their use once they were there. Lastly, I’ve used the published papers of people who worked to transform these technologies from the factory to the home garage to understand how this transformation took place.

In 2011, Mark Frauenfelder, editor in chief of *Make* magazine, outlined the most important tools for Makers: CAD software, 3-D Printers, CNC machines, Arduino

²⁸⁰ Zach Kaplan, “My journey With Maker Faire - Does the maker movement matter?” *Built In Chicago*, 19 June 2014. <https://www.builtinchicago.org/blog/my-journey-maker-faire-does-maker-movement-matter>.

Microcontrollers, and Rapid-Prototyping Services.²⁸¹ For many Makers, CNC machines serve mostly as prototyping tools. Some, however, saw in Making a future in which factories no longer exist. In 2012, the Economist declared a third industrial revolution was underway. Instead of the factory based mass production of the second industrial revolution, the third industrial revolution would be characterized by small-batch and customized production dependent on digital technologies such as 3D printers and Computer Numerical Control (CNC) machines.²⁸² Production, they argued, would now be a phenomenon of the home garage and small workshops. Other Maker affiliated entrepreneurs envisioned a “dematerialized future of manufacturing”²⁸³ or “build-it-anywhere distributed manufacturing.”²⁸⁴ In order to create such an economy, the garage workshop would have to be equipped for what Neil Gershenfeld calls personal fabrication. The first of the machines that he sees as a step toward this future is the 3D printer.

4.1 3D PRINTING

When adherents talk about 3D printing, the claims often become grandiose. 3D printing, it seems, will save us all, allows us to live in peace and prosperity, and, on a really good day, immortality, or at least a significantly expanded lifespan, is not out of

²⁸¹ Mark Frauenfelder, "The New Maker Toolbox," *Wired* 19, no. 4 (April 2011): 95-100.

²⁸² "The Third Industrial Revolution," *The Economist: Manufacturing*, 21 April 2012, <http://www.economist.com/node/21553017>.

²⁸³ Christopher Mims, "In the weird, dematerialized future of manufacturing, companies like AtFAB ship information, not parts," *Quartz*, 23 June 2013, <https://qz.com/97059/atfab-future-of-manufacturing/>.

²⁸⁴ Christopher Mims, "Forget 3D printing—3D subtraction is going to arrive in your garage first," *Quartz*, 12 July 2013, <https://qz.com/103705/forget-3d-printing-3d-subtraction-is-going-to-arrive-in-your-garage-first/>.

the question.²⁸⁵ While 3D printing is generally considered a new and innovative technology, it does have historical antecedents which layered materials in order to create a final product. Perhaps the best known of these are raised relief topographical maps, maps with three-dimensional topographic detail which have been available for almost 2,000 years. Many of these maps were created by placing thin layers of material atop of each other to create topographical detail such as mountains and ocean depths. Today, raised relief topographic maps have come full circle, and are often created using a 3D printer.

Before Makers began building 3D printers in their garages, 3D printing was an industrial product, one mostly utilized for prototype development. Chuck Hull is often hailed as the father of 3D printing. Hull used an additive process known as stereolithography to build, layer by layer, a plastic eye wash cup in 1983 and patented the process in 1986. His company, 3D Systems, sold the process mainly to car and airplane manufacturers, but also found a niche in the medical industry, where surgeons could use the technology to create exact models in preparation for surgery.²⁸⁶ Hull also created the file format which allows CAD files to be used to create objects with 3D printers.²⁸⁷ STL, short for Standard Tessellation Language or STereoLithography depending on the source,

²⁸⁵ Lauren Shade, "Immortality and 3D Printing," *PantherNow*, 8 January 2017, <http://panthernow.com/2014/07/01/immortality-and-3d-printing/>.

²⁸⁶ Shane Hickely, "Chuck Hull: the father of 3D printing who shaped technology," *The Guardian*, 22 June 2014, <https://www.theguardian.com/business/2014/jun/22/chuck-hull-father-3d-printing-shaped-technology>.

²⁸⁷ "Charles Hull," *National Inventors Hall of Fame*, <http://www.invent.org/honor/inductees/inductee-detail/?IID=499>.

is still the standard file format for CAD to 3D printing data. Hull was inducted into the National Inventors Hall of Fame in 2014.²⁸⁸

“While earlier work in Japan is quite well-documented, proving that this concept could be realized, it was the patent by Charles Hull that is generally recognized as the most influential since it gave rise to 3D Systems. This was the first company to commercialize AM technology with the Stereolithography apparatus.”²⁸⁹ “Further patents came along in 1986, resulting in three more companies, Helisys (Laminated Object Manufacture or LOM), Cubital (with Solid Ground Curing, SGC), and DTM with their Selective Laser Sintering (SLS) process. It’s interesting to note neither Helisys or Cubital exist anymore, and only SLS remains as a commercial process with DTM merging with 3D Systems in 2001. In 1989, Scott Crump patented the Fused Deposition Modeling (FDM) process, forming the Stratasys Company. Also, in 1989, a group from MIT patented the 3D Printing (3DP) process. These processes from 1989 are heavily used today, with FDM variants currently being the most successful.”²⁹⁰ “The terms Rapid Manufacturing and Direct Digital Manufacturing (RM and DDM) have gained popularity to represent the use of AM to produce parts which will be used as an end-product.”²⁹¹

²⁸⁸ Ibid.

²⁸⁹ I. Gibson, D.W. Rosen, and B. Stucker, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing* (New York: Springer, 2015), 34.

²⁹⁰ Ibid., 34.

²⁹¹ Ibid., 37.

In 1993, MIT professors Michael Cima and Emanuel Sachs coined the term 3D printing when they patented a printer which could print plastic, metal, and ceramic parts in three dimensions.²⁹²

For Neil Gershenfeld, the director of MIT's Center for Bits and Atoms, personal fabrication, based around the 3D printer, is the revolutionary idea of the early 21st century. Gershenfeld teaches "How to Make (Almost) Anything," a course at MIT wherein students learn to use tools such as 3D printers and CNC machines to make things.²⁹³ Gershenfeld was surprised first by the response, over a hundred students attempted to sign up and secondly by why the students wanted to make things. The course had been envisioned as a way to help researchers create machines for their research. The students in Gershenfeld's class, however, signed up for the class because they had always wanted to make something, and these personal projects often had nothing to do with research or even practical production.

Gershenfeld sees a future wherein *Star Trek's* replicator is a reality, constructing what we need from subatomic particles on up.²⁹⁴ While we can now build very, very small things in this manner, Gershenfeld and most of his students use a wide array of tools to build almost anything from more traditional construction materials: plastic, metal, wood, and an assortment of other resources.

²⁹² Bethany C. Gross, Jayda L. Erkal, Sarah Y. Lockwood, Chengpeng Chen, and Dana M. Spence, "Evaluation of 3D Printing and Its Potential Impact on Biotechnology and the Chemical Sciences," *Analytical Chemistry* 86, no. 7 (2014): 3240-3253, <http://www.doi.org/10.1021/ac403397r>.

²⁹³ Neil Gershenfeld, *Fab: The Coming Revolution on Your Desktop—From Personal Computers to Personal Fabrication* (New York: Basic Books, 2007), 4.

²⁹⁴ *Ibid.*, 5.

Perhaps the most direct influence on the Maker movement was CBA's FabLab project. In 2001, the Center for Bits and Atoms created a lab at MIT with the tools needed to make or measure almost anything. At this point, a 3D printer alone cost over half a million dollars, making them almost impossible to obtain for personal use.²⁹⁵ With a grant from the National Science Foundation in 2005, MIT equipped workshops with tools needed for rapid prototyping and development and opened them to the public, both in America and abroad. Tools in FabLabs generally include a 3D printer, a CNC milling machine, a way to print circuit boards, and laser or plasma cutters. As of 2009, FabLabs no longer worked under MIT supervision, but the Fab Foundation, which helps create new FabLabs. This change of leadership has not hindered the spread of FabLab, in 2017 there were fifty-nine domestic labs, and 579 FabLabs internationally, mostly in developing countries.²⁹⁶ The Foundation helps keep FabLabs across the globe in communication with one another creating a "manufacturing network, a distributed technical education campus, and a distributed research laboratory working to digitize fabrication, inventing the next generation of manufacturing and personal fabrication."²⁹⁷ For many Makers, a FabLab was their first experience with 3D printing. For others, the fame, or perhaps, infamy, of the RepRap project among open source initiates drew them into 3D printing.

The idea behind RepRap, short for Replicating Rapid-prototyper, was to create a Von Neumann machine, a machine that could replicate itself. RepRap claims to have

²⁹⁵ Kaplan, "My journey With Maker Faire - Does the maker movement matter?"

²⁹⁶ Will Hollman, "Makerspace: Towards a New Civic Infrastructure," *Places*, November 2015, <https://placesjournal.org/article/makerspace-towards-a-new-civic-infrastructure/>.

²⁹⁷ "About," *FabFoundation*, <http://www.fabfoundation.org/index.php/about-fab-foundation/index.html>.

started the open-source 3D printer revolution, as the machine was the first to be available to the public at a reasonable cost (though that does not take into consideration the cost to obtain the skills needed to assemble an early RepRap.)²⁹⁸ They cite the Free Software Movement as an inspiration and the RepRap designs are all open source. The RepRap cannot, however, actually print all of itself. As of 2017, the machine was able to create approximately 70% of its own parts.²⁹⁹

Ratto and Ree argue that the RepRap's major impact was in providing a foundation for the creators of MakerBot. MakerBot, an open source 3D printer kit, requires a good deal of assembly, though not the rigorous technical know-how and tedious acquisition of hard to find parts that Rep Rap construction did at the advent of the project.³⁰⁰ MakerBots can be bought ready to plug-and-play. RepRap, however, played an important role in bringing 3D printing to the public eye. The 3D Printing Hall of Fame inducted Adrian Bowyer, the RepRap founder, in 2017, citing his role in bringing 3D printing to the public at large.³⁰¹

The 3D printer itself was wide open for experimentation. While plastic was the standard printing media, the ability to print in other media from wood to human skin soon attracted both amateur and professional innovators, artists, and even chefs. While artists have modified 3D printers in a plethora of ways, and chefs have found yet another way to

²⁹⁸ "RepRap," *RepRap*, <http://reprap.org/>.

²⁹⁹ "About," *RepRap*, <http://reprap.org/wiki/About>.

³⁰⁰ Matt Ratto and Robert Ree, "Materializing information: 3D printing and social change," *First Monday* 17, no. 7 (2 July 2012), <http://firstmonday.org/ojs/index.php/fm/article/view/3968/3273>>.

³⁰¹ TCT Awards, <https://tctawards.com/hall-of-fame/>.

use chocolate, it is perhaps the ability to print human cells that most enchanted innovators.

One obstacle that surgeons face is needing a scaffolding to keep things in place in damaged bodies. This scaffolding needs to be bioresorptive, made out of a material that the body can absorb and not reject. Traditionally, surgeons used the patient's own tissue for scaffolding (autogenous tissue), since this material was unlikely to be rejected. In many cases, however, the patient simply does not have enough available tissue for the surgeon's needs. 3D printed materials have been used for bone grafts, hydrogel soft tissue scaffolding, and may, in the future, be used to create whole, working organs.³⁰² Another avenue, in which 3D printing is used in the medical industry, is custom drug implants, which can release medication at a steady rate inside the body.³⁰³

Much more established is the use of 3D printing to create exact medical models of patients who need difficult surgeries. This allows the surgeons to practice in advance, in cases such as brain tumors and heart defects, on exact replicas of the body instead of standardized models.³⁰⁴ In 2013, scientists at Princeton and John Hopkins created a 3D printed bionic ear. The ear, with its complex curve and cartilage substructure, is one of the most challenging reconstruction sites for plastic surgeons using traditional techniques. Using a 3D printer, these scientists could create an ear, layer by layer, instead of using autogenous tissue as a base for reconstruction. They printed living cells together with the electronic components that would be needed for the ear to "hear." "Specifically, we

³⁰² Gross et al, "Evaluation of 3D Printing and Its Potential Impact on Biotechnology and the Chemical Sciences."

³⁰³ Ibid.

³⁰⁴ Ibid.

demonstrate 3D printing of a chondrocyte-seeded alginate hydrogel matrix with an electrically conductive silver nanoparticle (AgNP) infused inductive coil antenna, connecting to cochlea-shaped electrodes supported on silicone. Taken together, the result is three-dimensional integration of functional electronic components within the complex and precise anatomic geometry of a human ear.”³⁰⁵ They did not use a particularly expensive or industrial 3D printer. The team utilized a Fab@Home 3D printer with a syringe extruder, which they purchased at The NextFab Store in Albuquerque. The printed ear matched the CAD schematics, the living cells flourished and the coil antenna was found to be functional. When the first (right) ear worked, they modified the CAD file, and printed a left ear, and were able to “hear” good quality sound in stereo.³⁰⁶

The medical field is not bereft of amateur Makers, however. Paul McCarthy, whose son Leon was born without fingers on his left hand, 3D printed a prosthetic for the boy when the family could not afford the standard medical appliance. He was not the first person to do so, and in fact, followed directions he found on YouTube and a public domain design published on Thingiverse.³⁰⁷ Robohand, a mechanical hand prosthesis, was designed by Ivan Owen and Richard Van As. Owen, who had previously dabbled in creating mechanical hand for cosplaying at science fiction convention, had the mechanical knowhow and Van As, who had lost fingers in a woodworking accident and could not afford the \$10,000 plus prosthesis recommended by doctors, worked together to

³⁰⁵ Manu S. Mannoer et al, “3D Printed Bionic Ears,” *Nano Letters* 13, no. 6 (2013) 2634-2639, <http://www.doi.org/10.1021/nl4007744>.

³⁰⁶ Ibid.

³⁰⁷ “Dad Uses 3D Printer to Make His Son a Prosthetic Hand,” *Huffington Post*, 4 November 2013, https://www.huffingtonpost.com/2013/11/04/dad-prints-prosthetic-hand-leon-mccarthy_n_4214217.html.

design a hand prosthesis that could be built cheaply. The work went slowly as Owen and Van As had to mail prototypes back and forth across the world from South Africa to Seattle. MakerBot donated the project two 3D printers, and the team scrambled to learn how to use them efficiently. The 3D printers let the designers cut mailing time out of the process and the two were able to finalize the design. The Robohand is now designed to be 3D printed, and the standard PLA plastic resin that it is designed to be printed with holds up to day to day use.³⁰⁸ Multiple people use the Robohand as their primary prosthesis. The Robohand had become the E-nable hand, and is still being printed for children in need.³⁰⁹

3D printers are not only helping children who could not otherwise afford prosthesis, they have become a part of the educational world. Even museums find 3D printing brings something new to the experience. Cornell University with the US National Science Digital Library, created digital CAD files of each item in their Reuleaux collection that can be printed by anyone who visits the digital exhibit. This is especially relevant, as the Reuleaux collection is the largest collection of kinematic machines used to teach mechanical concepts to engineering students. While many of the originals were destroyed in WWII, Reuleaux commissioned reproductions and these reproductions comprise the core of the Cornell collection. The digital exhibit also offered a look into the university's collection of 19th century machine design books, as well as digital

³⁰⁸ Sean Gallagher, "Robohand: How Cheap 3D Printers Built a Replacement Hand for a Five-Year Old Boy," *Ars Technica*, 1 February 2013, <https://arstechnica.com/information-technology/2013/02/robohand-how-cheap-3d-printers-built-a-replacement-hand-for-a-five-year-old-boy/>.

³⁰⁹ Enabling the Future, <http://enablingthefuture.org/>.

simulations of each model.³¹⁰ Each kinematic machine is able to be printed “complete, functional, preassembled, and accurate,” from the exhibit.³¹¹ Besides the 3D printing of artifacts for tactile interaction with guests, museums have also made 3D printers available for use to the general public, though for hundreds of thousands Americans, a 3D printer is available in their own homes.

Matt Ratto and Robert Ree see the home 3D printer not as a product of a push from corporation to increase their market share, though by the 2010s this phenomenon had indeed begun, but instead as a push by hobbyist builders such as Makers. They point out that large big box electronics retailers which carry computer and 2D printers do not currently carry 3D printers. Instead, to purchase a 3D printer as a consumer, one must order the product from a specialty company, almost certainly over the Internet. Many of the companies, such as MakerBot, have their root in the Maker movement. Before 3D printers were available commercially at all, most hobbyists interested in using or owning a 3D printer had to build one for themselves. While there were directions online for such a project by the mid-2000s, such as the RepRap, these projects required considerable technical skill. Ratto and Ree argue that this needed technical skill along with the idea of a making a machine to make things, perhaps even another, identical 3D printer, appealed to the Maker imagination.³¹²

Jarkko Moilanen and Tere Vaden argue that “People engaged in 3D printing can be loosely grouped into the three categories in terms of technology adoption: developers,

³¹⁰ Lipson et al, “3-D Printing the History of Mechanisms,” *Journal of Mechanical Design* 127, no. 5 (2014): 1029-1033, <http://www.doi.org/10.1115/1.1902999>.

³¹¹ Ibid.

³¹² Ratto and Ree, “Materializing information: 3D printing and social change.”

early adopters and end users. “End users” refers to people who print objects with 3D printers but are not involved in making development either on 3D printing software or hardware.”³¹³ In 2013, Moilanen and Vaden found that people associated with 3D printing tended to be older, but slightly less educated than people associated with open sources software coding (59% vs. 80% holding bachelor degrees in one survey). They found that women were more likely to consider themselves end users of 3D printers than developers, whereas the opposite was true of men. The majority of people that Moilanen and Vaden surveyed considered themselves a part of the Maker movement, and over half had previously been involved in open source projects. The five most common uses for 3D printers were: functional models, artistic items, spare parts for research or education, and direct part production.³¹⁴ RepRap and Makerbot were the most common printers used.³¹⁵

Makers are not the only people excited about the possibilities inherent in 3D printing, NASA and the Air Force both see 3D printing as integral part of production in space. They hope that 3D printing will allow them to “reduced launch vehicle volumes” and “enable tailoring of launch vehicle systems.”³¹⁶ There is also hope that 3D printing in zero gravity will allow us to create things that cannot be made on Earth, with an eventual goal of moving space craft production to space. Both organizations were part of the process to create standards around additive manufacturing and 3D printing.

³¹³ Jarkko Moilanen and Tere Vaden, “3D Printing Community and Emerging Practices of Peer Production,” *First Minds* 18, no. 8 (5 August 2013), <http://dx.doi.org/10.5210/fm.v18i8.4271>.

³¹⁴ Ibid.

³¹⁵ Ibid.

³¹⁶ “3D Printing In Space,” Committee on Space-Based Additive Manufacturing, Aeronautics and Space Engineering Board, National Materials and Manufacturing Board, Division on Engineering and Physical Sciences, National Research Council, 2014, 9.

ASTM16 and ISO standards committees have come together to create a set of joint standards.³¹⁷ These standards break additive manufacturing into seven categories: (1) vat photopolymerization which includes processes like stereolithography. (2) material extrusion - a process in which material is deposited via a nozzle in layers to create an object (3) material jetting where multiple nozzles selectively deposit material onto a platform (4) binder jetting uses multiple nozzle to deposit material over a whole surface, the material only sticks in places where the binder was deposited, and the rest of the material is swept away (5) power bed fusion is similar to binder jetting, but the material is bound together with a laser or electron beam, (6) sheet lamination is usually a combination of additive and subtractive technology, wherein sheets of materials are bound together and then cut into shape, and (7) directed-energy deposition is a process where material is added with a wire feed system and bound with a laser or electron beam.³¹⁸

3D printing is already happening outside our atmosphere. Made In Space launched its ZBLAN optical fiber manufacturing system on a Space X rocket on 15 December 2017 for the International Space Station. The project will be the first monetized consumer product built in space. Made In Space first installed a 3D printer on the ISS in September 2014, and a second “machine shop in space” printer in 2016.³¹⁹ NASA hopes that this will not be the limit of 3D printing in space. They envision a future where, “Availability of construction material (e.g., metals, water) in space (e.g., on

³¹⁷ Ibid., 15.

³¹⁸ Ibid., 19.

³¹⁹ Mike Wall, “California Startup Made In Space to Make Optical Fiber in Orbit,” *Space.Com*, 28 October 2016, <https://www.space.com/34542-made-in-space-optical-fiber-in-orbit.html>.

asteroids or on surfaces of planetary bodies) enables the possibility of additively building settlements and other facilities without having to take expensive and bulky prefabricated materials out of Earth's gravitational field."³²⁰

4.2 COMPUTER NUMERICAL CONTROL MACHINES

In the post WWII era, great manufacturing behemoths such as Boeing and Lockheed-Martin filled their factories with a new type of machine. This machine was controlled by computers, instead of workers, in order to craft the complicated curves of an aircraft's wings. Today, these industrial Computer Numerical Control (CNC) machines have shrunk enough to fit on a home workshop's workbench and are just as likely to be found in your neighbor's garage as a factory. How then did the CNC machine go from the heights of American manufacturing to a common hobbyist's toy? I will argue that the Open Source computing movement was invaluable to this transformation.

Computer Numerical Control machines are tools which rely on a computer-aided manufacturing programs to automatically produce an object. CNC machines became a staple of industrial production in the years after World War II as computers filtered into the manufacturing process. These machines have helped companies like Boeing and Lockheed create airplanes, tanks, and most of America's military infrastructure. While CNC machine are still a vital part of manufacturing, they have also become a staple of the amateur garage workshop.

Large industrial tools that can create the same object over and over, exactly, are necessary for standardized production. Early in the nineteenth century, engineers and inventors searched for ways to create machines which could conform to the needs of

³²⁰ "3D Printing In Space," 38.

standardization. Cams, bits of mechanical linkages which could physically program machines that did a single task over and over, were the first step in this process. By the early twentieth century, electronics were added to this process. General Electric (GE) designed an electrically controlled system of servomechanisms to create a system of locks for the Panama Canal. It was not until the advent of computers in the wake of WWII that a large shift in manufacturing would be seen.

John Parsons, an aeronautics manufacturer, wanted to create plane rotor blades out of a single piece of metal in order to decrease the chance of the blades breaking in mid flight. In 1945, he brought in Frank Stulen, an engineer with the Air Corps, and together with some help from Stulen's brother Foster, an engineer at Curtis Wright Propeller, they incorporated punch card accounting machines into the process of designing rotors for both planes and helicopters. In order to create an airfoil shape, engineers had previously used seventeen points and connected them with a French curve. Between human error and the accuracy of the French curve itself, getting the correct shape could be somewhere between troublesome and impossible. Parsons and Stulen instead used two hundred points calculated with a punch card accounting machine. These points were given to a two man team, one serving as the x-axis and the other the y-axis of a milling machine, and the whole process created a much more accurate airfoil template.³²¹

³²¹ Russ Olexa, "The Father of the Second Industrial Revolution," *Manufacturing Engineering* 127, no.2 (August 2001), <http://www.sme.org/Tertiary.aspx?id=36002&terms=father%20of%20the%20second%20industrial%20revolution>.

Parsons was sure that a machine could be created to do the job of the two men on the milling machine, and was convincing enough that the Air Force Air Material Command gave him a \$200,000 contract to do the job. Parsons intended to build the machine in house, but found that he needed servomechanisms in order to get accurate positions and replace the human operators. He went to the MIT Servomechanics Lab to get them.³²²

Parsons and MIT clashed, and Parsons accused MIT of trying to steal his machine. MIT completed a prototype machine in 1952, and both applied for patents on CNC milling machines. Parsons and Stulen won their patent in January of 1958. Parsons partnered with Bendix to license the machines, but adoption was slow. Parson attributed that to both the slow progress of computer development and because, “the people who were trying to sell the idea didn’t really know manufacturing—they were computer people.”³²³ This need for both computer and mechanical tool knowledge would mark the entire process of CNC adoption both in industry and in the hobbyist market.

In its report to the government, MIT simply noted that Parsons Corporation terminated their sponsorship of the program, and that they continued to develop the CNC milling machine with funding from the Air Material Command.³²⁴ MIT’s milling machine was controlled by paper tape, faster and more efficient than punch cards, a tool meant to be “guided over the work without human intervention in response to a series of

³²² Ibid.

³²³ Ibid.

³²⁴ John Ward, “Automatic Programming of Numerically Controlled Machine Tools - Appendix B Reprint of July 1952 Report,” B-vii, MIT Department of Electrical Engineering Electronic Systems Laboratory, 1 September 1960, <http://www.dtic.mil/dtic/tr/fulltext/u2/241754.pdf>.

instructions previously recorded in a numerical code on such media as cards, paper tape, magnetic tape, or film”³²⁵.

The MIT report touted CNC as having seven benefits over normal machines:

1. All the machining operation which lie within the capability of the basic machine tool can be performed automatically.
2. The control equipment can be changed from one job to another in negligible time by simply inserting a new set of previously prepared instructions.
3. For a given job, the number of work setups as well as the time spent on each setup are reduced.
4. Control instructions can always be made as accurate as desired,
5. A single control system is capable of directing more than one machine and need not be located near the machine tool.
6. The instructions do not deteriorate with use, are readily modified through patching techniques, can be stored conveniently, shipped anywhere with economy and speed, and transmitted between factory installations by means of conventional teletype circuits.
7. Nearly all of the components in a numerical control system are commercial grade, readily available at moderate cost.³²⁶

Unlike previous machines which were “under the control of built-in devices such as cams, templates, masters, [and] limit stops”³²⁷ the CNC milling machine could

³²⁵ Ibid.

³²⁶ Ibid.

³²⁷ Ibid.

produce a number of different designs depending on the instructions on the paper tape. Each set of holes controlled the direction, speed, and distance the machine moved, before the next set of instructions moved it elsewhere. This allowed it to be used for smaller production runs than purpose built machines.

MIT built their machine on a Cincinnati Hydro-Tel acquired from government surplus, which allowed them to work in three dimensions, unlike Parsons' man-operated machine. They found that for the machine to work well the person writing the program had to have machining knowledge, since they made decisions such as determining the order in which operations were carried out and what type of cutting head would work best for the job. The MIT report suggested "junior engineers, design draftsmen, or members of the computing section,"³²⁸ were perfect for this job, but finding people with the right combination of knowledge was often difficult.

The members of the computing section were a particularly good pick if a user intended to create their paper tape programs with "modern digital computers such as the IBM," MIT argued in a paper for the government.³²⁹ These new digital computers were necessary for numerical control to become efficient enough to be useable. Just like Parson's two man milling machine, the MIT machine created curves by using many straight lines. So many straight lines were needed even for simple curves, that calculating without a digital computer was an onerous task. With complicated curves, the sheer timescale involve often precluded using a desk calculator.³³⁰

³²⁸ Ibid.

³²⁹ Ibid.

³³⁰ Douglass Ross, "Papers on Automatic Programming for Numerically Controlled Machine Tools, 6873-TM-3," 3 January 1958, 2.

The machine could also cut parts that could not be cut by a regular milling machine. MIT tested their accuracy by milling the male half of a Lunenburg Lens, a bowl shaped piece of aluminum and magnesium that needed accurate tooling across its entire surface. The first run on the milling machine took almost 20 hours, but the team was able to produce a lens with “known accuracy all over the surface,” which previously had been unachievable.³³¹

Originally, computer programmers at MIT created a library of subroutines that they hoped would be able to create any part a machinist might need. They found, however, that the library itself was cumbersome, and that the subroutines had to be edited for each specific part in order to achieve acceptable results.³³² In 1952, it took four man hours to program the machine to cut a cam and five minutes to actually cut a cam, whereas a man operated machine took four hours to cut a cam with very little preplanning time needed. MIT embarked on a mission to create a better way to program for machine tools in order to decrease preparation time.³³³

Patrick Hanratty developed PRONTO, the first language for numerical control systems. This language was used in several of the earliest systems. Hanratty had been trained as a singer before World War II, but damaged his vocal cords in a plane crash and had to find new employment. He had experience with analog computers during the war and ended up as computer programmer for Convair. In 1957, Hanratty joined General Electric and started work on a control language for a Milwaukee-Matic. This language

³³¹ “Appendix B Reprint of July 1952 Report, B-16.”

³³² Ross, “Papers on Automatic Programming for Numerically Controlled Machine Tools, 6873-TM-3,” 3.

³³³ *Ibid.*, 3.

became the Program for Numerical Tooling Operations, or PRONTO. It only worked on 2 ½ axes, and was soon superseded by the Machine Tool Director (MTD) software which could work in all 3 axes.³³⁴

The industry, however, standardized around the APT (Automatic Programmed Tool) language at the urging of the Air Force, who wanted a standard language among all its contractors. APT was written by Douglass Ross, the head of the Computer Applications Group in the Servomechanics Lab, and programmers on loan to MIT from the major aeronautics companies, and eventually was adopted through the aeronautical industry.³³⁵ The Air Force and MIT both had staffing problems. MIT needed more people with experience to work on the project. The Air Force had those people, but did not have the money to loan them out. Douglass Ross and the Air Force split the project into pieces, so that the Air Force could have its' personnel work on the project in-house, and then send the results to MIT.³³⁶

APT was originally run on MIT's Whirlwind I computer and ran the CNC milling machine that MIT had previously built. APT allowed the programmer to skip the unwieldy subroutine library and instead create "new curves on the basis of points and curves already specified in the language."³³⁷ The goal was to go efficiently from draughts

³³⁴ Patrick Waurzyniak, "Masters of Manufacturing: Patrick J. Hanratty," *Advanced Manufacturing*, 1 July 2010, <http://advancedmanufacturing.org/masters-manufacturing-patrick-j-hanratty/>

³³⁵ Ken McKinley and Norman Sanders, "An Industry Perspective on the Beginnings of CAD," *Inroads* 40, no. 2 (June 2008): 128- 129.

³³⁶ Judy O'Neill, "An Interview with Douglass T. Ross – OH 178," Charles Babbage Institute (1 November 1989) 20, <https://conservancy.umn.edu/bitstream/handle/11299/107611/oh178dtr.pdf?sequence=1&isAllowed=y>.

³³⁷ Ross, "Papers on Automatic Programming for Numerically Controlled Machine Tools, 6873-TM-3," 5.

person with an engineering drawing to a new “parts programmer” who could describe the information from the drawing into APT statements. Once written in APT, the program was handed over to punch tape transcriber who used a keyboard to punch the program into paper tape that a digital computer (with the help of an APT master deck) could read. The computer then produced commands for the machine director tool on another paper tape. That tape then told the machine director how to move the tool.³³⁸

John Francis Reintjes, the director of the MIT Servomechanism Laboratory at MIT, claimed that APT had “reduced the programming time on a particular part from 200 man hours down to 5 man hours through the use of APT.”³³⁹ While an improvement from the library system, with its more flexible approach, APT was still cumbersome. “An example of the type of APT language statement which can be “understood” by that system is GO RGT, WITH, TL LEFT, ON, CIRCLE/CENTER, PNT 3A, RADIUS, + 5.025 \$\$ which obviously means ‘Go right, with the tool on the left side, on the circles whose center point is at 3A... and whose radius is 5.025 inches.’”³⁴⁰

Besides the finished product, MIT’s machine also created a vector path on an oscilloscope, so that the program’s output could be checked without having to cut material. When a physical check was needed, Styrofoam was used instead of metal or wood, because an error was unlikely to cause damage to the machine when cutting

³³⁸ “Automatically Programmed Tool,” *MIT Science Reporter*, 1959, <https://infinitehistory.mit.edu/video/mit-science-reporter%E2%80%9494automatically-programmed-tools-1959>.

³³⁹ *Ibid.*

³⁴⁰ Douglass Ross, “Papers on Automatic Programming for Numerically controlled machine tools, 6873-TM-3,” 7 January 1958, 26.

through such a soft material.³⁴¹ With these checks in place, MIT went on to create and improve on several more CNC machines.

While these systems created a geometric shape, all of the input was done via numbers coded on to tape or punch cards. In the late 1950s, engineers at Boeing who wanted to calculate a curve sent punch cards representing equations to the computer, received numbers back, and then turned those numbers into curves by hand. This process became easier when the computing department purchased an analog plotter and wrote a program that allowed the mainframe to print lines. By 1960, it was possible to define the entire outer surface of an airplane in the computer. The plotter, however, could only produce images of thirty square inches of image, and was not yet accurate enough to replace manually drafted material.³⁴²

In 1961, to prove that computers were capable of not only of cutting but also of drafting accurate lines, Norman Sanders, at Boeing, and his team created a program that would command a diamond etching head to etch their lines onto an aluminum sheet with a computer-controlled APT machine. This first test was a success and the group convinced Boeing to allow them to test the system for use in the design process. To prove that these drawing really were accurate, they had the computer create randomly selected parts from Boeing's 707 and each drawing was painstakingly checked on hands and knees using a microscope. This task, while arduous, was the best way engineers could propose that would be convincing for a management audience. In the end, after painstaking testing, it was determined that the computer had accurately recreated the

³⁴¹ Ibid.

³⁴² Norman Sanders, "An Industry Perspective on the Beginnings of CAD," *SIGCSE Bulletin* 40, no. 2 (June 2008): 130-131.

lines. This accomplishment led the company to decide that the Boeing 727 aircraft would be built, but not designed, using the help of computers. The Boeing 737 and 747 were also built using the same system, and only after the completion of the 747 did Boeing adopt a commercially available CAD system to design parts for creation with their CNC machines.³⁴³

The diamond etching system also led to an error checking method. Sanders and his colleagues would replace the cutting head on these numerical-controlled machines with a pen, in order to produce a drawn output. As there was no other way to visualize the commands given to the machine, this method allowed the user to check for errors, forerunning large plotters.³⁴⁴

As computer micro chips hit the scene in the 1960s, CNC machines became both cheaper and smaller, and companies outside the military-industrial complex began to adopt them for manufacturing. Soon CNC machines were present in most American factories, as they came to be able to produce high-quality standardized objects without the need of skilled workers.

As well as using CNC machines, American companies dominated the market in manufacturing them in the 1960s and 70s. By the 1980s, however, American market shares in all machine tools were falling. In 1987, President Ronald Reagan, in reaction to the “machine tool crisis” launched an initiative to make American machine tools competitive in the global market. After the original dominance of American companies in CNC machine manufacture, both Germany and Japan had begun outselling domestic

³⁴³ Ibid., 132.

³⁴⁴ Ibid., 129.

competitors by 1980 by focusing on the low- and mid-end market. The Machine Tool/Manufacturing Technology Conference (MT/MT), held in June 1987, gathered both government and industry experts who decided that the first two priorities would be designing upgraded sensors for the machines and creating next generation controllers for CNC machines.³⁴⁵

The Air Force considered CNC technology vital to both America's economic competitiveness and for having access to quality manufacturing for defense purposes. In 1989 in the wake of the MT/MT Conference, they sponsored the Next Generation Controller (NGC) project with the goal of creating standards for an open system that "allows independent designers to develop interchangeable and interoperable controller components."³⁴⁶ With Air Force funding, Martin Marietta Information and Communications Systems designed an open architecture controller and created The Specification for an Open System Architecture Standard (SOSAS). SOSAS created a standard way to control machine tools, including CNC machines, robotic, measurement and process control tools across vendors.

APT, the language used by industry to control CNC machines, was a "vendor neutral" programming language, one that did not rely on a specific vendor or their hardware, but could be used with any machine. NGC called for a system that was not

³⁴⁵ William P. Shackleford and Frederick M. Proctor, "Use of Open Source Distribution for a Machine Tool Controller," National Institute of Standards and Technology, Nov 2000, 1.

³⁴⁶ United States Air Force, "Mantech Project Book," 1993, 81.

only vendor neutral, but also “interoperable, interchangeable, and portable,” in line with the then current best practices for open systems.³⁴⁷

The National Institute of Standards and Technology, which had participated in NGC by outlining a method for component communication in a SOSAS system, began to develop the Enhanced Machine Controller project. The project had two goals: to create public domain software that could reduce life-cycle cost, and for the open system to work with both new, high-end machines as well as retrofitted machines. The center of this system was the Host Machine Executive (HME), a combination of software and hardware which performed the basic functions of the machine.³⁴⁸ The software, which was also known as EMC, would be published in the public domain, a move which unknowingly helped lead to the boom in hobbyist CNC machine use.

NIST tested EMC with the help of GM, using a personal computer (PC) at Lawrence Livermore National Laboratory to control a CNC machine tool at a factory in Pontiac, Michigan. “EMC accepts programs in G-code and generate control signals to motor controllers to precisely control machine tools.”³⁴⁹ After a successful run, they were able to port the software to Linux. It was during this period that the project caught the attention of open source enthusiasts, and the code moved to SourceForge, and open-source hosting site.³⁵⁰ While not all open architecture projects are also open source

³⁴⁷ Martin Marietta Astronautics, “Next Generation Controller Specification for an Open Systems Architecture Standard – Overview”, 28 Sept 1994, 6.

³⁴⁸ Ronald Lumina, “The Enhanced Machine Controller Architecture,” 5th International Symposium on Robotics and Manufacturing, Maui, HI, 14-18 August 1994.

³⁴⁹ “The Enhanced Machine Controller Project,” http://wiki.linuxcnc.org/uploads/flyer_v2.pdf.

³⁵⁰ William P. Shackleford and Frederick M. Proctor, “Use of Open Source Distribution for a Machine Tool Controller,” National Institute of Standards and Technology, Nov 2000, 2.

projects, being open source benefited EMC tremendously. EMC was not intended to be an open source project originally, but with its origins in the public domain, interest from a community of motivated developers, and the fact that its source code had to be modified to each specific type of machine, it quickly became a communal open source project.³⁵¹ Open architecture is when publically available specifications delineate the components and behavior of a system, whereas open source projects usually involved the public release of source code. Being both gave EMC a guide to work from and an enthusiastic work force to accomplish its goals.

The EMC community originally coalesced over a CAD/CAM email listserve, but quickly moved to their own dedicated listserve. Shackleford and Proctor argue that the community members involved in development were not the general group of programmers that most open source activities attracted, but instead were mostly university engineering departments and machine shop hobbyists. NIST found the people with both programming and machine tool experience were their best audience.³⁵²

EMC forked into two separate development projects, Machinekit and Linux CNC both of which stopped using the name EMC due to legal pressure from the EMC Corporation, a disk storage company. As EMC was open source, developers could also modify it into salable software. Art Fenerty worked on the EMC project, before splitting off to create Mach, a machine controller program that could be run on Windows. His company, Artsoft, started selling CNC software that could be used on personal computers in 2001.³⁵³ This decreased the upfront knowledge costs for many machine tool hobbyists,

³⁵¹ *Ibid.*, 6.

³⁵² *Ibid.*, 6.

³⁵³ “About Us,” Newfangled Solutions, <http://www.machsupport.com/about-us/>.

as Windows and the installation of software on a Windows machine required less computer acumen.

By 2000, CNC machines had infiltrated even the most protected of artisan production niches. In 1998, John Suhr left Fender Guitar to open a guitar studio of his own. Instead of relying on hand made production, Suhr brought a CNC into the notoriously old school realm of instrument production. Guitars are all intricate curves, and Suhr's studio is able create custom guitars for elite players using CNC.³⁵⁴ By 2017, CNC has become such an entrenched part of guitar manufacturing, that the National Science Foundation supported the National STEM Guitar Project, which includes a focus on teaching middle, high school, and college faculty about CNC fabrication of guitars. Educators create their own guitar with a CNC machine and a curriculum to bring their knowledge back to their students.³⁵⁵

For modern Makers, CNC machines such as routers and mills go hand in hand with the more famous 3D Printer. CNC routers have become a mainstay of Maker Faire, with companies competing to capture the hobbyist market. Some, like the Handibot made by Shopbot, are small enough to be portable. The Handibot router can be used on an area as small as an end table and can also work against a wall. Many hacked and personal CNC machines are controlled via a personal computer. First, a CAD program is used to

³⁵⁴ Bernard Heuchemer. "CNC's help custom guitar maker rock the house," *Wood & Wood Products* 105, no. 7 (2000): 63.

³⁵⁵ "Welcome to the National STEM Guitar Project," *STEM Guitar*, 2017, <http://www.guitarbuilding.org/>.

design the desired object and create drawings of each specific part. Then a CAM program produces the g-code that the machine controller will use to direct the CNC machine.³⁵⁶

Yana Boeva argues that, “digital fabrication, based on the principles of Computer Numerical Control (CNC) systems, is actually much closer to the mass-production process than it is to traditional craftsmanship, but through its small scale of production it appears as tailor-made to the end-user.”³⁵⁷ Automation and robotics have steadily encroached on traditional manufacturing jobs, decreasing the manpower needed to manufacture goods. While many argue that a factory free manufacturing economy is unlikely to occur, there are companies experimenting with new modes of production. Companies like AtFAB sell digital files to instruct their consumer’s CNC routers and mills to create their product. Until CNC machines become as common as the home printer, however, most small CNC machines serve as prototypers for start-ups, garage based entrepreneurs and innovators, hobbyists and Makers.

The utility in prototyping made CNC machines invaluable and, as the Maker movement grew, their interest in CNC machines that were small enough to fit in a garage workshop and cheap enough to be purchased by a hobbyist also grew. The Maker movement is often most closely identified with 3-D Printing. 3-D printers create objects by printing layers of plastic into the desired form. Charles Hull created the first additive

³⁵⁶ Jeremy Cook, “Software Advice For Anyone Thinking About a CNC Router,” *Hackaday*, 23 December 2013, <https://hackaday.com/2013/12/23/software-advice-for-anyone-thinking-about-a-cnc-router/>.

³⁵⁷ Yana Boeva and Bruno Chies, “Yet Another Industrial Revolution – A Dialogue on Tensions in Digital Fabrication,” *Eastern Association for the Study of Science and Technology*, July 2017, <https://easst.net/article/yet-another-industrial-revolution-a-dialogue-on-tensions-in-digital-fabrication/>.

process to print a 3D object in 1983. The machine, called the SLA-1, printed a green cup and was recently honored by the American Society of Mechanical Engineers as a Historical Mechanical Engineering Landmark.³⁵⁸ Today, the 3D printer market, including printers for hobbyists, is a 5.1 billion dollar business.³⁵⁹

CNC machines and their subtractive process of object creation initially received less reporting, but have become just as important as 3D printing to the Maker movement. CNC machines, have been a staple of production processes since the Cold War, and have none of the “innovation” appeal of the 3-D printer. Because We Can, an architectural design-build company which started using a Shopbot for prototyping in 2005, brought a tabletop Shopbot CNC PRT-alpha aimed at the hobbyist market to the first Maker Faire, held in the Bay Area in 2006.³⁶⁰ Since then hundreds of CNC machines and CNC produced projects have been shown at Maker Faire.

4.3 MICROPROCESSORS AND ARDUINO

At the heart of both CNC machines and 3D printers, whether industrial, commercial, or hobbyist built are the microprocessors that control them. How then did the microprocessor go from a part of commercially created computers to the building block of amateur electronics, and how did specialized microprocessors like the Lilypad

³⁵⁸ Ken Elkins, “Original 3D Systems printer named ASMA engineering landmark,” *Charlotte Business Journal*, 18 May 2016, <https://www.bizjournals.com/charlotte/news/2016/05/18/original-3d-systems-printer-named-asme-engineering.html>.

³⁵⁹ TJ McCue, “Wohlers Report 2016: 3D Printing Industry Surpassed \$5.1 Billion,” *Forbes*, 25 April 2016, <https://www.forbes.com/sites/tjmccue/2016/04/25/wohlers-report-2016-3d-printer-industry-surpassed-5-1-billion/#31>.

³⁶⁰ Jeffrey McGrew, “Big News about the MAKE show,” *What’s Happening Now At Because We Can*, 19 March 2006. <http://www.becausewecan.org/node/161>.

Arduino attract a significant female user base where CNC machines and 3D printers have not?

Single board microcontrollers, first commercially available in 1971, were used by the computer industry to help power the personal computer revolution. Intel's first microcontroller was used not only in personal computing, but was also found in video game consoles and other computing technology.³⁶¹ By 1977, competitors, such as Texas Instruments, were advertising their microcontrollers for technically minded hobbyists.³⁶² Microchip Technology's PIC microcontroller, became a favorite of hobbyists when it came out in 1975, and its cousin, the Picaxe, which could be programmed in BASIC instead of C was also a commercial success on the hobbyist market. Both are still sold and used today, but they no longer have the market cornered.³⁶³

The Arduino microcontroller, created in Italy for design students, and released as open source hardware swept the hobbyist community. Its release in 2005 coincided with the burgeoning Maker movement holding the first international meeting of Makers: Maker Faire Bay Area. Arduino boards did not initially do much to alter gender dynamics in computing electronics. The Arduino's best-known contribution to this area was that it provided open source hardware that was within the reach of the computing hobbyist community. Arduinos, metaphorically, provided the computing brains that allowed the

³⁶¹ Oral History Panel on the Development and Promotion of the Intel 4004 Microprocessor: Federico Faggin, Hal Feeney, Ted Hoff, Stan Mazor, Masatoshi Shima. Interviewed by Dave House. Recorded 25 April 2007 at Mountain View, California. CHM Reference Number: X4024.2007.

³⁶² "Implementing Space War," *Byte Magazine*, (Vol. 02, No. 10, October 1977), 35, <https://archive.org/details/byte-magazine-1977-10>.

³⁶³ Alasdair Allan, "Which Board is Right for Me?" *Make*, 7 February 2014, <https://makezine.com/2014/02/07/which-board-is-right-for-me/>.

user to run the programs that controlled their inventions. Both cheaper and easier to use than earlier microcontroller kits, the first Arduino board was created as a tool for design students and became one of the most important forces behind Maker creation due to its accessibility. Despite this broader demographic appeal, users were still predominantly male.

Computing electronics is a world of wire and solder; a world that society has traditionally considered masculine. Microcontrollers like Lilypad Arduino and Adafruit's FLORA, however, appeal to the oldest of feminine hobbies: needlework. The introduction of the original Arduino microprocessor to the market in 2005 produced a small, but nonetheless important shift in gendered participation in microcontroller hobbyism, with female-headed companies such as Adafruit encouraging women to take up computer electronics. Historic trends in hobby adoption and the wide range of uses of the Lilypad Arduino made it a more attractive option to women than its other Arduino counterparts because of its utility in female favored projects and the familiarity of its application. The Lilypad and its successors have thus played a critical role in the entry of women into contemporary computing electronics hobbyism, and the Makers movement more broadly.

Tinkering with personal computers, whether through program creation, hardware customization, or some combination, in the home garage or basement has become a stereotypical male activity. This narrative places men in male coded spaces—the garage and basement—doing isolated but creative leisure work. Social scientist Jane Margolis and computer scientist Allen Fisher, writing on gender in computing, argue that this leisure computing is an impetus for future computer related employment. Published in

1990 and providing the standard narrative since then, Margolis and Fishers' *Unlocking the Clubhouse* shows a pattern of girls and women being pushed out of computing incrementally through the actions of their parents and peers. Unlocking the computing clubhouse with its "no girls allowed" sign, then, they argue, is the only way to increase the numbers of women in computing.³⁶⁴ Recent statistics published by the National Science Foundation reinforce these data behind these trends, showing that the percentage of women who received a bachelor's degree in computer science has been decreasing since 1985. This decline is not represented in other scientific fields, many of which have seen an increase in degrees awarded to women.³⁶⁵

Software developer Leah Buechley argues that Margolis and Fisher's approach has failed and that it is necessary to find new ways of bringing women into computing. Instead of "unlocking clubhouses," she suggests the best way forward is to "build new clubhouses," by changing the technology to suit already extant female patterns of interest, especially interest that are in some way excluded or derided by proponents of the idea that technology is masculine by nature.³⁶⁶ Whether or not computing communities are discriminating against women, Buechley argues that they are "limited in breadth—both intellectually and culturally."³⁶⁷ For computing to engage more women will require producing computer electronics that take advantage of skills women may already have in

³⁶⁴ Jane Margolis and Allan Fisher, *Unlocking the Clubhouse: Women in Computing*, (MIT Press, 2003).

³⁶⁵ National Science Foundation, "Science and Engineering Degrees: 1966-2010," http://www.nsf.gov/statistics/nsf13327/content.cfm?pub_id=4266&id=2

³⁶⁶ Leah Buechley and Benjamin Mako Hill, "LilyPad in the wild: how hardware's long tail is supporting new engineering and design communities," DIS '10 Proceedings of the 8th ACM Conference on Designing Interactive Systems, 199-207, 202.

³⁶⁷ *Ibid.*, 204.

order to lower the barrier to entry. It also means creating technology that can be used in projects that appeal to women. Buechley took these ideas and created the LilyPad Arduino, a waterproof microprocessor that could be connected to a circuit via conductive thread.

Historian of technology Rachel Maines argues that needlework is the oldest of feminine hobbies. Aristocratic women in the 17th and 18th century did decorative or “fancy work,” as a way of adorning clothing and passing time. This type of activity was democratized in the nineteenth century and middle class women used increasing leisure time to indulge in needlework as a hobby, especially as mechanized sewing lessened the time involved doing mending and “plainwork.”³⁶⁸ Quilting, embroidery, and other forms of needlecraft allowed women to gather to socialize, bringing them together to create objects of both beauty and utility. As Rozsika Parker shows in *The Subversive Stitch: Embroidery and the Making of the Feminine*, embroidery and other fancy needle work in the West were linked with women’s worthiness as wives and mothers, and, more than that, embroidery was the “natural” work of women.³⁶⁹ Embroidery was not just about being skilled at sewing, about also about possessing and reinforcing the necessary feminine attributes of care, patience, precision and a willingness to do repetitive and time consuming tasks without commensurate compensation.

During World War II these attributes were among the selling points for recruiters looking for women to be ballistic calculators, doing repetitive mathematical work, for which their male employers argued they were the best candidates due to their patience,

³⁶⁸ Maines, *Hedonizing Technology*, 26.

³⁶⁹ Rozsika Parker, *The Subversive Stitch: Embroidery and the Making of the Feminine* (London: I.B. Tauris, 2010), 4, 11.

accuracy, and willingness to do such repetitive work.³⁷⁰ Historian Janet Abbate argues that skills that women already possessed were recast by recruiters as making them particularly fit to undertake technical and mechanical jobs during WWII.³⁷¹ Before the war, ballistics calculation was the realm of men. Labor shortages and cultural factors limited who could work in what job, and so in order to make ballistic calculation a palatable job for a woman to hold, the narrative of what a ballistics calculator did changed, making that work more female coded even as this changing narrative did not reflect any change in the reality of their work. As historian Jennifer Light shows, these female computers composed the pool from which the first computer programmers were selected. While the women who programmed the ENIAC were described as simply plugging in the equations that male scientists and engineers wanted to run through the machine, their jobs were much more complex. They turned algorithms created by men into programs the computer could run through a process that the women, themselves, had to create, because developing the machine's programming had not been the top priority of the men who built it. The computers programmed to take over ballistic calculations and so much more might have been designed by men, but they were programmed and maintained by women.³⁷²

The ENIAC, which has a much contested place as the first computer, was not only a product of female computer programmers, but also women working in hardware and support staff. While engineers oversaw the project, assembler and 'wire men', who were

³⁷⁰ Jennifer Light, "When Women were Computers," *Technology and Culture* 40, no. 3 (July 199): 460

³⁷¹ Janet Abbate, *Recoding Gender: Women's Changing Participation in Computing* (MIT Press, 2012), 19.

³⁷² Light, "When Women were Computers," 470.

almost all women, physically assembled the machine piece by piece and wire by wire. It took miles of expertly placed wires placed by women, for the female computer programmers to be able to do their jobs moving those wires to create programs.³⁷³

While women continued in the computing field after WWII and many more joined in the 1960s and 1970s, hobbyists interested in electronics and computing were mostly male. Computer hobbyists joined a long line of other male-coded hobbies, including woodworking and auto tinkering, which took place in male-spaces of the home such as the garage and the basement. Computers were considered both appropriate leisure activity and, eventually, something that could lead to entrepreneurial success. Tellingly, the original Apple Computer was built in a garage workshop that would become almost as storied a part of Apple's history as the computer itself, when Apple's Steve Wozniak and Steve Jobs transitioned quickly from garage-based innovators to multi-millionaire professionals and became the face of the personal computing revolution. Apple, along with companies such as Hewlett-Packard and Dell, helped create the image of the masculine garage not just as a space for tinkering, but as a place where digital innovation could lead to entrepreneurial glory.

For many women, however, home based crafts were undertaken in the kitchen and living areas. These crafts were supposed to be neat and productive, a niche that needlework filled nicely. While needlework lost its most favored status as a female craft in the latter half of the twentieth century, it too saw a resurgence along with other Do It Yourself (DIY) communities like the Makers. So entwined with modern ideals of self

³⁷³ Thomas Haigh, Mark Priestly, and Crispin Rope, *ENIAC in Action: Making and Remaking the Modern Computer* (MIT Press, 2018), 61.

sufficiency, the DIY movement is an umbrella term for all the hobby and amateur work people undertake for their own use or happiness. While the DIY aspect of needlework remained, what it meant radically changed. The subversive qualities of knitting, embroidery, and other needle-orientated female crafts, such as Underground Railroad quilts, are championed by “craftivists,” women and men who turn to needlework and other crafts in order to “investigate and educate themselves and others in ways that imaginatively empower, deepen understandings of living and directing one’s own life, promote respect for diversity, build community, and engage makers in a participatory democracy.”³⁷⁴ Still others take up needlework for similar reasons as their forebearers; from a desire to create useful and beautiful things in their leisure time.

Nor are traditional women’s skills harnessed for technological progress a new thing. Core rope memory, the ROM type memory of the Apollo guidance system, had to be encoded by hand. NASA found the skilled workers needed to do so in the textile factory workers of New England. These women, both Caucasian and African American, worked in pairs to weave wire with a needle through core holders loaded with “doughnut-shaped” magnetic cores and around small nylon pins (which were later removed), in specific patterns to permanently create the programs needed to reach the moon.³⁷⁵

In Bolivia, indigenous Aymara women use traditional knitting to craft medical devices called occluders. These devices are used to block holes in the heart, a problem that is common in high altitude locations. For adults, these devices can be industrially

³⁷⁴ Elizabeth Garber, “Craft as Activism,” *The Journal of Social Theory in Art Education* 33 (2013): 60.

³⁷⁵ MIT Science Reporter, “Computer For Apollo,” 1965, YouTube Video, 29:20. <https://www.youtube.com/watch?v=ndvmFlg1WmE>.

produced, but the devices that are needed to fix the smaller hearts of children are much more difficult to make. The women work in clean rooms, weaving a super-elastic metal called nitinol into tiny, top hat shaped devices, designed by Dr. Franz Freudenthal, which allows doctors to fix patent ductus arteriosus without performing open-heart surgery.³⁷⁶

Limor Fried, who *Wired* magazine made the face of the Maker Movement, runs Adafruit, a tech company which sells microprocessor kits and other computer electronics projects. For Fried, sewing was her first passion. Arduino was her second. She helped bring the Arduino from Italy to the United States and created simple projects using the microprocessor to rally interest in both Arduino and microprocessor enhanced Maker projects. Instructables, a site where Makers can document their projects and share them with the Making community, contains thousands of Arduino run projects from ben-k's Tree Climbing Robot to thesystemis's EyeWriter 2.0 which allows the user to draw digitally with their eyes.³⁷⁷

While the original Arduino board opened computer electronics to a broader audience including designers and artists, there have been significantly more female users of another Arduino, the Lilypad which became commercially available in 2007. While many women currently in STEM fields reject the idea of "feminizing" (which often amounts to little more than making the object in question pink instead of beige), Leah Buechley, then at MIT, took this idea further. Capitalizing on the Creative Common license, Buechley created the Lilypad Arduino, which could be sewn into a circuit.

³⁷⁶ Ignacio de los Reyes, "The Bolivian women who knit parts for hearts," *BBC News Health*, 29 March 2015, <http://www.bbc.com/news/health-32076070>.

³⁷⁷ ben_k, "Tree Climbing Robot," *Instructables*. <http://www.instructables.com/id/Tree-Climbing-Robot/>, and thesystemis, "The Eyewriter 2.0," *Instructables*, <http://www.instructables.com/id/The-Eyewriter-20/>.

Conductive thread, utilized in place of solder and wire, is used to connect the microprocessor to LEDs and other gadgets to create a wide range of projects. These projects, often based on conventionally female activities like sewing, fit within the longer historical trend of women using female-coded skills in computing, from basic math of WWII female “computers” to secretarial typing.

Buechley collected data on Lilypad users, both as consumers and as a community of users, in the form of sales records and project documentation. While only ten percent of Arduino sales in the United States were to women, that number rose to forty percent with Lilypad.³⁷⁸ This gender differential is even larger when looking at projected documentation published on popular websites. Two percent of documentation for Arduino projects was created by women, whereas sixty-five percent of the documentation of Lilypad projects was created by women.³⁷⁹ For Buechley, this is positive news, “There is a long history of systems and curricula designed to attract women to computing, but to our knowledge in no instance have researchers documented an autonomous computing community that is—naturally and without external influences—dominated by women.”³⁸⁰

This new clubhouse has opened its doors to innovative social justice projects and a wide range of minorities. micah cárdenas, a trans femme Latina hacktivist, used Lilypad Arduino to create “a line of mesh networked electronic clothing with the goal of building autonomous local networks that don’t rely on corporate infrastructure to function, inspired by community based, anti-racist, prison abolitionist responses to gendered

³⁷⁸ Buechley, “Lilypad in the Wild,” 202.

³⁷⁹ *Ibid.*, 203.

³⁸⁰ *Ibid.*, 203.

violence.”³⁸¹ Mesh networks, similar to those recently used by protestors in Hong Kong, are wireless networks that operate on a peer-to-peer basis and do not need access to larger systems to sustain the network. In these networks, “Each board talks to every neighboring board, transferring packets across the ad-hoc network to the edge, where there is a router or a gateway out into the wider world and the internet.”³⁸²

These clothing designs use LilyPad Arduino and Xbee wireless transmitters to create a mesh network which alerts other users when a person is in danger.³⁸³ Released as an open source project, other artists and activists have joined the project, excited about the prospect of “fashion hacking for social reorganization.”³⁸⁴

The development of female-coded computer electronics is just one of the interventions undertaken to increase the number of women in computing and data on the success of Adafruit and the LilyPad Arduino promise a continuation of trends established during midcentury. Needlecraft provides a familiar skill for some women that increases their access to computer electronics as a hobby, while their commitment and innovation have created new avenues to explore and experiment with technology for fun and fulfillment outside the computer industry. Though both needlework and computer electronics are separately large and growing hobbies, together they can be used to create radically new projects which stretch the boundaries of both arts. The development of

³⁸¹ micha cárdenas, “Local Autonomy Networks: Post-Digital Networks, Post-Corporate Communications,” *Journal of the New Media Caucus*, CAA Conference Edition, 2013, <http://median.newmediacaucus.org/caa-conference-edition-2013/local-autonomy-networks-post-digital-networks-post-corporate-communications/>

³⁸² Allan, “Which Board is Right for Me?”

³⁸³ “Background,” <http://autonets.org/background/>.

³⁸⁴ micha cárdenas, “Local Autonomy Networks: Post-Digital Networks, Post-Corporate Communications.”

open source software provided female computer hobbyist with an opportunity to change the narrative surrounding their participation. Though this has, as in the case of the Lilypad, been an explicit attempt to “feminize” computing, the products of these efforts reveal a far deeper engagement with society and technology as a result of women’s participation. Alternative avenues to engagement with computer electronics through traditional female-coded skills also encourage women to transfer those skills to a professional arena, as well as increasing the diversity of the Making community and increase its impact on the world.

CHAPTER 4

MAKING SPACES

For Joe Dwyer, plastic water bottles are a problem to be solved. Dwyer, a founder of the Reforge Makerspace, is building a tool to turn water bottles in rope, in hopes of decreasing his own environmental footprint. In doing so, he is participating in both the broader craft movement and the nationwide push towards environmental sustainability. The Reforge recycling bin is a plentiful source of the bottles, and Dwyer is very aware that China has recently refused to take America's plastic for recycling. Looking for a creative solution, Dwyer stumbled upon a tutorial on Instructables, a hub of Maker inspiration on the Internet. While we sat down to talk about Making and Makerspaces, he left the tool running. Dwyer usually oversees the whole process as he tweaks the tool he created, but this day he was distracted, and when we finished, he had a blob of plastic instead of rope. This failure did not discourage him; instead it was just another data point in making a tool that works consistently.³⁸⁵

In this chapter, I argue that the Maker Space is in essence a cooperative garage, an outgrowth of the work done in home garages, and that the physical location of the Makers Space enables a community which is often experienced over the internet to create face-to-face communities. These communities did not spring forth fully formed, instead they are a product of decades of mechanically and technologically oriented professionals, such as

³⁸⁵ Oral History Interview with Reforge Members, 3 March 2018.

Mechanics' Institutes, and hobbyists, such as adherents of the DIY movement, creating ideals not only of technological tinkering, but how such a tinkerer should live in relation to the community and to the world at large. Makers like Dwyer, along with the revival of more traditional small scale production ranging from craft beer brewing to traditional wooden boat building, are redefining the craft movement in America. Their projects range from Dwyer's effort to create rope to prototyping better CNC controlled routers for home use.

Maker communities have an ethos of experimentation with technology, hands-on engagement with work, and small-scale craftsmanship. These modern tinkerers of electronic technologies use work to form and reaffirm their own identities. Their small-scale hands-on work rejects the larger American work culture that typically sees high technology as something mass-produced and created in the well-funded corridors of corporate research and development labs. While not all Makers would recognize their experimentation as craft work, it is craftwork none the less, evidenced by the combination of design and creation of their project being undertaken by a single person as Morrison suggests is the hallmark of craft. Craftwork allowed Makers to create communities of design instead of relying on well capitalized corporate conglomerates that restricted access to knowledge and materials.

The computer revolution created a new front in the conflict between craftwork ethos and the profit motivate goals of large corporations. At the end of World War II, the military and most people in university computer departments saw digital computing as a serious machine to solve serious problems. Steven Levy argues that the true computer users, who he terms hackers, such as members of MIT's Tech Model Railroad Club

(TMRC) used the university computers, usually during the middle of the night, to write programs for the sheer joy and excitement of coding. They created such programs as the expensive typewriter, a simple word processor, and the expensive calculator, before moving on to other ventures, including video games. These Hackers, Levy argues, may not have created the architecture of the digital computer, but they did create the “true” culture of the digital computer.³⁸⁶

This hacker culture was different from the professors and graduate students who were merely attempting to solve a problem or get a degree. Levy argues that the hackers created a culture of open information and sharing that directly led to Open Source Software and indirectly to Open Culture projects. The MIT hackers were mostly undergraduates who used the computers to teach themselves how to do things. They created programs and a culture in which those programs were open to being improved and modified by others. Locking computers away from the user and making programs that could not be “hacked” was an affront to these hackers, who had no problem crawling through ceilings, cracking safes, borrowing tools, and picking locks to get what they wanted – more computer time. As these hackers went out into the workplace, their culture of hacking spread with them, introducing those not from MIT to the ideas of open improvement of programs, and that computers should, above all things, be fun.³⁸⁷

Robert Cringley argues that personal computing was developed by hackers and amateurs, mostly on accident; they simply wanted machines to play with, and to get them, they ended up creating a multi-billion dollar industry. In the late 70s and early 80s

³⁸⁶ Steven Levy, *Hackers: Heroes of the Computer Revolution* (New York: O’Reilly Media, 2010).

³⁸⁷ Ibid.

it was unclear what form personal computing would take, as amateurs as well as mainframe companies vied to dominate the market place. The Homebrew Club was an epicenter of amateur personal computing innovations. Steve Jobs and Steve Wozniak created the first Apple computer while other members created programs, created their own computers, and generally invented pieces necessary for the personal computer revolution. The innovative nature of the early personal computer market meant that most of these machines were “hackable,” or open to user modification.³⁸⁸

The Apple Computer was built in a garage workshop that would become almost as storied a part of Apple’s history as the computer itself. Steve Wozniak and Steve Jobs transitioned quickly from tinkerers to professionals and became the face of the personal computing revolution. They, along with companies such as Hewlett-Packard and Dell, helped create the image of the garage not just as a space for tinkering, but as a place where digital innovation could lead to entrepreneurial glory. The era of the personal computer that these craftspeople-and tinkerers-turned-entrepreneurs helped usher in would bring microchips and computers into the daily lives of millions. Personal computers moved out of the hobbyist arena into a multi-billion dollar industry and cemented the idea that garage-based craft work could lead to financial success.

Richard Stallman, a computer programmer from MIT in the 70s, is perhaps most associated with the foundation of the open source movement. After MIT switched to a proprietary system that irritated Stallman, he decided that he would create his own open, UNIX compatible system, GNU. In order to keep others from turning GNU into proprietary software, he came up with the idea of “copyleft,” a copyright which gives

³⁸⁸ Robert Cringley, *Accidental Empires*, 33.

users the right to use, modify and redistribute as long as anything they created from the software was also copylefted.³⁸⁹

From this foundation, the Open Source Movement was born. The term Open Source was coined by Christine Peterson in 1997, and took a more permissive view of proprietary software than Stallman's Free Software and copyleft system. The most famous open source software, the Linux operating system, was initially released as open source in 1991, and has since become a competitive, mainstream option on the operation systems market.³⁹⁰ The open source movement was not limited to software, but also inspired many who were intrigued with the potential of computer hardware.

Like many future computer enthusiasts, TJ Nelson received an IBM Active computer as a child, and promptly took it apart, much to the dismay of his parents. His interest in taking things apart to find out how they worked was accompanied by an interest in putting things back together to make them work better. His desire to take apart computers was not unique among technically inclined children. But for Nelson, neither tinkering in his own garage workshop nor earning a Ph.D. in the computer sciences, was enough. He and several friends opened their own Makerspace, ReForge, in Charleston, SC in 2016.³⁹¹

The Maker movement, or at least the label Maker, came from *Make* magazine, a DIY magazine focused on technology. Dale Dougherty, *Make* magazine's CEO, claims to have coined the term for the audience his magazine is intended to reach, people who

³⁸⁹ David Bretthauer, "Open Source Software: A History," *Published Works* (2001): 7, http://digitalcommons.uconn.edu/libr_pubs/.

³⁹⁰ *Ibid.*, 18.

³⁹¹ Oral History Interview with ReForge Members.

make things. Dougherty, who has reached out the public with the message that everyone is a maker through his magazine, his book, and hundreds of speaking engagements, is evangelical in attempts to convince people to make things. “The joy of making,” Dougherty says, “is greater than anything you can buy.”³⁹² Making, Dougherty argues, is about recreating the world, building communities of skill and knowledge, and invitation to no longer “conform to the present reality.”³⁹³ He is so enthusiastic about the movement, that he sees in it “the same revolutionary attitude,” as the American Revolution as embodied by Thomas Jefferson.³⁹⁴ While this claim is certainly hyperbolic, his enthusiasm is catching. The term Maker has not been stable, many groups use it differently, and it’s meaning as been significantly broadened as the term has been adopted by quilters, knitters, and others who make objects. For Dougherty, this expansion is exactly how he wants Makers to be viewed, for others the inclusion of craftwork outside the technological realm is a step too far.

Make magazine sponsors Maker Faire, the largest yearly showing of Maker production in the world (though this has grown, and now Maker Faires happen across the world almost every weekend of the year) and Dale Dougherty’s answer to the World’s Faire. The first Maker Faire took place in the Bay Area in 2006, and was quickly followed by another large Maker Faire in New York. The Faires showcase everything from fire breathing robot dragons to the latest advances in garage CNC machines to sustainable mud dyeing.

³⁹² Dale Dougherty and Ariane Conrad, *Free to Make: How the Maker Movement is changing our schools, our jobs, and our minds*, (Berkeley, CA: North Atlantic Books, 2016), xvii.

³⁹³ *Ibid.*, xxi.

³⁹⁴ *Ibid.*

Many Makers have come together to form cooperative workspaces called Makerspaces. Some, like Fab Labs, are non-profit ventures with university backing, some like TechShop, are for-profit franchise, but most Makerspaces are community run spaces without outside backing. These Makerspaces are basically large work areas where members pool their resources to purchase tools that would often be outside a single member's purchasing power. Some Makers eschew the garage workshop; some because they live in apartments, some because they cannot afford to equip such a space, and some just prefer to work in a more communal environment. Many people, both inside and outside the Maker movement have still maintained garage workshops. Even though Nelson is a founder of a Makerspace; he still keeps a garage workshop and works in it on a regular basis.³⁹⁵ For many Makers, their garage workshops are a point of pride.

Makerspaces, whether in home garages or larger communal set ups, are not just about CNC machines, 3D printers, or Arduino, though all those tools would be at home in such a space. ReForge operates out of 2500 square feet in an industrial park alongside small machining and fabrication companies. Each member has a card that allows them 24/7 access to space and tools. The space includes both social and co-working areas, as well as an electronics shop, which includes soldering, welding, and circuit board equipment; a wood shop, which includes a table saw, band saw, and two CNC routers; a fabrication area, which includes several 3D printers and a laser cutter; and a craft center, which includes a vinyl cutter and sewing machines.³⁹⁶ Early Makerspaces like Fab Labs needed more support, but over the last ten years the capital needed to start a Makerspace

³⁹⁶ Oral History Interview with ReForge Members, 3 March 2018.

dropped precipitously, and “by 2012, the world now had a \$999 3D printer, a laser cutter that cost about \$2000, a vinyl cutter for \$299 and Inventables launched the Shapeoko CNC Mill which costs \$600. This was a milestone for digital fabrication. It meant that for less than \$5000 you could build a Maker Lab.”³⁹⁷ This steep decrease in startup costs has allowed individuals across the world to come together to start Makerspaces.

Both small and large Makerspace have a variety of tools beyond the high-tech, industrially derived tools that tend to be associated with such spaces. Artisan’s Asylum, one of the largest and well known Makerspaces, not only has a digital fabrication and design lab, but they also have a full range of sewing machines and sergers, jewelry making tools, a bike shop, and a screen printing shop.³⁹⁸ Freeside Atlanta, another community based non-profit hackerspace/Makerspace or, in their own words, “an unbounded blank canvas for creation, where ideas can be put to the test, things set on fire, and the stuff of legends cast in the forge of blood, sweat, and tears,” has a garage for automobile hacking, a biohacking lab, a ham radio shack, a darkroom and is building a podcast studio.³⁹⁹ Both of these Makerspaces are open to the wider community. “For makerspaces to become similarly ubiquitous and sustainable platforms, they need to offer the kind of institutional stability that will support meaningful community programming, educational opportunity, and grassroots economic growth.”⁴⁰⁰

Some Makerspaces also serve specific populations. Double Union, in San Francisco, is a Makerspace for women and non-binary people. Double Union grew out of

³⁹⁷ Kaplan, “My journey With Maker Faire - Does the maker movement matter?”

³⁹⁸ “Shops & Equipment,” *Artisan’s Asylum*, <http://artisansasylum.com/workshops/>.

³⁹⁹ “Our Space,” *Freeside Atlanta*, https://wiki.freesideatlanta.org/fs/Our_Space.

⁴⁰⁰ Hollman, “Makerspace.”

AdaCamp 2013, a tech conference for and by women. Much like the women of the cooperative garage, women often feel excluded or forced to prove themselves in male dominated spaces. Bean, Farmer and Kerr point out that in 2012, 81% of Makers were male. While they argue that women are most likely undercounted in these types of surveys because of the way respondents were reached (through male-dominated Makerspaces), and because women often engage in creative work that is not “taken seriously as ‘making,’” there is still clearly a majority of male Makers.⁴⁰¹ Just like the women in the co-operative garages, many women do not come from a background where their family’s technical skills were passed on to girls, and thus are more hesitant in pursuing technical education, even in informal settings, especially those that are male dominated. “The proposition that technical participation can be a route to social and civic egalitarianism tends to elide a history in which the codes of masculinity and whiteness have been codified around dominance, over both technology and other social groups.”⁴⁰² Even more, “Almost half of all makerspaces are member-driven clubs, suggesting that committed early adopters are driving the movement.”⁴⁰³ It also illuminates why these workspaces might have diversity problems, as they operate like clubhouses instead of workspaces.

Double Union originally was only open to those people who identified as women, but opened to non-binary people in 2018, and retained consultants to help make the space

⁴⁰¹ Vanessa Bean, Nicole M. Famer, and Barbara A. Kerr, “An Exploration of Women’s Engagement in Makerspaces,” *Gifted and Talented International* 30, no. 1-2 (2015): 62, <https://www.tandfonline.com/doi/abs/10.1080/15332276.2015.1137456>.

⁴⁰² Christina Dunbar-Hester, “Radical Inclusion?: Locating Accountability in DIY,” in *DIY Citizenship: Critical Making and Social Media*, edited by Matt Ratto and Megan Boler, (MIT Press, 2014), 84, <http://www.jstor.org/stable/j.ctt9qf5jb>.

⁴⁰³ Hollman, “Makerspace.”

welcoming to women of color and other underrepresented people. They also explicitly critiqued the flaws in radical feminism's organizing efforts when considering how the Makerspace would be run. Referencing Jo Freeman's "The Tyranny of Structurelessness," a talk given at the Southern Female Rights Union in 1970, they rejected many of the organizational (or lack therefore) choices of groups like WAC and *Mechanica*.⁴⁰⁴

Freeman argues that one of the largest hurdles radical feminism faced in pushing its agenda forward was its adherence to the structurelessness of consciousness raising groups. In rejecting structure as a form of oppression, these groups often had a difficult time organizing anything beyond conversation. Instead, Freeman suggests groups use seven principles to create democratic structure when organizing groups: delegation of specific authority to specific individuals; requiring people in authority to be responsible to the larger group; distribution of authority among many individuals; rotation of responsibility; tasks matched to ability, interest and responsibly, not popularity; access to information by all individuals, not just authorities, and equal access to group resources for all individuals.⁴⁰⁵ Double Union adopted these principles as the basis of their governing structure, and has so far been successful in balance the needs of a working, creative community and organized advocacy.⁴⁰⁶

Other Makerspaces also focus on specific populations. *Liberating Ourselves Locally* is a Makerspace in Oakland, CA for queer and trans people of color and seeks to

⁴⁰⁴ "About," *Double Union*, <https://doubleunion.org/about>.

⁴⁰⁵ Jo Freeman, "The Tyranny of Structurelessness," <http://www.jofreeman.com/joreen/tyranny.htm>.

⁴⁰⁶ "About," *Double Union*.

create a space open to Making for social justice.⁴⁰⁷ Mothership Hacker Moms is a Makerspace aimed at self-identified mothers of any gender, and includes onsite childcare, so that moms can learn to knit, solder, or use CNC routers.⁴⁰⁸ Some Makerspaces, like Makerspace Urbana, in Illinois, have specific hours limited to women, trans, gender queer, and non-binary people in order to create a welcoming space and attract new and more diverse members.⁴⁰⁹

Makerspaces aimed at children and families have also increasingly become part of educational settings such as libraries, museums, and schools. Blaze Starkey, a teacher at the Mní Wičhóni Nakíčiziŋ Owáyawa (Defenders of the Sacred Water School) in the Sacred Stone Camp at the site of the Standing Rock protests, started the TradLab, a Makerspace with a Lakota spin. Starkey says the goal of the school is to “give a traditional Lakota education, but we also want them to be superstars in reading, science, math, and writing – not just so they can excel in the system but so they can critically address the system.”⁴¹⁰ For Starkey, Making is a vital part of this education. He argues that indigenous schools need to help students “innovate and create off of our own traditional technologies to solve problems that we’re facing and that I think really everybody is facing and I’d like to see us be able to benefit from those things too.”⁴¹¹

This idea that Making can be an integral part of education is growing. Emily Pilloton’s

⁴⁰⁷ “About,” *Liberating Ourselves Locally*, <https://oaklandmakerspace.wordpress.com/about/>.

⁴⁰⁸ “FAQ,” *HackerMoms: Welcome to the Mothership*, <https://hackermoms.org/faq/>.

⁴⁰⁹ Makerspace Women and Trans Open Hours, *Makerspace Urbana*, <https://www.facebook.com/events/143735332846512/>.

⁴¹⁰ Roamingravitz, Instagram, 3 December 2016, <https://www.instagram.com/p/BNINHq3loGx/>

⁴¹¹ CrossRoads 2017, “Young Makers as Today’s Agents of Change,” YouTube Video, 54:07, <https://www.youtube.com/watch?v=RCoYb5tv79g>.

Girl's Garage is a Makerspace dedicated to girls 9-18. Its sister project, Studio H, is a Maker program that started in Bertie County, NC, and focuses on middle and high school age students. Pilloton argues that girls need to have the "capacity to shape one's world through building, tinkering, re/designing, or hacking."⁴¹² She also argues for collaboration between Makerspaces and museums, writing that "Together the museum and the faire stake out the limits of the modern maker spectrum, which oscillates between bleeding-edge application and grown-up play, between small businesses and corporate giants, between promising technology and unfulfilled potential."⁴¹³

Sociologist Christina Dunbar-Hester differentiates between making, which "emphasizes technical *participation*," and open source software projects "where technical *virtuosity* is paramount." She argues where open source coding can be a very elitist culture, that participation allowed Making to be open to a wider group of people. Dunbar-Hester considers a group who originally engaged in radio piracy and then transformed to become free airwaves activists. These activists linked their identities as Makers to their political goals. Part of this activism involved going out into the community and teaching people to build their own radio stations.⁴¹⁴ For Dunbar-Hester, Making is linked to agency, allowing people to have hands on control of the creative process, and that with this agency come a political identity.⁴¹⁵ "The activists envision "everyone" as a potential "maker," and thus DIY citizenship as accessible to all. This wide access was seen by the group as a way of creating a more inclusive community as

⁴¹² "Maker Empowerment Revisited," *Agency by Design*, 28 January 2014, <http://www.agencybydesign.org/maker-empowerment-revisited/>

⁴¹³ Hollman, "Makerspace."

⁴¹⁴ Dunbar-Hester, "Radical Inclusion?" 76.

⁴¹⁵ *Ibid.*, 77.

well as dispensing previously inaccessible technical knowledge to the community who had previously been excluded from this kind of work.⁴¹⁶

Yana Boeva argues that, “many of these [maker]spaces and collectives began as a counter-reaction to the ‘slow’ and inaccessible modes of research and production.”⁴¹⁷

Many Makers have a background in computer programming, manufacturing, engineering or science, and come to Makerspaces to creatively explore skills that they learned through their employment. Allyson Sutton argues that Makerspaces in the south are found in areas that already have a long history of craftsmanship.⁴¹⁸ For Kimberly Sheridan and her co-authors, Makerspaces functioned much like studio arts learning environments, sharing four key structures: demonstration lectures, students at work, critiques, and exhibitions. While these structures were often less formalized in Makerspaces than in studio arts setting, without a set teacher-student division, they were still all present.⁴¹⁹

Makerspaces profited from the experience of the largely digital open source movement, and their attempts at creating physical coding spaces, generally called hackerspaces (though the terms hackerspace and makerspace are often interchangeable among members). The Open Source movement not only paved the way for the tools which Maker’s rely on, such as the garage workshop CNC machine, but also provided a

⁴¹⁶ Ibid., 77.

⁴¹⁷ Boeva and Chies, “Yet Another Industrial Revolution – A Dialogue on Tensions in Digital Fabrication.”

⁴¹⁸ Allyson Sutton, “12 Must-See Makerspaces for Southern Creators,” *DIG South*, 2 August 2016, <http://digsouth.com/2016/08/02/12-must-see-makerspaces-for-southern-creators/>

⁴¹⁹ Kimberly Sheridan et al “Learning in the Making,” 510.

foundation of communal technical work in the digital realm that Makers exploited for their own needs in the physical realm.

For many Makers it is this idea of meeting others with their interests “in real life” that is a draw for Makerspace. Even with space at a premium, most Makerspaces include an area for members to hang out away from tools. The team found that Makerspaces aimed at adult served a social function, often as a primary part of member’s experiences. These types of Makerspaces usually see entrepreneurs and hobbyists as their main membership, though people without technical skills do sometimes join in order to learn them.⁴²⁰ While disparate in skill level and domain of interest, they still see a community of practice in Makerspaces of this type.

The Makerspaces not only provide a social hangout space and access to tools, they also became a site of many startup companies. These startups and smaller artisan producers benefited from the growth of internet marketplaces like Etsy and Kickstarter, which allowed these small entrepreneurs to directly reach customers without their products ever being on a store shelf.⁴²¹ It is this economic facet of Makerspaces that has attracted the most attention from both the U.S. government and the corporate world. In 2009, President Obama launched the Educate to Innovate initiative, which was aimed at improving math and science scores of American students. Its goals were to bring CEOs into the process of improving STEM education, recruiting and educating 100,00 new STEM teachers, bolstering federal investment in STEM, and reaching out to historically

⁴²⁰ Kimberly Sheridan et al “Learning in the Making,” 512.

⁴²¹ Kaplan, “My journey With Maker Faire - Does the maker movement matter?”

underserved communities to create a more diverse talent pool.⁴²² The White House also held its own Maker Faire modeled on the World Maker Faire and its forerunner, the Maker Faire Bay Area, the largest gatherings of Makers — a festival of all the innovative ways science and technology can be played with from Arduino-powered fire breathing dragons, three dimensional printers or bioluminescent yoghurt.

Makers are defined by their hands-on approach, their desire for creative control over cutting-edge technology and science, and their cooperative approach to creating and disseminating their experimentation with contemporary technology. For some, Making was a way to move towards a start-up company and the tradition twenty-first century way of making an impact on science, technology, engineer and mathematics (STEM) fields. For most, Making was an amateur activity, one they might not have expected to be declared a revolution when they were tinkering in their garage. Makers, as the *New York Times* put it, are in the business of “social tinkering.”⁴²³

The social tinkering that is Making, the article suggests “is also about pushing back against the passivity that technology has bred.”⁴²⁴ This view — that technology makes humans lazy and unable to focus, and that technology and not humanity, is the active agent in the relationship — is both relatively common, and a source of much consternation among the popular press. The idea that Making is a solution to technologically-induced passivity suggests that the activity is both new and unique.

⁴²² “Educate to Innovate,” *The President Obama White House*, <https://obamawhitehouse.archives.gov/issues/education/k-12/educate-innovate>.

⁴²³ Anand Giridharadas, “The Kitchen Table Industrialist,” *The New York Times*, 13 May 2011. http://www.nytimes.com/2011/05/15/magazine/the-kitchen-table-industrialists.html?pagewanted=1&_r=0

⁴²⁴ *Ibid.*

Making, however, is part of a long history of citizen science, amateur engineering, and tinkering with electronics during the nineteenth and twentieth centuries that forward thinking entrepreneurs and policy makers, including President Obama, have heralded as the frontier of manufacturing in the twenty-first century.

This federal recognition of Making and Makerspaces as essential to America's future economy has brought in new sources of funding. Perhaps most controversially was DARPA funding. DARPA (Defense Advance Research Project Agency), which under the acronym ARPA funded research that led to computer time-sharing and eventually the Internet, provided grant money to *Make* as well as several educational Makerspaces. This money allowed *Make* to help approximately 1000 high schools build Makerspaces, but for critics it also exposed students to ideologies of violence that should not be in public schools. Kevin Driscoll attributes this uneasiness to the libertarian hacker roots of Maker culture, but *Make's* Dale Dougherty points out that MIT, the birth place of hack culture, has been running with ARPA and DARPA funding for half a century. This conflict of the hacker ethos with the reality that even as prices decrease, Makerspace equipment is still expensive and that the American defense complex has been interested in producing people with engineering and technological know-how since at least the Morrill Act of 1862, is one that had not yet played out, but will surely be a point of contention as Makerspaces and Makers themselves figure out where they fit in their communities and nation.⁴²⁵

⁴²⁵ Kevin Driscoll, "The Dark Side of DIY – Makerspaces and the Long, Weird History of DIY Hobbyists & Military Funding," *Civic Paths*, University of Southern California, <http://civicpaths.uscannenberg.org/the-dark-side-of-diy-makerspaces-and-the-long-weird-history-of-diy-hobbyists-military-funding/>

Makerspaces may seem like the cutting edge of communal work spaces, but Hollman links Makerspaces to a broader tradition of technical knowledge. Starting with Mechanic's Institutes, public subscription-based organizations that brought both technical knowledge and infrastructure such as "libraries, lecture halls, laboratories, and in an era before widespread artificial lighting, illuminated reading rooms," for working class mechanics and engineers.⁴²⁶

Mechanic's Institutes began as a Scottish phenomenon and quickly spread through the English speaking world. Heriott-Watt University founded in Edinburgh, Scotland in 1821 claims to be the first Mechanic's Institute. The school places their formation in the Scottish Enlightenment as a project that hoped to spread scientific and technical education to artisans and mechanics. Formed by Leonard Horner, linen merchant, and Robert Bryson, clockmaker, with the hopes of increasing their apprentice's knowledge of practical science, the School of Arts Edinburgh was an overnight success, and their model, known as Mechanic's Institutes, became a basis of a type of practical scientific and technological education of artisans and mechanics.⁴²⁷

In the United States, mechanics had begun organizing to provide charitable services for themselves and their families as early as 1785. The General Society of Mechanics and Tradesmen of the City of New York expanded its charitable work to include a free school for members in 1820, which included classes for both boys and girls. This school became a Mechanics' Institute in 1858. Along with the school, the

⁴²⁶ Hollman, "Makerspace."

⁴²⁷ "The Edinburgh School of Arts – A Revolution in Education," *Heriot-Watt University*, <https://www.hw.ac.uk/services/heritage-information-governance/history/edinburgh/school-arts.htm>

General Society also opened a library which catered to boys who were apprenticing in the trades, and thus need to utilize a library at night, since they worked during the day.⁴²⁸

Nor was this phenomenon limited to urban New York. The Ohio Mechanics' Institute was founded in 1828 in Cincinnati, a city which the census reported had 24,831 residents in 1930. Much like the General Society, the Ohio Mechanics' Institute organized a school, established a library, and sponsored lectures. The school is now the University of Cincinnati.⁴²⁹

The lectures and classes in the 19th Century were not limited solely to the mechanical. In accordance with their objective to promote the “diffusion of useful knowledge,” the Institute offered a wide variety of topics.⁴³⁰ In 1857, the Mechanics' Institute hosted lectures on English Literature, Natural Philosophy, Astronomy, Magneto-Electricity and Molecular Forces.⁴³¹ The Institute also sponsored a yearly exhibition. Exhibits included steam powered inventions of every type including farming equipment, a sawing machine, and steam engines, as well as fabrics and textiles, and daguerreotypes and other representative fine arts.⁴³²

The Institute also saw the publication of the work and intellectual discussions of its members as a part of its mission. The Department of Science and Arts came into being

⁴²⁸ “About the General Society of Mechanics & Tradesmen,” *The General Society of Mechanics & Tradesmen of the City of New York*, <https://generalsociety.org/?p=1>.

⁴²⁹ “Ohio Mechanics Institute,” *Ohio History Central*, http://www.ohiohistorycentral.org/w/Ohio_Mechanics_Institute.

⁴³⁰ Robert B. Warder, *Scientific Proceedings of the Ohio Mechanics' Institute* (Ohio Mechanics' Institute, 1882), 1.

⁴³¹ *Fiftieth Anniversary of the Ohio Mechanic's Institute* (Wilstach, Baldwin & Company, 20 Nov 1878), 20.

⁴³² *Ibid.*, 26.

in 1881 with the mission “to bring the scientist and the artisan into closer relations, and to promote a community of feeling between thinkers and workers.”⁴³³ The Mechanics’ Institute Library and Chess Room in San Francisco is still operational. Founded in 1854, the Mechanics’ Institute was funded with Gold Rush money to help those skilled workers left unemployed by the end of the Rush. Today it hosts chess matches as well as a full subscription based library, community lectures, classes and workshops.⁴³⁴

As child labor declined, apprentices who normally would not have attended high school, and instead would have gotten further education through Mechanics’ Institutes or on the job training, became a large part of the student body. The question of what training they should receive in high schools, which previously aimed at preparing children for college, became a pressing concern. Vocational education in the United States was originally developed for these students who did not plan to attend college, but were leaving high school for a specific blue-collar career like welding or plumbing.⁴³⁵ In 1917, Congress passed the Smith-Hughes Act which added vocational education to public school curriculums.

The Education Amendments of 1976 called for equal access to vocational education, as well as banning sex based discrimination by vocational educators. In 1977, William W. Stevenson argued that an important part of following the mandates of the Amendments was to change how vocational educators thought. For Stevenson, gender

⁴³³ Warder, *Scientific Proceeding of the Ohio Mechanics’ Institute*, 5.

⁴³⁴ Warder, *Scientific Proceeding of the Ohio Mechanics’ Institute*, 5.

⁴³⁵ Emily Handford, “The Troubled history of Vocational Education,” *American RadioWorks*, 9 September 2014, <http://www.americanradioworks.org/segments/the-troubled-history-of-vocational-education/>

blind market capitalism with profit as its driving motive, not the social structures of the past, would be both the true force of change and the true measure of success of the Amendments.⁴³⁶ Even as the legal ability to discriminate by gender in vocational education was banned, informal discrimination and other cultural barriers kept girls out of shop classes. In 2004, 2% of students in shop classes were female, and vocational education still drew primarily from impoverished and traditionally underserved populations.

Vocational programs also were often not academically challenging, and some failed to meet the minimum academic standards for their students. As manufacturing jobs disappeared in America, so did vocational classes aimed at putting students into those jobs, and the number of students taking vocational classes diminished by nearly 75% between 1982 and 2004. When No Child Left Behind was passed in 2001, student in vocational programs had to take standardized tests alongside their academically tracked peers, and the results were often dismal. Critics argued that vocational classes were a form of non-academic tracking, and that since these classes generally were populated by students from traditionally impoverished and underserved communities, vocational education was a tool of social stratification, funneling students into lower paying trade jobs instead of white collar work that required a college degree with far-reaching consequences.⁴³⁷

⁴³⁶ William W. Stevenson, "The Educational Amendments of 1976 and their implications for vocational education," Information Series No. 122. National Center for Research in Vocational Education Publications, 1977, 10.

⁴³⁷ Scott Bartholomew, "why we cannot afford to lose CTE in schools," *International Journal of Vocational and Technical Education* 6, no. 20 (September 2014): 10, http://www.academicjournals.org/article/article1411122711_Bartholomew.pdf

Shop and other vocational classes are disappearing entirely from the educational system. Some states, like Massachusetts, have successfully integrated vocational and academic education into a new high school experience that aims to give students multiple options after high school. Others, like California, have almost completely eliminated vocational education in favor of academic courses aimed at getting every student to college.⁴³⁸ For many this shift away from vocational education is problematic, as approximately 70% of high school students do not go on to college. Why then are they being solely prepared to attend college?

Even college bound students find vocational education useful when programs are tailored to contemporary needs. *Make*, the mouthpiece of the Maker movement, is headquartered in Sebastopol, CA, a place where local schools had all but done away with shop class. In a corporate-academic partnership, *Make* invited students from local Analy High School to learn about Making at their office shop. Students flocked to the opportunity, and the school and *Make* eventually teamed up to turn the old shop classroom in a Makerspace when demand outstripped space at *Make* headquarters. The Makerspace has been a success, not just with kids who would normally be in vocational classes, but with the whole student body. Making brings together math, engineering, and problem solving, and places them in an environment where students feel like they are learning useful skills. Students who normally struggle with academic subjects, often find that they can master them in the context of the hands-on approach of the workshop.⁴³⁹

⁴³⁸ Emily Hanford, "A 21-st century vocational high school," *American RadioWorks*, 11 September 2014, <http://www.americanradioworks.org/segments/a-21st-century-vocational-high-school/>

⁴³⁹ Ken Robinson, "Why Schools Need to Bring Back Shop Class," *Time*, 8 May 2015, <http://time.com/3849501/why-schools-need-to-bring-back-shop-class/>

Some Makers, like David Morris, would rather see kids at local Makerspaces, than building Makerspaces in schools. Schools, Morris argues, ruin everything. Morris has seen programs fail because teachers who are not Makers do not receive enough training to be able to use, teach, and repair the technology in their classrooms and often receive little or no training in the Maker ethos. For Morris, a CNC router that you build with your own hands is better than an expensive industrial machine. The industrial machine might be more accurate or more powerful, but it's a machine that you do not know inside out, which makes both use and repair more difficult.⁴⁴⁰

For others, like philosopher and mechanic Matthew Crawford, mechanical competence is not only an important part of education, but he, like Sennet, believes that it a basic human need. Both argue that humans both derive satisfaction and understanding of the world through the making of concrete things. These views are not limited to the realm of philosophy or academia. Adam Savage, perhaps most famous for his role co-hosting *Mythbusters*, recently undertook a cross country tour of Makerspaces to promote Making and making Making accessible to more people. He also runs a non-profit, Nation of Makers, dedicated to helping Making grow. One of his biggest points of advocacy is that people need to make things to be happy.

For Nelson and other Makers, one of the most important parts of the Maker Movement is the idea that things are not disposable. Scraping and salvaging, from dumpster diving to simply reusing leftovers, is at the heart of the Maker ethos. Makers not only want to make things, they want to make things that can be repaired, repurposed or recycled with knowledge and a little ingenuity. Nelson and fellow Maker David Morris

⁴⁴⁰ Oral History Interview with Reforge Members, 3 March 2018.

have reused materials found in dumpsters, on the side of the road, and from businesses and institution getting rid of older tools and materials.⁴⁴¹

For Adam Savage, scrounging and scavenging is an integral part of Making. As part of a roundtable video podcast, Savage outlined the best way for Makers to obtain materials. As well as Nelson and Morris' techniques, Savage suggests looking for motors and other moving parts at pick and pull junkyards, free/scrap bins from businesses and schools, and building relationships with people who might have scrap materials that Makers might be looking for.⁴⁴²

In this, Makers, like Joe Dwyer and his water bottle recycling machine, have been fighting against the rising tide of disposability in American culture. Single use items, such as paper towels and tissues, became a staple in the United States at the turn of the 20th century. Lucas argues that in the 19th century, waste was seen as a product of inefficient home management, but as reformers for public health and hygiene advocated for new standards of cleanliness, disposable items became standard household items. These disposable items and their moral system of hygiene lived in tension with the older ethos of thrift, which valued reuse, repurposing, and recycling.⁴⁴³

The advent of organized municipal waste collection systems and an expansion of indoor plumbing turn of the twentieth century changed how people dealt with waste.⁴⁴⁴ No more was the privy to double as a site of household waste disposal. Manufacturers

⁴⁴¹ Oral History Interview with Reforge Members, 3 March 2018.

⁴⁴² Will Smith, "Scrounging, Buying, Finding Materials," *Still Untitled: The Adam Savage Project*, 19 March 2013, <http://www.tested.com/art/makers/454197-scrounging-buying-finding-materials-3192013/>

⁴⁴³ Gavin Lucas, "Disposability and Dispossession in the Twentieth Century," *Journal of Material Culture* 7, no. 1 (March 2002), 6-7.

⁴⁴⁴ *Ibid.*, 10.

also changed their practices. In the late 19th century, it was common for manufacturers who produced goods sold in glass bottles to forbid their reuse by customers, and instead collected the bottles and reused them themselves. Other goods, which came in metal or ceramic packaging, were meant for household reuse. The invention of the automatic bottling machines, however, combined with new ideas of appropriate hygiene, ended this practice.⁴⁴⁵ It also led to the decline of the networks of labor that profited from scavenging worn out goods and reselling them for recycling, including rag dealers and bone collectors.⁴⁴⁶

Disposable packaging originally meant paper products, but expanded to plastic and other synthetics by the end of WWII. Lucas argues that these single use products helped make the association between hygiene and single use.⁴⁴⁷ Packaging, however, was not the only single use item on the market. The safety razor with its disposable blades debuted in 1903, and paper cups and plates were used on trains, in schools, and by the 1920s, in soda shops and other casual dining spaces. Paper towels joined the lineup in 1931, and by 1932 “planned obsolescence” was the goal of many a corporation.⁴⁴⁸ Bernard London, the man who invented the phrase, meant for the government to step in and create a life-span for products after which they must be destroyed in order to help the economy during the Great Depression. But manufacturers did not need the government to

⁴⁴⁵ Ibid., 11-12.

⁴⁴⁶ Susan Strasser, “Waste and Want: The Other Side of Consumption,” *German Historical Institute Annual Lecture Series*, no.5 (1992): 18, https://www.ghi-dc.org/fileadmin/user_upload/GHI_Washington/PDFs/Waste_and_Want.pdf.

⁴⁴⁷ Lucas, *Disposability and Dispossession*, 11-12.

⁴⁴⁸ Strasser, “Waste and Want,” 18.

enforce such a decree; instead, planned obsolescence simply became the strategy of producing items that would self-destruct over the course of their use.⁴⁴⁹

“Eye-appeal,” the idea that there was added value in making a product aesthetically pleasing to customers, also became increasingly important in the 1920s and 1930s. Whiteley argues that this created the foundation of “style obsolescence,” a planned obsolescence in which a product would no longer look fashionable in two-to-three years, even if it still functioned properly.⁴⁵⁰ Companies like Sears Roebuck started producing the same functional object in a new style every year. The product perhaps most affected by this style obsolescence was the automobile. The hand-crafted style of elite automobiles became the goal of all car manufacturers. In 1927, both Ford and General Motors moved from the idea of technical perfection at minimal cost, to a new rotation of car designs that were focused on the shifting aesthetics of fashion. Thus, the lines and curves of a car’s body became an important reflection of their owner’s social standing and ability to replace a car when it went out of fashion, regardless of its performance.⁴⁵¹

By the 1950s, Life magazine declared “Throwaway Living” the height of modern progress, one in which the burdens of the housewife were being lifted by technology.⁴⁵² Less than 15 years later, “Throwaway Living,” would not be a revolution to be celebrated,

⁴⁴⁹ Jessica DuLong, “The Birth of America’s Disposable Culture,” *Wonders & Marvels* (June 2010), <http://www.wondersandmarvels.com/2010/06/the-birth-of-america%E2%80%99s-disposable-culture.html>.

⁴⁵⁰ Nigel Whiteley, “Toward a Throw-Away Culture: Consumerism, ‘Style Obsolescence’ and Cultural Theory in the 1950s and 1960s,” *Oxford Art Journal* 10, no. 2, The 60s (1987): 3.

⁴⁵¹ *Ibid.*, 6-7.

⁴⁵² Ben Cosgrave, “‘Throwaway Living’: When Tossing Out Everything Was All the Rage,” *Time*, 15 May 2014, <http://time.com/3879873/throwaway-living-when-tossing-it-all-was-all-the-rage/>.

but a serious problem to address. Vance Packard became an early, well known critic of this practice in 1957. For Packard, planned obsolescence was not progress; instead it was waste that was created through corporate manipulation of the public for profit. Others followed in his footsteps, and by the 1960s, planned obsolescence was no longer a term to celebrate, but one to hide. Instead, corporations tried to convince consumers of their product's integrity, while still rolling out a new model every year.⁴⁵³ Peter Wilby argues that waste, especially corporate waste, is an inherent feature of capitalism, as much as "inequality, job insecurity, loss of community and so on."⁴⁵⁴

While companies stopped celebrating planned obsolescence, they did not change their production or sales methods, and consumers did not change their consumption habits. In, fact, production, purchasing and waste all increased in the face of criticism of throwaway living. The problem of waste was bad enough that the federal government stepped in and solidified their authority over solid waste management in the United States between 1965 and 1976.⁴⁵⁵

From 1970 to 1990, individual Americans produced an entire pound more of waste every day on average, and while paper and paperboard are the most prevalent items found in domestic waste, electronics also play a role in waste creation.⁴⁵⁶ Some electronics were marketed as disposable, like the disposable camera, which hit markets in

⁴⁵³ Nigel Whiteley, "Toward a Throw-Away Culture," 8.

⁴⁵⁴ Peter Wilby, "Why Capitalism Creates a Throwaway Society," *New Statesman*, 28 August 2008, <https://www.newstatesman.com/society/2008/08/waste-supercapitalism-policy>.

⁴⁵⁵ "American Waste Practices," *Disposable America: Explore the History of Disposability Through Object Stories*, <https://disposableamerica.org/american-waste-practices/>.

⁴⁵⁶ Ibid.

the 1980s. For less than ten dollars, these plastic and cardboard cameras took decent snapshot photographs. In 1992, 21.5 million disposable cameras were sold, and then thrown away.⁴⁵⁷ Other electronics were simply victims of planned obsolescence, whether through going out of style or ceasing to work. 44.7 metric tons of electronics make their way to a landfill every year, and the average smartphone has a lifespan of 21 months.⁴⁵⁸

For the technology market place, planned obsolescence went hand in hand with blackboxing technology. While the Apple 1, released in 1976, was easily taken apart by a curious customer, the customer is not meant to be able to ever see the inside of the latest Apple product, the iPhone X. Matthew Crawford argues that, “an engineering culture has developed in recent years in which the object is to “hide the works,” rendering the artifacts we use unintelligible to direct inspection.”⁴⁵⁹ This inaccessibility or blackboxing not only means that consumers cannot repair their own purchases, but that kids like Nelson cannot take them apart to modify or learn from them.

For all that single use products and short-lived electronics have cornered the market, not all Americans want to live the throwaway life. Campbell argues that as mass production increases in both quantity and arena, so does the impulse to counteract it. These attempts to counteract, however, are just as often colonized by mass production as soon as they become popular. As more people create gourmet meals at home, more

⁴⁵⁷ Della Keyser, “Kodak and Fuji Square Off: The Golden Age of Throwaway Cameras,” *Disposable America: Explore the History of Disposability Through Object Stories*, <https://disposableamerica.org/course-projects/della-keyser/kodak-and-fuji-square-off/>.

⁴⁵⁸ Stephen Leahy, “Each U.S. Family Trashes 400 iPhones’ Worth of E-Waste A Year,” *National Geographic*, <https://news.nationalgeographic.com/2017/12/e-waste-monitor-report-glut/> and Andy Walton, “Life Expectancy of a Smartphone,” *Houston Chronicle*, <http://smallbusiness.chron.com/life-expectancy-smartphone-62979.html>.

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people need the tools and teaching media to be able to do so. Popular DIY Pinterest pins are quickly turned into products for the shelves of big box stores like Target. Campbell also points to the decrease in the middle class employee's ability to work creatively and without oppressive oversight, and to movements to make mass consumption a better fit with upper middle-class ideas of cultural superiority.⁴⁶⁰ This creative impulse often means Makers are interested in finding new solutions to old problems.

For some, open source hardware has become a revolutionary lifestyle. Marcin Jakubowski, an adherent to the idea of self-sufficiency and burnt out after a Ph.D. in fusion physics, started the Global Village Construction Set. These fifty industrial machines can be built from scraps and spare parts and would provide everything that a village would need to be self-sufficient. Jakubowski started in 2009 by building a tractor for around \$7000 (a comparable commercial tractor costs around \$45,000). He has now built sixteen of the fifty machines on the list.⁴⁶¹ For Jakubowski, "The more people relied on themselves for goods and services, rather than on experts and large corporations, and the more people shared what they knew, the more efficient and equitable human society would become. Eventually, material scarcity would disappear."⁴⁶² Making, for Jakubowski, is the best way to create a better world.

Jakubowski's farm is a continuation of an American tradition according to Eakin, starting with the do-it-yourself farm communes of the 1840s. Not only in its ideological fervor, though the communal farms of the 1840s were more focused on spiritual

⁴⁶⁰ Campbell, "The Craft Consumer," 38.

⁴⁶¹ Emily Eakin, "The Civilization Kit," *The New Yorker*, 23 & 30 December 2013. <https://www.newyorker.com/magazine/2013/12/23/the-civilization-kit>

⁴⁶² Ibid.

fulfillment than self-sufficiency, but also in the setback and less than promising results.⁴⁶³

Paul Boyer argues that “the impulse to form highly cohesive communities knit together by a common ideology and a shared vision of social harmony has been a constant in American history,” almost as much as the much vaunted American individualism.⁴⁶⁴

While this impulse is not uniquely American, affiliative and communal utopian groups have played a large, if somewhat unheralded, role in American life. For Boyer, this impulse is found in groups as far ranging as “millenarian visionaries immersed in Bible prophecy” and “secular ideologists searching for alternative to the emerging urban-industrial order.”⁴⁶⁵ Jakubowski and his followers can be found in this second group, and perhaps, if less intensely, the rest of the Makers and members of the women’s co-operative garages as well.

If Jakubowski’s communal utopia is a bit farfetched, FarmBot’s emphasis on individual gardening may be more practical, despite the \$3700 price tag. FarmBot is a gardening tool, based on a CNC machine, that lets gardeners offload the hard work of gardening to a machine. Where industrial farmers use tractors and other large automated machines, FarmBot shrinks these machines down into a single robot, capable of gardening a 2.9m by a 5.9m bed. Gardeners use a graphical interface that resembles SimCity to plan out their plots. Each type of plant has individualized care instructions that can be adapted for the environment or other needs. The FarmBot is Open-Source and

⁴⁶³ Ibid.

⁴⁶⁴ Donald E. Pitzer, “Introduction,” *American’s Communal Utopias*, ed. Donald E. Pitzer (University of North Carolina Press, 1997), 5.

⁴⁶⁵ Paul Boyer, “Forward,” in *American’s Communal Utopias*, ed. Donald E. Pitzer (University of North Carolina Press, 1997), x.

hackable, and includes CAD files of all its parts for those who want to build or repair their own machine. For off-grid farmers, it can be powered by solar power and can use collected rain water.⁴⁶⁶ FarmBot also works with disability services to help people who have physical limitations be able to garden, and with NASA helping to develop ways to grow food on the Moon and Mars.⁴⁶⁷ The machine uses a Raspberry Pi computer with an Arduino microcontroller, a sure sign of its Maker lineage.

For many Makers, Making and citizen science go hand-in-hand. The Open Source Beehives Project tracks the health of bee population through sensors that members made to monitor bee hives. All of their data, as well as the plans for the sensors and hive boxes, are open source and available on their website.⁴⁶⁸ The sensors detect changes in the sound bee colonies make in order to find a noise that indicates the hive is undergoing colony collapse. The Project sells these Buzz Box sensors but also includes all the documentation for hacking and making the sensor on their website.⁴⁶⁹ They also include two different hive box models, both design specifications are available and can be constructed using a CNC machine. ““Our aim is to create a mesh network of smart colonies, generating data to share openly on the Smart Citizen platform for study of Colony Collapse Disorder and its causes,” Copley Smith says. “We want to encourage

⁴⁶⁶ “FarmBot,” *FarmBot*, <https://farm.bot/>.

⁴⁶⁷ *Ibid.*

⁴⁶⁸ “The OSBH Project,” *OpenSource Beehives*, <https://www.osbeehives.com/pages/about-us>.

⁴⁶⁹ “Hardware Documentation,” *OpenSource Beehives*, <https://docs.opensourcebeehives.com/docs/hardware-documentation>.

and lower barriers to backyard beekeeping, while educating best practices and creating automated alert systems for beekeepers.”⁴⁷⁰

Whether Makers are producing rope from discarded plastic water bottles, reviving vocational studies, or intervening in the ecology of bees, Makerspaces are built on the combined foundations of the mostly digital Open Source movement, its hacker ethos and the mostly physical world of DIY culture. The communities of knowledge and craft created in these spaces unite technological savviness with the satisfaction of craftwork. While many people, including both policy makers and Makers themselves, see Making and Makerspaces as a new and separate phenomena, they are indeed part of the American system of creating and coming to grips with technology.

As corporate needs and governmental policy shift focus from creating a cadre of employee-engineers to individual technological entrepreneurs as the locus of American economic growth, so too has citizens experience of technology in the hobbyist world changed. No longer do boys line up to create perfect replicas of a stage coach in order to be seen as technologically and mechanically proficient future employees. Instead, students of all genders and races bring their inventions to the White House Maker Faire in hopes that theirs will be the next stock market breaking startup company. Nor are students the only demographic with this dream. Making, unlike model building, is not only a hobby taken up to show dedication and skill in hopes of acquiring a quite different job, but is for many Makers the job itself. For some Makers, Makerspaces are a place to

⁴⁷⁰ Ben Schiller, “Can a Smart Beehive Network of Open-Source Hives Help Stop the Bee Apocalypse?” *Fast Company*, 18 November 2013, <https://www.fastcompany.com/3021740/can-a-smart-beehive-network-of-open-source-hives-help-stop-the-bee-apocalypse>

start creating a few products, sold to consumers via Etsy, while keeping a day job. Others start in Makerspaces and go on to create hugely profitable companies like Makerbot. Still others just want to spend their evening with fellow Makers, playing around with circuit boards for themselves.

Whether or not Making is the Third Industrial Revolution that will shift manufacturing from factories to the home garage, it is a force to be reckoned with both in the engineering and education worlds as it changes how people view their interactions with technology. Along with the sustainability movement, Making shows Americans that disposable is not the only option of the things we surround ourselves with. Creating durable goods, imbued with care and character is not a lost art, and in fact may be just as important as the 3D printer to the future of the American economy.

CONCLUSION

Laura Moore, an advocate for queer people, civil rights, and housing equality, and a separatist lesbian, opened the St. Louis Women's Garage in the 1970s after offering her services as a mechanic to other women at music festivals. The garage could not afford hydraulic lifts, so the entire operation was woman powered, and among changing tires and replacing water pumps, Moore taught a coterie of young lesbians about being queer. Kris Kleindienst, one of women Moore taught to repair cars, remarked that "there is nothing about class, race, and sex, but *especially* class, that I did not initially learn while also being told how [sic] loosen a lug nut or tighten a fan belt."⁴⁷¹ The garage she built was not merely a place to repair cars. It was a space in which culture was both crafted and passed down to other lesbians. Moore recognized that the oral and experiential transmission of culture among the queer community was not enough, and helped found the St. Louis Gay History project after years of collecting and saving documents pertaining to St. Louis's queer history on her own.⁴⁷²

While the ideology may be different, the communal nature of the Women's Garage as a space of identity crafting through working with one's hands is much the same as the Makerspace. The transmission of knowledge, both tactile skill based craft and the more ethereal ideas of crafting identity that are transmitted side by side, are the core of both

⁴⁷¹ Kris Kleindienst, "Laura Ann Moore and One's Place in the Family of Things," *kriskleindienst*, 27 April 2015, <https://kriskleindienst.wordpress.com/2015/04/27/laura-ann-moore-and-ones-place-in-the-family-of-things/>

⁴⁷² *Ibid.*

these garage spaces. What we make and how we make it is, perhaps, more about crafting our identities than crafting objects.

Matthew B. Crawford, who earned his Ph.D. in political philosophy and then went on to repair motorcycles, advises people that work is most rewarding when it is done with one's own two hands and when the product of that work has measurable results. This is a statement both the women of the 1970s cooperative garages and the members of the Maker movement could agree with. In a way, Crawford's insistence that work is best done when it is hands-on and completed by a single person is not too different from William Morris's definition of useful work. Morris calls for the worker to actually produce something, and that something must be a thing that the worker can and wants to use.⁴⁷³ "Not only his own thoughts, but the thoughts of the men of past ages guide his hands; and, as a part of the human race, he creates," Morris argued as he attempted to convince the people of the late nineteenth century that handmade was better.⁴⁷⁴ A statement not so different from Crawford's argument that in both blue collar and white collar work "Scattered craft knowledge is concentrated in the hands of the employer, then doled out again to workers in the form of minute instructions needed to perform some part of what is now a work *process*."⁴⁷⁵

Beyond this basic agreement, all four groups differ on the politics of work and its rewards. Unlike Morris and Ruskin, neither Crawford nor the Maker Movement rejects capitalism. Crawford's advice, much like that of Beard's advice to boys at the turn of the

⁴⁷³ William Morris, "Useful Work versus Useless Toil."

⁴⁷⁴ *Ibid.*

⁴⁷⁵ Matthew B. Crawford, *Shop Class As Soulcraft: An Inquiry Into the Value of Work*, (New York: Penguin Press, 2009), 39.

twentieth century, does not ask readers to change the system that they live in, only to choose types of work that may empower them as people. This then begs the question, can everyone in a society make those choices, or is Crawford merely attempting to ameliorate the existential angst of a privileged subset of the American upper middle class?

Crawford's work focuses on production to the exclusion of consumption, but this, in the end undermines his argument. Demand for the products of everyday life is unlikely to go unfulfilled, and it is hard to imagine a system where all of these items could be produced through the type of work that Crawford champions. Whether we are postulating artisanal handmade toilet paper or satellites built from start to finish by a single person, the production of the most complex and the most mundane product both seem difficult to imagine without the division of a large amount of labor and industrial machinery. Should we embrace the impossible self sufficiency of Emily Mather's homesteaders and seek to remove ourselves from the underlying systems of production in our society to attempt to produce all of our own goods?

For Morris and Ruskin, as well as the radical feminists of the 1970s cooperate garage, systemic change was an important part of their work. While both had their impacts on larger society, the changes they proposed and attempted to live out have failed. Socialism is not ascendant and women do not make up anywhere near half the mechanics in the United States, and neither the labor ideals of Morris nor the collective cooperative system within many of the women's garages were sustainable in a capitalist system. The craftspeople of the Arts and Crafts movement created handmade goods in the hopes of supporting themselves, and thus had to market the goods they created to a populace who both wanted such goods and could afford them. Problematically, this left

them with an elite, wealthy clientele, such people as Morris' philosophy named enemies of their proposed socialist changes. They could not support themselves by selling their goods to the people they wished to, because those people could not afford their goods. The women's garages' dedication to collectivist organization deprived them of a strong core of committed members who could carry the project through troubled times, even as they were undercut by technological changes in cars themselves.

Making and Makers have entered the mainstream of American life. There is, perhaps, no clearer signal of this, than *Making It*, a reality television competition that pits Makers against one another for a cash prize.⁴⁷⁶ While the show uses a broad definition of who a Maker is, the idea that Makers are following in the footsteps' of the clothing designers of *Project Runway*, and the bakers of *The Great British Bakeoff*, is indicative of their transformation from niche hobby to a mainstream American pastime, which in the future may undermine some of the more radical tenets of the Maker movement in a search for profit.

As Sophie Gilbert argues, both *Making* and *The Great British Bake Off* are television shows for a weary people in a troubled time. Unlike many highly competitive reality shows wherein contestants produce a good of some sort, both shows are more likely to feature contestants and hosts hugging one another than denigrating another's efforts.⁴⁷⁷ While failure does have its consequences (constants are let go from the show

⁴⁷⁶ Jen Chaney, "Making It Is Reality TV That's Good for the Soul," *The Vulture*, 30 July 2018, <http://www.vulture.com/2018/07/making-it-amy-poehler-nick-offerman-review.html>.

⁴⁷⁷ Sophie Gilbert, "The Existential Comfort of *Making It*," *The Atlantic*, 21 July 2018, <https://www.theatlantic.com/entertainment/archive/2018/07/the-existential-comfort-of-making-it/566402/>.

once an episode) both shows attribute them to contestants having bad days rather than contestants lacking skills. Skills, and the appreciation thereof, are central to both the format and the audience's enjoyment. The difference between the *Bake Off* and *Making It*, however, lies in those skills and the ways in which contestants utilize them. All contestants on the *Bake Off* are amateurs, and they may not support themselves through baking.⁴⁷⁸ The Makers of *Making It*, however, have no such barrier, and for the most part all support themselves through crafting or design work.⁴⁷⁹

The question then is whether becoming part of the mainstream destroys the original motivations and community standards of the Maker movement. The Makers of *Making It* all participate in selling their craftwork, a venture in which most crafters do not succeed or are even able to attempt. While platforms like *Etsy* have allowed more people to easily set up shop, handcrafting is a hard business. While the show explicitly claims that it hopes to inspire home crafters, and has seemed to inspire a few journalists to, at the very least, buy craft supplies, it makes entrepreneurial crafting look glamorous, without showcasing the hard work and startup capital such a vocation requires.⁴⁸⁰ It also brushes over the fact that most of the materials used in the contestant's DIY style projects are themselves mass produced. The show is too new to say if it will have the same impact on

⁴⁷⁸ "Helena Horton, "Bake Off stars go social media shy after two years of Instagram celebrities," *The Telegraph*, 25 August 2018, <https://www.telegraph.co.uk/news/2018/08/25/bake-stars-go-social-media-shy-two-years-instagram-celebrities/>.

⁴⁷⁹ Christina Dugan and Karen Mizoguchi, "Meet the Contestants of Amy Poehler and Nick Offerman's New Crafting Show *Making It*," *People*, 20 June 2018, <https://people.com/tv/amy-poehler-nick-offerman-making-it-cast/>.

⁴⁸⁰ R. Eric Thomas, "Amy Poehler's Crafty New Show Will Make You Feel Better Than Anything Else on Television," *Elle*, 1 August 2018, <https://www.elle.com/culture/movies-tv/a22606682/amy-poehlers-making-in-crafts-review/>.

Making as the *Great British Bake Off* has had on baking, which the *New York Times* declared the cause of a “golden age for baking” with a Britons baking more both at home and professionally, and consuming more baked goods (one British super market saw an 881% increase in baking sales).⁴⁸¹

Even if *Making It* does have a similar impact on crafting to the *Great British Bake Off*'s baking, there is no telling whether it will have an effect on the wider Maker movement. For all that the show calls its contestants Makers, and labels their work making, for many people who use a much narrower definition of Making as a part of their identity, the show may fall flat. After all, contestants on the show have yet to use any of the tools that have marked the Maker movement, nor has there been much creative engagement with technology beyond the light bulb. Still, the show has been renewed for a second season, and there may be 3D printers or Arduino driven projects in our future.

Most craft apprenticeship started to disappear at the turn of the last century, and the ones that remain are programs most often run by labor unions, which are also facing extinction. Vocational education of all kind is a vanishing option in American public schools. Worse, while new forms of craftwork are created by curious artisans on a seemingly daily basis, many traditional forms of craftwork have gone extinct or become endangered. The Heritage Crafts Association of the United Kingdom keeps a list of extinct and endangered crafts, those that have died in the last generation, and those that no longer have enough trainees to sustain them into another generation, using a system much like those utilized to categorized endangered animals. These crafts range from the

⁴⁸¹ Melissa Clark, “‘The Great British Bake Off’ Changes the Way the British Bake,” *The New York Times*, 18 October 2016, <https://www.nytimes.com/2016/10/19/dining/great-british-bake-off-recipes.html>.

making of cricket balls to blowing scientific glassware to piano making.⁴⁸² While there is no comparable list for endangered craftwork in the United States, many of the crafts on the list are also likely endangered or extinct in America as well. There is, in both the United States and the United Kingdom, an interest in reviving such craftwork. The question that these advocates face is how to create a cohort of skilled craft workers in an era where there is no sustainable vision of high school level vocation education and an expectation that to succeed in life one must attend a four-year college.

Previous to the decline in shop classes and other vocational education post-WWII, most craftwork education in the school system was held in middle and high school for students who would most likely never go to college. With the decline of these offerings in high school and the increase push for every student to attend college, much vocational education has been pushed to community colleges. Community colleges offering two year associates degrees have become the place to learn the work of the traditional blue-collar jobs: plumbing, electrical work, and HVAC repair, but these institutions do not often offer class work in more traditional craftwork. Schools focusing on reviving dying craftwork, and not on the modern focuses of vocational education for plumbers, welders, and HVAC repair, like the American College of Building Arts have witnessed massive increase in interest in the last decade. The American College of Building Arts is one of the many organizations working to make craft education a sustainable part of the higher education landscape. Students at the American College of Building Arts, a four-year university, learn traditional crafting skills such as timber framing, stone carving,

⁴⁸² “Categories of Risk,” *The Heritage Crafts Association*, <http://heritagecrafts.org.uk/redlist/categories-of-risk/>.

masonry, and architectural iron work, alongside more traditional academic classes offered by other four year universities. This is not the only model for reestablishing and handing down traditional craftwork in the American education system. Schools such as the Northwest School of Wooden Boatbuilding and The Landing School have been teaching once dying traditional craftwork skills as the basis for an associate degree for forty years. Many more schools put on workshops and certificate programs in traditional craft skills.

For students at such institutes, craftwork is neither the individual doing good work for the sake of the work itself to produce an object for one's self that often define hobbyist craftwork, nor is it the imagined craftwork of Morris and Ruskin that separated craftspeople from the larger system of craftwork that made guilds and handcraft flourish in the Middle Ages. Instead, the work of these students more clearly calls back to the artisanal ideals of the eighteenth century and the more complicated forms and the profit based motives of such workers. Most students, whether they received a certificate, an associate, or a bachelor degree, intend to take the skills they learn at these institutions and apply them towards earning their living. For them, craft is not a hobby, nor is it purposeless toil, instead it is, perhaps, a vocation, or at the very least, a foundation for a life.

For the men and boys who utilized the garage as a workspace in the first half of the twentieth century, craft was part of the pursuit of an ideal masculine life. An ideal bolstered by advice publications, hobby magazines, and corporate programs. For the radical feminists who formed garage cooperatives in the 1970s, the communal garage was a site of repair and maintenance, but more importantly a place and a community in which to craft self-sufficiency. While the repair and maintenance work they undertook

are perhaps not easily defined as craft, the struggle to create both individual and communal identities in resistance to patriarchal ideals certainly is. To the members of open source software movement, craft was a way of retaining and reimagining the work ethos of the early hacker movements. Here we see a craft that is not limited to analog media, and instead is defined by an adherence to a communal standard of labor practices. For the Makers who utilized the foundation of the open source movement to create, craft is a path of discovery through an embrace of wonder in a world where technology is becoming rigid and occluded from most users. To the next generation of professional craftsmen, craft is perhaps a rejection of both Morris and Ruskin's design simplicity and faux Medieval craft ideals as well as the ideals of global, disposable mass production. Instead, these new craftspeople will have to negotiate their own meaning of craft and craftwork, one which may harken back to the artisans of the eighteenth century and their exquisitely detailed products and commercial goals, or which may go beyond this to create another meaning for craft all together. Craftwork, whether part of creating an individual's identity, expressing belonging to a group, or a means of gaining income, has been fundamentally defined by its historical and communal context.

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