

2019-10-31

Makers in the Workshop

op'tLand, Raymond Michael

op'tLand, R. M. (2019). Makers in the Workshop (Doctoral thesis, University of Calgary, Calgary, Canada). Retrieved from <https://prism.ucalgary.ca>.

<http://hdl.handle.net/1880/111198>

Downloaded from PRISM Repository, University of Calgary

UNIVERSITY OF CALGARY

Makers in the Workshop

by

Raymond Michael op't Land

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF DOCTOR OF PHILOSOPHY

GRADUATE PROGRAM IN COMMUNICATION AND MEDIA STUDIES

CALGARY, ALBERTA

OCTOBER, 2019

© Raymond Michael op't Land 2019

Abstract

Makerspaces have grown as sites of innovation since the turn of the 21st century, but the processes and methods by which they have directly contributed to innovation have been underexplored. Makerspaces exist as communal hi-tech workshops that draw on networks of knowledge in order to create their community, and they live and die by this community as well. Building on literature on both innovation and communication, this dissertation will examine the communities at three specific makerspaces in the Calgary area, and ethnographic fieldwork and participant observation will inform the rich text that serves as the data for the case study approach. By examining the development process at makerspaces, this research asks 1) how are the ideas and inspirations for the development of a new technology transferred between developers and their collaborators, 2) what sources of inspiration and new knowledge do the developers use for both the subjective and functional components of their design, and finally 3) what is the role of the makerspace as a third place where developers can collaborate and share ideas during the development process? This research contributes in three areas: 1) it informs current theories on innovation on the processes that involve subjective elements in the process of innovation; 2) it advances the literature on makerspaces and their communication processes, especially their study in Canada, and 3) it initiates and advocates for the development of a critical maker studies, as a counterpart to much of the literature in the area published to date.

Keywords: innovation, makerspaces, communication, ethnography, critical maker studies

Acknowledgements

This work could not have been completed without the encouragement and generosity of many, many people over the years. First and foremost, this includes the varied members of the University of Calgary Inno Lab, from 2006-2010, including Dan Meeking, Stefan Mendritzki, Ben Li, Meaghan Brierley, Kelly Bergstrom, Jacob Foster, Dr. Cooper Langford, and Dr. Richard Hawkins. The work and discussions there formed the foundation for what I know about innovation. The makers of the Calgary region, those creating, making, organizing and running the events that are the lifeblood of a maker community were also instrumental, generously answering my questions. Throughout my academic career I have learned an incredible amount from my cohort and their collective intelligence, and they have always been patient in explaining things to me: AnneMarie Dorland, Rebecca Carruthers Den Hoed, Mohammed Eshfalani, and TA Pattinson all commented on draft versions of this document, and I thank them specifically. Finally, my friends and family have been a source of continued support, encouraging me along the way: Sharen op'tLand, Eugene op'tLand, Derek Nyen, Jeffrey Oneski, Dwayne Kowalchuk, John Tanaka, and Chad Gould-Hawke. And most of all, Anna Li. Thank you all so much.

Dedication

In loving memory of Jan (John) op'tLand (1938-2013).

Machinist, Draftsman, Maker, Father.

Table of Contents

Abstract.....	ii
Acknowledgements	iii
Dedication	iv
Table of Contents	v
List of Tables	ix
List of Figures and Illustrations	x
Glossary	xi
Epigraph	xii
 Chapter 1: Introduction	 1
1.1 Relevance	2
1.2 Context	3
1.3 Audience & Significance	5
1.4 Theoretical Overview	6
1.5 Methods and Approach	8
1.6 Outline.....	8
 Section I: Review of Literature.....	 11
 Chapter 2: Makerspaces.....	 12
2.1 Makerspaces	12
2.1.1 Makers	17
2.2.1 Maker History, Politics, & Ideology.....	18
2.3 Maker Communications & Culture	25
2.3.1 New Media.....	25
2.3.2 Old Media.....	26
2.3.3 Maker Identity: Culture & Brand	27
2.3.4 Events and Competitions	27
2.3.5 Brand	28
2.4 Maker Research: Schools of Thought	29
2.5 The Challenge of Making	32
 Chapter 3: Innovation	 34
3.1 Three eras of Innovation Thought:	36
3.2 Phase 1: Schumpeterian Innovation	37
3.2.1 Innovation	38
3.2.2 Invention.....	39
3.2.3 Technology	40
3.2.4 Entrepreneur.....	42
3.2.5 The Firm.....	43
3.3 Phase 2: Neo-Schumpeterian Innovation Theories.....	44
3.3.1 Diffusion	47
3.4 Phase 3: The Current Era of Innovation Theory.....	49
3.4.1 The School of User-driven Innovation.....	50
3.4.2 The Soft Innovation School.....	52

3.4.3 The Current Era Neo-Schumpeterian School.....	55
3.4.4 Incipient Theories of Innovation.....	56
3.4.4.1 <i>Common Innovation</i>	57
3.5 Understanding the Current Era of Innovation Theories: Process, Source, and Context.....	58
3.5.1 Process-oriented theories of innovation.....	60
3.5.2 Source-oriented theories of innovation.....	61
3.5.3 Context-oriented theories of Innovation	62
3.6 Innovation and Makerspaces	63
3.7 Summary & Conclusion	64
 Chapter 4: Methods in Makerspaces	67
4.1 Ethnography and innovation	67
4.2 Ethnographic Method.....	68
4.2.1 The Case Study Approach	69
4.2.2 Bias.....	72
4.2.3 Validation	74
4.3 Detailed Description of Research Project.....	75
4.3.1 Research Sites	76
4.4 Analysis.....	77
4.5 Archetypes	78
4.6 Fieldwork.....	81
 Section II: Case Studies	83
 Chapter 5: Protospace	85
5.1 Background	85
5.2 A tour of the space	86
5.3 Digital.....	90
5.4 Tools	91
5.5 Activities & Events.....	92
5.5.1 Monthly Meetings and the AGM.	93
5.5.2 Open House	94
5.5.3 Tours.....	96
5.5.4 New Member Orientation.....	96
5.6 Training and Instruction.....	99
5.7 People	100
5.8 Projects	101
5.9 Processes	103
5.10 Other observations.....	105
5.11 Case Study 1 Summary: Protospace	106
 Chapter 6: Tikkun Olam Makers.....	108
6.1 Background	108
6.2 The 2017 Makeathon	112
6.2.1 Projects	113
6.2.2 People.....	116

6.2.3 Makeathon Weekend.....	120
6.2.4 The Gala	126
6.3 TOM Calgary and areas of innovation	130
6.4 Case Study 2 Summary: TOM Calgary.....	132
Chapter 7: Archeloft / Fuse33.....	133
7.1 Background	133
7.2 Locations.....	134
7.2.1 Archeloft 2016.....	134
7.2.2 Fuse33	138
7.3 Makers and Members.....	144
7.4 Events.....	144
7.4.1 MakeFashion 2016.....	146
7.5 Case Study 3 Summary: Archeloft/Fuse33.....	147
Section III: Discussion, Analysis, and Findings	149
Chapter 8: Discussion.....	150
8.1 Archetypes Revisited	150
8.2 Case 1: Protospace Archetypes.....	151
8.3 Case 2: Tikkun Olam Makers Archetypes	158
8.4 Case 3: Archeloft/Fuse33 Archetypes	163
8.5 Comparison of Archetypes.....	165
8.6 Archetypes and Research Questions	171
8.6.1 Subjective Elements.....	171
8.6.2 Ideas and Inspirations.....	173
8.6.3 Sources of Inspiration	173
8.6.4 Makerspace as a Third Place.....	174
Chapter 9: Makerspaces, Innovation Systems, and Archetypes	176
9.1 Makerspaces as Innovation Systems	177
9.1.1 The Four Schools, Revisited	178
9.1.2 Makerspaces and Innovation.....	179
9.2 Archetypes of Innovation	185
9.2.1 Makers	186
9.2.2 Marketeurs.....	187
9.2.3 Software Model Influence	188
9.3 Critical Maker Studies	189
9.3.1 Maker ‘Engagement’.....	191
9.3.2 ‘The sadness factory’	191
9.3.3 Branded anti-consumerism.....	193
Chapter 10: Conclusion.....	194
10.1 Summary of Findings	194
10.2 Contributions	195
10.3 Opportunities	197
10.4 Next Steps	199

10.5 The Challenge of Making, Revisited	201
10.6 The Future of Making	202
Appendix A: Detailed Methodology	204
A.1 Journals.....	204
A.2 Numbering.....	204
Appendix B: Timeline of Fieldwork.....	205
References	206

List of Tables

Table 1: Core Makerspace Technologies.....	14
Table 2: Summary of Archetypes	167
Table 3: Journal Entries	205

List of Figures and Illustrations

Figure 1: Southern Alberta Makerspace locations (“Hackerspaces.org,” n.d.)	5
--	---

Glossary

AGM	Annual General Meeting
AI	Artificial Intelligence
ARPANET	Advanced Research Projects Agency Network
CAD	Computer-aided Design
DIY	Do-it-yourself
FLOSS	Free/Libre and Open-Source Software
FOSS	Free and Open-Source Software
GNU	Gnu's Not Unix
GPL	GNU Public License
ICT	Information and Communications Technology
LED	Light Emitting Diode
MDF	Medium-Density Fibreboard
MIT	Massachusetts Institute of Technology
NK	Need-Know
NSF	National Science Foundation
PC	Personal Computer
PPE	Personal Protection Equipment
R&D	Research and Development
RFID	Radio-frequency Identification
STL	Stereolithography; also, a file type for CAD software
TOM	Tikkun Olum Makers
Torx	A type of screw head
USB	Universal Serial Bus
WEIRD	White, Educated, Industrial, Rich, Democratic

Epigraph

“... the street finds its own use for things.”

William Gibson, *Burning Chrome*, July 1982

Chapter 1: Introduction

Since the turn of the millennium, makerspaces have grown in popularity as a shared communal space that fulfills the role of workshop, clubhouse, and meeting area. Popular in North America – spreading out from both California and New England – and Europe, with major centers in Germany, Spain, and the Netherlands, these spaces have spread so that many urban areas may host multiple spaces. What the members get up to at these locations is pretty much anything they wish – building do-it-yourself (DIY) projects, learning and using new or expensive tools, and creating fashion or new wired technologies. But the essential elements of the makerspace are its creativity and innovation, birthing new products and ways of doing things.

What the makerspace represents as a site is an area to study this creativity and innovation, as each space operates somewhat differently and independently, with its own people, tools, rules, and systems in place that make it unique as a community unto itself, and position it in the larger maker community. These makerspaces are instantiations of micro-systems of innovation, and the variances between them allow for a comparative analysis of the processes of innovation to be looked at *in situ*, though perhaps not in a controlled laboratory setting. By tracing the connections, flows of ideas, and knowledge transfer – the communication – at the makerspace, then the innovation systems will be revealed.

Communication in the innovation process occurs along specific pathways and processes. As the makerspace represents a communal resource, with multiple persons possibly being involved or providing input during the life-cycle of a project, and any such work is by its nature collaborative, focusing the research question is necessary. It may be more readily available to follow the communication by identifying unique subjective elements in the innovation process, whether it is in design, development, or invention. Cultural artifacts and processes draw from a

wide range of influences. Previous studies of innovation have likened these influences to aesthetics (Stoneman, 2008, 2010), design (Bucciarelli, 1984, 1988; Utterback, 2006), and the creative industries (Caves, 2000; Potts, 2009; Potts & Cunningham, 2008). Other cultural elements may also impact innovation processes, and these can include media (Peters, 2015), communication, and more. To encapsulate the full range of influences that might be included under this broad category, we will classify all of the above as “subjective elements.”

The research question asks: how do subjective elements influence knowledge transfer that occurs in communication networks present during the innovation of a new technology at a makerspace? Several other questions follow from that due to gaps in the relevant innovation literature: 1) how are the ideas and inspirations for the development of a new technology transferred between developers and their collaborators, 2) what sources of inspiration and new knowledge do the developers use for both the subjective and functional components of their design, and finally 3) what is the role of the makerspace as a third place – neither home nor work (Putnam, 2001) – where developers can collaborate during the development process?

1.1 Relevance

The research has the potential to provide relevant contributions in a number of areas: it addresses gaps that exist in both the innovation and socio-technical literature, and provides a further case for the role of subjective elements in the processes of innovation. Much of the innovation literature recognizes that these subjective elements have an influence on innovation (Andari, 2007; Cunningham, 2011; Eltham, 2013; Oakley, 2009; OECD, 2005; Stoneman, 2010); their collective call is for an examination of the process. “The relationship between ‘hard’ and ‘soft’ innovation needs to be articulated better” (Cunningham, 2011, p. 244), and that relationship is also one of the things this work seeks to address. The problem of the influence of

subjective elements outlined in the research question is alluded to in much of the literature, but lacks a definitive answer. Given that there is a common recognition of the need for research in this area, there is the potential to provide a significant contribution to the innovation literature through this current research project. The socio-technical literature does not have the same specific call for research into subjective elements; it is merely the absence of these factors within the literature that suggests this research may be a worthwhile contribution. In addition, due to the makerspace being a relatively recent phenomenon the relevant literature is small but growing, and there is an opportunity to discuss their role as a site of influence and a local informal knowledge network, and to contribute significantly to studies in this area.

By investigating the makerspaces as sites of innovation, we can look at three instantiations of different ways of conceptualizing a “system of innovation.” What occurs at the makerspaces is different than innovation being driven due to pragmatic elements, as seen in both institutional R&D and Swann’s “common innovation” (Swann, 2015). The process of innovation is more *transparent* here because of what these spaces are. Metaphorically speaking, makerspaces are like the operation of three different beehives, all engaged in innovation, but with different ways of making the honey. Whereas common innovation (Swann, 2015) and open innovation (Chesbrough, 2003) both function as a *hypothesis* about how innovation takes place, what studying the innovation process at makerspaces can afford is evidence of how innovation actually occurs. What makers are doing exemplifies innovation at a microscale, and exemplifies innovation as a whole, providing a fractal glimpse of the totality of the process.

1.2 Context

The investigation into innovation at makerspaces was conducted in Calgary, Alberta Canada. Calgary has a number of features that make it stand out as a locus of innovation:

tradespersons and engineers, universities, and an artistic community. The presence of three dynamic and lively makerspaces and their integration into the local arts and technology scenes are indicators of the potential innovation that occurs here. There are several festivals that are dedicated to the arts and science, and the oil and gas sector that is seen as central to Calgary's economy provides for an abundance of work in engineering and the trades. The combination of these two features – the trades and the art scene – together allows for a critical threshold of individuals involved in “making” as part of their livelihood, and this has external effects.

The municipality of Calgary is home to approximately 1.3 million people, and the driving industry is the oil and gas sector. Much of the work that goes into the extraction efforts at the Alberta Tar Sands in the North of the province is based here, and a number of affiliated businesses, like finance, logistics, and oil and gas-specific engineering and manufacturing is based out of the city as well. There is also a thriving industry in woodworking and cabinetry, with office equipment manufactured locally. It is these elements of light industry that are essential to making as a pursuit; the knowledge base and skills are present in Calgary. The economic downturn that followed the decline in oil prices hit the industry heavily in 2014, and a number of the negative effects have persisted (CBC News, 2016). One of those is that trained individuals may no longer have work access to the tools of light industry, and so will look to other solutions for their problems. The makerspaces fill one such needs gap, and there is opportunity in the Calgary technology sector for employment for those with these skills, creating an incentive to gain them (Zubairi, 2018).

The arts scene in Calgary is also active, with several colleges providing training in the field, and festivals that celebrate art and science celebrated in the city. Chief of those is the annual Beakerhead festival, founded by Mary Anne Moser, which is now in its sixth year. It

features art installations and exhibits spread throughout the downtown core, with an emphasis on discovery, novelty, and aesthetics. Similarly, the MakeFashion event has featured wearable technology fashions on the runway, displaying elements of *haute couture* since its inception in 2012 by Shannon Hoover. In 2018, these two events combined and ran concurrently, further linking the arts and maker communities in Calgary. The maker community in Calgary does not exist in isolation. While the particular geography of the Canadian prairies can be a challenge when it comes to distance, other makerspaces do exist in nearby areas, as seen in Figure 1.



Figure 1: Southern Alberta Makerspace locations (“Hackerspaces.org,” n.d.)

1.3 Audience & Significance

There are multiple audiences for this work. For research in innovation, this dissertation can speak to the necessity of looking at subjective elements as either a driver or key component of the innovation process, and comment on the “invisible literature” of heterodox theories within

this field that studies how people actually interact. This work can also investigate the processes of innovation present *in situ* at the makerspace, and can be used to uncover and investigate any archetypes of innovation that may be present at the sites. For work in the field of communication, this work may provide insight as to the role of communication within small communities of technology developers, and the extent that communication is critical in a 21st century third place that exists outside of home and work, like a makerspace. In addition, the project will be one of the first academic explorations on Canadian makerspaces, and one that focuses on a critical study of the makerspace as both conceptualized and actualized.

1.4 Theoretical Overview

With the goal of using the empirical work to address shortcomings in existing first-order theories of innovation and communication and to provide useful information about the knowledge dynamics occurring during this development process, it is important to state that not all theories of innovation are directly related to the problem at hand. The key issue as identified in the research question is one of influence and engagement. The gaps in the literature in innovation do not directly address this question of engagement, and while this provides a great opportunity to contribute to the field, it does so at the expense of making the theoretical approach more complex than necessary. Because there is a need to draw on multiple fields of research, there are concerns that must be addressed when connecting them together.

One of the issues with this research is the lack of information on subjectivity that exists within the socio-technical and innovation literature: there is little mention of the role of subjective elements such as the arts and aesthetics on the innovation process. There is an econometric bias to much of the work in the innovation field, and this can cause problems with

analysis – the analytic work is competent, but very tightly bound to the research focus and normative approaches prevalent in the field, using metrics like R&D spend and sales figures as proxies for innovative activity. Research on innovation has followed these proposed approaches as laid out in the Frascati and Oslo manuals (OECD, 2002, 2005), but these can be completely oblivious to data that does not fit within the prescribed framework.

Despite these issues with the innovation and socio-technical theories, each field has strengths that can be brought to the project. A brief summary of how they are expected to connect together follows. The innovation literature, specifically from the OECD research manuals (OECD, 2002, 2005), provides a solid, positivist foundation against which the other theories can build. While the econometric bias of the framework may not be appropriate or sufficient to address 'How' questions like this research is asking, it does allow for all sources of information to be treated evenly: when conducting a quantitative analysis, like should be compared with like. However, this econometric work is not the key focus of the research; it is only a foundation. The work on innovation connects directly with the communication field through two points of contact. One is the work on diffusion done by Rogers (1983), the other is the work on lead users and the locus of innovation by Von Hippel (von Hippel, 1994, 2005). Von Hippel's concept of “sticky” information parallels the foundational work in communication studies conducted by Innis on the bias of time and space (Innis, 1999). The locus of innovation connects with place and the public sphere through to other social imaginaries like recursive publics (Kelty, 2005). The concept of the lead-user (von Hippel, 1988) links the various theories through to the work of the developers and designers, such as the work of Norman (1990) on affordances, and the interest in design-inspired innovation (Utterback, 2006). Finally, this work brings the research back full circle to the field of technology and innovation. The multiple

connections reinforce the support of the whole structure. Each of the theories have weaknesses, but the mutual reinforcement and support of the theories should allow for these issues to be addressed or mitigated.

1.5 Methods and Approach

This project is an ethnographic study that observes technology developers (“makers”) at the site(s) of their work (“makerspaces”) during the period leading to the exhibition of their projects at public events and immediately after. The goal is to observe their communication over time, and to trace the influence of subjective elements through the knowledge transfer process that these developers use. Several makerspaces and events in the Calgary area serve as research sites for the project, and are detailed in three case studies. Each of the cases will focus on one makerspace, and the events most closely associated with that space. These makerspaces include Protospace, the Tikkun Olam Makers (TOM) (and their annual Makeathon), and Archeloft and Fuse33 (a makerspace that closed, moved, and reopened under a new label). These locations were observed on multiple occasions during a two-year period from 2016 to 2018.

1.6 Outline

The remainder of the dissertation proceeds from the Research Questions. Part 1 focusses on the foundational literatures of both makerspaces and innovation, as well as the methodology to be employed in their investigation during this project. Chapter 2 will focus on Makerspaces, defining what they are, and how they came about. A key part of this is the identity of makers, individually and as a group, and the modern maker movement as a whole, with its foundations in

European and American hacker culture. This chapter will also detail some of their key influences in media, and how these have influenced the development of the maker subculture.

Chapter 3 is focused on Innovation, with an overview of the framing of various phases of innovation theory, and the schools of thought that have arisen. Beginning with the Schumpeterian framework of entrepreneurialism and creative destruction, the chapter proceeds through an era of Neo-Schumpeterian theories, before arriving at the new schools of innovation thinking of the current era. Categorizing the theories by the process, source, or context of innovation is also conducted.

Chapter 4 is focused on method, and how previous research has been conducted in makerspaces. Ethnographic fieldwork and case studies on makerspaces already exist and this chapter will draw on those previous studies to inform this research. Data collection is done via participant observation and interviews, and this will inform the three cases that make up the core of this research project. This chapter will describe the analytical framework and how identifying the archetypes of innovation present will aid in understanding the processes at a makerspace.

Part 2 of the dissertation follows, detailing the three case studies that make up the observation and interview data gleaned during the research process, with each case comprising a single chapter, from 5 to 7. The cases include: Protospace, a “traditional” makerspace operating as a non-profit; Tikkun Olam Makers (TOM), an event-driven volunteer organization that pairs makers with persons with disabilities; and the Archeloft/Fuse33 (A/F33) makerspaces, which focus on “soft” projects, including fabrics, textiles, and wearable technology, and are heavily involved in the MakeFashion events. Each case study will detail the space, the individuals, the events, and processes involved in the space.

Part 3 of the dissertation follows, including the Discussion, Findings, and Conclusion.

Chapter 8 contains the discussion of the various archetypes of innovation found in the narratives of the makerspace case studies. These four categories of archetypes – the people, roles, governance systems, and artifacts – are described for each case, and then comparatively in order to describe an overall picture of innovation in Calgary area makerspaces.

Chapter 9 directly compares the archetypes at makerspaces to the existing schools of thought on innovation, confirming or disconfirming what these schools of thought say. This represents the findings of the study. The research questions are also addressed with respect to innovation theory. Three new archetypes of innovation found at the sites are identified. In addition, the findings speak to the literature review on makerspaces, and identifies the need for a critical maker studies and what that may entail.

Chapter 10 concludes the dissertation, by addressing the research question(s) and the key contributions of the study to the innovation and makerspace literatures, as well as overall comments on the study, its viability, and the opportunities for future research.

Section I: Review of Literature

This section focuses on the literature that exists as a foundation for the subject. As the topics of both makerspaces and innovation are broad and intersectional, this can cross a wide variety of fields, including those with subjective elements like art and aesthetics, design, software development, manufacturing, anthropology, sociology, economics, and more. The makerspace literature will highlight the current writing, as well as provide a history and underlying ethos of the movement itself. The innovation literature will provide an overview of the field, drawing on both foundational works and current theories as they are presently framed. In addition, the methodology to be employed in the investigation of makerspaces will be outlined, consisting of the ethnographic fieldwork and the analytical focus on the archetypes of innovation.

Chapter 2: Makerspaces

Makerspaces are a 21st century phenomenon that has older roots – a combination of the shared machine shops of the 1970s and the various forms of hackerspaces that allowed for access to the internet in the early days of its growth in the early 1990s. These hi-tech communal workshops have been lauded for their potential to contribute to the economy (Anderson, 2012), integrate into the global supply chain (Fallows, 2012), lift people out of poverty (Fallows, 2016), spur creativity and innovation (Parks, 2005), and to rebuild local economies (Tierney, 2015a) – to drive innovation, productivity, and growth – but to-date the data is not yet present to support these claims. Academic work has concentrated on describing the phenomenon and speculating on the potential, and is only recently beginning to look at it from a critical perspective. This published work has come from a variety of fields, which include educational, design, and sociotechnical approaches. Within the research there is still a need to focus on the processes and identify the key challenges that makerspaces face and represent. This chapter seeks to provide an overview of these challenges, outlining key areas of current research for those working on makerspaces. While the academic literature is rapidly increasing in quantity, there is still the need for a survey of the field, so this chapter will provide an overview of the makerspace literature, key concepts, development history and politics, communications and culture, schools of thought, and the challenge that making represents.

2.1 Makerspaces

The makerspace is a relatively new phenomenon—a transformation of the workshop of the traditional artisan and craftsman, an update of those places embedded in the basements and garages particular to Western suburbia—that combines both traditional tools and practices with the high-tech tools of the 21st century, hosting a stunning array of computer-controlled devices

such as laser cutters, 3D printers, and electronics and robotics workbenches (Lang, 2013). By taking this ramped-up workshop and making it public, makerspaces have created a shared space for learning and understanding, a site of collaboration and community, a third place (Putnam, 2001) – situated between ‘home’ and ‘work’ – that is dedicated to the pursuit of ‘making’ (and innovation). The members and participants self-identify as ‘makers’ to some degree and are free to pursue projects that satisfy their wants, solve their problems, or meet their needs. This is done under a model of sharing and collaboration, drawing on lessons from the beliefs and practices of the Free-and-Open-Source Software (FOSS) movement, and applying them to the world of ‘stuff’. This digital materiality, and its ongoing emergence at makerspaces and elsewhere in the 21st century can potentially have broad impacts on society. Recognizing the early stages of makerspace development occurring here and now will be relevant to later research on the topic.

Makerspaces allow room for building, hacking, combining, creating, making, and they also allow for the combination and recombination of techniques both new and old, and in so doing exist as a site for the development of innovations as recombination is a crucial element of the innovation process (Hawkins, 2012; Swann, 2015). Recent trends in the study of innovation suggest that novel approaches may be a key factor in the processes and sources of innovation, whether it is taking place in firms (Chesbrough, 2003), collaborative networks (Gloor, Paasivaara, Schoder, & Willems, 2007), or in the creative industries (Potts, 2009).

The makerspace is at its core a shared workshop and communal space. The makerspace is an instance of “commons-based peer production¹” (Troxler, 2010), or to use an earlier term, a

¹ Peer production is defined as the creation of goods through mass collaboration (Benkler, 2003).

“shared machine shop” (Hess, 1979). A place outside of home and work² where members can work on projects, chat with others of a similar inclination, and be exposed to new ideas and technologies. The makerspace may encompass a vast array of possible technologies; not all makers will be into everything (if that were even possible), but many members will have a passing familiarity with quite a few of the tools, techniques, and media that are present at a makerspace. Makerspaces are generally focused on a core set of technologies that includes electronics, microcontrollers, wood working, metal working, machining, computer programming, 3D printing, laser cutting, and other related DIY pursuits (robotics, drones, biohacking, wearable electronics, etc.). Some related fields include costuming, cosplay, fan culture, crafts, and others (Lang, 2013; Parks, 2005). These core technologies can be roughly grouped according to an underlying era of technological development from which it was drawn (as seen in Table 1, below).

Traditional	Industrial	Technological
Blacksmithing	Machining	Electronics
Weaving	Milling	Microcontrollers
Woodwork (traditional)	Welding	Programming
Leatherworking	Wood Working	Raspberry Pi
Sewing	Metal Working	Robotics
Metal casting		3D printing
		Laser cutting

Table 1: Core Makerspace Technologies

² This matches the conceptual definition of a “third place” (Putnam, 2001).

Makerspaces exist in a wide variety of places, in artists' lofts and industrial bays, public libraries and converted schools, dilapidated squats and research universities. Despite this variety, there are common characteristics across these locations. Makerspaces also maintain themselves via a wide array of funding and organizational models: as collectives, for-profit or not-for-profit organizations, government-funded or group-organized groups, and many others (?).

The term makerspaces is itself contested and changing: makerspaces are the latest iteration of this term (Han, Yoo, Zo, & Ciganek, 2017; van Holm, 2017), partly derived from O'Reilly Publishing and the Maker Foundation, partly drawing cues from other authors (i.e. Anderson, 2012), and partly as a means of distinction, as a means of distancing from the pejorative "hacker." Common terms for this kind of space includes FabLab (Gershenfeld, 2005), Hackerspace (Troxler, 2010), and Hacklab (Maxigas, 2012). FabLab, one of the earlier forms of the makerspace, was developed by Neil Gershenfeld and his group at MIT's Center for Bits and Atoms in 1998 and then exported to a number of other locations worldwide (Gershenfeld, 2005; Walter-Herrmann & Büching, 2013). Unique elements of the FabLab include the focus on machine tools and the funding model. Hackerspaces are the collectives that grew out of computer and electronics labs, mostly in Europe (Maxigas, 2012). They offered services similar to an internet café, without the more restrictive nature of these commercial spaces. HackLabs were also European, but these grew up in a different political environment, often in squats or other collectives, allowing access to computing (and the internet) resources, back when this was not common (in Europe in the 1990s). The cultural form of the early Hacklab was more akin to 'anarchic internet cafes' (Maxigas, 2012).

Makerspaces can also vary in political, ideological, and financial dimensions. Of these, the financial dimension is most significant, as funding is key and most hackerspaces need some form of revenue stream to stay operational. Funding can include membership fees, grants, donations, etc. (Mortara & Parisot, 2016). Just as there are many funding models, there are as many different political and ideological models that [go into] makerspaces. From libertarian, capitalist, and anarchic models (Maxigas, 2012) through to more liberal and communitarian ones (Cavalcanti, 2013), there is a home for most viewpoints.

The shared social elements uniting a makerspace are often ideological, based on a manifesto or founding document (Hatch, 2013). These commonalities can be seen in earlier anthropological research on a makerspace ancestor: the hackerspace, where a survey of various hacker groups provided six³ criteria “for what being a hackerspace means” (Moilanen, 2012a):

1. “it is owned and run by its members in a spirit of equality”
2. “it is not for profit and open to the outside world on a (semi)regular basis”
3. “people there share tools, equipment and ideas without discrimination”
4. “it has a strong emphasis on technology and invention”
5. “it has a shared space (or is in the process of acquiring a space) as a center of the community”
6. “it has a strong spirit of invention and science, based on trial, error, and freely sharing information”

Within these criteria, some of the tenets of the maker movement come to light. It is also apparent that based on the above criteria, some private and private-collective spaces may not

³ Moilanen states five, but adds a sixth characteristic in the text.

qualify as a hackerspace, despite self-identifying as such. Still, the focus on openness, equality, discovery, invention, sharing and community are laudable. The events that led to the development of this particular ethos will be covered in the Maker History section below.

There has been a semantic shift that has occurred in the literature on the movement, moving from “hacker” to “maker.” The reasons why this has occurred are complex, and tied directly to the idea of maker as an identity. Aside from the semantic difference in using “maker” (shifting the position from destruction to creation, from meddler to builder), the change in language has also helped the group distance themselves from the media-maligned “hacker,” which often is used with a pejorative undertone. The focus of earlier work on “hacking” (Levy, 1984; Thomas, 2003) was on a different group of individuals, even though there is still some overlap in identification and membership in common between the two (Maxigas, 2012).

2.1.1 Makers

The key component of makerspaces are the makers themselves. The spaces thrive on the activities and the projects of the participants, and no amount of funding or array of cutting-edge tools can make up for the lack of community if the members are not there. They may self-identify under a number of different categories or labels, but “makers” seems most broadly applicable (despite its corporate underpinnings), and is the one referred to here.

The makers may be involved at many levels: as craftsmen, as community organizers and opinion leaders, and as merchants of their creations, both to the community and to the world at large (van Holm, 2017). At every level, makers act as entrepreneurs (Anderson, 2012; Gershenfeld, 2005; Hatch, 2013; Parks, 2005).

Traditionally, makers have skewed to a demographic that has considerable overlap with the early IT culture in the United States, though as the movement has spread and

internationalized, this is changing. Makers tended to a particular set of demographic characteristics typical of North American suburbia: affluent, middle class, with enough disposable income and leisure time to pursue DIY projects and making things as a hobby. This group has significant overlap with the WEIRD (White, Educated, Industrial, Rich, and Democratic) population demographic (Henrich, Heine, & Norenzayan, 2010).

2.2.1 Maker History, Politics, & Ideology

While the modern maker movement began in 2005 with the publication of Dan Dougherty's column in the initial issue of *Make* magazine (McCracken, 2015), the antecedents go back much further (Han et al., 2017). The two earliest strands are those of the shared machine shop and DIY (Do-It-Yourself) movement (Hess, 1979; Noble, 1984; Sennett, 2008; Smith, 2014), and that of the FOSS (Free & Open Source Software) movement, which began in the 1970s, but gained momentum in the 1990s and early 2000s with the release of the Linux operating system (Moilanen, 2012a; Raymond, 1999; von Hippel & von Krogh, 2003). These twin developments of shared workshops in Europe and of shared source-code for programming were brought together in the computing and electronics-heavy environment of the early makerspaces.

The shared machine shops were developed in London from 1983-86 in order to allow laborers to share the means of production (Smith, 2014). These were created from a radical response to capitalism and unemployment, and their ideology was deeply political. Of course, while DIY culture and crafting practices stretch back millennia (Crawford, 2010, 2016; Sennett, 2008), the modern development and re-development of the practice takes place in a particularly narrow stretch of recorded history, within the economic conditions and confines of capitalist

economies in late modernity. This may represent a particular structural bias in the community, with the assumptions and biases of the WEIRD demographic (Henrich et al., 2010) driving the discourse. For much of the world, the particular practices of making and makerspaces are simply “necessity” (Ames et al., 2018).

The Free and Open-Source Software (FOSS) movement brought a similar DIY ethos to the world of computing. While hobbyist computing has long been around, and had been a part of the inception of many of the current larger tech companies, early personal computing often required a working knowledge of the innards of the computer, following the device paradigm of technical objects (Borgmann, 1984). Coupled with this was the development of the programs to use the computers more efficiently (Raymond, 1999). This development work drew the interest of individuals and groups from a spectrum of disciplines, and the work formed connections between them.

Raymond goes on to describe those connections: “the origins of hacker culture, including pre-history among the Real Programmers, the glory days of the MIT AI Lab, and how the early ARPANET nurtured the first network nation,” are tightly linked to the FOSS movement (Raymond, 1999). Following these initial steps, the development of Linux (a clone of the Unix Operating System developed for PC hardware) by Linus Torvalds, and his subsequent release of the code for free on the internet under the GPL (GNU Public License) which allowed for free redistribution and modification of the software as long as the original source code and attributions were included with the files (Himanen, Torvalds, & Castells, 2001) put a powerful suite of programs in the hands of the skilled amateurs and hobbyists, and removed the programs from the tightly controlled mainframe architecture. The concurrent rise of the internet led to a rapid diffusion of both the software, the code, and the underlying hacker ethos of the movement.

The particular practices that make the FOSS community innovative has been examined elsewhere (Graham & Mowery, 2006; Haddon, 2002; Kelty, 2005; Moilanen, 2012a; Troxler, 2010; von Hippel & von Krogh, 2003), but these practices cross over directly into the development of the maker communities as well.

When looking at hackerspaces specifically, there are three recognizable development waves that cross paths with the maker movement at various point (Moilanen, 2012a, pp. 94–95):

1. early 1990s—hackers built meeting spaces in (?) San Francisco and Boston
2. late 1990s—European, Germany and Austria, with openness about the work taking place
3. early 21st c.—Global reach, dovetailing with the maker movement (but not exclusive to that)

These waves fit within a genealogy of various movements of hackerdom. Moilanen (2012a, p. 108) updates a chart⁴ that shows the various generations of Hackers⁵. These comprise: “True Hackers” (1952); Phone-phreakers (1960–2006); Hardware hackers (1970); Game hackers (1980); Microserfs (1982); Open source (1991); and Peer Production (2001). These various generations all still exist to a certain degree, overlapping and occasionally intersecting, with the experiences of one group informing that of the others. The only generation that has 'ended' is the Phreakers, as the last “phreakable” carrier shut down in 2006. The newest generation, commons-based peer production focused on “individuals collaborating in producing cultural content, knowledge, and other information and indeed physical goods” (Troxler, 2010, p. 2), and is the one most directly connected with the current maker movement.

⁴ Drawing on Taylor (2005), who in turn based his work on Levy (1984/2010).

⁵ Approximate start dates included in parentheses.

As the makerspaces were being formed, they drew together these elements of crafting and computing. Re-integrating the kitbashing and kludging of the Model Railroad clubs that formed the basis for the early computing societies (Raymond, 1999), the makers began creating the elements that they needed for themselves. Escalating software requirements begat increasing hardware requirements, and these went hand-in-hand with the skills to make them. Modified computer cases, and custom cooling solutions for PCs went hand-in-hand with creating and modifying one's home to match retrofit and accommodate the digital requirements of a wired future. The ability to digitize everything, through RFID tags, microcontrollers, and power efficient LEDs made any material object a potential artifact for making. The DIY ethos of FOSS spilled back into the physical space of the real. This happened organically, evolutionarily, as like found like within the nineties and oughts, and a new movement was born of these joined streams.

As the crafting streams and FOSS streams came together, there was a parallel thread of institutional development of makerspaces as well. Chief among these is the pioneering work done by Neil Gershenfeld of MIT, as detailed in his book *Fab* (2005). Gershenfeld is the director of MIT's Center for Bits and Atoms, and in the late 1990s and early 2000s was working on developing what would become the FabLabs, a blueprint of a makerspace that could be distributed to various locales in order to bootstrap innovation. This work, as one of the forerunners described it, was something that was actually new, and serves as an important chronicle of that development: "More than mere consumers of technology, we are makers, adapting technology to our needs and integrating it into our lives. Some of us are born makers and others, like me, become makers almost without realizing it" (Dougherty, 2005).

What the makers do, when they get together, is start changing the world around them. The makerspaces are a site of a recursive public (Kelty, 2005), constantly reshaping their space

based on the rules of the collective. However, where Kelty was discussing the ability of online publics to change their digital habitat, makerspaces are physical sites, bound to the material realm. The makers may enact some of the same beliefs and practices of their digital counterparts, but there are some constraints they face. While there are valid reasons to assume some continuity in the makerspace – the physical nature of the building being most prominent – the possibility for change is always present. The maker movement has strong ties to the FOSS movement and the advent of peer-production as a form of technological development that coincided with it. However, while there is current work on peer production (Benkler, 2006; Booth, 2010; Moilanen, 2012a; Troxler, 2010), according to Moilanen, however: “the description of the peer-production movement as a hacker generation needs more research and thought.” (2012a, p. 109). Overall more analytic work on peer production is required.

Members of the maker movement will frame their work in terms of rights (Frauenfelder, 2007), or occasionally *protocols* (Busch, 2012). Observe “The Maker’s Bill of Rights,” from O’Reilly Publishing’s *The Best of Make*TM:

“Meaningful and specific parts lists shall be included. Cases shall be easy to open. Batteries shall be replaceable. Special tools are allowed only for darn good reasons. Profiting by selling expensive special tools is wrong and not making special tools available is even worse. Torx is OK; tamperproof is rarely OK. Components, not entire sub-assemblies, shall be replaceable. Consumables, like fuses and filters, shall be easy to access. Circuit boards shall be commented. Power from USB is good; power from proprietary power adapters is bad. Standard connectors shall have pin-outs defined. If it snaps shut, it shall snap open. Screws better than glues. Docs and drivers shall have permalinks and shall reside for all perpetuity at archive.org. Ease of repair shall be a

design ideal, not an afterthought. Metric or standard, not both. Schematics shall be included.” (Frauenfelder, 2007).

However, this Bill of Rights is very prescriptive; a list of do’s and don’ts that are meant as a guide and a set of best practices to allow for interoperability, adopting the practices of the FOSS movement and translating it into analogous terms for the material culture of the space. The Bill of Rights is also a reminder of two things: a) that the particular style of one space may not be for everybody, and they may look elsewhere when that’s the case, and b) there are multiple different models and revenue streams involved under the umbrella of “makerspaces”. The particular tools, techniques and processes that are mentioned in the above list are indicative of the spaces that are common to the author, and not necessarily representative across makerspaces. It is very focused on personal computing and electronics hacking, and these may not be as prevalent, or engaged with at all, in the context of other makerspaces.

The political is deeply embedded in hacker culture, the historical antecedent to maker culture. The early hacker culture was littered with both arrests, as detailed by Levy (1984), Sterling (1993), and Thomas (2003), and seen in various published manifestos. Chief of these is the relatively brief ‘Conscience of a Hacker’ (AKA “The Hacker Manifesto”) written by ‘The Mentor’, Loyd Blankenship (1986). Blankenship outlines the underlying ideology of hacking, as a right obtained via technocratic mastery of the system. The key portion of the text is as follows:

“This is our world now... the world of the electron and the switch, the beauty of the baud. We make use of a service already existing without paying for what could be dirt-cheap if it wasn't run by profiteering gluttons, and you call us criminals. We explore... and you call us criminals. We seek after knowledge... and you call us criminals. We exist without skin color, without nationality, without religious bias... and you call us criminals.

You build atomic bombs, you wage wars, you murder, cheat, and lie to us and try to make us believe it's for our own good, yet we're the criminals.

Yes, I am a criminal. My crime is that of curiosity. My crime is that of judging people by what they say and think, not what they look like. My crime is that of outsmarting you, something that you will never forgive me for.

I am a hacker, and this is my manifesto. You may stop this individual, but you can't stop us all... after all, we're all alike.” (Blankenship, 1986)

This compares with other recent digital manifestos: *Program or be Programmed* (Rushkoff, 2011), and *A Hacker Manifesto* (Wark, 2004), both of which are less hostile and confrontational. These newer manifestos are explicitly political and aimed at emancipation and highlighting the injustices of modernity under late capitalism. The final manifesto in this modern triumvirate is *The Hacker Ethic* (Himanen et al., 2001), outlining how the software hackers involved in the FOSS movement were dealing with the material realities of software in the 1990s.

Maker culture seems less virulent than its forebearer from the 1980's, less oppositional and in your face, and more willing to go along and work within the confines of the system (it has been constrained by the neoliberal ideologies that dominate production culture). Gone are some of the countercultural elements, the 'punk' in cyberpunk, though they exist in the aesthetics that are still evinced by the population. But the number of arrests are way down (Sterling, 1993).

However, activism is still alive and well and the political element has not left the movement. In November 2017, the FabLab in Grenoble France was the target of an arson attack by anarchists, who anonymously claimed credit for burning the site in order to fight against their political “nuisance” (la redaction, 2017-11-28) (Braybrooke & Smith, 2018).

2.3 Maker Communications & Culture

Building a community or a movement does not happen *sui generis*; modern movements will require the leveraging of modern communications media, and the maker movement is no different. The movements close ties with new media sees rapid and early adoption of these elements, with YouTube Channels, Twitch streams, and the various social media all deployed by makers for promotion and learning. And despite this close tie to the new, traditional media can be just as influential, with book and magazine sales also contributing significantly to the development of maker culture. For the culture of makerspaces itself, the identity as a maker, as well as the branding of makers, makerspaces, and their tools are key contributors. And finally, the events, competitions, and exhibitions of works provide both a key outlet for display, but also an impetus for the creation and completion of projects by the makers as well. These elements – new media, old media, culture, brand, and events and competitions – will all be discussed in turn.

2.3.1 New Media

One of the principal avenues of cultural connection for the maker community is through the new media – basically any digitally-connected or computer-mediated communication (Flew & Smith, 2018). While the new media are currently in the process of absorbing and engulfing the old media (see below), they are still distinct enough that a difference can be made. The use of internet chat forums, websites, YouTube and other video channels, podcasts, and various other social media have been one of the key drivers of maker culture (Anderson, 2012). Maker culture has also been at the forefront of the adoption of the online delivery platforms with the creation of websites for plans and digital files (Shapeways, Thingiverse, etc.) as well eBooks and other digital objects (Humble Bundle), in addition to crowdfunding platforms (Kickstarter, Indiegogo,

Patreon) and digital storefronts (Etsy, eBay, others) being incorporated as part of the revenue stream for a makerspace, or the related crafters and artisans.

The new media was birthed alongside the cultural progenitors of the makerspaces themselves. The HackLabs, hackerspaces, and internet cafes that allowed for the development and access for a new generation of internet users in the 1990s (Maxigas, 2012) morphed into the makerspaces of the 21st century.

2.3.2 Old Media

Despite the focus on new media within makerspaces, traditional or “old” media also have a strong influence. Old media consists of those mass media formats that are not delivered through a computer (though this boundary is changing due to the recent shifts in digitizing everything). Old media would include print, radio, film, and television. While many of these are delivered digitally now, the basic format of the media remains. Of those listed, television and print have the largest sphere of influence (Flew & Smith, 2018).

Maker television media includes programming that is tied to DIY culture, largely found on American cable channels such as Discovery and TLC, as well as PBS and other syndicated content. Programs could include the various “garage” shows, such as Orange County Choppers, (and others) with their focus on metalwork, welding, and the associated skills for restoration of vehicles. Another cluster of maker-adjacent television programming is the various “workshop” shows, such as the venerable New Yankee Workshop (*New Yankee Workshop*, 1989), and its various imitators. To be clear, neither of these genres of programming are maker-specific, they merely cover much of the same tools and techniques, and as such serve as inspirational media figures for the maker culture. A third media program cluster is that of the various exploratory shows as typified by Discovery’s *Mythbusters* (*Mythbusters*, 2003), which ran for 10 years prior

to ending in 2016. Programs of this type focused on building experiments and testing them in a scientific fashion. The overall process of their “build” process for their experiments mirrored much of what can be found at a makerspace on an average weekend. Finally, there are a number of craft-focused reality programs, where the participants compete in building items each week, and again, these are maker-adjacent in their content. The very mass market nature of old media means it can have an outsize influence on the values and identity of a niche culture as a whole, becoming a common cultural touchstone that members can identify with.

2.3.3 Maker Identity: Culture & Brand

One of the key elements of the makers is the constellation of socio-cultural factors that make up the larger identifiable maker “identity.” This has largely been underexplored to date, though elements of it are obvious, and it extends past the political and ideological elements outlined earlier, while embedding these elements throughout. Within the late-modern media landscape, this culture persists throughout both old and new media, with a particular focus on those delivered digitally: YouTube, webpages, social networking, and the like. And deeply connected to the culture at the core of the maker identity is that of the maker as a *brand*. This particular element of late capitalism has a unique influence on the maker culture as a whole. Each of these elements will be touched on in turn.

2.3.4 Events and Competitions

Maker culture is also driven by various events and competitions. The Maker Foundation’s MakerFaires and MiniMakerFaires provide regular annual events. Short term, focused challenges, including various local and global Hackathons and Makeathons (such as the Global Game Jam and the Tikkun Olam Makers, respectively) work towards developing solutions for those that are not served by the market. An example is the First Robotics

Competition, founded by inventor and serial entrepreneur Dean Kamen, with participants competing worldwide. The unifying factor about these events and competitions is that they bring together the maker community, often drawing in participants from a wide geographical area or from widely disparate demographic groups that are not traditionally serviced by the normal maker demographic.

2.3.5 Brand

Making now exists as both a culture and a brand, both having formed out of the identity of the early participants. As mentioned above, this identity was the initial form; it has changed and grown since the recent increase in visibility and scope of the maker market. That a cultural and subcultural component should arise seems obvious, that from an identity these would then be co-opted as a brand and sold back to new participants also seems an obvious consequence in late-capitalism, but one would imagine the co-evolution of countercultural elements and technical proficiency would limit the ability of the identity to be commodified. But the prestige of belonging to the group – the cultural or social capital – coupled with a change in tech requirements (the rationalization and commodification of the tech for ease of use) has grown the available pool of participants. This has been both a boon and a bane. (More positive than negative though). Among the positives: “Ease of use” allows makers to spend more time making and not struggling with basic material issues. Decreased cost has opened up the pool of available [or potential] projects, as many now become feasible with the entry of \$5 microcontrollers and ubiquitous Wi-Fi and Bluetooth connectivity, and more people entering the field generate a larger pool of ideas, with the drawback of increased the demand and pressure on available spaces as more entrepreneurs enter the area.

2.4 Maker Research: Schools of Thought

Current literature on makerspaces can be gathered into three main groups: the literature made by and for the makers themselves: the websites, print magazines, how-to books, and various internal documents that are so crucially important to a subculture (Hebdige, 1981); business literature: secondary sources that often tout the growth of field or marvel at its potential, bringing the maker phenomenon to a larger audience; and academic literature that investigates and promotes the movement from a variety of approaches, or schools of thought.

The maker-generated literature, either produced by or for the subculture, is focused on getting out and getting things done. Much of it is published by the Maker Foundation or the Make™ imprint of O'Reilly Publishing in the United States, though other publishers are also involved. The publishing covers the full gamut of topics and trends that one are likely to see within a makerspace (Aliverti & Maietta, 2015). Outside of the manuals, the how-to guides, and the project books, there exists a range of inspirational and populist works that serve to stoke the fires of the movement. Titles like *Makers: the New Industrial Revolution* (Anderson, 2012) and *The Maker Movement Manifesto* (Hatch, 2013) give a sense of the fervor of those behind the maker phenomenon.

By contrast, much of the writing in the mainstream business literature, focusses on the potential of makerspaces to jumpstart the “second industrial revolution” (Anderson, 2013; Brynjolfsson & McAfee, 2014; Edmondson, 2016), with particular attention paid to the new technologies that are available at the spaces like 3D printing (McCue, 2015; “Print me a phone,” 2012), as well as an economic focus on the value of these technologies to industry. A parallel trend in the news is about the development and location of makerspaces in public libraries (Waldman, 2014; Wang, Wang, Wilson, & Ahmed, 2016). Yet another trend is the development

and growth of makerspaces in developing countries, particularly China (Mozur, 2014; Tierney, 2015a), and what that trend of growth could mean for advanced economies as well.

The academic literature relating to makerspaces represents a broad range of disciplines, from engineering and computer science to anthropology, sociology, education, and library science. It is difficult to confirm if these varied approaches to the study of makerspaces constitute several *schools of thought*. Academic inquiry into the field is still in its nascent stages, and largely falls along disciplinary lines. While there is some boundary flexibility between these fields, makerspaces cross disciplinary lines by their very nature, blurring boundaries between fields of knowledge and mixing the results in novel ways. Current work on makerspaces exists in sociotechnical research and literature tied to innovation and economics. One common feature is the terminological confusion typical of a new field of inquiry. Though at the micro-level, differences exist between FabLabs, Hacklabs, Hackerspaces, and Makerspaces, at the macro-level all are instances of "makerspaces."

Academic work on makerspaces coming from the field of engineering and computer science stems from foundational work that details the development of early forms of the spaces. This can be seen in the early work on institutional spaces (Gershenfeld, 2005). Other material further chronicles the development of the FabLabs. (Troxler & Wolf, 2010; Walter-Herrmann & Büching, 2013).

Computing science literature also investigates makerspaces, appearing in a number of conference proceedings (Hui & Gerber, 2017; Moilanen, 2012b; Savage, 2013; Troxler & Wolf, 2010). Key elements focus on the linkages with Open Source software, and the entrepreneurial nature of the work that took place within the makerspaces.

The social sciences, too, are inquiring into makerspaces. A growing amount of sociotechnical literature in sociology and anthropology covers the field, and the Society for the Social Study of Science has devoted a number of panels to its coverage in recent years (Boeva & Chies, 2016). As makerspaces represent a site, and makers a subculture, there has been a fair degree of work done in the fields of the sociology of science (Han et al., 2017; Holman, 2015; Maxigas, 2012; Signal, n.d.). The growing volume of articles and panels in the sociotechnical literature suggest that the topic is on the cusp of coalescing around this field of inquiry.

Finally, within the economics and innovation literature some recent work has come to light, evaluating the makerspace with respect to its contribution to open innovation (Chesbrough, 2003). Work focused on makerspaces covers a broad range of theoretical approaches (Böhmer, Beckmann, & Lindemann, 2015; Capdevila, 2014; Fixson & Marion, 2014). Of key interest is how makerspaces may contribute to the local economy (van Holm, 2017). Research conducted in the state of Georgia using interviews with people at makerspaces in smaller CMAs discusses how lead users and “accidental entrepreneurs” (which exist in other economic literature), are formed via the inputs and processes of the makerspace. The list of inputs includes members, tools, and the workspace, the *hypothesized* outputs include new ideas, accidental entrepreneurs, (real) entrepreneurs, prototyping, and workforce training

As there have been few critical pieces of the maker movement as of yet (Rubenstein, Linder, & Taha, 2018; Tierney, 2015b), these potential opportunities and criticisms are merely suggestive, and focused on methodological issues within the makerspace.

Other opportunities present at makerspaces can be seen from an academic perspective. The makerspace represents a unique site to investigate current trends in innovation theory (Gloor et al., 2007) and entrepreneurship (Sousa, 2012; Sousa, Salavisa Lança, & Fontes, 2012). The

innovative practices of the makers and the related FOSS groups represent some of the ongoing challenges that have led to emergent theories of innovation, so the potential to study it firsthand is a great opportunity. There has been increased interest in makerspaces since the project began, with new events unfolding at an accelerated rate. In 2016, the joint conference between 4S and EASST brought together multiple academics, with 11 panels over 3 different streams discussing makerspaces and related issues during the length of the event (Boeva & Chies, 2016).

Finally, the results of the previous conference started seeing publication. Thirteen of the presenters from Barcelona published their work in August of 2018 in a dedicated issue of the *Journal of Peer Production*. Edited by Kat Braybrooke and Adrian Smith, the papers were brought together under the theme of “Institutional Encounters,” or institutionalism for short. The issue covered the gamut of empirical academic work on the subject, and expanded the range of peer-reviewed published work available. While the coverage was good, and comments directly on makerspaces as an institution, the articles’ focus was on the sociotechnical aspects, and not as directly connected to innovation. Despite all these recent efforts, the academic discourse has been lacking a critical voice. To date, there has been limited peer-reviewed work published *critical* of makerspaces, though that may be changing, both with entries in the Braybrooke and Smith issue and others that may be in press.

2.5 The Challenge of Making

Makerspaces are a new, late-modern approach that allows people to find innovative solutions to the problems and challenges they face; approaching makerspaces academically will require that same interdisciplinarity and novelty that facilitates innovation. The challenge of makerspaces is ensuring that we use all the tools that are available to us.

What the maker phenomenon currently represents is an opportunity to investigate the processes of invention, innovation, development, and design from a raw, up-close perspective. While a number of studies have touched on makerspaces as a site of innovation (Böhmer et al., 2015; DeFeo, Harding, & Wood, 2016; Holt & Braun, 2012; Kim, 2016; Lindtner, 2012; Robertson, 2010; Roma, Minenna, & Scarcelli, 2017), a thorough investigation of the processes occurring at the makerspaces still needs to be done. Even though there is a peer-reviewed journal that incorporates some of the issues that encompasses the makerspace “constellation” (*The Journal of Peer Production*), peer production itself is only one fragment of that constellation. The increased academic interest, and growing amount of research work conducted by both established academics and graduate students indicates that we are at the start of a flood of data on makerspaces. For example, in 2013 4S (the Society for the Social Studies of Science, the largest conference for the field of Science and Technology Studies) had 3 panel sessions dedicated to makerspaces and related issues. In 2016 at 4S Barcelona, that number had risen to 11 panel sessions, divided across 3 separate streams, with some 55 separate presenters (Boeva & Chies, 2016; Braybrooke & Smith, 2018). This, coupled with the other conference presentations (Hui & Gerber, 2017) cited in this work, suggests the field’s broad and expanding reach.

As this chapter has demonstrated by reviewing the previous literature, makerspaces (and makers) are diverse, heterogeneous, polysemous, and highly variable, despite their shared characteristics. The differences in funding, organization, politics, ideology, location, and demographics can make this a wildly diverse place to study innovation and its resulting processes. The challenge of makerspaces then, especially for future researchers, is to recognize the breadth and scope of the potential undertaking and to focus on the particular elements that are relevant to the study.

Chapter 3: Innovation

If makerspaces are a locus of innovation, then understanding what innovation is and how it fits into the development process at a makerspace will be crucial. Innovation is broadly accepted in society, in marketing, and in daily life as a net positive, and many assumptions about what innovation is and how it works go unquestioned. Most lay definitions find innovation synonymous with either “novelty” or “invention,” depending on the context, and while either answer is fine at a first approximation, a more detailed definition is required. These definitions may be rooted in the past, and may miss some of the essential elements of innovation as it is practiced in the networked era of the 21st century. Defining innovation as “the implementation of a new (or improved) product” (OECD, 2005) or simply “commercialized invention” (Schot & Steinmueller, 2018) provides a direct, workable framework sufficient for exploration. Within this framework, it is necessary to detail a theory of innovation that can be understood by looking at three successive phases of its intellectual development, beginning with the initial work of Austrian economist Josef Schumpeter, followed by the era of neo-Schumpeterian theorists, and the subsequent changes that brought about the current era of innovation theory, starting roughly from the 1990s onward. This chapter will pursue each in turn, highlighting foundational elements and areas that are relevant to the current research on makerspaces.

Of these three eras, the current era may be the most challenging, as understanding the current era requires looking at the major schools of thought that have developed within it. These schools fall into three main groups: User-driven innovation, focused on the user of the innovation and their relation to technology (Chesbrough, 2003; von Hippel, 1986, 1988, 2005); theories of Soft Innovation (Potts, 2009; Potts & Cunningham, 2008; Stoneman, 2008, 2010) that focus on innovation in aesthetic fields, or aesthetic influence on technological innovation; and

finally Neo-Schumpeterian theories focused on evolutionary economics, diffusion studies, and system and network approaches that still find use, but now find company among the intellectual playing field (Gloor, 2006; Gloor et al., 2007; Mazzucato, 2015; Potts, Cunningham, Hartley, & Ormerod, 2008).

A fourth group exists, those of other theories and approaches that invariably arise and do not fit in these schools. For purposes of categorization, we shall group these theories under the label of “incipient theories”. These theories can remain invisible to the orthodox literature. One example is Common Innovation (Swann, 2015), focused on those areas of incremental innovation that fall outside the traditional national systems of innovation or R&D. Because of the multiplicity of items that fall within this incipient category of innovation literature, this study will draw on just one: common innovation, plus the three schools mentioned already, as the theories most relevant to the current research.

By returning to the roots of innovation theory this chapter will develop a picture of the current state of the field, and how to understand the current era in terms of how each theory situates the cause of innovation in order to understand the makerspace as a concept. This conceptual framework will take the current era of theories and categorize them among three broad categories: those that focus on the Source, the Process, or the Context of the innovation. A summary of how the various theories interact provides a more complete picture of innovation in the 21st century. The chapter will close by addressing how these innovation theories that are relevant to makerspaces situate innovation, and how this aids in the analysis of innovation during the maker activities under observation.

3.1 Three eras of Innovation Thought:

Innovation is something that has been around for aeons, being “around since markets began.” (Gault, 2010, p. 3). More recent is the academic interest in innovation, and the development of theories about what it is, what benefits it confers, and what drives it. Early mentions of innovation start occurring in the 19th century with List and Marx (Hawkins & Davis, 2012, p. 237). But the conceptualization of innovation began in earnest within the work of Josef Schumpeter (1934, 1939, 1962). This period characterizing the early part of the 20th century was dominated by an interest in technical change (Freeman, 1994). The discourse of the era was framed as one of innovation for growth, where the technical advances of mass production were being brought to bear on more sectors of the economy (Schot & Steinmueller, 2018). Following this was an era that has been labelled neo-Schumpeterian, with a focus on “the actual process of invention, innovation, and diffusion within and between firms, industries, and countries” (Freeman, 1994, p. 464). This work developed in the second half of the 20th century, with elements persisting through the 1990s and beyond. During this period the discourse around innovation had changed, shifting to one of national systems of innovation, as comparative advantage between states held sway (Gault, 2010; Lundvall, 1992; Schot & Steinmueller, 2018). The final era is the current era, lacking a label that hindsight and history will one day provide (though it is currently sufficient to conceptualize it as post-Schumpeterian (Hawkins & Davis, 2012)), starting with work done in the 1980s, 1990s and thereafter based on innovation as an area of research in its own right instead of an adjunct to other disciplines. The new challenges of the 21st century have started to shift the discourse enough that it can be framed as an era of transformative change (Schot & Steinmueller, 2018) where large global goals of sustainable development, relief of inequality, and full and productive employment.

3.2 Phase 1: Schumpeterian Innovation

Conventional theories of innovation draw from work done by the Austrian economist Joseph Schumpeter, who stated that “capitalism is an economic system characterized above all by evolutionary turmoil associated with technical and organizational innovations” (Freeman, 1994, p. 464). This turmoil is the oft heard of gale of ‘creative destruction’ (Swann, 2009). But this turmoil is also characteristic of growth; of the four kinds of economic growth (knowledge, investment, commercial expansion, size effects), the lion’s share comes from “increases in the stock of human knowledge” or “Schumpeterian growth” (Mokyr, 1990, p. 6). Schumpeterian growth can be identified by technological change, and this technological change can be characterized by a ‘residual’ that is unaccounted for by increases in capital or labor when looking at growth (Solow, in Hawkins & Davis, 2012). This growth from technological change and innovation results in “new value from new combinations of both new and existing factors” and “a qualitative change in how new value is produced” (Hawkins, 2012).

For Schumpeter, the relevant problem in understanding technological change “is not how capitalism administers existing structures, but how it creates and destroys them” (Link & Siegel, 2007, p. 23; Schumpeter, 1962). This creative destruction is the essence of economic development. In other words: “development is a disturbance of the circular flow. It occurs in industrial and commercial life, not in consumption. It is a process defined by the carrying out of new combinations in production. It is accomplished by the entrepreneur” (Link & Siegel, 2007, p. 23). This has deep implications for other areas of society: it follows, therefore, that capitalism is not an administrative structure (i.e. suited for governance), but it is functional, however, as it allows for the development of new technology through innovation.

The entrepreneur enters the equation here, as Schumpeter saw successful innovation as an act of will, not intellect (Link & Siegel, 2007, p. 24; Schumpeter, 1934). The entrepreneur is *the* central figure in innovation, supplying the instrumental use of will that brings an innovation to the market. It is they who add value to the economy by creating new combinations of existing factors of production (Hawkins & Davis, 2012). This is consistent with one of the criticisms of Schumpeter: that he never had a coherent theory of innovation (Ruttan, 1959), but rather his focus was on entrepreneurship, and the effects those individuals has on the economy (Freeman, 1994, p. 468). There is also evidence in Schumpeter's theory of entrepreneurship of the environmental and Darwinian influences on his work, and these were developed more fully in later eras. To further understand Schumpeterian innovation, it is important to look at some of the key components addressed by the theory: technology, firms, entrepreneurs, and invention. But first, some comments about innovation itself.

3.2.1 Innovation

"Innovation" is widely used as a term in the Public Sphere, appealed to in advertisements, media, business, and politics. Innovation also tends to be often misused or misunderstood, being used as a stand-in for 'novelty' or 'creativity'. Innovation is often used synonymously with invention, yet the latter is only a small part of the process. For example, one understanding is that: "An invention is something new. An invention becomes an innovation when it is put in use" (Link & Siegel, 2007, p. 3). This concept of 'use' is key to understanding innovation as the 'successful exploitation of new ideas' or the process of 'bringing a new invention into commercial use' (Swann, 2009). All of the above can be seen in Schumpeter's work, as for him innovation was "doing things differently in the realm of economic life" (Hawkins & Davis, 2012, p. 237; Schumpeter, 1939).

The market is a key element in deciding the fate of innovations; coupling a new technology to a market or creating a market for that technology (Freeman & Soete, 1997) is a necessary function in the development of an innovation, and this function is often fulfilled by an entrepreneur. What the entrepreneur brings together in this coupling process is a need with the technical knowledge for its solution (Freeman & Soete, 1997, p. 200). This knowledge does not have to be new, only the application of it to the current problem. Bringing in a technical solution that exists for another industry to the current problem at hand is still innovation (Link & Siegel, 2007, paraphrased). The method by which this technical knowledge often arrives is in the package of an *invention*.

3.2.2 Invention

Invention is the creation of something new. It is the bringing of something new into the world. While this is no small feat, it is only a portion of the process, with innovation at the endpoint. At its most basic level, invention is “a linking of some purpose or need with an effect that can be exploited to satisfy it” (Arthur, 2007). This basic level suggests there is more to the process than just fortuitous insight (Usher, 1962). Within a linear model of innovation (Swann, 2009, p. 23), we begin with Research and Creativity, moving to the second stage of Invention, followed by a stage of Design and Development, and concluding with Innovation at the end of this path, representing when the entity is first put into commercial use; either within a firm or offered on the market (Gault, 2010, p. 42; Swann, 2009, p. 23). In this model, the invention is not really innovative if it never makes it out of the prototype stage. This commercial exploitation is one of the key differentiators of invention and innovation. For Schumpeter, with his focus on the value created by the entrepreneur during the process of innovation, this commercial path for the technical product was necessary (Ruttan, 1959).

Invention is the generation of new ideas, through research or creative expression that leads to the development of new products or processes. Development is the process of turning the results of research (e.g., patents, plans, knowledge) into something that may be brought to market. It is of note that invention falls in the middle of the process of the normally black-boxed R&D. “R&D is not innovation until it connects to the market (Gault, 2010, p. 18), but neither is patenting or publishing, for that matter. Within this proposed model, Design is nebulous and hard to pin down, but generally focuses on the introduction of subjective or aesthetic factors (elegance, quality, etc.) as a component of the innovation process as a whole. From there, as the new idea is brought into use, as it is ‘successfully exploited’, it can be considered an innovation (Swann, 2009). ‘Successful’ might be the key word, due to changes in access to markets in 21st century late-capitalist models; in 2018, the rise of internet-enabled services has allowed for more inventors and creators to directly reach a market, quicker than even before. Either we are awash in ‘innovation’ or perhaps a tighter definition of ‘successful invention’ is in order. However, as getting an invention to market is a key element of the coupling process of innovation (Freeman & Soete, 1997), the opportunities that are available to the inventor in the 21st century are not to be discounted, as they far exceed what was discussed by Schumpeter.

3.2.3 Technology

Theories of innovation have tended to look at the process through the lens of technology where new artifacts and inventions are viewed as the agent of change, and this view has been present since the inception of the field. Schumpeter was interested in technical innovation, but at the time of his writing this was a heterodox point of view in economic thought (Freeman, 1994, p. 463). Technological change has been variously called a ‘Black Box’ (Rosenberg, 1982) the ‘Lever of Riches’ (Mokyr, 1990), and more (Freeman, 1994). Early work on the history of

technology paid attention to the process of invention (Jewkes, Sawers, & Stillerman, 1969; Usher, 1962), but innovation was sparsely addressed relative to mainstream interest in labor and capital.

Innovation in the broader context is more than just technological change: innovations in marketing, business organization, or supply chains may not be technologically focused (Gault, 2010; Stoneman, 2008), and recent developments in emerging theories of innovation also have a broader view of how innovation can be applied (Swann, 2009). However, much of the early literature on innovation did focus on technology, often debating whether it had a push or pull effect relative to innovation.

Technological push is the process where the entrance of a new technology was the impetus for more creative destruction and turnover in the market, and it exists in contrast to demand-pull theories of technical change. There is an argument that Schumpeter is a proponent of technological push (Freeman, 1994, p. 467), but the evidence within Schumpeter's own writings is scant. Ruttan (1959) argues that there is little evidence of a theory of technology in Schumpeter's work, being hardly mentioned by name. Technology was closely linked to the market vis-a-vis innovation: "The fascination of innovation lies in the fact that both the market and the technology are continually changing" (Freeman & Soete, 1997, p. 202).

Modern innovation theory expands on the basic concept: innovations may be categorized in a number of ways. The primary method is to distinguish them by the form they take: as a product, process, business method, or organizational method. Service innovations are generally included with products, but there is some categorical flexibility here (Hawkins & Davis, 2012; Swann, 2009), that will need to be addressed by emerging theories. Innovations can also be classified by the degree of change they bring: whether they are incremental, radical, or

architectural in nature (Freeman, 1994; Swann, 2009). Radical innovations are rare, but can have a large impact. However, contrary to expectations, it may be the accumulated total of small incremental innovations that produce the lion's share of economic growth in the world (Baumol, 2003; Freeman, 1994; Mokyr, 1990). The nature of innovation can also change depending on the organizational context in which it is explored (Kanter, 1988). As the scale increases: from project, to organization (or firm), through to the institutional environment, the determinants of what constitutes an innovation therefore changes as well.

3.2.4 Entrepreneur

The instigator of this process of innovation, *the* key figure in Schumpeterian theories of innovation, is the entrepreneur. They are the prime mover who engenders risk in others and effects change in the world. Entrepreneurs were exceptional individuals who were willing to face the hazards and risks of innovation (Freeman, 1994, p. 466). The successful entrepreneur is one defined as "...someone who specializes in taking responsibility for and making judgmental decisions that affect the location, the form, and the use of goods, resources, or institutions" (Hebert and Link, 1988, p.155; Link & Siegel, 2007, p. 3). The entrepreneur has often been associated with the businessman, and while there can be some overlap, they are not necessarily the same thing: "Everyone is an entrepreneur only when he actually "carries out new combinations," and loses that character only when he has built up his business, when he settles down to running it as other people run their businesses" (Schumpeter, 1934, p. 78). It is the activity that is key in determining whether an actor is filling the role of an entrepreneur. Schumpeter recognized that in large firms, R&D had become bureaucratized. In this instance, a development engineer at this firm fulfilled the role of entrepreneur. (Freeman, 1994, p. 467).

There are other characteristics that make for an effective entrepreneur, and these are often cognitive in nature, based on knowledge, aptitude, and intelligence. Entrepreneurs possess “an aptitude for leadership stem[ming] in part from the use of knowledge, and knowledge has aspects of a public good” (Link & Siegel, 2007, p. 25). This knowledge is multi-faceted: the entrepreneur will have to have enough technical knowledge about the invention as well as enough knowledge about the needs of his (potential) market, and in order to successfully navigate the process of innovation. This market knowledge is a key contribution of the entrepreneur, who perform a social function: “The social mechanism of innovation is one of survival in the market” (Freeman & Soete, 1997). The entrepreneur possesses these qualities, this knowledge and tolerance for risk, and the ability to navigate it. Just as businessmen who have settled into a routine fall out of the entrepreneurial class, there are many who are engaged in the market who are not involved in innovation. Schumpeter posited two types of agents as contrary to the ‘representative agents’ of economic theory of the time: entrepreneurs, and imitators (the larger group) (Freeman, 1994, p. 466). What separates the two groups is not technical in nature: “The quality of entrepreneurship and **good communications** are fundamental to the success of the technical innovations” (Freeman & Soete, 1997, p. 203 emphasis added).

3.2.5 The Firm

The firm is the final component relevant to the Schumpeterian era that will be addressed here. While there has been relevant and influential research that delves into the nature of the firm (Coase, 1937; Penrose, 1959), we are focused on material that looks at the firm with respect to innovation directly. The rise of the firm was due to the changing conditions in research at the start of the early 20th century. By the end of the First World War “corporate R&D had replaced the contract laboratory as a centre of American R&D activities” (Freeman & Soete, 1997, p.

198), but “during the 20th century the main locus of inventive activity shifted away from the individual inventor to the professional R&D laboratory...” (1997, p. 192). As increased research focus on the firm was one of the components of the transition to the neo-Schumpeterian era of innovation research, it will be discussed there.

3.3 Phase 2: Neo-Schumpeterian Innovation Theories

Following Schumpeter, a second era of innovation theory began, drawing from his work, and expanding it off in new directions (Freeman, 1994). Rising from the postwar interest in development, and looking for ways to maintain and expand the growth in industry that resulted following WWII (Schot & Steinmueller, 2018), neo-Schumpeterian research focused on “the actual processes of invention, innovation and diffusion between firms, industries and countries. (Freeman, 1994, p. 464). This manifested in an increased number of empirical studies on those very topics, and this information was quickly put to use (Freeman, 1994; Lundvall, 1992). Much of the neo-Schumpeterian work followed a normative, positivistic approach to quantifying and tabulating the economic data available following World War II (Hawkins & Davis, 2012). The neo-Schumpeterian approaches include the beginning of various systems approaches to innovation (Freeman, 1994), notably the rise of evolutionary economics (Nelson & Winter, 1982). Focused on the firm as the level of analysis, these approaches analyzed the skills and routines that contributed to the ability of the firm to maintain itself, and instituted changes to its processes in order to adapt to new situations in its environment.

The neo-Schumpeterians were not some monolithic block, however, as there was remarkable diversity of thought among the work that was conducted in this era. Despite that, there were some common intellectual underpinnings. The neo-Schumpeterians “share the

fundamental postulate of Schumpeter (and Marx) that capitalism is an economic system characterized above all by evolutionary turmoil associated with technical and organizational innovations” (Freeman, 1994, p. 464). Neo-Schumpeterians would also take the results of their empirical studies and use them to criticize much of Schumpeter’s work. This did not overturn it, directly, but provided proof that supported, expanded on, or occasionally disproved the earlier hypotheses. Key contributions were made also by the neo-Schumpeterians to the study of firms.

Within the system view of innovation, the firm may be one of the actors that exert influence through their activities and linkages, but it is the functions that they provide that are important to study. Christopher Freeman and Luc Soete (1997) identified how the firm matters to the study of innovation:

- The firm able to monitor new science may be first to a new possibility. Strong in-house R&D may enable it to convert this to a competitive advantage.
- The firm in touch with customers’ requirements may learn of novel ideas or sources of dissatisfaction, which leads to new products.
- Successful entrepreneurship and good management is the capacity to link technical and market possibilities, by combining two flows of information and new ideas.

(p. 202)

However, the firm is not the be-all and end-all in innovation studies, despite its prominence: not all firms are innovative. The definition of an innovative firm is “one that has implemented an innovation during the period under review” (OECD, 2005, p. 152). This seems like a remarkably low bar to clear, and this may be a problem for research in the field. They may not be the most important source of innovations either; Freeman and Soete (1997) note the chain

of progression for new technologies: “the most persuasive and important technologies start in the public domain in government laboratories and universities, then move to instrument makers and capital goods manufacturers with strong R&D, and only in the final stage to large consumer goods industries and services⁶” (1997, p. 186). These consumer goods occupy much of what is written on innovation.

Conventional innovation theories tend towards a focus on the traditional paradigm of innovation research: technology, products, and processes (TPP). ‘Processes’ has been extended in recent years to include marketing and organization as well, and ‘Services’ as a category may show up in various places, as either a product or process; service is more about a mode of delivery. This focus has been a problem in traditional innovation research (Hawkins & Davis, 2012). Along with the focus on technology is a focus on quantitative, econometric data. Many of the key studies of innovation use metrics from the OECD or other national and international data sources (Gault, 2010). This can lend a degree of consistency to research reports conducted using this paradigm, with the potential drawback of not being able to account for results that do not fit within this narrow paradigm.

Industries and firms can have both forward and backward linkages to the rest of the economy. Forward linkages are those that put forth innovations, through new products or output. Backward linkages are the demand for new innovations and products by the producers themselves. This can be seen in the creative industries, where the demand to produce new and novel products drives the creators to demand new and improved tools and materials.

⁶ Freeman and Soete are commenting and amplifying what was written by DeBresson (1991).

3.3.1 Diffusion

Innovations do not spread instantaneously; their adoption takes time. This time can be seen in the transmission and uptake of a new idea or innovation. Within the innovation literature much of this is explained by the process of diffusion. Stemming largely from the work of Rogers ([1962]1983), this diffusion of innovation occurs as different groups have different needs and a different willingness to use a new (novel) piece of technology (Becker, 1970). In Rogers' formulation, the classification of these different groups include innovators, early adopters, the early and late majority, and finally the technological laggards who are last to take up a new innovation. Rogers was looking at the process of farming technology when he originally did the case work behind the study; the degree to which that maps clearly to other areas of technology or non-technological areas of innovation like the creative and cultural industries needs to be examined for each study.

The diffusion process under Rogers' model also involves a large amount of communication; diffusion is a component of the knowledge dynamics of innovation. However, Roger's communication model is somewhat simplistic, using an epidemiological approach (or a sender/receiver model, after Shannon and Weaver (1963)) where knowledge is like a 'hypodermic needle' that is 'injected' in the recipient (Rogers, 1983). A more robust model of communication may be needed.

The diffusion of an innovation generally follows an 'S-curve' when looking at how it is applied against a population: low numbers of adopters to start, and then steeply increasing as it gains widespread popularity, levelling off as the last few hold-outs start using it (Rogers, 1983; Stoneman, 2010). That this pattern of adoption is maintained over scales: people, firms, clusters, industries, etc., suggests that diffusion may follow a power-law distribution (Stoneman, 2010).

Diffusion has been studied in a number of different fields, each looking at different metrics when evaluating the consumer and their tolerance for risk. However, the diffusion of innovation curve still holds true, though the slope of the curve can differ depending on a suite of factors including the nature of the products, related, rivalrous, or complementary goods, or other externalities (Stoneman, 2010, p. 208). Due to this, the products need to be examined individually to determine what the factors are.

One of those factors can be the influence of the adopter themselves, and their social standing within the larger network (Becker, 1970). The decision to adopt a new innovation can be based on the perceived risk to the adopter. Those with a more marginal reputation, on the fringe of the network, are more likely to pursue a riskier strategy, relative to those who have more to lose if the adoption of an innovation fails.

The neo-Schumpeterian theories of innovation took Schumpeter's initial work and area of interest, that of innovation, the entrepreneur, and technical change, and built upon it, conducting empirical research and testing the findings with the tools available. This application of systems theory, the recognition of path dependence, lock-in, and other evolutionary features of economics led to the development of a paradigm focused on TPP, and a discourse framed around national systems of innovation (Freeman, 1994, p. 484; Schot & Steinmueller, 2018, p. 9). However, as further work was done there was a recognition that the theory was incomplete, and that large sectors of the economy were not adequately represented by the prevailing paradigm. Many of the new emerging theories of innovation in the current era are an attempt to redress this imbalance.

3.4 Phase 3: The Current Era of Innovation Theory

There is no set starting point for the current era of innovation theory. It arose out of the challenges that the neo-Schumpeterian theories were having explaining current findings of innovation research during the 1980s and 1990s. This followed the shift to the National Systems of Innovation framing that occurred during the 1980s (Lundvall, 1992; Schot & Steinmueller, 2018). As a new frame dominates the discourse on innovation, theories work to deal with the challenges presented in this discourse, eventually created a new frame, in the classic example of a Kuhnian paradigm shift (Kuhn, 1996). The development of innovation theory follows this pattern as well. Each of the three main schools of thought discussed below were developed to address a particular shortcoming of conventional innovation research and the findings therein, taking the focus away from the firm, institutional R&D, and national development, and expanding it to look at the role of users, the arts, or that of citizen's everyday practices. These various areas of study found no end to the amount of innovation going on or the forms it would take, and the contributions that each area made back to either the national accounts, or to better understanding the underlying process of innovation itself.

More than just new schools of thought, the current era can be framed as one of “transformative change” (Schot & Steinmueller, 2018), as the dominant discourse on innovation shifts to account for the changes occurring in world economies around the turn of the 21st century. This discourse is driven by the authors and their works, several of which will be discussed below as we look at the major schools of thought in the current era of innovation theory. The theories drive the frame of discourse (through an iterative process).

3.4.1 The School of User-driven Innovation

Challenging the neo-Schumpeterian focus on the firm and national systems of accounts from the previous phase, user innovation looks for the feedback from users to the firm. Users are “not just sources of information for innovation,” but “they are also innovators who change their products to suit their needs” (Gault, 2010, p. 18). Users change their processes as well, and are more flexible and adaptable to changes in most categories of innovation. User-driven innovation is described in a number of different ways: user innovation (von Hippel, 1986, 1988), democratized innovation (von Hippel, 2005), citizen innovation (Eskelinen, Garcia Robles, Lindy, Marsh, & Muent-Kunigami, 2015), or open innovation (Chesbrough, 2003). Studying User Innovation has been problematic⁷, and as such has not been addressed by orthodox research guidelines (OECD, 2005). From the perspective of innovation research focused on the firm, user-innovation is a subset of process innovation (as is marketing and organizational innovation), and “the only place for the individual consumer ... is as a source of information for the firm that engages in product innovation” (Gault, 2010, p. 43). However, the underlying argument for the user innovation paradigm is user innovators are not simply collaborators with the firms that produce the product innovations, even though the mainstream literature treats them as such. The collaborator in innovation is more than an information source, as collaboration allows the exchange of knowledge among participants (Gault, 2010). There are ongoing arguments on whether innovation starts or stops with the consumer. (Hawkins & Davis, 2012, p. 239). Users tend to be problematic for other reasons as well: “What user innovators do with their IP raises some questions for IP policy as part of innovation policy” (Gault, 2010, p. 19). This has been an

⁷ as it falls “outside of the mainstream of Oslo manual discourse” (Gault, 2010, p. 18),

ongoing issue in both the study of innovation, and the maker community (Levy, 2010; Sterling, 1993) and others.

Democratized innovation is a part of the user-driven school, based on the idea that users are able to innovate for themselves (von Hippel, 2005). This spreads out the process of innovation among more participants, and brings with it certain benefits to the firms that are willing to embrace this strategy. This focus on users contrasts somewhat with the conventional innovation focus on large firms, as was suggested by Schumpeter (Freeman, 1994; Swann, 2009). In a democratized framework, users can benefit from the shared innovations of others (similar to the Open Innovation model discussed above), and because users are the innovators, they may share their innovations freely, if they wish (though some restrictions may apply). With democratized innovation, there is a functional relationship between the user and the manufacturer, whereas with open innovation we saw just the firm—firm relationship. This is due in part to the rather expansive definition of the ‘user’ in the model: normally the term ‘user’ conjures an image of the lone individual, but here it can mean any group in size from an individual, to firms, up to and including Boeing as an example (von Hippel, 1986, 2005); ‘user’ as deployed is close to scale free. While there is a great degree of utility in this consistency, there may be significant structural and environmental differences between those operating at either end of the spectrum (for an example, see Haddon, 2002).

Why do these ‘lead users’ pursue these innovations? If there is a want or need they have (and recognize) that does not exist, they may be motivated in a way that a producer might not be. The ‘lead user’ acts as a prime mover or instigator, an archetype that shows up again and again in the literature under many different identities. The lead user also recognizes that traditional practices may not produce exactly what they want or need. This was recognized by Schumpeter

(1962, p. 92), where most new consumer goods are produced in a manner that is initially unsatisfactory, and then refined to a form that is good enough to conquer a market. This improvement in product quality is something that Schumpeter considers a “practically universal feature.” More than just quality, products developed by them have “greater commercial attractiveness” (von Hippel, 2005) where attractiveness is defined as the sum of novelty plus generality of market demand.

The democratized innovation framework pays particular attention to capital growth and investment, as the role of the user may be contrary to mainstream orthodox theories of equity accumulation needed for capital growth. A private-collective model of funding can occur within a democratized innovation framework, where the users contribute their own private resources in creating the innovation (von Hippel, 2005; von Hippel & von Krogh, 2003). This may be seen in open-source software projects, and other areas have adopted the model as well. While democratized innovation has gained some traction in the software sector, the majority of manufacturers still conform to the conventional paradigm as the source of new product innovations.

3.4.2 The Soft Innovation School

Soft innovation is the study of innovation that looks to incorporate the role of the creative industries and aesthetic factors into the analysis. Where innovation research has traditionally looked at measurable changes within the manufacturing and production process – the TPP paradigm – soft innovation steps away from this, looking at changes within the aesthetic realm, and is primarily concerned with “product innovation and product differentiation” (Stoneman, 2010, p. 7). “Soft innovation is innovation in goods and services that primarily impacts upon

aesthetic or intellectual appeal rather than functional performance” (Stoneman, 2010, p. 22).

Both these elements of appeal – aesthetic and intellectual – can be highly subjective, and evaluating them empirically can be incredibly difficult. For example, ‘aesthetic’ in this instance is “‘the science which treats of the conditions of sensuous perception’. Today, sensory is a more appropriate word than sensuous and it is this meaning that has been adopted here. Aesthetic is thus taken as encompassing not only sight but also touch, smell, and sound” (Stoneman, 2010, p. 22), drawing on a Kantian framing of the aesthetic⁸ (Shusterman, 2006). Operationalizing these subjective elements to allow for economic analysis often needs to be accomplished via a proxy of some form.

There are two paths in which Soft Innovation may occur which reflects the bidirectional nature of aesthetic influence. The first of these paths is: “innovation in products that are not generally considered functional in nature but instead offer aesthetic appeal, i.e. appeal to the senses or the intellect. The introduction of any new aesthetic product or product variant is taken to be a soft innovation. Examples are music, books, film, fashion, art, video games, etc.” (Stoneman, 2010, p. 23). This encompasses a wide swath of what are termed the “culture industries” (Ginsburgh & Throsby, 2006), and the significant economic impact they have in OECD countries. The second path of soft innovation is “aesthetic innovations in industries the output of which is not aesthetic per se but functional.” (Stoneman, 2010, p. 24). These bi-directional paths of soft innovation are considered to run in parallel with conventional forms (products, processes, organization, marketing), but this may be subject to criticism.

⁸ Shusterman (2006) comments on how Kant’s framing of aesthetic from the *Critique of Judgement* (1952): ‘The judgement of taste is aesthetic’ and its ‘determining ground [of pleasure or displeasure] cannot be anything other than *subjective*’.

Indicators of soft innovation appear in the innovative outputs (Bakhshi & McVittie, 2009) of marketing and novelty, and measured by the traditional metrics of sales and market share. Soft innovation can impact the proliferation (or diffusion) of a particular good. This impact is representative of the influence soft innovation has on the market, and this affects the economic welfare as a whole (Stoneman, 2010), though this measurement is done via proxies, and may be difficult to directly account for in market research. Another critique is that the output of these creative industries may not be truly ‘innovative’ at all: that the introduction of a novelty is in itself insufficient, especially when the “product” consists of repetitive variations of mostly similar ‘content’ (Müller, Rammer, & Trüby, 2009). For example, Disney’s latest billion-dollar release from Marvel Studios may not be innovative when compared to the other films. Additionally, the model that soft innovation uses is ‘highly asymmetric’, counting the hits and ignoring the misses, as it were, when picking winning innovations to analyze (Eltham, 2013). This results in a focus on bestsellers and chart-toppers, while ignoring the long tail (Anderson, 2006) which may skew the results.

Related to soft innovation, one school of thought that is currently receiving much attention is Design Innovation (Utterback, 2006). It is currently gaining some deserved attention due to the rise of design-centric research (“design thinking,” etc.), driven by the success of Apple, and other leading technology companies who are lauded for their design and use it as a means to distinguish themselves in the marketplace. Design-thinking requires straddling multiple fields *well*, and still requires real talent (as well as time and money).

3.4.3 The Current Era Neo-Schumpeterian School

The proliferation of theories of innovation during the current era has not seen the disappearance of Neo-Schumpeterian approaches; they remain robust and viable, and are more closely tied to mainstream economics and econometric studies than other theories in this era. Neo-Schumpeterian approaches have been refined and redeveloped, with the underlying focus on evolutionary economics, network approaches, and systems approaches to innovation all being bolstered by the advent of powerful new tools of data collection and data analysis. The current neo-Schumpeterian approaches follow the trajectory they set in the earlier era.

One of the underlying trends in theories of innovation has been the recognition of the power of network effects. For instance, Metcalfe's Law on the value of a network being equal to the square of its users (Benkler, 2006) has been recognized in similar approaches in innovation theory. Examples of network models can be seen both directly, in collaborative innovation networks (COINS) (Gloor, 2006; Gloor et al., 2007; Potts et al., 2008), and indirectly.

Many network models of innovation also use a system-theoretic approach, and the two approaches dovetail seamlessly. Network models have these common characteristics: "A system consists of actors or economic agents. The actors engage in activities, and have linkages with other actors. As a result of the activities and linkages, there are short-term outcomes and longer-term economic and social impacts" (Gault, 2010, p. 21). The deep connection of the system-hybrid model with innovation research is important. As the "current innovation system is global, complex, dynamic, & non-linear" (Gault, 2010), it is important to recognize that theories will need to be able to analyze such a system. To this end, theories that engage in a systems approach – "a method of understanding the actors, their linkages, and the outcomes of the activities **and** linkages" (Gault, 2010, p. 3, emphasis added) will be vitally important.

The entrepreneur is also heavily present in this era, as later research identified the role of various entrepreneurial forms (Freeman, 1994, p. 468). The nature of their role changed due to the effects of the network. The entrepreneur still engendered risk in others, but their influence could be measured by their centrality within the network. Outside the quantifiable measures of social network analysis, this centrality could be seen in the entrepreneur's gatekeeper function, or in the titles that were bestowed upon them – product champions, business innovators, network coordinators – all terms that masked the entrepreneurial function that they fulfilled. The nature of the shift in the market meant that often the only place for the entrepreneur to function was embedded within a larger corporate or industry structure.

The knowledge dynamics of innovation are not simply one-way; this is why the epidemiological approaches of Rogers and Stoneman do not quite hold. Feedback from the users to the producers is also a valuable part of the cycle, as is business-to-business communication as well (Bakhshi & McVittie, 2009; von Hippel, 1988, 2005).

3.4.4 Incipient Theories of Innovation

There is an element that is underlying all the theories of the current era, inherent in their underlying assumptions. What is invisible in the current innovation literature is the essence of how people really interact (see p.5). Attempts to include subjective criteria, like the subjective elements of the creative industries (Potts & Cunningham, 2008; Stoneman, 2008) or elements from design (Cautela, Deserti, Rizzo, & Zurlo, 2014; Utterback, 2006) speak to this missing element. Similar attempts at engaging on networked spaces and user feedback mechanisms in the innovation process attempt to account for this as well (Gloor, 2006; Gloor et al., 2007).

Where technical change and innovation was first hypothesized as a residual factor that was not

accounted for in national accounts of labour and capital (Schot & Steinmueller, 2018), so too is there a missing residual factor of interaction and communication in innovation theory that must be accounted for. The remainder of this chapter is an attempt to work toward a formulation of what that residual factor actually is.

3.4.4.1 Common Innovation

Common innovation (Swann, 2015) is a recent foray into understanding the innovation that occurs outside business innovation. Recognizing that there are fundamental elements of innovation that are unaccounted for in the mainstream innovation literature, and that the destructive effects of business innovation often get elided (i.e. described as “negative externalities,” if at all) within that literature, Swann looks to an alternative that portrays the difference as one between monetary wealth and real wealth, or between the theories of Mill and Ruskin, respectively. For monetary (or mercantile) wealth (or M-Wealth, as Swann describes it), much wealth creation does revolve around business, but this is not the sum total. This increase in business wealth often does little for real wealth (or R-Wealth) creation. Swann uses an example of a Hollywood movie as an illustration: “The stars & director get top billing, but the cast of credits is **long**, many people derive their livelihood from it, people without which the film **would not get made.**” (Swann, 2015, p. 212, emphasis added). Common Innovation is a collection of interconnected innovation processes undertaken for pragmatic reasons by those directly impacted by it that often otherwise fall outside of commercial interests.

Common innovation also examines the negative impacts of certain innovations. This is focused on the destruction half of Schumpeter’s ‘creative destruction’. The negative effects (pollution, waste, worker and firm displacement, pathological effects of consumerism, etc.) can be seen in a variety of industries, from bookstores and local manufacturing to software and high-

frequency trading, and these negatives may far outweigh the positives of M-wealth creation through innovation. (though positives still exist, obviously), but it can be difficult to calculate. By contrast, Swann likens common innovation to a ‘benign breeze’(2015) that contributes more directly to real wealth.

Common innovation can impact nearly all areas of the economy, including education, science, the arts, business, social-economic environment, the natural environment, consumption, and health. These categories are interconnected, and a given area of common innovation (such as household innovation, or an individual working on a hobby) can intersect with many of them. Tracing a path between these shows that the cumulative effects of long value chains can exceed that of any initial steps. For any given category, common innovation may add directly to it, exploit it to enhance other categories, or exploit other categories to enhance the one the innovator is interested in. The challenge of common innovation is that it may not leave a paper trail; there is the perverse fact that if a man marries his housekeeper, the national account *falls* because the wage (transaction) is removed from the equation, but the work is still getting done (Swann, 2015, p. 224). The final result is that “Common innovation will increasingly become an antidote to business innovation, and even some features of business itself.” (Swann, 2015, p. 228). Business is not the only source of Innovation, and strong R-wealth can compensate for weakened business ties. For Swann, as for Ruskin, “there is no wealth but life”, (Swann, 2015, pp. 222–223).

3.5 Understanding the Current Era of Innovation Theories: Process, Source, and Context

While a unified theory of innovation has not yet appeared during the current era of transformative change, it is possible to provide some structure to the proliferation of approaches that exist. One of the emerging trends of the current era in innovation research is the recognition

of the flaws in the TPP approach, and a search for new alternatives has begun (Hawkins & Davis, 2012, p. 238). This search has given rise to a number of the differing schools of thought in the current era, as theories attempting to address the TPP shortcomings, and those looking at expanding the context of what constitutes innovation find common ground. These approaches may be largely characterized as post-Schumpeterian (Hawkins & Davis, 2012). At their root, these theories present a dynamic view of innovation, even though they differ on “the process whereby an invention becomes an innovation” (Link & Siegel, 2007, p. 3).

Bringing structure to the plethora of new sub-categories of post-Schumpeterian innovation theories can be accomplished by categorizing them based on how the theory situates innovation: whether by process, source or context. Process-oriented theories look at the dynamics of innovation and the underlying mechanisms behind the change along some point of the process. They can be focused on agents or users (von Hippel, 1986, 2005; von Hippel & von Krogh, 2003), or on the interaction of the innovators (Chesbrough, 2003; Graham & Mowery, 2006), either through business models and values chains, or via Collaborative Innovation Networks (COINs) (Gloor, 2006; Gloor et al., 2007). Source-oriented theories are those whose primary interest is on what factor or effect causes innovation. This can be grounded in aesthetics and the creative industries like soft innovation (Cunningham, 2011; Potts & Cunningham, 2008; Stoneman, 2008, 2010), design-inspired innovation (Utterback, 2006), consumer demand (McMeekin, Green, Tomlinson, & Walsh, 2002), and social network markets (Potts et al., 2008). Context-oriented studies follow the trends set forth via conventional approaches to innovation, but can be focused on a specific area or a specific field (Wolfe & Holbrook, 2000), and are often defined by the geography or industry they study. The boundaries between these three areas –

process, source, and context – are somewhat permeable, and as such there will be some categorical overlap between the large groups.

For process-oriented theories, the tendency is to assume the source of innovation (generally occurring due to technology) is static, and question the underlying dynamics. Many process-oriented theories look at technology in some fashion, whether it is at the firm (Chesbrough, 2003) or in the development processes (Gloor, 2006). For source-oriented and context-oriented theories, the tendency is the reverse: using traditional TPP metrics (Stoneman, 2010) and methods, but applying them to unique, under-examined sectors of the economy, questioning the origins of novelty as it is introduced into the market. There are always exceptions to the above tendencies that may be observed.

3.5.1 Process-oriented theories of innovation

Process-oriented theories in the current era often fit well with conventional approaches in innovation, building off or commenting on the traditional TPP research that exists in heterodox innovation research. Within this paradigm it is the process of innovation and its attendant benefits (knowledge, reputation, and problem-solving) which are often reason enough to undertake the project (von Hippel, 2005, pp. 7,60-61). Process-oriented theories can also be distinguished by their political economy approach, with their attention to the money: the business model, value chain, or funding model of the innovator is often key for understanding how the process works, and this can be seen in all three of the models shown. This attention to the business model can be sometimes neglected in theoretical constructs; over time, the difficulty of providing long-term income can be a problem that causes innovations to fail. Many innovators marginalize this necessity, assigning it to some nebulous ‘services’ or ‘contracts’, to their later detriment (Graham & Mowery, 2006).

Process theories share a number of common features:

- They draw heavily on conventional theories and adapt new modes of thinking about innovation.
- They are focussed on the money or value chain (this is not surprising as they often are situated within economics literature).
- They create network-oriented models, or at least recognize the need for the network.
- They scale down to individual users of small groups.
- Focus on knowledge, skills, reputation effects.

The combination of these features is what helps delineate a theory as being process-oriented.

Examples of innovation theories that are process-oriented includes Chesbrough's Open Innovation, where the paradigm is that valuable ideas can come from inside or outside the company, and can go to market internally or externally also (Chesbrough, 2003, p. 43). This shift has been initiated by the 'knowledge abundance' of the 21st century, with the end of traditional 'knowledge monopolies'. Similarly, Von Hippel's Democratized Innovation is process-oriented because it deals with TPP models, but in a democratized framework where, users can benefit from the shared innovations of others and they may share their innovations freely if they wish. Collaborative Innovation Networks (Gloor et al., 2007) are also process-oriented as they situate the development of innovations within an evolutionary framework.

3.5.2 Source-oriented theories of innovation

Source-oriented theories of innovation are distinguished from process-oriented theories in that they look at the root causes of innovation. Source theories includes theories that focus on the impact of creative individuals and industries, the role of aesthetics (Stoneman, 2010), and design (Utterback, 2006), as well as the impact of users wants and demands (McMeekin et al., 2002), and the market-generating effects of social networks (Potts et al., 2008). What these all have in

common is the shift away from a technological focus to incorporate a broader range of novelty-generating activities under the umbrella of innovation. As part of the shift away from technology, there is also a shift towards alternative ways of assessing the value of the good, with elements of symbolic or social capital showing up throughout.

What are the features of Source Theories, and how are they different from process-oriented theories above? Source theories:

- Look at root causes of innovation.
- Focus on creative individuals (and creative industries).
- Investigate role of subjective elements & design.
- Incorporate user wants and demands.
- Study market-generating effects of social networks.

Examples of source-oriented innovation theories include soft innovations — work on innovation in the creative industries and aesthetic influence on technical innovation (Stoneman, 2008, 2010) — and design-inspired innovation (Utterback, 2006). In both these examples, subjective elements like aesthetics and design are key components of the innovation process that impact the market success of an innovation, but do not show up in the traditional measurements of TPP or national accounts.

3.5.3 Context-oriented theories of Innovation

Context-oriented theories are those that look at a particular phenomenon or location. While elements of ‘context’ exist in other theories of innovation, the context-dependent theories are often tied to a locale, firm, or industry (e.g. ‘Innovation in Alberta’, or ‘Innovation in the Oil & Gas Industry’) (Langford & Josty, 2015; Wolfe & Holbrook, 2000). Context-oriented work can be situated at a location, study an innovation network, or examine a particular practice. Context-oriented research can be qualitative in nature, but is not exclusively so; it is often

research that may involve case studies, journals, thick description, and other methods of investigating ‘messy’ topics.

Where the process vs source dynamic covers many of the emerging post-Schumpeterian innovation theories, context-oriented theories may capture those that exist outside that binary dynamic or those that float within the incipient literature on innovation. Features of context-oriented theories include:

- Look at root causes of innovation.
- Focus on location or micro-level of analysis
- Provide a granular level of detail
- Apply qualitative methods
- Are process or source agnostic
- Fall outside other methods of capture or analysis

An example of context-oriented innovation would be Swann’s common innovation (2015). In the case studies that are given in the text, the locale or practice – whether it is in the home, through hobbies, or the like – can be important to the innovation process. Common innovation does cross over with both process and source-oriented theories to a degree (i.e., the barriers are permeable to a degree), but context matters.

3.6 Innovation and Makerspaces

Based on the preceding information in this chapter, two questions remain: what does an understanding of innovation theory mean for investigating the makerspace; and conversely, what can a makerspace, and its community, communication, and knowledge management practices contribute to innovation theory? Answering the second question is one of the goals of this project; the first question can be addressed here.

Within the makerspace, there are entrepreneurs, but not all makers are entrepreneurs. A key component of this study will uncover the role of the entrepreneur within the makerspace. “The crucial contribution of the entrepreneur is to link the novel ideas & the market” (Freeman & Soete, 1997, p. 201). How this takes place, and questions of *where* the market actually is relative to the makerspace need to be addressed.

Despite being a locus of user innovation, there is just as much firm-based innovation that is going on in makerspaces. Some of it is shifts in the firm themselves, and some is the creation of new firms (Anderson, 2012; Tierney, 2015a) This is analogous to the concept typical of fit under market or organizational innovation.

Modern innovation theories have incorporated the shift in industry and within technology firms brought about by commons-based peer-production and free-and-open-source software (FOSS), as well as underlying changes in telecommunications and hardware in the 21st century. Makers are at the forefront of this, and at times have skirted the legality of various IP regimes.

A number of common features come out of the analysis of modern theories of innovation that are relevant for the study of makerspaces. While it may appear that studying makerspaces may be ‘context-dependent’ (and to a degree that would be correct—it is), the core components of the process and ideology of both makers and ‘peer-production’ move the study of innovation of makerspaces away from other context theories.

3.7 Summary & Conclusion

Theories of innovation have undergone a significant shift in the breadth and scope of their inquiry in the first century or so of their development. From their inception as an explanation for the residual factor of technological change that was unaddressed by economic theories addressing equations focused on labour and capital, they have grown to include data-

heavy analytical exercises consistent with modern economic theory, focused on neo-Schumpeterian approaches interested in evolutionary economics, systems, networks, and dynamics, to other approaches focusing on users, aesthetics, or common forms of innovation. These new forms, in the current era of innovation theory, allow for a broader range of human activity involved in invention and creativity to be addressed, and a more robust general consensus on innovation may appear.

Separating the modern theories into the three orientations – process, source, or context – allowed for a useful distinction to be made about the various common themes present within modern innovation theories. Several of these recognize the power of the network, notably collaborative innovation networks and social network markets, and this dovetails with the suggestion of using a system-theory approach to understand modern innovation activities. Drawing on other literature, it is possible to bring these streams together and understand how they act in concert, as exemplified by the modern maker movement.

Makerspaces, as a site of invention and creativity, allow for some forms of innovation to take place. Understanding how innovation occurs will be helpful at recognizing it when it happens at a makerspace, as questions remain about where and what kind of innovation is taking place. Given the history of recent innovation theories, it appears that the makerspace meshes well with those theories, having grown up during a similar time and drawing from some of the same intellectual history. Making sense of how innovation occurs at a makerspace provides a useful environment for looking at innovation theories in the ‘wild’, so to speak. Makerspaces have, since their inception, been the result of user innovation and user-driven innovation. And they also remain locales of common innovation, as they maintain much in common with craft and hobby industries, and much of the work there would not show up in a system of national

accounts. With this in mind, drawing on the theories of the current era of innovation research, and how they can be conceptualized in the frame of an era of transformative change allows for the creation of an analytical framework that can be used when conducting the ethnographic fieldwork, the participant observation, and interviews that will form the bulk of the research.

Chapter 4: Methods in Makerspaces

Makerspaces offer the opportunity for innovation and communication researchers to study the dynamics of the innovation process as it is occurring in a particular location. Understanding the role of the makerspace as a site of innovation will require new work that looks at the sites in-depth, with an eye to the processes occurring therein and the development of a means to compare the observations. Ethnography offers a path towards understanding how makerspaces might affect the way people innovate; it is “the disciplined study of what the world is like for people who have learned to ... think, and act in ways that are different” (Spradley, 1980). The thick description developed through ethnographic fieldwork provides a new opportunity to observe the processes of innovation at these sites. Ethnographic work has been conducted at makerspaces before (Moilanen, 2012b; Troxler, 2010), but the fieldwork conducted at the spaces and their predecessors has focused on the description of the sites or the groups, and not that of the innovation processes themselves. This chapter will make the case for the relevance of using an ethnographic approach to studying innovation at makerspaces. Three case studies of existing makerspaces in the Calgary area provide the sample for this project, and the methodology focusses on ethnographic fieldwork, participant observation, and interviews. The data collected in the three case studies is analyzed for examples of innovation archetypes and the subjective elements that are present at the makerspaces during the period of observation.

4.1 Ethnography and innovation

Traditional innovation research often relies on quantitative data drawn from statistical sources: surveys, industry data, patents, R&D spending, and the like. This data can lack the level of detail needed to actual capture the innovation processes *in situ*. Many of the new theories of innovation have been attempting to broaden the scope of innovation research in order to address

the shortcomings of the data. More than just a change in scope, a change in context is required.

What the makerspaces offer is a site for observing the potential emergence of an innovation system or ecosystem at a small scale, where the sources of innovation may be easier to detect and the processes more visible. Arguably, the makerspace environment, which is largely populated by individual creators, allows for innovation to occur differently than in more commonly studied contexts like universities, corporate R&D labs, or even “skunkworks.”⁹ The makerspace affords an opportunity to examine innovation dynamics up close and personally. This would suggest a hands-on, qualitative approach.

As noted in Chapter 3, several new trends are emerging in theories of innovation and entrepreneurship that seek to go beyond the traditional boundaries of firm-centered technological change and to consider more of the subjective social, personal and cultural dynamics (Gloor et al., 2007; Potts et al., 2008; Sousa et al., 2012). The traditions out of which the makerspace movement evolved represent some of the ongoing challenges that have led to emergent theories of innovation.

4.2 Ethnographic Method

The purpose of this research is to observe the dynamics of innovation processes present at a makerspace as engaged in by the participants. Ethnography has been described as the “holistic depiction of uncontrived group interaction over a period of time, faithfully representing participant views and meanings” (Goetz & LeCompte, 1984, p. 51). Ethnographic research has a long tradition, drawing a line back to the early cultural anthropology of Malinowski (2013

⁹ A skunkworks is an autonomous research group, often within a corporate framework, popularized by Lockheed (Augsdorfer, 2005)

[1922]). Subsequently, however, the development of this domain has been inherently multidisciplinary. The challenge within the field has often been bridging the gap between the various groups conducting ethnographic fieldwork, as the different research goals have allowed for the development of different approaches and different dialogues about the method (Eisenhart, 1988).

This can include different methods for gathering the data. Eisenhart (1988) highlights four: participant observation, ethnographic interviewing, a search for artifacts, and researcher introspection. These roughly coincide with the methods highlighted by other authors: social interaction, direct observation, informal interviewing, collecting documents, etc. (Seale, 2012; Silverman, 1993). Using all four in a mixed-method approach allows for a degree of *triangulation* to be achieved. Much like the surveyor or the historian (Gaddis, 2002), the ethnographer is able to home in on the object of study, and bolster the validity of the findings. This mixed-method approach was employed in this research project in a comparative case study framework. The work draws on the idea of a multi-sited ethnography – research conducted over different locations separated by some distance (Atkinson, Coffey, Delamont, Lofland, & Lofland, 2001; Harkness, 2007) – or alternatively, a connective ethnography which follows participants across multiple sites (Field and Kafai, 2009; Hine 2000).

4.2.1 The Case Study Approach

The case study is a descriptive approach to looking at the qualitative research data (Yin, 2009). Five key factors of case study design include the questions, propositions, and unit of analysis, the linking logic, and the interpretation criteria (Yin, 2009). The research questions have been discussed previously: 1) how are the ideas and inspirations for the development of a new technology transferred between developers and their collaborators, 2) what sources of

inspiration and new knowledge do the developers use for both the subjective functional components of their design, and finally 3) what is the role of the makerspace as a third place where developers can collaborate and share ideas during the development process? The proposition that a makerspace functions as a site of innovation, with a micro-system of innovation present, and the distinctions between the spaces as relevant, derives from these questions. For this research project, the unit of analysis for each case study (Yin, 2009) will be the makerspace itself. The scope of each study expands beyond that, however, as each space participates in key events critical to the space but taking place outside its boundaries. These extrinsic events will also be incorporated into the cases where appropriate.

For this study, the sites were chosen for their proximity, relevance, and degree of connection to a particular maker-centric event. These choices are addressed in the research design. Logistics and feasibility were the primary factors that impacted these choices; conducting multiple case studies did not. Certain decisions for and against will always need to be made when conducting ethnographic research (Yin, 2009, p. 45). As Yin states, there is an advantage to looking at multiple cases in the research design: the makerspaces under observation may exhibit elements of single cases – unique, critical, and revelatory (Yin, 2009, pp. 38–42) – but the particulars of the cases are not known before the investigation begins. Following Kidder and Judd (1986), validity and reliability of the observation was enhanced by the use of multiple data-gathering methods at each site. These consisted of external observation, participant observation, and interviews.

The interpretive framework

The logic of the work is inherent in the choice of method, as “ethnography ... actually labels a kind of logic rather than a unit of study” (Agar, 2004, p.17). How this connects to the

analysis for this research project is hinted at by Bucciarelli (1984), as he distinguishes between two different modes of analysis in his NSF study on engineering practices: a narrative mode focused on the generation of thick description of the observational data, and a topical mode, in which the instrumental categories are labeled prior to analysis. This dovetails with the iterative nature of the qualitative work being done (Heyink & Tymstra, 1993). The sites are examined, notes are taken, and categories are drawn and labeled based on the initial observations. This ‘generic’ labeling allows for the creation of categories of analysis. Bucciarelli (1984) draws from anthropology to establish four categories: ecology, social organization, development cycle, cosmology. Following the lead of his established research, we create four categorical *archetypes*: people, artifacts, rules, and governance structures. These categories allow work to be conducted in the topical mode, where the events from the narrative mode, gathered in the case studies, can be unpacked and explored.

The case studies combine descriptive information of the site with a narrative of the dynamic interactions between the participants, the materials, and the tools at the location. This helped uncover the micro-level innovation that occurs at the site. Three separate case studies were built, based on primary ethnographic research (Denzin & Lincoln, 2018) conducted at the makerspaces and events associated with those spaces. These case studies each consist of an environmental scan of the facilities, a detailed description of the organization, and an account of the practices and interactions undertaken and ongoing within. Part of the participant observation is “watching modes of appearing,” as described by Spiegelberger in Bruyn (1970, p. 284). Even familiar objects like a 3D printer or drill press will be subject to the same thick description as everything else in the space so that the observer’s familiarity with the artifact does not (significantly) impact their own understanding. Data was gathered via participant observation,

recorded via diaries, journals, and electronic recording, as recommended by Seale (2012, p. 163).

This data forms the bulk of the material in the case studies.

In order to address the research question on the influence of *subjective* elements at makerspaces (and the ancillary questions of the transfer of ideas, sources of inspiration and new knowledge, and the makerspace's role as a third place), the researcher employed direct observation, and conducted personal interviews with the participants at the makerspace. The interviews were arranged via personal contact with principals at various makerspaces, and evolved out of the observational portions of the case study research. These interviews followed a semi-structured format, and a journal was kept and the conversation electronically recorded (Byrne, 2012; Seale, 2012). Current approaches in innovation research that have attempt to track the influence of subjective elements in innovation use statistical information such as sales data, market share, and visibility, and these approaches are both outside the scope of this current study and not finely-tuned enough to find evidence of the existence of those subjective elements. This data functions at a larger scale than the micro-occurrences that are actually present within a makerspace. By bringing the lens closer to the subject and undertaking a qualitative approach, those micro-occurrences being to appear within the field of view.

4.2.2 Bias

As the researcher is embedded as an observer in each of the case studies and comes to the study of the sites as a knowledgeable practitioner with some background and familiarity on the sites and the processes there will inherently be some degree of bias in the fieldwork. One of the key challenges of ethnographic research is addressing this bias inherent on part of the observer (Eisenhart, 1988; Seale, 2012; Silverman, 1993). A means to address this bias is to show my own personal standpoint of the researcher, so that my biases – my enthusiasm, my background,

and my affinity for the subject – can be taken into account. My *enthusiasm* for makerspaces stems from the possibilities they hold; a recognition of the potential that they contain to allow me to work on projects of a personal interest, and the recognition that others may have access to the same or similar potential, regardless of their background. My *background* was largely technical. I grew up as the son of a machinist turned draftsman, with access to a large array of tools at home, and visits childhood visits to the workplace included looking at awe at the scale prototypes of what was to become the Syncrude plant being constructed in northern Alberta. I attended a vocational high school in Calgary with extensive facilities for the trades, including the electrical and electronics classrooms that existed alongside the more traditional wood, metal, and auto body shops present on the campus. Following high school, I pursued the trades at the Southern Alberta Institute of Technology, before a working career and subsequent return to academia. What this background provides is a working knowledge of the trades, their language, tools, and skills, as well as an ingrained understanding of what the makers are attempting to do when engaged in a project. Learned behaviors of design, prototyping, testing, and building were all part and part of the process of my learned experience.

My background manifests itself as an *affinity* for the makers and their work. This allows for access to the members of the group, and allows for myself, as the primary research instrument (Seale, 2012) to approach them on their own terms. This addresses one of the key concerns of early ethnographers: the issue of membership (Schutz, 1964). While not completely of the group, I am sufficiently of it to not be a complete stranger, though I am able to deploy the stranger's level of objectivity when making observations of the group for which I have an affinity. Thus, despite the unavoidable nature of bias, rather than being a negative it is something that can be mitigated and even embraced. Heyink and Tymstra (1993) suggest that

this perspective is to be encouraged: “The researcher's influence on the results of his survey are not considered an inconvenient 'bias', but it is described explicitly and as an essential factor of the method of research.” (1993, p. 292).

4.2.3 Validation

Aside from bias, the other key concern for ethnographic field work is the validity of the data (Silverman, 1993, p. 149). In an ethnographic project, validity entails ensuring that the truth value of the research is maintained, and that claims do not draw on spurious correlations. Validity is ultimately about trust in the research and the methodological process, and can be achieved through the *reliability* of the study.

Reliability is the consistency of the study, with which “instances are assigned to the same category ...by the same observer on different occasions” (Hammersley, 1992). For this study, with a single observer situated at multiple sites over a lengthy period, the key element is *synchronic* reliability: “the similarity of observations in the same time-period” (Silverman, 1993, p. 145). This research project is iterative – the same sites are revisited multiple times, with periods of reflection in between the periods of immersion within the makerspaces – and reliability can be drawn through the consistency of observations across the 18-month time-period of the research. Through the repeated visits, consistencies in observed patterns of behavior can be drawn from the observations, and inconsistencies can be reviewed and addressed.

What the ethnographic method provides, relative to this project and the innovation literature, is a method of generating data that goes beyond traditional quantitative metrics and is not reliably captured by heterodox innovation studies, that would otherwise get lost in the process. The makerspaces are all unique in their own way, and must be navigated slightly different in each instance. The *iterative* nature of ethnography, continually returning to the sites,

looking at different events (or the same event or space in different contexts: time of day or time of year) allows for distinctions to be made in those subjective elements that are common or unique to each makerspace. The challenges are in scope and scale, in never feeling that it is done, of not knowing where the edges of the map may be, and for how long the study may need to run. This is impacted by the limited means and resources available to this study. As the length of time increases, the management of the data, the number of notebooks, recordings, images, and the like also increases, further compounding the task of analyzing the data. The strengths of the ethnographic method outweigh these challenges. The task of contributing something new to innovation research, of comparing sites of innovation during the lengthy *process* of innovation, requires the hard work and effort that goes into conducting a multi-sited longitudinal study, such as the one in this research project.

4.3 Detailed Description of Research Project

The case studies were developed out of the ethnographic fieldwork conducted by the researcher. No additional researchers worked on the project. Findings were recorded in a number of different documents, including several journals, audio files, and a gallery of photographs and video images. A timeline of visits and key events is included in Appendix A, and has been noted in the case studies where relevant to a specific observation, quote, or occurrence. The fieldwork took place at a number of different sites, as required. There were four primary makerspaces visited during the 18-month period of observation (two were combined as one location moved and re-named itself). In addition to these, there were a number of locations where maker-related events and exhibitions were being held that were also included. Interviews took place at multiple locations, including the makerspaces, the events, and on

occasion various alternate locations such as coffee shops, food courts, and offices, depending on subject availability. Detail on the sites follows.

4.3.1 Research Sites

For this study, the primary focus of research was the physical locations of three Calgary area makerspaces and related events affiliated with those spaces, observed directly during an 18-month period from 2016 to 2018. The research followed the meetings and development process of groups in the Calgary area leading up to the events, mostly through their work at communal makerspaces including Protospace, Archeloft and Fuse33, and the virtual ‘space’ occupied by the Tikkun Olam Makers volunteer group. Events include the 2016 MakeFashion show, held at the end of March for the last several years, and the 2017 TOM Makeathon. The MakeFashion event draws together a number of developers from the Southern Alberta region, as well as a few groups from outside the geographical boundary, and pairs them with artists and fashion designers to produce works of ‘wearable technology’ – computerized and technologized fashion products, similar to the Apple iWatch. Several of these sites have “open house” days where the site is available to the public, as well as weekly and monthly events, and these were visited and examined. Taken together, this time surrounding an event at a makerspace provides a window where the communication processes and knowledge dynamics may be studied. In addition, the immediacy of an upcoming event increases the likelihood that members are present and actively involved in projects at a makerspace. The ethnographic fieldwork was conducted during the period beginning in the summer of 2016 leading to the September 2016 MiniMakerFaire and Beakerhead Festival, and continuing through to the fall of 2018. The rationale for choosing these locations as part of the multi-sited ethnography is their size and relative public profile in the community.

As the makerspaces are actively engaged in the public sphere, it is easier both to interact with them, and to observe their interactions (thought their members) with the community at large. A number of other events exhibit the same general characteristics as the proposed cases: these characteristics include a focus on a single communal event, with participants from a number of different groups and communities that display their work after a short but intense development process leading up to the event. Example events include: the Beakerhead Festival in Calgary, a celebration of arts and science; the Calgary Hackathon, a data-based development festival sponsored by the City of Calgary; and the Calgary MiniMakerFaireYYC, which has been running since 2013 and is patterned after the format popularized by the Maker Foundation in California and the first Maker Faire in 2006 (Anderson, 2012). The MakeFashion event mentioned above is similar to these, a local annual event that began in 2014, where the engineers and arts communities within Calgary came to display their combined projects. Since their inception, these events have both grown, and command more public notice than most other local alternatives. The MakeFashion event is part of the larger trend towards wearable technology, a market that is expected to significantly grow in coming years, and a technological market that relies heavily on subjective appeal.

4.4 Analysis

The narratives of the three case studies are analyzed with respect to the research questions, with the intent of uncovering the methods and processes of innovation. Each case is reviewed with particular attention paid to the various archetypes of innovation that are present in the space (or its related events). Drawing on Bucciarelli (1984), these archetypes are the categories or domains in which the ethnographic research is situated. Bucciarelli was studying the design processes that occurs within engineering firms (1984, 1988), and while these are not

specific to the makerspaces, they can inform an approach to the analysis. Lacking an established literature on engineering design, Bucciarelli takes a ‘generic’¹⁰ approach in creation of categories of analysis, drawing from anthropology to establish four categories: ecology, social organization, development cycle, cosmology (1984). These categories exist within what Bucciarelli calls the ‘topical’ mode of analysis; having established the ‘narrative’ of the site through observation during a period of time, he returns to the gathered data to tease out the concepts and categories that may be most relevant to the exploration of the data. The categories for this research project differ from his, as the subject matter is different, but the overall tenor is the same. The categories of archetypes in this study include the people, the artifacts, the rules, and the governance structures observed at the sites. Once these archetypes of innovation are isolated, they are used for a comparative analysis of the various archetypes to each other and to the innovation process as a whole.

4.5 Archetypes

Archetypes as used in this dissertation are similar to the platonic idea of an archetype: part exemplar, part stereotype, part cultural form, yet more than any one of these things. The concept of archetypes are typically drawn from popular understanding of psychology, and equated to human actors, including when applied to innovation (e.g. Hill, 2016). Archetypes have a long history with innovation, and the entrepreneur and the firm can both be considered archetypal when mentioned in the literature. Archetypes are best defined by the categories they come in; there is a formalist and structuralist element to them, which brings shape to the innovative activity. The archetypes are ontological categories that can account for multiple

¹⁰ In this case, generic means categorization in different genres

subjects – they may manifest differently in different locations. They also are flat – drawing from flat ontologies (Bogost, 2012) like Actor-Network theory (ANT) (Callon, 1986; Latour, 2005; Law, 1992), the archetypes treat human and non-human actors similarly. But while ANT and similar methods treat their subjects symmetrically (Harman, 2009), the archetypes exhibit a degree of separation; the categories are distinct, and like is compared with like. They archetypes from one category may exhibit influence and impact on other archetypes in other categories, but they generally do not cross over. They are different classes of things.

When used in the context of innovation, these archetypes are the recurrent themes that both come up and encapsulate that Platonic idea of a maker, a makerspace, or an element contained therein. Within a category of archetypes, they are differentiated by theme. These categories include the people, the artifacts, the rules, and the governance structures. For example, the archetype categorized as a governance structure could be the “board of directors,” but each makerspace could instantiate this in a different way. One makerspace could operate as a collective, with an elected board of directors; another could have a volunteer board, voted on, but with several years’ experience in the organization, and relying on outside support; a third may rely on a corporate structure, with a CEO and various VP roles filled. Each of these is identifiable as the “board of directors” and fulfilling those functions, but is identifiably different from each other as well. The description of each of these archetypes, their structures and roles, for each category at each makerspace will be done in the analysis chapter, followed by a combined analysis. These archetypes represent various common themes of innovation. There is some characteristic overlap that exists between the archetypes in a given category: it is possible for an archetype to exhibit multiple characteristics, for something to be both ‘industrial’ and ‘donated’, for example.

The **people** archetypes are the makers, the directors, the facilitators, the instructors, the hobbyists, the casual builder, the curious, etc.; the “who” question about the occupants of a makerspace. The **artifact** archetypes are the tools, the documents, the media, the devices, and the projects. The projects are the most important of this group, because so much of what was observed was tied to the project, and there are formal rules around these, both in deadlines and in work, and in the instantiation of innovation. The project is key. The archetypal **rules** are the operational rules by which the makerspaces function, the “how” by which it operates. They allow for the interactions between the people and the artifacts in the space, and they provide a structure on each of them. Each space has a slightly different set of rules. Some are imposed by the artifacts, some are applied to them, some are related to them. Finally, the archetypal governance **structures** address the “why” questions. They include those things that are intrinsic to the organization and to the makerspace. There are also governance structures that are extrinsic as well. These are the events, the policies, the rules, and regulations that supply an overarching framework on the makers and their spaces.

Within this study, the four categories of archetypes are the people, the artifacts, the rules, and the governance structures. Given the topic of study of makerspaces, a fifth category of the location or place may seem warranted, but that is an archetype that exists at the level of the analysis that we want to investigate, so it is not granular enough. The makerspace is described by the aggregate information of the other archetypes. These four categories of archetypes listed are not exhaustive or exclusive; different analyses may focus on other archetypes. They are simply a way of arranging and parsing this particular set of topical data (Bucciarelli, 1984, p. 190).

Within a given category, different archetypes may exhibit variation in how they manifest when observed in a given case, even though they are largely identifiable as the same. For

example, an archetypical *rule* characteristic of the *empowerment* that exists throughout maker culture may be instantiated differently at each location. This difference does not affect the archetypes as an analytical unit, but how a given archetype is differentiated does provide a means for comparison of the different spaces as they are instantiated.

4.6 Fieldwork

Observation was conducted over a period of 18 months, from 2016 to 2018, and eleven different primary locations in addition to secondary sites. These locations included the makerspaces (four locations), the external meeting areas for TOM (two locations), the sites of events related to each of the makerspaces (five locations) and a number of secondary sites and public locations for interviews. At each of these locations, the researcher initially entered the site as a member of the public, walking through the front door and observing the site as a newcomer to the location. If admission was charged, the researcher purchased a ticket at General Admission or Student rates, as applicable. If a tour of the facility was available, it was taken, but if unsupervised exploration was allowed I would proceed to move through the space and note a detailed log of the facility or site in a journal and take pictures if possible (see Appendix A for details of documentation). Photographs and video were taken in accordance with a CFREB-approved research ethics application.

At the locations, an overview of the facility would provide information on the various groups, individuals, and projects that were on display at the site. A general overview is provided, as the list is non-exhaustive. Photos of objects of interest were taken for later recall and note taking. Documentation from the various sites (e.g., flyers, note pages, business cards, etc.) was also collected for archival and elicitation purposes. These artifacts – the photos, documents, and journal notes – were collected in various folders based on each event (see Appendix A).

Participation in the sites included taking courses (where offered), attending open houses, and members' meetings, monthly and annual general meetings, clean-up events, and other events as available. Additional visits during both peak and off-peak hours were conducted. These allowed for both an insider and outsider perspective on the space, as well as the opportunity to observe the functioning of the space in instances of both high and low participation volumes, with varying degrees of visibility to the public. Differences in the operation of a site during periods of public or open access can be compared to periods of 'normal' operations. During these periods of participation, introductions are made and informal discussion provides the groundwork for identifying individuals willing to be interviewed for the project, who may have specific information or are open to discussing their work for a research perspective.

Interviews were conducted either at the makerspace or at a neutral location. The interviews at neutral locations were conducted for the members of Tikkun Olam Makers, who did not have a regular site of their own. Interviews were semi-structured and focused on the research questions. The interviews were recorded in a journal as well as on a digital file for later playback and recall.

The data collection was an iterative process; sites were visited multiple times, if possible. Some events could only be visited during a single period, but if it was a multi-day event, an attempt was made to visit at different dates and times. Reflection on the observations occurred after each visit or period of observation. This in turn informed subsequent visits. (Additional information on scheduled visits is located in Appendix A).

Section II: Case Studies

This section contains the data gathered during the course of this research: three case studies of three groups of makers and their makerspaces. The groups are located within the Calgary area, though they draw on members from a larger geographical footprint, and include Protospace, the Tikkun Olam Makers, and the Archeloft/Fuse33 group. The research work draws from participant observation at the sites and events, interviews with members, and analysis of their available texts, including both online and printed materials, and the tools and artifacts the makers use. Each of the case studies is structured around a description of the makerspace, the people, projects, events and tools that make up the space and bring it to life, though not necessarily in that order. What the case studies represent is three instantiations or different ways of conceptualizing a “system of innovation.” Each makerspace operates in different ways, with different goals and different members. These systems of innovation exist within the makerspace at a micro-level, and as noted earlier (in Chapter 3), provide an opportunity to view the innovation process in detail.

Protospace.ca

Protospace is one of the older makerspaces in Calgary, and is the one that most closely follows the model of a “traditional” makerspace. It operates as a collective, with membership fees being paid monthly or annually for access to the two light-industrial bays that they currently occupy in Calgary’s Northeast. Tools are either donated or purchased as a capital expense by the group. Other work, maintenance, and general use of the facilities is conducted by the members, and is usually self-directed or done during weekly and monthly events.

TOM: Tikkun Olam Makers

The Tikkun Olam Makers (TOM) is the Calgary chapter of a program that began in Israel in 2013, where the makers were working with persons with disabilities (what TOM calls “need knowers”) in an effort to find solutions that would assist them in daily living that are particular to their needs and that may not exist within the market (or exist only at a prohibitive cost). The group is largely made up of college or university students (often from the Engineering faculty at the University of Calgary or from SAIT, though all are welcome) and other interested individuals. The TOM group is different than the other makerspaces in that the “space” it occupies is mostly virtual; they have semi-regular meetings and take proposals, but they largely use other facilities, and then come together for a 72 hour “Makeathon” where the various groups do blitz work on their need-knowers’ problems over the course of a weekend. How they go about this process is described here.

Archeloft / Fuse33

Archeloft was an artist-focused makerspace situated in a former art gallery in downtown Calgary, where a number of the members were interested in the development of wearable technology. Some of its members were key contributors to the YYCMakerFaire and the annual MakeFashion show in the city. In 2017 Archeloft closed, and the principals moved out of the downtown core to found a new makerspace called Fuse33. Interviews with both members and the principals, the spaces’ role in promoting wearable technology, and the reasons for the move, are included here as part of the case. The combined locations are abbreviated A/F33 unless discussing a specific instance.

Chapter 5: Protospace

The most “typical” of the Calgary Makerspaces, the research at Protospace was conducted via site visits, interviews, and participant observation that occurred over the course of 18 months, from December 2016 to May 2018. Following the background information, the chapter continues with a descriptive narrative walkthrough of the site itself and the digital materials that Protospace hosts and uses. The focus is on the events and activities that are crucial to the development and maintenance of the makerspace as a third place for its members. The people, tools, and other materials are also examined. Within Protospace the intersectionality of makerdom is revealed, as the makers here are into a bit of everything that constitutes the maker universe.

5.1 Background

Founded in 2009, Protospace is one of the older makerspaces in Calgary, and is the one that most closely follows the model of a “traditional” makerspace. It operates as a collective, with membership fees being paid monthly or annually for access to the two light-industrial bays that they currently occupy in Calgary’s NE (J1-078).

Much of the activity of the club takes place virtually. The Google groups, the docs, the archives, and the general discussion, make the place seem much livelier than it otherwise is when only visited in person. The digital objects that are part of the fabric of Protospace include a wiki, a blog, a Google group, a Google drive, a static website, with embedded web objects, and other materials therein.

5.2 A tour of the space

Protospace occupies two bays of a light industrial strip in Calgary's Northeast, situated between an automotive body shop and a geotechnical firm, and surrounded by the proliferation of other similar small and medium businesses that power any major urban area (A1). There is some signage indicating its location, including a placard near the street to help direct in new members during their weekly open houses. The front, street entrance is mostly non-descript, the back garage entrance even more so. Most new members will be introduced to the space from the front (J1-077). Here we see a small lobby or waiting area, with a small desk, a few display units showing off several of the members projects, and various posters and signs for rules and upcoming courses and events. The floor still has the tiled laminate of some prior tenant, and there are other signs of the converted nature of the space. The difference in the space from similar nearby light industrial tenants is readily apparent, however.

To the left is the electronics workbenches and storeroom, with a plethora of testing equipment of various current and historical vintages. Much of it is connected, and shows signs of being in some form of regular use, though some appears to be in someone's state of “maybe someday” anticipation (J1-078). Immediately to the left of that is a closed room with a glass wall – some former manager's front office – now occupied by a row of 3D printers, usually in a state of operation. A monitor and keyboard is on the same shelf, along with a small electronic scale and a tip jar for members to contribute to ongoing costs, on a per-ounce basis. Above and to the side are shelves holding a variety of spools of plastic, like a rack of oversized bobbins, of various makes and materials with labels like PLA, ABS, and Nylon (A1, J2-045).

Further on is a lounge with a unique door entry, as the members have rigged it to open with a pull cord that is not immediately obvious. The lounge itself is like a Victorian sitting

room, with several laser-cut sculptures, and a few video screens about, evoking a steampunk aesthetic. The door beyond is rigged with a push button and slides apart like the doors on the Enterprise (from *Star Trek. The Original Series*, not the later iterations). This leads into a clean and tidy kitchen, with a small vending machine, water cooler, fridge, microwave. This is pretty typical, save for (again) a tip jar for members to contribute to what they use. They are free to bring their own, of course, but contributions to the community are expected, if not exactly mandatory. At this point we have crossed over into the second bay, and a path leads past the storage closet and washrooms to the back. (There are several other doors between this front of the house and the back house, in the lobby and electronics room, but we have passed them on this tour) (J2-045).

The path leads into the back of bay 108, past a pinball machine, into a large two-story space comprised of concrete and cinderblocks. Steel framed industrial shelving is along the left wall, along with project shelving and a large work bench and shop table on the right. The newcomer is assaulted with a cacophony of objects: some light, geometric forms hang from the rafters, signs dot the area, and two large, coffin-like objects with glass lids are immediately on one's left, with attached terminals (A1). These are the laser cutters, usually found in operation on some kind of material. The smell of burnt wood is usually in the area. One cutter is rather large and shows signs of age on its blue-painted construction (J1-110); the other is smaller and more modern (J1-123). The project table exists past this space, three large workbenches put together creating a 6'x9' island in the middle of the room. Beyond this is a rather compact metal working area, containing a metal lathe, mill, and CNC cutter (J1-084,093). Six-foot tall dividers are just beyond that, covered in a thick-black glistening rubber. This encloses the welding area, and provides some protection to the rest of the denizens. The ground floor of the racking to the

left contains an assortment of other metalworking tool on semi-permanent stations: grinders, a chop saw, a drill press. Past this is the after-hours entry and exit, with the security system, pass key, and rigged keylock tied to one of the spaces' Twitter accounts (J1-077). This is the primary entrance for most members during regular hours.

Heading back to the shop table, a set of stairs leads up to a landing with a bell (J1-080). There is a rather large door cut through the cinderblock wall to bay 110. Moving through this leads to the second bay, and the wood shop, which is fully functional and recently expanded. To the right is another set of stairs up to the members' storage, the classroom, and the offices. Near the base of the stairs are the various shelves for material that is free to a good home, or for anyone that needs to use it (J1-081). At any given time, this is a collection of cables, circuit boards, discarded electronics, and various off cuts. The recycling bin and garbage are both located conveniently nearby, signifying its likely next step if left unclaimed. The wood shop, and the wood storage area, is next to this. There is a sizable array of wood shelves, 2x4s, baseboard, strapping, and acrylic and other materials, along with vertical storage for sheets of plywood and mdf, the diet of the laser cutters in the previous bay (J1-081). The table saws, band saw, drill presses and various sanders are all serviced by a shiny new ducting system, installed within the last six months as a capital expense on the behalf of the collective. This has allowed for removal of the (copious) amounts of sawdust generated by the tools, and has improved the overall conditions of the space (J1-134). Past the wood storage are the doors back to the front part of the space, to the lounge and the electronics lab.

Bay 110 continues to the high garage doors that belie its earlier role. Occasionally this open space might be occupied by a member's car while they work on it, though this is (mildly) discouraged. A (large capacity) compressor is nearby, and the open area sometimes does double

duty as a spray booth of sorts, made from a converted Canadian Tire pup tent salvaged (or donated) and repurposed by some enterprising members (J1-133).

???

Upstairs in the loft above the offices are the previously-mentioned member storage, repurposed 6-foot-high metal shelving, with bin locations marked in octal notation. A leather couch and a few chairs surround a table that provides an ample view of Bay 110. A door leads to the multi-function classroom / meeting room, and a few offices. This is the space that hosts the members' meetings and instructional workshops on the various tools (J1-077,084,134,135,165). Within, a half-dozen computers line a low shelf along the wall, with space for other members to open a laptop or portable device. The space is dominated by a conference table, large enough to seat a dozen, with a terminal in the middle connected to the projector to throw light on the wall for presentations or the like (J1-084,093). As with the other spaces, various projects cover the walls, 3D printed gizmos or laser cut artwork, sample cuts or test work. Everywhere shows signs of the members' *presence*. This space is occupied and in use.

Protospace is a hub of activity in terms of technology and practices. There are two parallel streams at work here: traditional crafts and tools, and new tools and techniques. The traditional crafts can include fields like woodworking, cabinetry, machining and milling, and the electronics workbench. The collective experience of the makerspace comes into play with these traditional crafts, and the stock of knowledge of career machinists and cabinetmakers that make up the space is hard to find elsewhere. The new tools and techniques are those that are more typically touted when people describe makerspaces: laser cutters, 3D printers, CNC machines, etc. There is an influx of new machinery that occurs on a semi-regular basis, and with each one the members discover and disseminate the use, as well as collectively discovering the techniques

and best practices that work for the item, both in general, and for the specific context of a shared tool in a makerspace.

5.3 Digital

As important as the physical space is to the makers, the digital life of Protospace is equally vibrant. With Protospace having a number of members with strong computing backgrounds, either professionally or through training or self-teaching, the digital world inhabited by Protospace is quite rich and diverse. Much of this is through their website¹¹ and the ancillary web services linked to it, such as the wiki for the space's information and publically accessible documents, as well as the quick links to the dynamically generated members pages and course information. All member transactions are handled through this locally maintained web service.¹²

More importantly than that are the various services that make use of various Google-branded products, including the Google discussion groups, the Google Drive storage, Google Docs shared documents, and the various calendar tools on offer (J1-077). However, the most important of these, by far, are the discussion forums. Google discussion groups are where most of the digital life of the makerspace occurs. There are two main groups: Protospace-discuss, which is public, searchable, and open to all, with no confidential discussions, and the Protospace-admin group, where the directors can discuss executive business (J1-077).

¹¹ <http://Protospace.ca/>

¹² <https://my.Protospace.ca>

A different source of Protospace's digital life is that of the broader maker web, including digital tool repositories, Free and Open-Source Software, instructional videos on YouTube and other streaming sites, and instruction manuals and project plans for the myriad things that get worked on here. This maker web also functions as a supply source for the array of materials consumed in making, as well as for the components needed to maintain the common (and not so common) tools that are held at the workshop (J1-077,084,110).

The modular platform technologies that characterize user innovation are widespread at Protospace. Additionally, the user-driven innovation has occurred in the various digital components of the makerspace, the website, the wiki, the calendaring app, etc. A few other examples include the door lock, webpage, funding model, etc. (J1-077).

Open innovation is *the* key component of innovation at Protospace, as the FOSS tools and ethos that underlie the maker movement also serve as the foundation for the both the digital life at the makerspace as well as the ethos and ideology that govern the shared space. Both the webserver and many of the programs that are used for the digital and CNC tools are built off of open source software.

5.4 Tools

The tools at Protospace are a mix of new technology, recent innovations in woodworking, and donated and handed-down tools that encompass everything from light industrial metalworking machinery to hobbyist workbench equipment. The space itself functions as a form of tool library, a DIY shop in miniature, with hundreds of items available for the ready use of the members. With respect to the larger tools, user-driven Innovation does occur, as it does with the newer tools as well. The makerspace is in contact with Trotec, the manufacturer of the more

modern of their 2 laser cutters (J1-123), and various members are heavily involved in various web forums and external digital communities when working on electronics, robotics, and 3D-printing projects. Tying into the fundamental maker ideology, the space generally treats all the tools and machinery as potential objects open for innovation (J1-078). Regular maintenance and repairs are conducted by the members of the space, either by the more experienced members, or by those who are interested or invested in a particular tool. This can be seen with the ongoing work on the 21st century tools (3D printers, laser cutter), but more prominently with the vacuum former, the metal lathe, and the metal mill. This work includes: upgrading the machinery to add functionality that may not have been included with the original purchase, gift or build; sourcing parts (which can be difficult for decades-old imported machines) (J1-080); and providing additional labour required to get these tools up and running reliably, and were all factors that were both driven and conducted by members on-and-off over a period of time (J1-080,134).

5.5 Activities & Events

Protospace's main function as a community can be seen in the regular events that are hosted at the site. Some of these are obligatory due to its status as a non-profit. Both the Monthly meeting (J1-080,134,135,165) and the Annual General Meeting (J1-135) must be conducted as they are in the bylaws, yet it is three other regular events that really contribute to the life of the community. These include the Tuesday Open House, the Monthly New Member Orientation (J1-080), and the Monthly clean-up (J1-081). In addition to these mandatory and regular events, there are other events on the calendar – the classes and training (J1-084,093,110,123), movie nights (J1-133), and various other get-togethers that are held at the

space that transform it from a workshop into a club or a community space. These will be detailed in turn.

5.5.1 Monthly Meetings and the AGM.

The mandatory events are those that are more “official,” in that they are listed in the charter of the non-profit that Protospace.ca is listed, and as such must be done on a regular and consistent basis, and they must also follow certain rules of order. Though Robert’s Rules of Order is not explicitly invoked, standards include taking minutes and attendance, and ensuring that there is a quorum (A1, J1-080). Both the Monthly Meetings and the AGM cover much of the same topics, with the AGM conducting additional business including going over the club financials, the election of the current board of directors, and any site-specific business that needs to be addressed, including new capital expenditures (for equipment) and other initiatives (J1-135). Monthly meetings can deal with much of this as well, especially if it is of a time-sensitive nature. Otherwise, the monthly meeting focused on regular business: courses being offered, upcoming events (both internal and external, like when the club does outreach at the Comic Expo or other civic event like the MakerFaire (J1, J2, A1) or Beakerhead festival (J2)), tool maintenance, and other issues (A1, J1-080,134,165).

And while the meetings can be civil, they can still be contentious. There are various groups within the space that have pooled their resources to ensure it operates, but often find themselves brushing against the others. This also occurs with respect to the management / board of directors, and the members at large. As an example, at the monthly meeting of 2018-05-18 (J3-052), there were accusations as to the discretionary use of funds by directors on behalf of the club. This was argued at length, and discussions about the use of the accounting software that is

done by the club, the costs of switching to new software, the issues with the bank allowing either open access, or requiring a full sign-off for any use of funds (thus preventing emergency or time-sensitive use of moneys on behalf of the club) all came to light during the discussion. It can be a bit overwhelming for a dude that just needs a table saw a couple times a month.

Vote counting and tabulation is the key means of resolving issues. Votes are held and tabulated based on the members present. While this is nominally democratic, the tendency for only 20-30 members being present at any given meeting, and for rhetorical suasion to occur during the discussion and debate about any motion means that a small subset of the club will have outsize influence on its direction and day to day operation (J1-165, J3-052). For those members who just want regular and consistent access to the facility, this is not an issue, but it can lead to some disagreements and departures. Proxy voting is also a practice that is normalized, where a member who cannot attend will pass their vote to another on their behalf. On occasion, members (usually just a select few) will solicit proxy votes from those who cannot make it.¹³ There are rules in the guidelines that allow for this (it must be announced to the directors 48 hours prior to the meeting, etc.), but in practice it consolidates multiple votes into the hands of a few of the more vocal members (J3-052).

5.5.2 Open House

The most consistent event at Protospace is the Tuesday night open house (J1-077,133,147). The members of the space have opened the doors of the space to the general public from 7-9 every Tuesday for the last several years, allowing for prospective members or

¹³ As a member, I received an email request on 2018-03-19 to delegate my vote by proxy at an upcoming member's meeting that I would not be able to attend.

interested and curious parties to come in, take a tour or wander about, and see what occurs at the space. The walkthrough is much like the one described at the beginning of this chapter. The open house attracts a high percentage of the regular members as well, as it has become a regular time where one is generally assured of somebody being there. Members will meet, share projects and stories (about technology, the space, their projects, their jobs, the news or whatever is going on), and socialize. A number of members will also go to the local pub after, but that is only for a small subset of the users. A label printer near the front door will generate a name tag for anyone entering the space; mandatory for visitors, optional but strongly encouraged for members (A1). A rack or two of single sheet pamphlets detailing the various tools and programs available at the space is within easy reach of the front desk (F1). These pamphlets cover the usual: laser cutting, 3D printing, the lathe, the wood shop, and some of the digital tools available as well. While the space does have a dominant web presence, the easy availability of the print copy makes it convenient for the prospective member.

The open house is very seasonal and event driven, however. On some evenings, particularly in the summer, there are very few members present, sometimes under a dozen (J1-134). Those that are there will still be hanging out, having a coffee, or working on a project, but the overall energy for the space is lower. It is a place that thrives on busy-ness. This seasonal nature can be due to the environment: when it is nice out and the nights are long, fewer people want to spend time in a workshop. When there is an event upcoming, like the Comics Expo, Beakerhead, MakeFashion, or the MakerFaire – or in the weeks after the event, then visitor numbers are high, and this is something that the space works at in order to attract and retain new members against the churn.

5.5.3 Tours

During the course of the open house night, visitors will be given a tour of the space by one of the members. Often they will wait at the front lobby until there is “enough” people to run the tour (though this is a subjective amount), or every so often, so as not to keep visitors waiting too long. The members providing the tour don’t have a set script to follow, and so with this latitude are free to provide their own information about the tour (J3-036). According to a long-time member, each member giving a tour gives one of two types of talks: the “look at all the cool things you can do” tour, or the “only manly men need to apply; it’s not for everyone” tour (J1-165). One is project and goal driven, and one is identity driven. I call these “inspirational” and “aspirational,” respectively. Which pitch succeeds depends on which talk appeals to which audience. The regular members seem to be a self-selecting group.

5.5.4 New Member Orientation

The other regular event that is hosted at the space is the New Member Orientation (J1-077). This is one of the most important in terms of the culture and community of the makerspace. Occurring on the first Tuesday of every month, this begins around 7:30 or so, after the open house has been running for a bit, to give both current and prospective members time to arrive, tour the space, socialize, etc. Generally hosted by a long-standing member, this event is the real introduction to the makerspace, detailing the policies, procedures, and philosophy. These include the internal rules and procedures, as well as the vetting of new members.

Rule and procedures for the space are simple and to the point. They repeatedly mention the need for respect – some tools are not owned by the space, but are on long term loan, and members may have both projects and materials stored and worked on at the space that took expenditure in time, effort, and money. If unsure, members are asked to speak up, to ask, and to

find out (J1-077). And labelling things is not a bad idea either. As one of the directors explains (during the sessions I attended), the underlying ethos of the space is that of a “Do-ocracy” (J1-078). At its core, a Do-ocracy is about enabling those participating it to be active and autonomous, within reason. The rules of the Do-ocracy are:

- if you can solve a problem or make an improvement: DO IT
- if action harms another maker or project then DON'T
- if unsure, then discuss and contribute

This ethos is situated in an empathic mode: members are advised to balance the Do-ocracy with a concern for others (J1-078).

There are a number of obligations that are requested of members. “No dying” is chief among these, and they do spend some time going over safety concerns. “Respect others” is another, as is reaffirming that this is a “Shared workshop,” with an emphasis on the ‘shared’, and for members to treat equipment properly (with lockout tags, labelling, proper maintenance and clean-up, etc.). There is also a request to maintain the space, to “clean up after yourself +5%.”

The core value for the space, as explicitly mentioned in the orientation is “Cooperatively Sharing Space” (J1-078). Other commandments include “Be excellent to each other”, “Don’t be easily annoyed”, “Don’t be excessively annoying”, and the “golden rule”. These are tailored for a space with a large amount of members who may be very focused on their own work. There are a number of other values that tend to be held in common by the members. According to one of the directors, these include: “rampant consumerism is probably not the best”, so being able to build or craft items you want is a better alternative (they recognize there is some contradiction in this, as a lot of purchasing of new material and new technology does take place at the makerspace) (J1-078). There is also a recognition that “the scientific method is useful” (and

“mysticism, less so”), so test it out, or think things through when attempting a new project. Also, there is a value of “reuse and recycle”, which is endemic to the makerspace (J1-077). A lot of old or discarded tech passes through the space, with members attempting to make something useful of it, refurbish it, salvage it for parts, or when all else fails, trash it. But along that process, a given piece of tech may pass through a number of hands or stations.

The administrative details of the makerspace are also laid out. Protospace is run by a board of directors, who are the legal authority of the operation. During the period of observation there was six members on the board, but it can be amended up or down in the club bylaws (J1-078,079). The official policies were currently in process of inscription and codification, getting them down in one place, as the space was undergoing a period of transition, and dealing with the influx of members, new interest in makerspaces as a whole, and competition in the local area with other makerspaces. More information on the club policies is available through the online archives of the makerspace¹⁴, and pointers to them are also provided to new members during the orientation (J1-077).

Protospace partners with a number of other organizations in the Calgary area, either due to overlap in members and areas of interest or shared goals and ideology. At the time of observation there were twenty partner organizations in the Calgary area, and these included the Calgary Tool Library, FIRST robotics competition, WCRS (Western Canadian Robotics Society), MakerFaire YYC, University of Calgary Engineering, and others (J1-079).

Vetting of new members occurs after a probationary period. This can often take a month or so, depending on the level of commitment of the prospective member. (It took the author

¹⁴ <https://wiki.protospace.ca>

approximately 6 weeks, mostly due to scheduling conflicts (J2-052). During an Open House event on a Tuesday night (J1-080,134) (usually; it could also occur during the Monthly Meetings or AGM, as there would be enough members on hand, but there is usually other business to attend to as well), the prospective member needs to get the signatures of two members in good standing on the application form. In addition, they will have needed to have already attended the New Member Orientation, and likely helped at a monthly clean-up or other event as well. Once this is complete, at the end of the night, the prospective members will be introduced to those assembled, (a minimum of 11 members need to be present in order to be vetted), and they will be questioned after they have introduced themselves and pled their case. Questions can often include “what skills do you have” or “what knowledge do you bring”, but other questions may focus on riddles or bits of nerd pop-culture trivia (Star Trek vs. Star Wars, in the author’s personal example) (J2-052). Once the new member is vetted, they need to register on the website, and a keycard will be prepared for them so they can access the space at any time using the cardlock for the unit (J1-079).

5.6 Training and Instruction

Training and instruction are key elements of the community life at the makerspace. A large part of this is in the use of the tools that are already available. New members have to take a course facilitated by one of the senior members before they are allowed access to the device. Courses will generally cost a nominal fee (usually in the \$5-10 range), and take from 4-7 hours on a Saturday or Sunday, depending on how many people are available or interested. The courses are mandatory, before use of the more advanced equipment in the metal shop (the lathe, mill, and CNC router) (J1-084,093), as well as the laser cutters (J1-110,123), the welding rig,

and several other devices. There is another categories of classes that is based more on interest. Some are offered by members based on projects they are working on, and some are provided by the members bringing in someone to speak about a topic that was of interest. (The development of this latter program was an ongoing process during the period of observation) (J2-050,052).

An example of the kinds of things included on the class board is: Welding: basic MIG, plasma cutting and safety; Woodworking Stationary Saws; Tormach: CAM; Woodworking: stationary tools; Laser cutting and engraving; Electronics: learning to solder; Metal: working with the lathe; Metal: advanced lathe and mill; Welding: Aluminum Spool Gun; and CAD: Introduction to 3D CAD using Fusion (A1). This is not an exhaustive list, yet it covers what was offered during an 8-week period from Sept 30 to Nov 28, 2017.

5.7 People

The people that make up the Protospace are a demographic cross section of Calgary, with a couple of interesting factors. The facility is opening and welcoming of new members, but the regular user base is relatively homogeneous. Demographically, the makerspace is majority male (~98%) and white or of European descent (~95%). Due to membership restrictions, the space does not generally allow unaccompanied minors the use of the facilities, and most of the users are college age and higher (25+). Within this makeup, there are certain groups that tend to coalesce along generational cohorts. There is a set of retirees who enjoy the space as it allows them a place for projects and work that they may not have otherwise. They also have a large amount of experience to draw on when it comes to the use of tools, or for feedback on issues that members might encounter with their projects. There is a group of individuals aged 50+ still working on projects and getting stuff done. These tend to be some of the more involved in the

administration and functioning of the space. There is a large chunk of members in the 30-40 range, stereotypical geeks, makers, or craftsmen, who are building things for the home, or because they lost access to the shop they used to use at the company after getting laid off during the economic downturn. And there is a younger set of the 18-30 crowd who are active online and interested in the new tools and opportunities. These are all generalizations, of course, but these fit with other makerspace research (Moilanen, 2012b; Troxler, 2010; van Holm, 2017). In this instance, Protospace functions as a labour force. As mentioned, Calgary has been heavily involved in oil and gas industries, as well as resource extraction and light manufacture, and so has a large user base within the polity to draw from that is interested in the types of resources that Protospace can offer. Protospace draws heavily on the concept of citizen labour, with their stated political stance of the space as a "Do-ocracy" being closely linked to the idea that the members will get stuff done themselves. The space thrives on the collective labour of its constituents.

5.8 Projects

With over 200 registered (i.e. paying) members monthly, there are a lot of projects being worked on in the space at any given time (J1-135). Some take up significant room on the shelf or workbench, and some appear to be fixtures of the space itself. A simple typology can attempt to classify the projects, based on their description. There are four main categories: DIY crafting, learning or test projects, digital materials, and artistic projects.

DIY/Crafting is the first, as this is the most mundane of the types of projects. These are works that are typical of a workshop or crafting space, and may involve advanced tools and techniques, but are largely rote building or production. Simple 3D prints or laser cuts would also fall in this area; some of it is almost "work for hire" and the space is just used because they have

these tools in an accessible location. Much of the crafting that takes place in the wood shop is also of this variety, when a member needs access to the tools, or when a visitor needs the legs of a piano bench reduced by 2 inches and asks real nice (J1-133).

Learning or test projects are interesting, as they have elements of the DIY process, but they are projects done by a member who is learning a new tool or technique. They can have elements of whimsy: one of the projects by one of the younger members went from a 3D scan of their forearm, to a laser cut foam facsimile (J2), to using that facsimile in a mold (J1-080), subsequently using that mold for a test when exploring how to do metal casting (J1-147), and finally as a mold for the vacuum former (J3-050). The member retained the various forms of this project along the way, and the clear progression can be seen. In all instances, it was either a test or a demo of the tools, in multiple iterations. Members will often retain these test projects, as they may not be interested in continuing to do metal casting (for instance), but wanted to learn the process, so the item becomes a one-off.

In these one-offs and test pieces, the role of the subjective elements of art and aesthetics can be seen as a minor influence – it is present, and some of the end projects can be quite artistic, but it is rarely the stated goal of any project. Still, much attention can be paid to these same aesthetic elements of projects. The dual continuums of utility and beauty are both in play. Often early proof-of-concept prototypes can err to the functional or utilitarian side of things, with aesthetic elements added in on subsequent or final iterations of the project. The users can opt to “make it work, then make it pretty.” It is interesting that this is something that is regularly done; these projects are done by the makers for their own use and consumption, or for display during community events to other makers or the public, so it is not surprising that subjective concerns are accounted.

Digital materials are where many of the more interesting and experimental projects lay. These can include the integration of digital objects or microcontrollers in otherwise mundane pieces, or entirely new or experimental technologies. Examples of the former include various clocks, LED signage, embedded speakers, wireless pick-ups, automatic door sensors, and the like. Often these are done with small kits as the starting basis, but expanded into whatever the maker can create. Others are built based on a template or an idea in *Make* magazine, an Instructable, YouTube video, or similar, and can include larger projects like an arcade cabinet (A1, J3-050) or digital projector. The third set are those wholly new creations, which are often demoed at local exhibitions as items that were created and built by the makerspace (A1, F3).

5.9 Processes

Competitive engagement is a driving source of innovation at Protospace. Much of what makes it work is the collective experience and knowledge of its members, and this is driven by the makeup of the local polity, and tightly bound with its demographics as well. With a broad member base, Protospace bridges several traditional demographic divides, with much younger (18-25) members working alongside the middle-aged (30-55) and retired and semi-retired individuals (55+) who enjoy working in the space, which provides them an outlet for work and craft. For some of the members in the middle group, Protospace represents access to tools and materials that they may no longer have due to a change in work, or economic circumstances. Several members mentioned joining due to the economic downturn in the area in 2014.

There are several other areas of influence for Protospace, including community engagement, funding, and the space's position as a non-profit organization. Protospace is actively involved within its community as a site, engaged in a number of civic events relevant to the maker community, including the YYCMakerFaire, the Calgary Comic Expo, and the

international First Robotics Competition. They also do some outreach and engagement with local schools, though this is on a by-request basis. The industrial nature of Protospace's makerspace does not lend itself to school field trips. The space also functions as a classroom and de facto clubhouse / social area, with some members using the space for BBQs, movie nights, and other more social events with the members in common.

The marketplace is an ancillary factor for Protospace. The space will occasionally engage in market-like functions, providing discounts on certain products through group purchases and local discounts, or access to material suppliers (wood and aluminum specifically). This is a form of demand-driven innovation, for when an unexpected surplus in one area in the local region allows for members of the group to take advantage of a group buy, purchase, or the like, as demand-driven innovation is closely linked to procurement (Gault, p. 108). Otherwise, there isn't a whole lot of "demand" that goes on, outside of that of the members for the space, time, training, and access.

While the natural environment can be an important category for common innovation, at Protospace it is not one that comes into play directly save for the permissive nature of the site. Members can, and do, work on projects that contribute directly back to the natural environment, whether it is exploring home solar, or hydroponic set-ups, or aquaculture, but these are not primary areas of making promoted at Protospace. They are simply something that members can do if they are interested in pursuing it. This allow-ability function of the space can be a feedback to common innovation on its own.

Education, then, is one of the core areas of innovation of Protospace. It is part of their community building, and their new member accessibility and retention. It also serves as a (admittedly minor) revenue stream that shows up on the monthly and annual reports. For the

users, education can serve as both a barrier to entry (it may take time to use a specific tool, based on when `training` is available, or a user has been `certified`, and it also serves as a sunk cost, as members who are invested in an education and certification stream at Protospace may be more likely to remain once those tool privileges have been won. The ongoing education serves at the behest of the group members, as the training is only available if more experienced members possess it. It is also a factor in recruitment, as it is one of the things that comes up when a new candidate's application is reviewed to join the collective. It is central and ongoing.

Business is another prime area of innovation and entrepreneurship. Several members of the space use its sources to prototype or develop new ideas. While few (if any) members are actually running production out of the space, the ties between business and the makerspace are many and direct. This can include everything from deals on material and supplies at local retailers – consumables are a big area of interest among the members, as raw wood, mdf, aluminum and metal, acrylic sheets and printer filaments all get used in high quantities. One of the other ways that business is involved is in the business model: while Protospace is a collective workshop, it has been described (by the board, during one of the monthly members) as a business with 200 customers who require 24/7 access, which is different from the other retail or light industrial shops that share tenancy in the same strip of units.

5.10 Other observations

In the interviews, both from within Protospace, and from the other maker groups, there was a recognition that Protospace may not be a makerspace for everyone. In both the training and the new member orientation, the underlying ethos of masculine DIY culture was recognized as something that was not necessarily for everyone (J1-077, 135, J3-036). Members of the

Tikkun Olam Makers group had approached Protospace, both individually, prior to forming TOM, and collectively as a group, and Protospace was seen as intimidating or a turn-off, and not necessarily interested in having them present (J1-055,064). In addition, several of the founding members have broken away, either due to fractious disputes or differences of opinion. While the maker community in Calgary is large, Protospace is not representative of the entirety of the maker community, but rather just one portion of it. That they more closely tie to the traditional conception of a makerspace may be both a helping and a hindrance for the community at large.

Finally, consumption functions as an anti-category. What this means is that it is a driver for innovation as members of the makerspace are driven away from consumption, or at least traditional modes of consumption, in working on their own projects (J1-078,135,139, J3-050). This does not hold true for all members, and it is a driver for some more than others, but for those that are willing to take up carpentry, welding, or metalwork in order to craft goods for their personal use, let alone those who work on computing or electronic project because of a distrust or dislike for commercial offerings, this can be seen as a driver. It has been noted above that a high amount of consumables is used in the ongoing production that occurs at the makerspace, but this commodity consumption can be seen as anti-consumerist, at least in intention, moving away from retail capitalism.

5.11 Case Study 1 Summary: Protospace

Overall, Protospace in Calgary exhibits characteristics in common with many makerspaces worldwide. Its focus on building and maintaining a community through events and education do not make it atypical, but they contribute to it being successful, having run for nearly a decade and needing to expand its area to meet demand once already during that period. The

tools that it has available are more industrial than many makerspaces, and the facilities are closer to that of a machine shop than other spaces that have been surveyed. While this industrial focus does have an effect on both the membership and the projects that can be undertaken there, it allows for a broader focus of projects overall. This opens up opportunities for development and innovation that might not occur in other settings.

Chapter 6: Tikkun Olam Makers

Tikkun Olam Makers (TOM) is a non-profit that originally was founded in Israel in 2013 that matches teams of inventors and innovators with “need knowers” – persons with a disability – in order to find a solution to aid in their daily life that is not readily available on the market. Built on an open source ethos of sharing and technological development, the TOM group has spread across the world, with chapters being founded in a variety of locations. This case study will outline the activities observed from October 2016 leading up to and during the August 2017 version of the Makeathon that was run by the TOM Calgary group, as well as the projects and profiles of a number of the people involved, and a description of the event itself.

6.1 Background

Tikkun Olam Makers is a charitable non-profit organization that was founded in Israel in 2013. The words are Hebrew, meaning "Repairing the World" (J1-053,058,064). The organization is focused on using the collective efforts of its volunteers to provide solutions for persons with disabilities and their families, for needs that are currently not met (or are perhaps are out of reach in expense) in the market. TOM calls these persons "Need Knowers" (NKs). The Calgary chapter was founded in 2015 as the first TOM group in North America, and has run a number of weekend long events called alternatively Hackathons or Makeathons (J1-053).

TOM draws heavily on the open ethos of the FOSS movement detailed earlier, and stresses this in both their literature, recruitment, and practice. The plans for the various projects are made available in an online repository that is accessible under a Creative Commons license (J1-064). All the participants are aware of this, and it is one of the features of the work that gets buy-in from the participants. This is an exemplar of open innovation. TOM is built on a mandate of open access and protocols, with a demand to release any designs back to the community

through a Creative Commons license. The TOM teams rely on FOSS software and Creative Commons available designs where available to accelerate the development process during the period leading up to (and during) the Makeathon. Open innovation is a crucial element that allows the teams to develop the low cost, custom solutions for the need knowers.

TOM Calgary's method of operations lends itself in sharp contrast to the other more traditional and grounded makerspaces, as the distributed nature of the organization finds itself without a permanent long-term home. However, in terms of attitude, they still exhibit much of the maker ethos. TOM manages the challenges of its distributed nature primarily through its online tools, including Slack, Google Docs, and the parent organization's website (J1-058).

Organizationally, TOM Calgary is a non-profit that was incorporated in March 2016. The event began the previous year, with 4 teams participating in 2015; in 2016, it grew to 8 teams, with a "10x bigger budget" (J1-072). In 2017, this reached 14 teams total, however the members I spoke with did not disclose what that budget was for that year.

The local core membership of TOM Calgary is the organizing committee. This is made up of a number of volunteers. Mostly in their twenties, recent University grads, they are ambitious and highly connected and involved with the community (J1-053,067). They are here by their own choice, and that is reflected in the agency that they employ in their work. It is impressive to see. Demographically, there is a broad spread in both the executive committee (about 50/50 by gender), and the participants of TOM reflect their location and vocation in ethnicity, drawing people of all backgrounds. The only real motivator is the work that they do.

Demographically, the TOM Calgary membership at large outside the committee skews young in age, and is relatively diverse in both gender and ethnicity (J1-149). With the participants composed primarily of university engineering students and recent grads, they are

quite representative of the pool from which they draw. They are also draw heavily on their members as a labour force, as there is a specific goal for the project, with a specific desired outcome over deadlines. This is also unique among makerspaces as whole.

During the course of the year, TOM tends to make use of donated or cheaply available spaces, primarily on the University of Calgary campus. By operating as a student-run “club”, they have access to certain facilities like meeting rooms and board rooms at low or no cost (J1-55,058). This helps to keep the operational budget at a minimum, which allows them to focus funding efforts for the materials and Makeathon event itself.

Brand recognition is key to a number of the efforts of the members of TOM Calgary, as a site of social innovation that they employ. As part of an international project that has organizations in other cities, TOM counts as a brand itself. The TOM brand facilitates social entrepreneurship, acting as a draw for both talent and users, and can aid the organizers when trying to leverage it for funding, space, or other assets required to run the program (J1-059,072). This is used part and parcel with the competitive engagement. Brand recognition still occurs with a few brands affiliating themselves with TOM and the Makeathon event such as the Neil Squire Society and IEEE Spirit, but these largely do not dominate or intrude on either the space or the event as a whole (J1-149).

The nature of the work at TOM Calgary means that as soon as one event is done, planning begins for next year’s event. The growth that the group experienced from 2015 to 2016 was in evidence during the TOM monthly meetings that took place during this time. Direct observation of their monthly meetings began on October 26th, 2016 (J1-053); the group met on the last Wednesday of each month. At this time, they were meeting at the club room in the basement of the University of Calgary Students Centre. It was one place they could get for

nothing by leveraging their leaders' roles as students and masquerading as a student run club.

The room consisted of several 4'x 6' tables stretched in a row as if it were a boardroom, with the members arrayed around it on various folding and wheeled chairs.

During the meeting, the chair Colin directed business left over from the 2016 Makeathon, with follow-up on a number of outstanding projects, and the acceptance of new business as a project to be undertaken throughout the year, possibly prior to the next Makeathon (J1-054). The progress reports followed an assessment tool that they had adopted for the earlier 'thons: A PiNG meeting, where the respondent or team lead for the group or project listed the Progress, Needs, and Goals at the current moment for their team. This immediacy was key. Projects under discussion included: a wheelchair for a stroke patient that the team members had entered into a Design competition for the upcoming April, where the original materials for the hackathon build would not be sufficient; an issue with the IP rights regarding the Team Lift, and whether to treat their invention as a patent or as open source, and here another team commented on their own experience, and recommended speaking to the SEED folks at the University; and some issues with a gyroscopic cane, as they need to refine the build, but also need to replace a number of team members, and are wondering whether the entire project can be continued, or if it should be rebuilt from scratch. A general discussion on shop rates follows, with the TOM leadership noting that the rates for the engineering firm used at the last hackathon were in the neighborhood of \$120/hour, but club rates at the Mechanical Engineering facilities on the University of Calgary campus run from \$8/hour to \$35/hour, depending on the tools used (J1-054). Finally, a new item of business was introduced: a new project for a need knower, with a non-mobile child who cannot move unaided (J1-054). The main issue is that commercial solutions costs in the neighborhood of \$15-30,000, and there are limits on how much the two-level split bungalow the

couple dwells in can be modified. A brainstorming session follows, with a number of potential solutions proposed. Volunteers are requested, and assigned, and a connection between them and the parents is forged. Despite running for over two hours, the meeting ran quickly and efficiently. The TOM Calgary Makeathon is a paradigmatic example of demand-driven innovation. The projects the teams are working on would not get made without the specific and exacting demands of the end user, the need knower. TOM Calgary is an exemplar of the process.

Meetings subsequent to this are similar in kind (J1-067). Focusing on past projects that are still undergoing refinements or follow-up work, or teams that need advice or connections to mentors, industry, IP help, and other preparatory work for the upcoming event.

6.2 The 2017 Makeathon

The 2017 Makeathon ran in the middle of August 2017 (J1-149). Through donations and grants, the organizing committee managed to rent a sizable building for the occasion, and set up in the shell of a print shop in the light industrial sector of the Calgary's Northeast. The previous year's event had taken place in Cochrane, Alberta due to financing and availability. The year before, it ran concurrently with MiniMakerFaire YYC at the TELUS Spark Science Center (J0), but that building was not set up to accommodate the needs of a 24/7 weekend event like the Makeathon. The 2017 facility afforded the power and utilities requirements that the group needed, with enough office space and other rooms to allow for additional meeting rooms, fab rooms, and sleeping quarters as necessary.

The 2017 Makeathon featured 14 teams, each working on a project for a particular need-knower to solve an issue in their daily life (J1-157-159). Each of the teams included anywhere from 4-8 members. There were a few younger participants under 18, but the majority were in the

20 to 25-year-old age group typical of the university students and the organizing committee (J1-151).

The space was organized along several long rows of folding tables, which dominated the space. These tables were lined with folding chairs, and power was doled out to each row, with lengths of extension cords taped down to the concrete floor (A2, J1-149). Several other tables were off to the side, filled with the material brought to the event by the Neil Square Society, a non-profit out of Vancouver, British Columbia, that was working on building breath control devices for persons with reduced mobility (J1-149).

Around the main space were a number of fabricator areas: one with workbenches and hand tools; one with a number of power tools, including saws and a drill press; and one that contained several 3D printers for rapid prototyping of parts for the project teams (A2). An ad-hoc wireless network was set-up for the event, allowing internet access to the teams and the ability to send jobs to the printers, or externally. As the site was well-situated, it provided a lot of the resources, even if everything was assembled on a temporary basis, with the expectation that the site would be cleaned out after the weekend as if the makerspace had never existed. The focus was on the projects and achieving results over the 72 hours. A brief overview of those projects follows.

6.2.1 Projects

There were 12 main projects undertaken by groups at the 2017 TOM Makeathon (J1-150). Teams numbered between three and seven members, and they drew on a broad spectrum of member backgrounds and experiences. The demographic diversity was quite pronounced, and will be commented on later (J1-151).

Team Under Pressure – tasked with making a monitoring system / pressure sensor pad for a wheelchair seat, to avoid bedsores and other issues from prolonged seating. An electronically wired pad with 40 nodes was linked back to an iPad which sent push notifications to the user (J1-157).

Team Flexclip – an extended toeclipper for a need-knower with Spina Bifida, that allows them to act with a degree of independence in their personal maintenance. Solutions included a footrest, mirror, and clipper mechanism (J1-157).

Team Sharlene Speaks – a simple, non-distracting device for visual communication, with buttons linked to audio clips tied to an icon, that can be used for language training. The 10 buttons on the device are covered in plastic to allow for new icons to be added (J1-157).

Team Homegrown Cyclone – a modified tricycle to accommodate the needs of the need-knower, a double-leg amputee with early onset Parkinson's disease. No commercially available trikes are able to accommodate the height on the leg that the amputation occurred, and a locking break mechanism needed to be added as well (J1-157).

Team Lipsync Mounting – using the lipsync breath-activated input devices supplied by volunteers from the Neil Squire society, the team was tasked with providing three different mounting devices to meet the needs of three different need-knowers (J1-158).

Team Aaron's Finger Channel Surfer – the team modified a TV remote to be accessible to a need knower with cerebral palsy with mobility restricted to one hand. The remote was linked to the functionality of the joystick control for the wheelchair, so that it could serve multiple functions (J1-158).

Team Remote Blood Glucose Monitor – the need knower is a 12-year old with Type I diabetes. Their current monitor sends data to the computer, but the issue is that the alarm is too

low, and the parents do not have a way to monitor it remotely. The team created a wrist-worn device to intercept current info that transmits to an online server the parents have access to (J1-158).

Team Quad Brake – created a hand cycle brake for quadriplegics, with electronic signals rather than mechanical, to allow for easier use by the need knower (J1-158).

Team Help Remy – the need knower suffers from hemiplegia, which makes speech over the phone difficult. The team created an app with a number of pre-programmed messages. Some difficulties occurred in connecting this to the phone audio for it to be used live during a call (J1-158).

Team Heads Up – created a head brace for a need knower with amyotrophic lateral sclerosis (ALS) that holds up their chin, and is light enough to be removed by them allowing them to eat and drink unaided (J1-159).

Team Smartsense – need knower has an autistic son who gets overwhelmed with information on the internet, and needed a more accessible format. The team used the Wikipedia API to strip most content from webpages and present search results in a more easily understood format (J1-159).

Team Aut2Talk – created an app that helps an autistic child express their emotions, by reflecting facial expression back to him and reinforcing through audio recordings of his own voice what that expression is. This has aided the child in becoming more verbal (J1-159).

In addition to the teams, there were sponsors and other involved groups, several of which gave talks at the closing gala. These groups include:

Neil Squire Society – The Neil Squire Society¹⁵ is a Vancouver-based non-profit that focuses on person with disabilities. They led a project during the Makeathon – Makers Making Change¹⁶ – where people could assemble LipSync devices, using electronics kits and 3D printed casings. These devices allow for breath activation and control of computer input, similar to a mouse or joystick, and are widely used by persons with reduced mobility. The original SipNPuff device was created by the Neil Squire Society 30 years ago with a connection to an Apple IIe machine, and they have continued to be involved in their development. These completed LipSync pieces are distributed by the organization to persons in need of the device (J1-157).

IEEE SIGHT – The SIGHT (Special Interest Group on Humanitarian Technology) group is currently working with the Siksika First Nation on developing solar electrification and providing workshops to the members of the Nation. They were involved with TOM in 2016 in Cochrane, and remained a sponsor in 2017 (J1-159).¹⁷

Innovate Calgary – the business accelerator / incubator division of the University of Calgary is also involved in providing resources to TOM Calgary (J1-158).

Calgary Jewish Foundation – the CJF has been involved as a sponsor, with a number of members providing mentorship and leadership for the group, especially in TOM Calgary's earlier years (J0).

6.2.2 People

The people involved in TOM Calgary are split between several groups: the organizers, the need-knowers, and the volunteers themselves. Both the organizers and the volunteers could

¹⁵ <http://www.neilsquire.ca/about/>

¹⁶ <https://www.makersmakingchange.com/>

¹⁷ <http://sight.ieee.org/547-2/>

be classified as makers, and they may self-identify as such (J1-067). The need knowers as clients occupy a special position, outside of the norm for most traditional makerspaces. The organizers are generally young, recent college grads, though they may be working on a second or third degree, and are by and large in their late 20s (J1-067,149). The volunteers cover the gamut of age and demographic categories (J1-151), but those that are outside of college are or recently graduated are the exception (J1-151), not the rule, and may be involved for support on a particular tool or fulfilling a particular role (i.e. machining or logistics, etc.). Demographically, there is a pretty broad distribution among these two groups, outside of the traditional WEIRD archetypes assumed for the Calgary area, and for the maker community as a whole (J1-151, 157-159). The need knowers span the breadth of every demographic category one can think of.

During the period of observation from October 2016 to August 2017, a number of interviews were conducted with various members of the organizing committee of TOM Calgary, in advance of the 2017 Makeathon (J1-055,058,064,072). Drawing from the organizing committee, their contributions provide a snapshot of the profiles of both the TOM Calgary membership, and the larger maker community in Calgary. Condensed profiles of Kathryn, Colin, Tom, and Lauren follow.

Kathryn is the current president of TOM Calgary, which has now been rolled under the broader auspices of TOM Alberta (at the time of the interview) is a PhD student in Bio Medicine at the University of Calgary, who saw TOM as a means of involvement with Biomedical development (J1-058). Her research interests were “somewhat obscure,” looking at neuroengineering and neuroprosthetics (“both repair and augmentation”; “devices that interface with brain tissue”). She had been involved with TOM for 12 months at the time, and recently took on the role of President after the second Calgary Makeathon. Her role with TOM is “99%

leadership,” seeing her heavily involved in grants, partnerships, connecting with communities, as well as outreach and recruiting. Her previous background in Electrical Engineering (with a BEng and MEng) did not prepare her for her current role. Her interest in the maker movement and her university research was directly influenced by an interest in transhumanism, driven by television shows including *Star Trek: The Next Generation*, *Fringe*, and *House*. According to Kathryn “It was TV, TV that did it.” From her perspective, the biggest challenges facing TOM are the lack of space: “definitely a hindrance,” requiring significant workarounds. Other challenges in the Calgary maker community include the poor gender representation, though the wearables community does improve this somewhat.

Colin is one of the founding members of TOM Calgary (J1-072). He has a background in Energy Engineering, participating in the 1st graduate class in this discipline at the University of Calgary. Prior to that, he had a degree as a Mechanical Engineering Technician from SAIT, and as a Journeyman Cabinetmaker earned in a vocational high school. He volunteers with the Calgary Tool Library, in addition to TOM. Along with a friend, he saw a YouTube video for TOM Global, which sparked an interest in the program, and after starting the group with several other friends and participating alongside the 2015 YYC MiniMakerFaire, they received interest from the Jewish Community Center for initial funding.

Lauren has an electrical engineering background, with a MEng (J1-055). Her interaction with the maker community in Calgary started following the 2014 MakerFaire, when she bought a 3D printer for personal use and experimentation. She visited Protospace, but found the space intimidating, and so stepped back and looked for other avenues to participate, and joined TOM in July of 2016. Her current project with TOM is a grabber cane for a NK with Parkinson’s, working alongside 3 other members: a practicing Mechanical Engineer, a PhD in Electrical

Engineering, and a 16-year old with an interest in robotics. Her role in TOM has shifted to leadership, though her personal interest is in design. Part of that role is her understanding that the NKs need to be “kept in the loop”. By her estimation, the project achieved a functional design during the 2016 Makeathon (which was the goal), but lacked the subjective qualities that would allow for continued use and uptake. The team met the “technological threshold”, but did not achieve an optimal design during the 72-hour timeframe of the Makeathon. Having practicing engineers as part of the team was a huge bonus: Lauren claims that the TOM Makeathon was comparable to her capstone project, which was more intensive and rewarding, especially with the development of a tangible product. In addition to these, a number of new learned skills were developed, with the use and development of the motors and clutch for the gyroscopic crutch, and use of new materials in the 3D printers (in this case a flexible plastic). For her, TOM provided an experience and opportunity that was “Everything I could ever hope for” (J1-057), making what she had desired from her capstone back in 2013 come true.

Brian’s background is in health science research, with a MSc in Biomedical Engineering. He has been involved in Mechanical Engineering since the age of 10 (J1-064). He is accustomed to fab spaces through this experience, and has drifted into project management by necessity, not background. Behind the scenes he is involved in the fundraising for TOM, where approximately 80% of the funding (at the time of the interview in November 2016) was via Friend-of-Friend networks; other methods of fundraising met with limited success. Brian is also involved in community engagement for TOM, dealing with both traditional media and social media. With respect to making, he is currently focusing on the subjective components of a past project, where the NK commented that the device looked “like medical equipment”. Brian’s experience calls into question the model that TOM uses for dealing with past projects, and whether a support or

service model really works in the context of a non-profit, where TOM will essentially create a prototype over the course of a weekend, and then hand over that prototype (and the essential files) as part of the project. Brian came to TOM through his interest in makerspaces, and characterizes TOM as a “social enterprise” (J1-065). TOM’s current iteration, as a “space without a space,” has more cons than positives, but there are some, as their situation forces them to have greater community engagement, even as they lack some of the long-term solutions that having a physical site would provide.

6.2.3 Makeathon Weekend

The 2017 Makeathon began on Friday, August, 25 2017, and ran through for 72 hours until the following Sunday (J2-113, J1-149). There was some set-up work being done by the board members and volunteers on the Thursday evening before the kick-off, and a tour of the facility showed what they had to work with (J3-xxx). For the 2017 Makeathon, the group was based in a vacant light-industrial building in Calgary’s Northeast, that prior to the 2014 economic downturn had housed a fairly sizable printing company that serviced the Oilfield sector. With the industrial printers removed, it was a cavernous concrete room, surrounded by a gallery, and various empty offices and facilities. Electrical cable was being placed down to service several rows of folding tables, and the entrance was being staffed behind a table with handouts, T-shirts, and instructional bundles. Various posters and other signage was being placed by the volunteers for the crowd to come for the weekend. Finally, a temporary Wi-Fi hub was being set-up in the central area to allow for connectivity for the members and participants during the duration of the event.

Three separate “workshop” areas were assembled in the larger space, grouped around the types of tools that would be used there. These were a power tool area, with a lathe, drill press,

power saw, and the like, near the back of the building with adequate venting to the outside; a hand-tool area with several larger workbenches, clamps, vises, drill, and other assorted working areas; and a fabrication area, with several 3D-printers set-up and ready to go so the members could rapidly create new parts as needed during the duration of the event, when time is precious.

The event started Friday afternoon (J3-xxx). The teams had already been assigned, and had met with their need knowers prior to the event, so they had an idea as to the needs and requirements. There was a budget limit for the teams, and a strict time limit; the competition would cease in 72 hours, at Noon on Sunday. The first day saw a frenzy of activity, as teams assembled, received their initial instructions, and began work on their respective projects. Their work was focused from the outset; the nature of the hackathon meant that most teams had already met the need knowers in the weeks leading up to the event, or were at least aware of the challenges they faced and the expectations they had. Teams began assembling the required materials for the projects, allocating their resources, assigning workers based on skill, background, and interest, and splitting into sub-teams to get initial work done. A few of the teams began with a detailed meeting, outlining requirements (I would later find these were the teams with more software-focused solutions). After a few hours of activity, a PiNG meeting (J1-150) was called to do a quick check-in with the teams and confirm status of the work. One of the important items was getting estimates from the teams of the feasibility of the project (J1-150). This would end up being a recurrent theme over the course of the weekend. The PiNG meetings are one of TOM Calgary's innovative practices (J1-053,149), something they have every 6-8 hours during the course of the event, outlining the needs, requirements, and current status of the project. This process is currently adopted from outside the TOM, reflective of engineering practice in other environments, but is relevant here.

Within the constraints of the Makeathon, user-driven innovation does not happen, at least as traditionally defined. In this case, treating the project teams as the “users,” there is no time within the 72 hours of the Makeathon to interact with manufacturers, unless they have a pre-established relationship for the product or the goods. User-driven innovation demands these communication channels as necessary for the innovation to occur. However, if we consider the need-knower as the user, and the TOM project teams as fulfilling the function of “firms”, then the TOM makerspace is almost completely a case of user-driven innovation. The need-knowers will be working hand-in-hand with the TOM project teams during the course of the Makeathon, spending several hours each in direct contact with them as the project is built, tested, and refined. This is unique, as very few makerspaces, or other outlets, are as intimately connected between “user” and “firm”, save for perhaps bespoke tailors, haute couture fashion, or startup incubators (and even these are slightly removed from the process).

By Saturday at noon, things had gotten a little behind (J1-149). I was there in advance of the next PiNG check in with the teams, but that got pushed back to after 2 pm. It was conducted with 21 hours to go, and the organizers going around the room and letting everyone know this would be the last push, and with it being a weekend, probably their best chance to get materials if required (J1-150). As part of this PiNG, the Needs and Goals were described in terms of “to the next PiNG”, which should be running on time at approximately 8 pm, give or take. The teams were advised that the documentation for the projects would need to be submitted online according to the templates available on the TOM.org project page (J1-150). The expense limit of \$400 was discussed, letting teams know how remuneration would work.

Most of the teams were making progress. Parts were being fabricated: machined, printed, cut, etc. For those parts that required metalwork, getting those parts machined in time was

turning out to be a challenge (J1-150). The volunteers that were assisting with the machining were able to keep up, but it was a time-intensive part of the operation. This was also true of the 3D printed parts as well. While TOM can employ a lot of tools and techniques that are new to both the users and the firm as a whole, as new equipment or techniques are introduced to the users, these are rarely (directly) innovative.

Other teams faced similar challenges, regardless of the medium they worked in whether it was with electrical components, microcontrollers, or data structures. A team with a pressure pad sensor was spending an inordinate amount of time debugging the Arduino system in order to connect the controller to an Android phone (they had given up on a previous iPhone version) (J1-150). A team working on a glucose monitor is trying to optimize the power consumption so they can provide more mobility to the need-knower (J1-150). This highlights how user innovation functions at TOM Calgary, as the easy availability of platform technologies are what facilitate and allow for the Makeathon to function in the first place. Several of the key technologies, including the Arduino and/or Raspberry Pi micro controller boards, collaboration software such as Slack and Google Docs, and open APIs for Apple, Google, and others allow for the teams to bootstrap the projects quickly and efficiently.

A text-to-speech converter team has decided to drop an off-the-shelf solution due to safety and reliability issues, and is working on a new solution (J1-150). A different Arduino board has been swapped in another project for reliability concerns. A field trip to Active Components (a local electronics supplier) is organized by a couple of the teams that need replacement parts (J1-150). The list is lengthy, but well organized and well run. The amount of cross-chatter is minimal for a meeting with 20+ people present.

By 7 pm on the Saturday, the teams are still working, but are more dispersed (J1-151). Some teams have taken a dinner break, or relocated some of their work. The lines of folding tables are still arrayed with power cords, laptops, and coffee mugs (A2). There are approximately 50 makers right now, huddled around their projects. The gender split is 40:10, male to female (J1-151). Several of the need knowers are sitting with the teams, providing feedback, helping calibrate projects as they advance, or otherwise just viewing the progress. About 30 other people are around, most volunteers, with a few mentors and certified tool users (the machinists).

At 8 pm, they have the PiNG meeting with 16 hours to go. Some teams are done, or close to it (J1-151,152). The emoji app is developed, and they are now crafting the case components (J1-152). The joystick project used an off-site fabricator to get the components done quicker than was available locally, and are in the process of assembly: “basically done” at this point (J1-151). The autism speaks team is looking for some external help with debugging the microcontroller, they ask around. A team is having RF issues with the devices they are using, causing communication issues between the objects. The handcycle team is facing a challenge now, as they have the wrong steel for a part, but they assure the TOM leader that it is “workable” (J1-151). Interface issues are dominating, issues with iOS, and others. A final few teams are evaluating different prototypes they have been working on, to decide on which will receive their efforts during the final push coming over the next 16 hours (J1-151). As a final note for the meeting, the TOM leadership reminds the teams of the importance (and requirement) of the documentation for TOM Global, and asks if anyone has started (J1-152). The teams need to provide a 2-minute presentation during the gala tomorrow, with a maximum of 4 slides, focusing

on the Title (and Team), the Problem, the Solution, and the Build Story. The teams broke quickly, and got back to work. The night promised a frenzy of activity.

By Sunday morning, 7 am, there was evidence of that activity (J1-152). Speaking with Brian, who is still awake, the last team had just gone to sleep at 6:30 am, with another team at 4:30 am, and 2:30 before that. Not quite around the clock, but many of the teams worked late, alternating on and off with various members active at any given time. The final PiNG meeting is scheduled for 9 am (J1-153). Coffee and breakfast is delivered at 8 am, provided gratis by one of the sponsors (Tim Hortons). Perhaps 10 makers are up and working, and more straggle in. The high-pitched whirr of the drill press gets going at 8:20 am. With four hours left, three teams are actively working on their projects, and a few other makers milling about, with facilitators and related people making up the rest of the population (J1-153). Within 20 minutes, the population doubles, and the beehive of innovation feels like it is fully underway again. Frantic work continues, with some need knowers present with the teams. The degree of focus in the teams is intense: directed at the problem at hand, to the exclusion of outside interference or stimuli in some cases.

The final PiNG meeting takes place at 10:30 am (J1-153). It is quick and abbreviated, focused on confirmation of final status, as well as logistic information. The feedback from the teams, the Progress Needs and Goals, is substantially different from ones that have come before: “1) Printing new part (for size); 2) reprint of part, sautering; 3) PCB for debug, testing GUI; 4) App complete, working on UX; 5) assembly; 6) demo version ready, full part may miss deadline; 7) added padding for NK; 8) Bluetooth working, calling issues; 9) make it look pretty” (J1-153). A shift has occurred in the final push, though the exact point is different for different teams, where the change has gone from work on ‘functional’ elements of the build, and towards

‘aesthetic’ ones: GUIs, UXs, paint, sizing, ‘prettiness’ (J1-153). This is the last consideration. It does not matter if it is pretty if it does not work.

After this meeting work continues in the run-up to the call for “tools down” at Noon. Several teams have already decamped to other sites – either the University of Calgary or elsewhere – that have the facilities they require to complete the project. Teams are either mostly done, and working on the additional information like presentation slides and project docs, or are simply milling about and discussing other matters: school, games, TV, etc. Normal socializing and bonding activities. For those teams not at that stage, however, the work remains frantic, and the focus is “like a laser.” By 11:45 am, it looks like most of the teams are done (J1-154), though a few could likely see some “adjustments” done between now and the gala.

The cry for “Tools down!” goes out approximately at Noon. (J1-154). The clock remains somewhat flexible. Things shut down, and groups stand up and stretch. A couple of groups that were in the midst of sautering stuff finish the circuit or connection they were working on. Mostly, everyone is done. People wander outside to take advantage of the (free) food truck at the premises (Won Ton King is gathering some new fans today) (A2). After lunch the groups begin packing and assembling their equipment, and readying the projects for transport to the IEEE building on the University of Calgary campus. The display begins at 3 pm.

6.2.4 The Gala

Following the conclusion of the Makeathon at Noon on the Sunday, the teams had several hours to pack-up, transport their projects, and prepare them for the demonstration at 3 pm and gala event scheduled for 4 pm (J1-155). The event was held at the IEEE Building on the University of Calgary campus; according to TOM’s organizers, ideally it would be closer to the event (J1-154), but the building on campus, part of the Engineering buildings, provided an

appropriate venue for the gala. Twelve of the teams were showcased during the event, and they were shown to the crowd by the teams, with speeches from donors and dignitaries interspersed throughout. During the presentations, the need-knowers were front and center (A2), and this gave the audience a visual connection with those who would most benefit from the efforts of the makers involved in the project this year.

The projects are set up in a display area off to the side, on the ground floor lobby of the IEEE building, allowing the audience to walk through and ask questions of the makers (A2, J1-155). They are able to provide both technical information about their project, and the solution, as well as some of the challenges faced when working on the project.

The MC begins talking on the microphone, guiding the audience to take their seats, and provides some introductory information about the event: the numbers, the teams, the people and the sponsors (J1-154). She stresses the role of TOM: as a volunteer organization that bridges the gap between industry and persons with disabilities. The? Industry often fails to provide a solution if the market for a given product is less than 10,000 individuals, and when they do they often lack the personalization and customizations options that the NKs require.

The keynote speaker for the gala is introduced: Kiran Dhaliwal, an entrepreneur and need-knower (J1-154). She represents how the TOM teams' work with Need Knowers can have a positive impact on their lives, and she is well positioned to recognize and articulate the direct connection between making, innovation, and entrepreneurship. A Calgary native, she speaks of the energy and vibrancy of Calgary, even post-downturn, and how Calgary functions as an incubator for new and novel products due to the STEM proliferation and concentration that occurs in the city. She states that these are the tools available for the development and proliferation of new technology. Making these technologies available for the disabled has

changed work, allowing the NKs to participate more fully in life. For her, the stand-up wheelchair (A2) she uses (Kiran is quadriplegic) is liberating, allowing her greater function in her entrepreneurship. As she states, this technology: “truly changes people’s lives”. The challenge, or one of them, is that of an idea gap: “why only 12” teams? Why not implement them, and the process on a more regular basis?” (J1-155). She describes the challenge of staying motivated on a project like this – a marathon build over the course of a weekend – and that the solution for this, the source of motivation is the prospect of “meaningful work”. This meaningfulness is integral in the process of innovation, as she describes it (J1-155). Wondering aloud why innovations fail, she attributes it to the proprietary seeking of credit. By letting go of this, and the need to build a solution from scratch every time, developers and engineers are better able to leverage material that is already out there. This speaks to the underlying paradigms of the TOM movement, but also the maker ethos and FOSS movements as well. Kiran’s closing argument are words of encouragement to those working in small teams. Quoting Rupert Murdoch: ‘Big won’t beat small; fast will beat slow’ (J1-155).

The keynote speaker is followed by Dr. John Bertram of the University of Calgary Biomedical Engineering graduate program (J1-155). He stresses the value in “engagement with the community”, and how TOM, as an organization and collective is an exemplar of that. Speaking of the impact of radical innovations on society, of technologies like the internet or the automobile, Dr. Bertram describes how “it can be difficult to have the imagination to see what they will do”. According to the Doctor, the impacts of the projects are real but often unknown at the time of invention, and it is not until later, with hindsight, when we see what the changes the innovations have wrought. This is true on both the small, personal level of the interactions of the

TOM project teams with the NKs, and on the broader level of the effects of the innovations for society at large.

Following the main speakers, the gala proceeds with a presentation of the various teams, with the providing a short presentation of the project and demo of its use (J1-157-159). The need knower is introduced to the audience, as are all members of the team, and each team is given its due for finding a solution to the challenges it faced. (The order of the groups brought to stage is the same as listed earlier in this chapter; see page 113). Several of the significant sponsors also speak to the audience, and provide words of encouragement and support for the coming year.

The evening is rounded out with a speech from Colin Frances, outgoing TOM Calgary President and current representative of UCAN Developer Groups (J1-160). UCAN is the University Campus Ability Network. He speaks to the work done by the group, tying it to social media via #makingthedifference, as they engage with a TOM Makeathon-like project spread out over 4 months (or a single semester). The ongoing spread and engagement of the projects and processes started by TOM Calgary is real.

There are some final words of recognition and thanks, for the members and volunteers of the project teams, for the members of Kadima Dynamics and the Calgary Tool Library, and a few final words of note: in 2015 TOM Calgary was the smallest TOM group in the world, and the first in North America. By 2017 they had tied with New York City in terms of number of teams participating (J1-160). The advantages of the local context, of the people and civic attitude of Calgary are stressed as reasons for making it happen.

With that the gala, and the 2017 TOM Calgary Makeathon weekend, closes. Work begins anew for the incoming president, and the requirements for 2018. Expectations will be high, but the assembled makers have built an impressive community, that exists mostly virtually,

without a permanent space. Several groups are being sprung from this, from the roots of the original participants, with Kadima Dynamics, TOM Alberta, and the UCAN all drawing a lineage through TOM members.

6.3 TOM Calgary and areas of innovation

There are a number of areas where TOM Calgary has direct influence on areas of common innovation. Health is the primary area here, as the overall efforts of the TOM makerspace are devoted to improving the daily life of those persons with disabilities that have engaged with TOM as “Need Knowers”. Whether it is to make life more manageable or bearable, or simply to aid and assist, providing succor for those in need, the end goal of TOM's efforts is directly connected to Health.

Education as a category of innovation is also present, in nearly all aspects of TOM's work. Education on the part of the teams, with the knowledge transfer taking place as they learn of the needs and requirements of the Need Knowers through dialogue, observation and research, to the use of new tools, techniques, artifacts and objects in the pursuit of their goal. The role that the TOM Makeathon can also play as a capstone project for the engineering students and recent grads is also fundamental: several of the interview subjects commented on the Makeathon event being more valuable or a greater learning experience than their final project at the University (J1-056).

The sciences and the arts are both present, though neither are the dominant area of innovation. There is a process of learning, discovery, and experimentation that occurs during the TOM Makeathon, as the teams investigate the particular requirements of the need knower, prototype and test potential solutions, experiment with new materials or techniques based on feedback from the NK, and iterate through these steps multiple times. As it is practiced, this

process mirrors the process described by Swann (2009)¹⁸. Even though the teams may have an initial design based on analysis conducted prior to the beginning of the event so they have a clear focus during its duration, this cycle of learning and experimentation will come into play. Art and aesthetic requirements are often left by the wayside during the busy hustle of the time-restricted Makeathon (J1-153). However, it is a category that interview subjects are often conscious of their need for, and several expressed that explicitly during the interview (J1-056,064). Subjective features can help with long-term adoption of the project by the need knower, and are often one of the chief factors that teams will work on during after-action events.

Both business and marketing function as something as an anti-category for TOM Calgary. It is recognized that they are both tied to the mercantile wealth that is tied to business innovation (Swann, 2015), but it is the lack of interest or presence of both that serves as a motivator for TOM projects. Often the TOM work can come about because the specific demands of the need knower is too specific for a given manufacturer to provide a retail solution, or would do so at a prohibitive cost. The absence of the business to service these needs functions as a form of market failure, and TOM as an organization fills the gap where it exists. It can be recognized that these projects would not be viable, but the FOSS ethos that connects TOM with open innovation allows for these solutions created by TOM to filter back to the market (J1-054). There are after-action events where TOM project teams have looked to taking their designs to the market, with some success (J1-054,067). There is an opportunity here for some bridging between the TOM groups and another incubator project.

¹⁸ See p.39 in Chapter 3 of this document.

6.4 Case Study 2 Summary: TOM Calgary

TOM Calgary and its hackathon represent relatively unique approaches to the makerspace dynamic, with the space existing virtually and transitorily for much of the year, prior to its coalescence during a specific weekend in the summer. To continue with a metaphor, TOM Calgary is a beehive whose bees range over a very large territory, that come together for a specific purpose during a specific weekend on the calendar to make their honey. The amount of work that gets done during the makeathon is extraordinary. However, there are some concerns about the longevity of any given project, and how much some of them are projects that are compensating for market failure. With the lack of continuance that a physical space provides, TOM Calgary lives and dies based on the interest and drive of its board members, and their ability to sustain funding and interest in the larger community.

Chapter 7: Archeloft / Fuse33

Archeloft was an artist focused makerspace situated in a former art gallery in downtown Calgary that focused on the development of wearable technology. Some of its members were key contributors to the YYCMakerFaire and the annual MakeFashion show in the city. In 2017 Archeloft closed, and the principals moved out of the downtown core to found a new Makerspace called Fuse33. Observation was conducted from 2016 to 2018, and a number of the principals were interviewed, particularly about the reasons for the move. Based on the nature of the move and change, the sections in this case will be split in two, noting the event.

7.1 Background

The makerspace that is currently known as Fuse33 sits in the business revitalization district along the eastern portion of Calgary's 17th Avenue (J2-047). It began life over 10 years earlier as an offshoot of the Endeavour Arts Gallery in the city's Beltline on 1st street and 12th avenue, Southwest (J0). During this time the owners Shannon and Maria Hoover began getting more involved with the Calgary Maker community, hosting workshops and development of the early maker scene in the city. After some time, the gallery was shut down and transformed into Archeloft, a makerspace on the same site in the heart of the city (J2-047,J1-061). Much of this was a rebranding, and a change of the place from a gallery to a functional artist's studio. The amount of space devoted to traditional making was minimal, at least initially.

With the roots of the makerspace in the Endeavour Art Gallery, taking over that space and then transforming into Archeloft, before moving to the Fuse33 location, the arts are deeply interwoven with this particular makerspace. Much of the original work, and some of the business model, is still drawn from these roots, where artists rented out the space to function as a studio workshop that was co-located with the makerspace (J2-047). The connections that this

space has with the MakeFashion events and community is strong, and the drive toward allowing for making in the artistic realm (or with subjective elements) is quite developed (J0). Several of the principals were involved with external artist studios such as Jeff DeBoer's (J0), and these collaborations proved fruitful, resulting in some of the more innovative work done at local makerspaces. There is an entrepreneurial interaction with the artistic community that takes place here as well, with the site functioning as an incubator for artists or other to take off and get their own space.

7.2 Locations

7.2.1 Archeloft 2016

Archeloft occupies the second story above a mixed-use strip of stores in Calgary's Beltline, a fringe of older houses, retail, and light industrial dwellings that ring the South side of the city's core. The area is undergoing a new wave of gentrification, as coffee shops and yoga studios return to an area that had been relatively abandoned for several years as spaces more attractive to recent capital investment took priority. The Archeloft space was formerly an art studio, run by some of the same principals, converted to a makerspace to coincide with the market opportunity and the owner's interests (J2-047). Prior to that it had been a nightclub, a studio, a variety of places, and the evidence of this continuous repurposing of space can be seen in several of the features: the layers of paint and tile, the utilities, and most notably the plumbing (J0).

The makerspace is barely obvious from the street, with a placard occasionally being available on the sidewalk, and a sign within the glass door (A3). The main entrance is through a narrow (2-foot-wide) staircase that leads to the space above. The loft itself is fairly wide and open – a 12 ft. high ceiling gives a fair amount of space – and the east-facing street front

windows let in a lot of sunlight during the day (J2-047). The space still has hardwood floors that evince its earlier roots, and the space is open from wall to wall, though furniture and tables do divide the space into obvious sections. Arriving at the landing at the top of the stairs, the visitor is confronted with the vast array of projects that are underway (J2-047). The open plan makes everything that is being worked on visible to some degree. The landing has a small table on it, covered in pamphlets and business cards, and to the right of the landing is a small espresso bar. The owner/operator of the espresso bar operates it as part of the space. Turning to the left, the entrant sees a large worktable, 4 regular shop tables pushed together, occupying the center of the space. a number of projects sit on top of it, mostly electronics related, and wheeled shop stools ring the table to be used at a moment's notice (J2-048). Underneath the table, visible but tucked away, are scores of Rubbermaid and other plastic containers, holding projects and materials for various work, dimly hinted at through the translucent acrylic (J1-061).

Continuing on the clockwise trip around the perimeter of the makerspace, a number of more distinct areas of the space are sectioned off (J2-048). Part of Archeloft's funding model is to rent dedicated space to those artists and makers who want it, and lack the means to own their own space (J2-048). In this way Archeloft functions as a dual-purpose makerspace and incubator. One of the first spaces that one passes is from a local leather goods artist, who in the course of a year has generated enough business to look into pursuing her own place. The material she has left at Archeloft is in the process of being transferred over, but a few pieces remain, as an indicator of success and a reminder of where to find her. Archeloft charges by the size of these dedicated areas, within the larger makerspace (J2-048), so there is a different incentive on those that rent room to derive revenue from it, or at least not to keep it unoccupied. There is turnover evident at the space, over time, a tumult of movement and change.

Moving further brings the visitor to another large dedicated space, this one occupied by a documentary filmmaker and mixed media artist (J1-061). Tools of the trade abound, with a number of projects visible and being worked on. The prime window spot is taken up by an array of materials from the artist's projects; it serves as a de facto office and meeting spot within downtown Calgary, with a cache of cool thrown in. A few other work tables are nearby, close to the window, with the thickly lacquered finish on the wood top showing signs of use, and the green industrial primer of the metal frame showing chips and wear. Some of these tables show signs of being claimed with projects on the go, even though the makers are absent at the moment, with the smaller tables charged at a lower rate by the space. These ones don't show the more permanent occupation of the spaces described previously, however.

Moving to the far southeast corner, another large space is occupied, by a husband and wife artist/maker team (J1-061). He is upcycling used ammo boxes into guitar amplifiers; she is upcycling raw cardboard into cat dwellings, and working on a set of art pieces in transparent acrylic (J1-063). The worktable is occupied by the materials for the current work; various paints, inks and brushes, a makeshift dish made out of aluminum foil to be disposed of for the epoxy, the same lining the top to prevent anything getting through to the surface of the table. The various acrylic plates are assembled into the frame as they are completed. Work continues on the amplifiers as well; it takes some time to complete each one, but there is enough of a demand to warrant the time spent.

We have moved around the makerspace to the south wall. Along here, the makers have built up vertically, turning the area into a makeshift booth (J2-48). The next several feet of wall are occupied by vendors with materials more typical of a makerspace: laser cut artwork, lampshades, and the like; and a 3D printer club/vendor/material supplier (J2-048, F3). The

materials are arrayed around the space, business cards, an array of samples with prices, and a pointer to services (J2-048). The 3D printers in the next booth are moving, crafting objects based on the instructions drawn from an .STL file on a nearby laptop (J2-048). More material is available; the printers have a display for purchase as either a kit for home assembly (following the Betty Crocker or IKEA model of owner investiture, where a small amount of labour provided by the owner increases the affinity to a commodity product), or pre-assembled under a more traditional retail paradigm. They also have an array of the parts and filaments available, if needed (F3), and are linked to an enthusiasts' club, drawing members from the local universities and community at large.

The tone of the makerspace shifts here going west along the wall, with a couple tables devoted to textiles, sewing, and fashion (J1-061). Pieces of art are in this back corner, and the space opens up onto an area with several sewing frames and mannequins, and a few clothing racks within the area. It is somewhat brighter here, with the yellow light from overhead providing warmth. The shift represents the dichotomy of the space: the traditional maker focus, and the space specific focus on fashion and wearable technology. There are still nearby benches of course, with digital multimeters, sautering irons, and other tools of a different trade (J1-061), signaling the meeting of old and new craft industries, the hard and soft, and the intersectionality of makerdom, where anything that can be hacked or electronified is permissible and allowed. The tools available shift here as well, with a sewing machine and spools nearby (J1-061). The juxtaposition with the 3D printer – off to the left, still within the viewer's peripheral vision – is striking. Both taking spools of material, chattering away, under command and control, both with a legacy that runs through the punch cards of the Jacquard looms and the subsequent digitization of everything into a binary code understandable by our tools. There are no Jacquard looms in the

sewing area – not in this makerspace (J1-061), though they do exist in others (coons, 2018). The remainder of this back corner is given over to the textiles. Rolls of fabric and material, thread, and a larger table for measuring and cutting.

A more casual area exists to the viewers right, back in the center, occupying a space between the textiles and the large central table (J1-061). Given over to a low couch and a couple chairs and a table, it is a place for different work to take place; a meeting, a conversation, a thought, etc. Everything is loose and easily reconfigured, for an event, or exhibition, or just the need for floor space. All important functions, vital to the operations of the space.

We have nearly completed our tour of the space. Past a collection of dresses and costumes, a few more clothing racks, is a small hallway to the facilities and utilities (J0,J1-061). Reflective of the legacy of an 80-year-old building that has been continually repurposed during its existence by new occupants, and made to serve their needs, the hallway shows signs of the successive habitations, with layer upon layer indicating the archaeology of the space. The plumbing serves the tiny washrooms, and water is available (J0). Conduit for more modern services exists on the outside of the walls, painted over in a thick industrial white. Additional bulk storage exists with plastic containers filled with materials and media. A small space for food preparation (J1-061), the cramped spaces of so many back-of-house offices and buildings and restaurants, ubiquitous and everywhere.

7.2.2 Fuse33

Fuse33, the second space founded by the same principals as Archeloft, shares several traits in common with the old. Built in an old auto-body shop on 17th Ave East in Calgary's Forest Lawn district (J2-135), the area is currently undergoing a rebirth, as a massive amount of investment locally is spent on revitalizing the area, and a rapid bus line with nearby stops all

allow for easier access (J2-135). The space still has the massive roll-up doors typical of an auto body shop, while the old service counter area serves as a front office and meeting area (J1-169). Opening the frosted glass door allows access into this area (J1-169). A large OLED display is opposite the entrance, displaying upcoming events and motivational images on a continual slideshow loop (J1-169). The front room has more of the aura of a kitschy coffee shop than an industrial workshop: the front counter looks like it was appropriated from one, cut of a long thick slab of wood, with a cut and polished surfaced and a raw facing exposed to the viewer (A3,J1-169). The far right wall contains shelves made from long beams, strapped against the wall, constituting the space's physical library and repository of maker knowledge (J1-169). The books here are from a number of different eras on nearly all subjects relevant to a makerspace (A3,J1-169). Several low coffee tables support a Keurig machine and a water bottle. A portable clothes rack serves duty for the winter coats and jackets of the members. A shiny wood table with half a dozen chairs fills the rest of the room; the center of it occupied by members' things, and a single laminated page offering the plans for the table is taped to the corner closest to the newcomer to the space (A3). The overall place is inviting, and shows signs of inhabitation, but isn't that populated on a weekday afternoon (J2-137). The makers are off doing other things.

There are signs of the life of the space strewn throughout, though. Business cards and pamphlets are everywhere (F3). A large stand-up poster announcing a local community engagement and revitalization program exists between the main door of the space and the bar (A3). Beside that is the promo standup for Fuse33 itself, billing itself as "Calgary's biggest community shop", and showing the various membership tiers: Maker (\$60/month); MakerPlus (\$95/month) and MakerPro (\$130/month) (A3). Each tier comes with various levels of access to the space and the tools therein. A chalkboard behind the door cheerfully announces upcoming

training sessions, as if it was out of a trendy cafe that happened to offer certification in woodworking (Wednesday, \$40) metalworking (Saturday, \$40) and CNC certification every Monday (also \$40)(A3). In the first room, there are outward signs of the revenue stream and funding model, as well as the transactional nature of the service. It is community, but at a cost.

Fuse33 is a more full-service makerspace (offering a wider range of construction and fabrication opportunities) than its predecessor (A3,F3,J1-169). Those tiers, explicitly labelled "Maker", allow for varied levels of access, from the first tier that allows 3 drop in visits, and additional visits on a pay-per-use basis, as well as discounts on classes and the like. The more advanced tiers offer both unlimited visits during business hours (9 am – 9 pm. 7 days a week), and in the case of the most advanced tier unlimited storage, access to a dedicated workspace, and a digital entry code for 24/7 visitation (A3,F3,J1-169). Open innovation is present, as the makerspace draws on the FOSS tools that are inherent in the field, but it seems to be occurring at a more subdued level. It is not driving the underlying ideology of the space, and while the tools are there, there are barriers to entry and use.

Passing through those doors leads one into the shop floor. The checkerboard of vinyl tiling of the auto-body shop remains on the floor (A3), a remnant and a reminder of the inherent ability of makerspaces to reuse, recycle, and repurpose the materials and environment around them (J2-135). Industrial orange shop racking divides the space in two, allowing for the tools for wood-working and metal to be cordoned off from each other. The racking is filled with wood, and some members' projects as well. There's enough material here (some available for purchase) to allow for projects to be undertaken without an extra trip to the hardware store (A3). Shop tables are throughout the area closest to the entrance, tools and machines are further in the back, often out of direct line of sight. The space is clean and tidy; as much as one can be for a shared

workshop. Things are packed away, and while tools are evident, they are not filling every available area.

In the midday, the shop area is bright, with light coming in from the bay doors (J2-137). Walking through the spaces sees the more high-technology devices, the fabricators and laser cutters apportioned away from the shop floor, in what appears to be the old parts counter room of the body shop (J2-135). There is plenty of room and material here for work to be done on the members' projects. The second bay holds some of the larger machines. An array of saws, drills presses and lathes are stationed here on the shop floor. The mill is here as well (J2-135). Despite the number of tools on the shop floor, the area feels spacious, and there is room around them to engage in various projects without necessarily being on top of your neighbors. Everything has been recently swept up, and there isn't a lot of extra construction or components nearby.

A set of stairs near the back of the bay lead upstairs to the loft (J2-135). What was once offices, a break room, and additional storage space is now an area devoted to textiles and sewing, with sewing machines on one bench, and materials and a table nearby for the projects themselves. A continuity can be seen here, materials and tools carried over from the previous space. There are signs of work directly on the devices (J2-135), and the separate area, lit by electric light rather than the daylight of the main bay, allows for the precision work of sewing to get done without interference from the heavy machinery of the shop floor.

The rest of the loft area is devoted to member storage and the electronics workbenches (J2-135,J1-169). Materials are available for use, and the members have made the area their own. There are signs of use as well, but despite this the area feels relatively clean and well maintained. There are some older projects in storage, but only a minimal amount. The few signifiers of the

former purpose of the loft (auto parts storage) (A3, J2-135) come from the shelving and racks.

Most of the regular work of the space appears to be conducted elsewhere.

Brand recognition is a strong element at A/F33 – both internally and externally. The space is strongly branded with a sense of visual identity, and levels for various events, activities, and the space itself (J2-135). These are all linked to a social media presence, and they actively engage in projecting a consumer presence. There is also recognition and branding of some of the makers projects themselves (J2-135), as this makerspace functions as an incubator for some of the makers as they build their business and then move out to more permanent (i.e. dedicated) facilities (J1-169). A/F33 currently houses several artisans' workspaces as part of their business model, and they market their brand independently.

The A/F33 makerspaces innovates in both terms of technology and practices, with respect to their lead role in the development of new technologies relating to wearable fashion, and their exploratory work in biohacking. The practices that are involved here are also slightly different, as A/F33 fulfills some of the functions of an incubator, encouraging artists to set-up an area of the space while they take the time to get their business on its feet and underway.

The A/F33 space also is influenced by user innovation as it both makes *and creates* the modular platform technologies that are indicative of the area. They draw on some of the FOSS software that are used or the background in both the tools, and the material components common in wearable technology seen at MakeFashion events draw heavily on FOSS projects like Arduino and Raspberry Pi microcontrollers. Members of the A/F33 space have also contributed to User innovation by making (and selling) a wearable technology kit that can be bought by others users, schools, institutions for use there.

A/F33 has actively approached governmental and non-governmental organizations for additional funding and support, especially as they transitioned to the new space at F33 (J2-135). This is a prime example of Competitive engagement, as they leverage those resources for the betterment of the space.

A/F33 has a number of members who belong to visible minorities, and it does draw on a younger, urban demographic, but the biggest demographic difference is in gender (J1-169). The male/female split, while not quite 50/50, does approach that, and features a much larger number of their projects. Whether this is due to one of the founders being female, the foundations of the space as an art gallery, or their focus on wearable technologies and other areas of innovation in aesthetic categories (i.e. “soft” innovation; see page 52) is unclear at this time.

What the institutional background does do, however, is direct the innovation based on the labour force involved. A/F33 has large institutional stocks of knowledge and human capital based on its history and the makeup of its members (J1-169) in the aforementioned fields of wearable technology, and to a lesser degree in the creative industries and biohacking (F3).

The A/F33 makerspace has been the space with the most significant changes during the period under observation. This has contributed to a shift or broadening in scope, and with this shift a change in the innovation components has occurred as well. From its initial focus on wearable technologies, with room for electronics work and 3D printing at Archeloft, the larger space of Fuse33 has allowed for more space and infrastructure dependent projects to be undertaken, including welding, woodwork, laser and plasma cutting. The space affords the opportunity to pursue these projects to the group, but there are some more subtle changes as well. The space becomes divided between the various craft spaces, causing separation between the

groups, and the broadened scope allows for more, but it has become more of a ‘general purpose’ makerspace, less identifiable as a site for ‘wearable technologies’ than it was in the past.

7.3 Makers and Members

The membership of Archeloft/Fuse 33 is distinct from the other makerspaces in their age demographic composition, and backgrounds. Drawing more from the local art and design community, as is their focus, these spaces have a number of people who are accustomed to crafting and creating with a goal toward producing works that emphasize their subjective elements (J2-135), including works of wearable technology that include fashion pieces, artists looking to grow or expand their business, and contributors to local arts festivals like Beakerhead and MakeFashion. In addition to the founders / owners, there are several members who have been consistent participants in both spaces (J1-061,135), some of whom moved with the makerspace as it changed locations.

7.4 Events

Both Archeloft and Fuse33 are heavily involved in maker events in the Calgary area, with the founders being a driving force in creating the first MakerFaire in Calgary (J0,), and partnering with the broader maker community in the city. The members have also participated in technology showcases in areas like Shenzhen, China, Europe, and at the CES (Consumer Electronics Show) in Las Vegas (A3)¹⁹. This event-based approach has had a number of significant effects: it serves as a focus for projects (either by members or from the outside); it

¹⁹ Information about past shows is at <http://www.makefashion.ca/events/>

provides local visibility; and it drives recruitment. With the increased visibility and awareness, new member signups go up, and while not all of them become long term members, some do, and this helps alleviate the churn and turnover often seen with the makerspaces (J1-135). The three key events for the A/F33 group are MiniMakerFaire (J0), the Beakerhead Arts and Science Show (J0), and the MakeFashion Gala (J1-091).

The MiniMakerFaireYYC is the first of these events. Launched in Calgary in 2012 by local fans of the California Maker movement, in an attempt to replicate some of what they had seen internationally, and had been publicized on the internet and in magazines, the initial fair had a small number of exhibitors showing off and displaying their creations. A few information booths were set up. Held in the East Village of Calgary, along the Bow river, close to Fort Calgary outside the since redeveloped and gentrified Bow River pathways. The MiniMakerFaire continued to grow, constantly moving from year to year as it expanded past the size available. In 2017, it occupied a barn in the Spruce Meadows Show Jumping Facility on the south end of Calgary (J4). While this location had enough room, it was somewhat removed from the city, requiring cars or travel by shuttle bus to attend the event. 2017 marked the first time the event was a full MakerFaire, (as opposed to the “mini” ones that had been hosted in Calgary prior). Most MakerFaires follow the “Mini” branding, but licensing and registration fees are paid to Maker Media Inc. in order to associate themselves with the Maker Brand (“Benefits,” n.d.). A list of relevant benefits includes: the reach and visibility of the organization, the licensed materials and logo ware, the promotional opportunities that exist through the publishers, and the community “sharing best practices, suggesting solutions, and providing peer-to-peer support” (“Benefits,” n.d.), and while these benefits do exist and are real for the community, the key beneficiaries are often the event founders themselves.

This is because the role as an event founder has in turn shown a connection of the user-driven innovation occurring at the makerspace, in at least two dimensions. The founders of the MiniMakerFaireYYC (and MakeFashion) made visits to Shenzhen, China to look for production and supply pipelines for their product (J0). Sourcing supply chains in itself is not inherently innovative, but when you need to deal with a manufacturer to help build a new electronic device, then innovation is going to be inherently user-driven as the manufacturer is changing their process to spec the new product. The other form of user-driven innovation is the work done on wearable technologies, in the form of the kits made by one of the members (J4), to the feedback with suppliers for parts that can be useful for wearable technology. These can be seen in evidence at the MakeFashion events.

7.4.1 MakeFashion 2016

Events are critical moments within the maker community, bringing together the disparate groups and providing a specific period for them to share and display their projects to other makers and the broader community. Archeloft and Fuse 33 are tightly linked to MakeFashion, a wearable technology fashion show in Calgary that began in 2012, and initially drew on the talents of local Calgary designers and makers. Over the successive years, it grew in size and spectacle, from the lobby of the WestJet Corporate Center, to occupying the lobby of the TELUS Spark Science center in 2016. Taking place on April 2nd, 2016 (J0), the event was presented with the glitz of a runway fashion show in a major metropolis, and drew a few celebrities, local or visiting, into the audience, as well as an assortment of national and international teams, curators, and judges.

The arrangement at the Science Center presented a central runway down the lobby. The three-story high atrium of the place gave it an open, airy feel, and the rigging was lifted high

upon the stage (J4). There was a row of seating directly around the stage, for VIPs and other dignitaries, but for the majority of the audience the event was standing room only. A number of locations were set up for the cash bars common at catered events, and many of the audience members were milling about, looking at some of the other exhibits. The far end of the lobby was covered by an erected stage, draped in black fabric, with a large video screen projected with images and video from previous shows. The steel and black fabric was incongruous with the curves and laminated wood of the interior décor of the science center (J5).

The event begins at 7 pm. The lights dim, and a video displays on the screen (J5). An MC comes out to give a brief talk about the background and drive behind the show, its beginnings and the underlying ethos of development, craft, design, and making that led to this night, and the works of fashion that would soon be on display.

7.5 Case Study 3 Summary: Archeloft/Fuse33

The combined makerspaces of Archeloft and Fuse33 showcase the dynamism that exists within the community, and the potential for makerspaces to be at the forefront of a new technology, or field of technology, like has occurred with the wearable technology displayed through the MakeFashion event. In some ways the original makerspace arose as an ancillary need of the event, rather than the direct impetus, but this is due to one of the founders being involved with both programs.

A/F33 also represents something unique in the makerspace literature: that of a failed space. There has not been much focus on closed spaces in the makerspace literature: who wants to discuss a failed project. But the transition of the principals, and the transformation of the

space into Fuse33, with the subsequent change in directors allows for the reasons for that failure to be investigated and uncovered, and this will be further explored in subsequent chapters.

Section III: Discussion, Analysis, and Findings

The final section includes three chapters: the discussion of the previous case studies, which looks at the archetypes of people, artifacts, roles, and governance structures that are found in these spaces; the findings, in which we extrapolate the previous analysis in the context of the research questions; and the conclusion. The discussion chapter (Chapter 8) begins with a summation of the case studies: the overlying themes, the data, and what the research was trying to identify. Each of the three cases are analyzed through the lens of the archetypes that inhabit them. Following the cases, this chapter concludes with a combined analysis that looks for continuities or discontinuities between the three cases, and what these dis/continuities say about both innovation and the larger maker culture.

The research findings are presented in Chapter 9. Focusing on various elements common to maker culture as identified in the literature review of Chapter 2, this work will address those elements and examine how they might be applied elsewhere. This chapter begins with a review of the discussion and explicitly ties it back to the innovation literature to see how innovation functions at a makerspace, and the role that subjective elements like aesthetics play. In addition, key factors such as Engagement, the emergence of the Marketeur, the need for a Critical Maker Studies, and the advent of branded anti-consumerism emblematic in the maker movement are discussed.

Chapter 10 presents the final conclusions of the study: what was discovered, what it means, and where it might be applicable in current and future research, in the field of communications and the study of innovation.

Chapter 8: Discussion

The three cases – Protospace, TOM, and Archeloft/Fuse33 – provide three different forms of makerspace, with different objectives and business models employed to achieve their goals, drawing on different demographic sectors of the metropolitan area. These goals go beyond merely sustaining their existence, and include developing their community, market, and increasing reception (the audience) for their various projects. The means by which the makerspaces accomplish this is drawn from the archetypes of innovation that they employ. Archetypes are part exemplar, part stereotype, part cultural form, and in the context of innovation these archetypes include the entrepreneur and the firm. The makerspaces are the aggregate of the various archetypes that they are composed of (Chapter 4, p.78); each makerspace tells a unique story about ‘making’, and these narratives are told through the interaction of these archetypes. The summary of these stories follows. For the remainder of the chapter, each case study is examined for the elements within each category of archetype – people, the artifacts, the rules, and the governance structures. Specific occurrences of subjective elements and their interactions within the archetypes are highlighted. Once the examination of each case is complete, a comparative analysis of these categories across the case studies is conducted. The research questions are also reviewed in terms of the gathered examples. References to the project’s journals (see Appendix A) and theoretical literature are provided where relevant.

8.1 Archetypes Revisited

The analysis of the case studies proceeds by looking at the archetypes of innovation. As detailed earlier in Chapter 4 (p.78), the archetypes are the recurrent themes that encapsulate the

idea of a maker. The four categories of archetypes include the people, the artifacts (including projects and tools), rules, and the governance structures. The analysis will focus on describing each of these archetypes as they are present for each makerspace and then building from there to obtain a combined analysis. The people archetypes are the makers, the directors, the facilitators, the instructors, the hobbyists, the casual builder, the curious, etc. The “who” question about the occupants of a makerspace. The artifact archetypes are the tools, the documents, the media, the devices, and the projects, the question about “what” is being used or interacted with. The projects are the most important type in this group, because so much of what was observed was tied to the project, and there are formal rules around these, in deadlines, in work, and in the instantiation of innovation. These formal rules transform into archetypal rules through repeated use. The archetypal rules are those operational rules by which the makerspaces function, the “how” question by which it operates. They allow for the interactions between the people and the artifacts in the space, and they provide a structure for each of them. Each space has a slightly different set of rules: some are imposed by the artifacts, some are applied to them, some are related to them. Finally, the archetypal governance structures encapsulate the “why” questions. This includes those things that are intrinsic to the organization, to the makerspace, and there are governance structures that are extrinsic as well. These extrinsic structures are the events, the policies, the rules and regulations that supply an overarching framework for the makers and their spaces.

8.2 Case 1: Protospace Archetypes

With Protospace being both the oldest and the most ‘traditional’ (Moilanen, 2012a) of the makerspaces studied here, it is also the one that contains the broadest range of archetypes present

across all four categories. The people at Protospace run the gamut from those recently out of high school through to retirees who still require a space to work on DIY projects.²⁰ Those projects and tools, the artifacts, can cover a broad range of ‘typical’ maker crafts,²¹ but tend toward the industrial or shop side of things.²² The rules of the space are those of a non-profit collective, one that meets regularly and often, where the members may be occasionally fractious and at odds, and the governance structures serve to keep that peace, and maintain the continuance of the space, as well as its interactions with the larger community.

The people at Protospace comprise a range of archetypical makers. This category includes retirees, students, tradespersons, unemployed individuals who have lost access to a shop, itinerant inventors and tinkerers, and members of other categories who are on the Board of Directors. Each of them in turn has something that brings them to the space, and something they give back to it. First and foremost among archetypes are the tradespersons, as their attitudes and practices have heavily impacted the culture of the space via development and enforcement of the tacit rules, and providing the overall character and flavour of the shop. ‘Blue-collar attitudes with a DIY attitude’ go a long way in describing the underlying ethos of Protospace. The retirees and tinkerers are two other archetypes present, and they also make up a large part of the character at the makerspace. Interestingly, there is some overlap between these two groups. They are both likely to be around on a Saturday afternoon²³ or a Tuesday night,²⁴ where the

²⁰ This is a collation of the repeated site visits made during 2016 to 2018.

²¹ The list on page 101 highlights some example projects.

²² The space is divided into multiple areas, including a wood shop area, a metal shop area, a computing lab, an electronics workbench, and a 3D printing area. This is detailed in the walkthrough on page 86 onwards

²³ Monthly cleanups were on Saturday afternoons. Otherwise it was just normal weekend activity.

²⁴ Open Houses and New Member Orientation meetings. Typically, the busiest time of the week.

social elements of the space, and the ability to communicate with one's friends (or at least 'people of a similar mindset', as one interviewee put it²⁵) is prevalent. These members are also a large source of the shared knowledge of the space, because they are able to provide feedback (solicited or otherwise) on the projects on which one might be working. 'Students' comprise another archetype, characterized as those who are of college age, late teens to early twenties. They are more active in their projects, and the work that goes into building and maintaining the space, and are also more creative, following the Rule of Cool more often than not when engaged in projects around the space.

The directors are the final group of archetypal persons present. While not directly owners (Protospace is a non-profit collective after all²⁶), they are the makers who most exhibit the characteristic of ownership,²⁷ and are often engaged in projects of their own devising. They see Protospace (and other spaces like it) as a tool to aid in the completion of whatever they happen to be working on. The directors exhibit some of the characteristics of the entrepreneur,²⁸ but only in passing, in starting the space or instituting a new project. The entrepreneurs at the makerspace are more likely to be other members who are using the space in order to test or prototype new materials.²⁹ However, this is an area where the collective nature of the space, and the longer onboarding process work against it to a degree. Protospace is an effective if occasionally fractious community,³⁰ but other places may serve better as entrepreneurial hubs.

²⁵ Recorded during an interview conducted at Protospace. See J1-139

²⁶ As per the charter documentation at Protospace.ca, as well as stated during the AGM. (J1-135).

²⁷ This characteristic may or may not be present for given person-artifact dyads, but in this case is referring to the relationship between the director and the makerspace (as an aggregate of other archetypes).

²⁸ They engender risk in others, they are likely to start a new venture or project, etc.

²⁹ Noted from office interaction and leadership roles taken during monthly meetings and the AGM.

³⁰ Divisions are often vocalized during public meetings; see p 93. Also J1-135.

Archetypes within the artifact category at Protospace include the projects of the members, the tools of the space, both analog and digital, and the promotional materials of the space (e.g., the banners, posters, pamphlets, and handouts). The projects can be further categorized according to description: learning or test projects, DIY crafting, digital materials, and artistic³¹. For the artifacts in the space, the most common archetype is one best described as refurbished: the donated, the gifted, the salvaged, the recovered, the rescued and repurposed, all these archetypal objects find home within the makerspace³². Many of the larger artifacts, such as the metal shop equipment, the industrial laser, and others, have this aesthetic. They show signs of use, of repair, and of being added to the space from somewhere else. This aesthetic extends to the furniture, the fixtures, and more. Curiously, the effect of this archetype extends to the newer equipment as well: the newer 3D printers and the laser cutter that was a capital purchase a few years prior. The newer pieces of equipment are soon overtaken by the aesthetic of refurbishment, and thus fall within that archetype. It may be odd to characterize the archetype by the subjective element of its primary aesthetic component, but it is the best way to distinguish those elements, which may exist across other categories (tools, projects, devices, etc.³³).

The other archetype that goes hand-in-hand with the one of refurbishment is that of industry³⁴. Much of what exists in the space has the feel of a shop or of industrial equipment taken out of its natural home and moved into a space too small to hold it. The aesthetic is one of

³¹ Based on observation of what the members are working on during any given site visit. See also p.101.

³² This category of refurbishment is both an activity and a characteristic; it is broadly relevant in both cases.

³³ These other categories are also archetypal, but aside from the projects are not explicitly unique to makerspaces. This is why the concentration is on the novel elements (aesthetic characteristics, etc.)

³⁴ The industrial 'feel of the shop' is one that stands in sharp contrast to other elements and makerspaces, as noted.

work, characteristic of craft or of production. It is at once daunting and inviting, as it hints at the possibility of big projects, with the ensuing trepidation about what it may mean to undertake it.

The prototype is an artifact archetype which exists in contrast to the larger pieces of the tools and machinery of the space, and includes the projects of the members which are smaller and more personal. There is a sense of whimsy in many of the projects that the makers craft. Temporary one-off test pieces abound³⁵, and the wood supply cabinet is filled with off-cuts and slim sheets of MDF with the hint of partially-completed test burns from the laser cutter. There can often be multiple iterations of a project, with themes and motifs represented again and again as the project takes shape, reflected through the lens of multiple prototypes.

The media of the space is an artifact archetype as well³⁶. For a space where so much work is done digitally, the presence of physical media, mostly promotional, seem to come from another era or worldview. Posters, banners, handouts, and pamphlets of all sizes exist, everywhere. The front lobby, the introduction to the space, is a riot of these artifacts, in all variety to ensure that there is something there to be the right size for any particular potential member. Finally, the archetype of the brand is last category of artifact³⁷. Made manifest across the space, the logo for the space exists everywhere, burned in acrylic and wood, etched in metal, traced in the light of LEDs, and printed on all the above media as well.

Within the category of rules archetypes that govern the space there are both formal and informal rules. The formal rules that govern Protospace are those of the non-profit, the charter,

³⁵ These can often be binned or discarded after a time during a monthly clean-up session. They tend to accumulate to a point and are then discarded en masse if space is required or they reach a critical tipping point.

³⁶ Both physical and digital media is included.

³⁷ Again, the branding extends to the digital spaces (website, etc.) occupied by the members of the space.

and the adherence and compliance with local safety ordinances³⁸. These are all explicit and codified, though there are several items that shift between those boundaries, and are more typical of the informal rules. For instance, Protospace operates as a non-profit under the Chapter C-21 of the Companies Act (2000) of the Province of Alberta, and this entails certain obligations regarding meetings, filing, transparency, and the like. The continued status as a non-profit is a point of contention, as a large number of the members are content to just make stuff, and wish to leave the corporate aspects to others. The budget is also required to be reported regularly. Modifications to Protospace's charter must be done as set out by the rules of the board. Municipal codes regarding fire, electrical, and safety also come up, so part of the training of Protospace exists to inform members and to meet those requirements.

The informal rules that govern Protospace are largely tacit, and drawn from the rights that are embedded in maker culture (as seen in Chapter 2), or from workshop culture at large. The former draws from the elements of the “do-ocracy” that are stressed at the members' meetings³⁹, an act that bestows agency onto the members, to let them know that activity, engagement and ownership is required. In practice this agency can be intimidating, as the more invested members will proceed with doing what they want, while newer members may encounter friction in the space as they come up against those other projects and undertakings. Large projects often need to be “vetted” at a certain level, either by committee or by enrolling a number of other

³⁸ These are all available online, either through the makerspace's website, wiki, or other repositories.

³⁹ For examples, see page 93 and 96 in Chapter 5.

members to get things done⁴⁰. As with all such libertarian ideals, ones right to swing one's hammer ends at the other's nose.

There is a tacit workshop culture as an archetype that is also assumed, as many of the members have worked in a commercial workshop of some variety, be it welding, metalworking, cabinetry, or otherwise⁴¹. This culture derives in part from the local Calgary context, as there is a significant amount of light industry in the city and its environs. These tacit rules⁴² of the culture include an awareness of the shop around you and a personal responsibility for one's tools, workstation, and materials, and can involve the use of call-out tags, PPE, safe operation of and around the machinery, cleaning practices, etc. These are rules that one would hope are codified (they are)⁴³, but are probably made less explicit than one would like, especially for those entering Protospace's version of maker culture without that workshop background. This is another source of friction in the culture, between the long-term members and new entrants to the field. Beyond these rules are the small informal activities undertaken by the members on behalf of the space, which includes things like movie night, grilling food during the AGM and Monthly cleanup, and others.

The main structural archetypes at Protospace are the board of directors, and the related monthly and annual meetings⁴⁴. These work in concert with the rules, mentioned above, as maintaining the board is part of the Protospace's charter, but it goes beyond that as it acts as an

⁴⁰ There is a pathway from informal to formal that occurs here. The precise point at which one transitions from one to the other is flexible and often contested.

⁴¹ Revealed through repeated observation and interaction with makerspace members during the observation period.

⁴² They are most prevalent during the new member orientation and at the start of new classes.

⁴³ Copies are kept online at the website, wiki, and shared drive.

⁴⁴ See Section 5.5.1, page 93.

institutional gatekeeper, and steering mechanism, providing some feedback and leadership to what would otherwise be a rather haphazard collective.

Extrinsic forms of governance (i.e., not explicit rules) are those of the maker community in Calgary writ large. Protospace participates directly in a number of events, including the MiniMakerFaire and the Calgary Entertainment and Comic Expo⁴⁵, and provides tacit support to several others as members of participating teams work on projects while at the space for events including First Robotics⁴⁶, MakeFashion, Beakerhead, and others. This is governance by the calendar archetype, as the deadlines for these projects are outside the control of the members, and must be met through their own work. The lead up to one of the events can often see increased use of the facilities.

8.3 Case 2: Tikkun Olam Makers Archetypes

The archetypes at TOM Calgary reflect the nature of the space: they lack the permanence of the more established and situated spaces, but maintain the flexibility and agility that is customary of the literature about makerspaces and the FOSS community.⁴⁷ In some ways this makes them more representative of the ideal of a makerspace as represented in the literature. The people at TOM are by and large younger; the directors, the teams, the need knowers, as well as the facilitators and dedicated tool users all interact in the makerspace. The artifacts are all about the projects that are made for the need knowers, though the borrowed⁴⁸ and donated tools

⁴⁵ This was discussed at length during the monthly meeting just prior to the 2017 Comic Expo.

⁴⁶ Ongoing throughout the period of observation in 2017 and 2018.

⁴⁷ See Anderson (2012).

⁴⁸ The Calgary Tool Library is a key sponsor, loaning tools for the duration of the event.

and machines are a large part of it, as are the digital spaces that facilitate all the work. The rules are relatively simple and straightforward, covering the project, the deliverables and documentation, and the meetings⁴⁹; similarly, the structures are simple yet overarching, and despite their temporary nature (during the event) are persistent and global in reach, something not seen in other spaces (at least to this extent).

The archetypical people who participate in TOM Calgary can be divided into five groups: the volunteers and their teams, the directors, the need knowers, and the support personnel. The volunteers are all makers: working together, communicating virtually for months prior to the Makeathon event, communicating with the need knower for their project to understand the design constraints and challenges that they face, and then working within those constraints to develop a new invention, or successfully replicate a market solution at an affordable cost, or create something brand new. These volunteers rely on the skills of their team, and the time, cost, and material constraints challenge them to meet the goals of the project. They are archetypes of open-sourced innovation, as they rely on the FOSS materials and solutions to develop many of their projects. The volunteers are organized in teams and then tightly linked to a project. These teams constitutes a separate archetype rather than just a characteristic of the volunteers themselves. The functional teams are arranged by interest and skill, and the directors often have a hand in forming the teams by matching volunteers to a given project based on need. In practice, there can be a degree of serendipity involved, as people can end up on teams based entirely on happenstance, like being present at a meeting when a project is introduced.⁵⁰ This

⁴⁹ Available at the TOM Global website.

⁵⁰ Witnessed in 2016 (J1-067).

may not be the most efficient method of allocating resources, but in practice it works as it requires only gentle and occasional intervention by the directors. For those volunteers who do take a more active approach in selecting a team, what draws a given volunteer to a project is a confluence of subjective elements including the need knower's problem, past media influence, aspirational uses of new technology, and the volunteer's own personal background as well.⁵¹

The directors are all makers too, though they occupy a quite different space within the makerspace ecosystem. They are largely responsible for getting the various projects up and running, attracting sponsors, finding a location for the event, planning it, ensuring it runs smoothly, etc. The skills are more akin to a combination of project manager and event planner rather than as a maker directly. Those maker skills and experience do come in handy, in understanding the needs of the volunteers and teams, but many of them express frustration at the shift in job roles as it was not what they were expecting. The role they now inhabit is an entrepreneurial one. This entrepreneurial role or function is continual as well, as the directors have, to date, only stayed in the role for a couple years before moving on. There is a constant churn and a continual change to the project based on this staff turnover, though the function of the directors remains largely the same.

The need-knowers are both the client and the customer, and they exhibit elements of the entrepreneurial archetype as well, by instilling risk in the team and challenging them to meet their needs. These are the hallmarks of user-driven innovation, bringing their needs back to the producer or to a team that can successfully implement a solution to those needs. They are the

⁵¹ Drawn from four interviews with TOM members in 2016 and 2017.

instigator, and TOM Calgary acts as a bridging mechanism, what is called a Social Network Market (Potts et al., 2008), to match the need-knower to the project team.

Finally, the support personnel occupy a separate group of makers. Largely skilled tradespeople, or people with specific skillsets that are enrolled for the duration of the project to allow for rapid completion of certain parts with a minimum of fuss and issue. This represents something unique to TOM among makerspaces, but more common in other fab facilities, R&D firms, or skunkworks (Augsdorfer, 2005). The presence of the support personnel represents a capitalization of their tacit knowledge in service of the project.

The category of artifacts at TOM Calgary is comprised almost solely of the projects that the teams develop for the need knowers. The projects exist in a fashion that attract the engagement of all involved, the makers, the need knowers, and the audience. This is to be expected given the short time frame and intensity of effort that gets put forth during the Makeathon; the projects exist in a sympathetic, co-dependent relationship with the need-knower, and the identity of the maker is subsumed relative to that dyad. The linear relationship of engagement could be seen as Project -> Need Knower -> Maker, or occasionally (Project <-> Need Knower) -> Maker. Projects are the defining feature, i.e., how the teams are bundled and understood.

For TOM Calgary, it is of note how *little* the archetype of tools matters or has a presence within the space. They are often to the side in defined work areas, to be engaged with or deployed as needed, but they are subdued, their presence less. This may be due to the temporary nature of the space, or the borrowed nature of the tools themselves. Their main availability is for use by support personnel by some teams. Everything here during the Makeathon is

impermanent, to be disassembled at the end of the 72 hours, and so lacks a sense of permanence and embodied presence.

Archetypal rules for TOM Calgary are both informal and formal: the informal includes the ad-hoc requirements that govern the social contract during an event, and the formal are those that are mandated by the organization, throughout the year and during the event. Formal rules throughout the year are simply the monthly meetings, the ongoing flow of engagement and enrollment of the people: the makers, need knowers, and volunteers. During the event, the frequency of these meetings increases. The unique form of archetype for TOM is that of the PiNG meeting, detailing, the progress, needs and goals of each group in a roundtable, in 8 hour increments during the course of the event.

The archetypes within the governance category for TOM Calgary exist in two states: the year-round governance and the event governance. There are three archetypes which exist year-round: the board of directors, the advisors, and TOM Global. The board of directors are largely the only people who are consistently present over the course of year, in the time between Makeathons. They also fulfill a fundraising function. There are a number of advisors from the community, and their contacts with the TOM Global organization. Here, TOM Calgary is unique among the makerspaces studied, as it drew on a larger global group, though this is more common worldwide, with the FabLabs and other branded spaces. In another context, TOM would follow the dynamic of a franchise model, with the satellite operation receiving directions from the headquarters, but in the context of an event-driven makerspace the analogues are different, where the event is the driver, rather than the organization.

The second state of governance is the one occurring during the period of the Makeathon. During this second state, the same archetypes are present, but their role and priorities change.

Here the directors take on a more-involved and hands on role, actively involved in many of the minutiae of the event itself. As such, the Makeathon itself exists as an extrinsic governance structure. The reality of setting a date on the calendar, and making concrete an external date and time, focusses all work around that particular occurrence.

8.4 Case 3: Archeloft/Fuse33 Archetypes

The archetypes at Fuse33 are also identifiably those of a makerspace. Scanning the various archetypes, the people are recognizable as makers, though a different cross section of makerdom than the other locations. The trend is younger, millennial, more artistic, more hip, but builders and makers all the same. The artifacts are newer, showing less signs of use or refurbishment. Both the rules and governance structures could be characterized as corporatist. These is less of the feel of a collective and more the feel of a business.

The people occupying Archeloft/Fuse33 are recognizable as archetypes of the maker community. This archetype of the young working artist, the millennial maker, appears over and over, reflected in a number of members of the board of directors, as well as the long-term members. These millennial makers are driven, and self-motivated. Demographically, they occupy a spectrum of individuals in their late 20s to early 40s, with ties to the artistic community in Calgary rather than to the industrial community. While the gender dynamic approaches 80/20 male to female, ethnically the space draws from European ancestry. The transactional nature of the space sees less of a degree of continuance and more one of churn and overlap.

The other archetype that can be seen here is that of the marketeur. Entrepreneurial work takes place at the makerspaces, in a wide number of different ways. Some makerspaces around the world have ancillary functions as a start-up incubator and skunkworks (for R&D) allowing

for work to be done on new technologies or provides a space for burgeoning sole proprietorships or partnerships; A/F33 fulfills this role as well. The main entrepreneurial work that has taken place is in the creation of these markets themselves. The work done by the founders of each of these spaces is to provide a new room for a type of innovative activity, to charge enough money for it to keep it a going concern, and to use available events and functions as a source of recruitment to replenish and grow the member base for the organization.

The preeminent, archetypal artifacts of the two spaces are the works of art and fashion, either put on display or being worked on in progress. They draw the eye of any visitor, the mix of hard and soft innovation, the technology of the LEDs, circuitry and microcontrollers embedded within the textiles and fabrics of other sites of innovation of another age. There are strong subjective elements in these artifacts, and they exert an outsize influence in the maker community. The artifacts may become iconic, potentially to be used in promotional materials and highlighted in publicity photographs, either in print or online. As the works of wearable technology incorporate elements of fashion and design, there is a strong subjective component to what they display.

The archetype of the transactional model of the Archeloft/Fuse33 is most directly related in its rules. It is endemic at the place, with costs associated with most elements, and pricing for programs, members, activities, etc. all laid out. In this, the space is very upfront about the model, but there are subtle effects of the cost-based value model that come through when everything has a price and there are different tiers of membership. Functional inequality is built in the system, in a means to encourage users to upgrade. This is an adaptation from the world of software, where different tiers have different features unlocked, and of course this has existed in other forms as well. But given the trends of influence, of digital materiality, of software – and its

development and models – influencing the material world and its functions, this seems particularly relevant.

Governance processes exist here, intrinsically and extrinsically. Internally, through the development of a board of directors. Despite operating as a non-profit, the business model of the space derives its structure and incentives from a corporate model. The space is less of a community hub, and more a transactional one: a market, rather than a clubhouse. Extrinsically, however, the site is governed by the dictates of the community associations, the street redevelopment project, the grant issuers, and the municipality, and the larger events of the local maker community. This last system of governance provides one of the more consistent structures to the space; the rest are financial or regulatory, and would be largely similar regardless of kind of industry or organization was operating in that location. The makers' events drive the rhythm of the space, with members working in advance of the yearly events, creating new prototypes 8-10 months prior to an event, and acquiring the skills to work on them. (On one January morning, one of the creators affiliated with Beakerhead was in the shop to learn welding, for this year's Beakerhead, which was some 9 months later). The skills development, planning, and testing stages needed for these works is directly connected to the activity and dynamics of the space.

8.5 Comparison of Archetypes

Between the three cases, a number of common and divergent elements among the archetypes arise. These are addressed in two sections: the direct comparison of the archetypes in each category – people, artifacts, rules, and structures – and then an overall review across the

categories. A summary of the archetypes identified in each category is included in Table 2 on p.167. Similarities between the makerspaces exist within each category of archetype.

Beginning with the *people* category, the large number of people present at the makerspaces ensures that a variety of maker archetypes are present between all three sites. No one site has a monopoly on a given person archetype, but trends can be observed. There are two notable elements that can be drawn out, however. The first element is that each of the makerspaces exhibited a specific character, gained from the maker archetypes of the individuals involved with that space, and this was reflected in the nature of the space as well. Makerspaces tended to have more technologists, or tradesman, or youth, or artists, or entrepreneurs. Each of the groups of individuals are still identifiably makers. These groups shaped the character of the makerspace, which in turn became more like an artist studio, or a workshop, or a tech start-up based on the needs and inclination of the people present, and this shaping occurred in a mutually reinforcing way. Makerspaces developed a character from their makers, and that attracted similar individuals.

The second element was that despite this difference in character, there was also a similarity in role, between the executive for each of the spaces, and the regular members. The founders or executives could often have an outsize influence on the space. The makers – needed, and necessary – were also less directly involved in the operation of the site, usually. To return to an earlier metaphor, the makers are the worker bees in the hive, contributing to the building and creation of it, but often not individuated when looking at the space as a whole.

Comparing the sites, clear divisions can also be seen among them. There's an ongoing tension between individual projects and collaborative ones. The maker literature is redolent with the imagery and ideology of sharing, but in practice this is not always the case. TOM and it's

tethering of teams of maker volunteers to various projects is an example of this – it stands apart from the others. The groups work in concert towards their goal of developing a working goal for their need knower. A/F33 can have a similar dynamic, when there is a collaboration between an artist and a maker on a project for MakeFashion, for example, but this is not always the case.

Archetype	Protospace	TOM	A/F33
People	<ul style="list-style-type: none"> • Tradesmen • Retiree • Student • Director 	<ul style="list-style-type: none"> • Volunteer • Team • Need-knower • Support/Trades • Director 	<ul style="list-style-type: none"> • Millennial Maker • Artist • Board member • Marketeur
Artifact	<ul style="list-style-type: none"> • Refurbishment • Industry • Prototype • Brand/Logo 	<ul style="list-style-type: none"> • Project • Tools 	<ul style="list-style-type: none"> • Works • “Display piece” • Tools
Rule	Formal: <ul style="list-style-type: none"> • Non-profit • Charter • Ordinance Informal: <ul style="list-style-type: none"> • Do-ocracy • Workshop 	Formal: <ul style="list-style-type: none"> • Meeting • PiNG • Publication • FOSS Informal: <ul style="list-style-type: none"> • FOSS 	Formal: <ul style="list-style-type: none"> • Software Model • Transactional Model
Governance Structure	Intrinsic: <ul style="list-style-type: none"> • Board of Directors • Meeting Extrinsic: <ul style="list-style-type: none"> • Event • Calendar 	Intrinsic <ul style="list-style-type: none"> • Board • TOM Global • Advisors • Makeathon Extrinsic: <ul style="list-style-type: none"> • Calendar 	Intrinsic: <ul style="list-style-type: none"> • Business Model • Market Extrinsic: <ul style="list-style-type: none"> • Financial/Regulatory • Event • Calendar

Table 2: Summary of Archetypes

There are a larger number of projects instituted by and for the makers, either for personal use or for sale. Protospace exists at the far end of the continuum. Most makers at Protospace work on

their own projects, over time, with rare instances of collaboration. But they freely associate and provide knowledge when able, and the structure of the organization facilitates this.

The archetypal artifacts that are present at the spaces also embody each space's unique elements. In all three, there is a focus on the projects. How they are used and displayed is where the differentiation lies. For example, with TOM Calgary the projects exist to be handed off, to be given away. Similarly, at TOM the tools are temporary and transitory as well, with no real attachment felt to the borrowed objects. There is more of a focus on the projects and their completion at A/F33. The artifacts are kept, becoming part of the portfolio of the maker, and displayed, or shopped around, to be further refined. Protospace is the one makerspace where the projects become incorporated and sublimated into the space itself. Every door, sign, lampshade, fixture, and many of the tools are projects of current or former members, and they continually get added to and absorbed by the makerspace itself. In this way, the subjective affect of the Protospace is most reflective of its members. For all three spaces, certain projects and pieces can become iconic, used in promotional materials and widely distributed. This occurs not necessarily due to any technical acumen of the project, but more often due to the subjective and aesthetic elements inherent in the piece itself.

When examining the category of rules, it became apparent there were both formal and informal rules that existed. Based on the maker literature, one may assume that there are many codified rules, but in practice much is handled informally. The archetypal rule that exists amongst all of three of the makerspaces is one of empowerment, an adaptation of the golden rule that exists across myriad religions and philosophies: 'do unto others as you would have them do unto you'. Protospace's "DO-ocracy" ethic (p.154), TOM's openness, and A/F33's ties to the arts community are all examples. This rule ties into the underlying libertarian ethos that

empowers both the FOSS community and the early hackerspaces as well. The other archetypal rules that are common to the spaces are ones of governance, more formal, extrinsically bestowed by the needs of the state, the municipality, or the NGO. These can include fire and safety ordinances, accounting regulations, tax regulations, articles of incorporation, rules of order for meetings⁵², and similar regulations. The makerspaces exist within society, and are bound by those rules, despite any anarchic predilections of individual members or present in the various manifestos.

Governance structure archetypes are divided between intrinsic and extrinsic sources. The calendar is the most consistent archetype in this category, organizing and shaping the productive work that takes place in each space. Not all makerspaces take part in every event that occurs in the community, at least not to the same degree, but they are all involved in some events, and the larger events that engage the larger local community cast an outside influence that reflects back on the spaces.

The other structural archetype that arose, unexpectedly, is that of the software model influence, and how it was reflected in the business models of the various ventures. These models had characteristics that were both advantageous and disadvantageous, and provided benefits but also imposed certain restrictions when compared against each other. Protospace operated under a relatively open access model. Once admitted as a member, there was just a single fee that could be paid monthly or annually. Storage space was allotted to the member and tool access (after some training) was generally open and unrestricted, save for time and business constraints.

⁵² Such as Roberts' Rules of Order being used at Protospace, or the informal PiNG checkup meetings used by TOM Calgary during their Makeathon.

Conversely, Fuse33's tiered pricing model, with more features being unlocked at higher amounts, (and the low-level access being minimally functional, and unsuitable for any serious use) is similar to many paid software and app development pricing structures. The net effect of that can mean differential access and inequality at the makerspace, but it does provide some structure as well.

When viewed as a whole, a picture of each of the makerspaces starts to unfold, each telling their own narrative. Protospace exemplifies the *tradition* in makerspaces, occupying an older industrial site, with more in common with a machine shop with a few hi-tech additions. It has an older population – more individualistic – with each maker working on their own, but a more vibrant community with knowledge and public demonstration of projects shared with the community on a regular basis. Fuse33 is more emblematic of the *trend* in makerspaces: a more agile structure, and a funding model that encourages drop-in or ad-hoc use in its repurposed space. It is more attractive to a millennial crowd, but the long-term growth of its own community may take time. TOM lies in between these two – between tradition and trend – but also has ties to the most archaic model of hackerspace: without a site of its own, like the hackerspaces built in a squat, impermanent but providing a service to its users.

The differences between the makerspaces can also be seen in the present of the various archetypes. Three characteristics which differentiate the makerspaces in addition to “roles” are best described as “funding,” “resources,” and “goals.” Funding is critically important to the continuance of the spaces, and they employ a variety of funding models, from the purely collective (but private) funding model of Protospace, to the mixed methods of A/F33 with both grants and member fees, to the public/private model of grants and sponsorship that funds TOM Calgary. Resources represent the ties to the larger community, the social and human capital that

a makerspace can draw on to navigate everything from purchasing through to taxes and bylaws. Goals of each space can shape the overall ‘tone’ of the space. The focused, goal-directed nature of TOM Calgary, and to a lesser extent A/F33 with its ties to MakeFashion and Beakerhead, has a direct influence on the way the space is run and used. Conversely, the hobby, DIY, and social elements of Protospace leaves much up to the individual members, but the work done at the space can be very diffuse.

8.6 Archetypes and Research Questions

8.6.1 Subjective Elements

With these archetypes established of the various roles and the spaces themselves, the remaining task is to tie it back to the research questions established back in Chapter 1. From the outset, the research question asks: how do subjective elements act as an influence in knowledge transfer that occurs in communication networks present during the innovation of a new technology at a makerspace? The answer is largely contingent on the archetype of the makerspace that is observed, and the degree to which it is event driven. The influence works on two scales: one based on the time available for the project, and another occupying a continuum between functionality and aesthetics. For the first scale: to the extent that a makerspace is operating on a short-timeframe, then the focus may appear to be on working on the functional characteristics of the project, and addressing concerns about subjective elements as secondary. This may vary to a degree by the background of the person or their role (as captured by their archetype), and the degree to which subjective factors are the end goal of a project, but “functionality first” largely holds true. Subjective elements are then added in as a last step, if time allows. In these instances, the subjective elements can function “behind the scenes”, so to

speak, as a linguistic shorthand, either describing the project or the end goal, or rather for the maker to describe their identity and aspirations. The subjective elements are a shared language or code between the makers to describe and communicate the design elements of a project.

Conversely, on projects that are developed on a longer timeframe, the subjective elements become a more direct source of influence, often embodied in the artifacts, especially the past projects, of the members themselves. As they exist in development, on the workbenches and project shelves of the members, the elements of the projects are visible to those coming through the space. During the periods when the projects are actively being worked on, the development itself is inspiring to those around them. The project becomes a focal point of communication in the space, as other members of the space view and discuss it, feedback is solicited and provided, both in person and electronically, via the digital presence of the spaces, and the successive iterations of the project coalesce into an invention that solves the particular problem of the maker, as Arthur (2007) is the goal of invention in the first place.

Finally, for those projects where creating elements with subjective appeal is the end goal (the development projects for MakeFashion and Beakerhead being worked on at the Fuse33 space, for example): the subjective elements function as something entirely different. They are the process of art and design, produced through a makerspace as a site. Here work may be done on small scale prototypes, or with lower-cost materials, before being applied to an installation or a work of fashion, but the design process is still largely the same, working on the event driven scale of the first case, with an end goal in site, but requiring the time and multiple attempts at prototyping that is seen at the more occasional space.

8.6.2 Ideas and Inspirations

For the subsidiary research questions, some statements can be made as well. One: how are the ideas and inspirations for the development of a new technology transferred between developers and their collaborators? The transference is via a communicative act, but the act itself is often one that is embodied, instantiated in an object or artifact, and demonstrated through the craft of its creation, or the successive iterations of its prototypes, as each is attempted on its way to a finished project. This can best be seen in certain projects at all three makerspaces. At Protospace, several of the public projects (a custom MAME cabinet made by one of the members (J1-077,133,147) and a sample project that went through multiple iterations (see p. 101)) functioned in these embodied reservoirs of knowledge. With TOM, some projects persisted after the Makeathon and were discussed during subsequent meetings (J1-054), and during the Makeathon, each team's project took on this role, and allowed for both the project team, and external teams to provide feedback and comments. In Archeloft and Fuse33, the role of the artifacts in both the space, and with public events (like MakeFashion) took on this role. The artifacts that were brought from one site to the next helped maintain the continuity of the space.

8.6.3 Sources of Inspiration

Two: what sources of inspiration and new knowledge do the developers use for both the subjective and functional components of their design? The sources are varied: some come from media, drawing from other motifs and expected elements (the embodied elements of geek culture at Protospace are the best example of this: the sliding doors from *Star Trek*, the blue phone booth from *Doctor Who*, the control panel with HAL 9000's eye from *2001* embedded in the wall in the entry lobby) are all evidence of soft innovation – media influence on the creation of a new innovation – as they required specific work to embed them within the material fabric of the space

itself. Other sources tie directly to the current working projects, the aforementioned shorthand that happens when working on a quick project, such as at the Makeathon. In some instances, there is no direct influence, but rather the recreation of existing elements due to the materiality of the objects and technology. This came about when some of the designers at MakeFashion created works that echoed those from other sources, but did so due to material constraints, rather than particular direct ties to the source material.

8.6.4 Makerspace as a Third Place

Three: what is the role of the makerspace as a third place where developers can collaborate and share ideas during the development process? As seen in the summary, the makerspace is a third place, both digitally and materially, but each makerspace functions differently, and the way that the makerspace functions as a third place can both shape and be shaped by its members, and this can heavily influence the subsequent membership as well. A social path dependency exists, focused around the space, shaped by the initial founders, directors, and prominent members, and replicated forward from there. The digital elements are largely opaque to physical site observation, but highly active behind the scenes in all three spaces that were observed. The amount of communication that takes place digitally equals or exceeds that occurring on site. The makerspace also serves as a repository of the material artifacts: the tools and projects of the members, which as noted above, are instantiated objects of the communicative act. The space serves as a site of continuity, hosting the objects as they are shared between successive generations of members.

How these overall commonalities between the makerspaces under review comes together can be seen in the findings in the next chapter. From there, several additional observations can be drawn, including the role of engagement, and the specific (possibly unique) form of

entrepreneurial activity that appears in several of the locations. Two critical observations can also be levied against the makerspace concept as a whole.

Chapter 9: Makerspaces, Innovation Systems, and Archetypes

Theories of innovation developed as a means to address and understand technical change, and early literature in the field was framed as such. Work by Schumpeter focused on the role of the archetype of the entrepreneur in the innovation process. As technical achievements mounted in the 20th century – with improvements in mass production and distribution allowing for increased growth and access to goods – innovation was understood to occur in a system of interrelated processes which were continually evolving. In addition to technical change, there was an understanding that innovation could also occur in products, processes, and organizational forms. Moving forward to the present, the current era of innovation thought is framed as one of “transformative change” (Schot & Steinmueller, 2018) where innovation is a tool to be used to address the global challenges of the 21st century. Recent research on innovation has expanded into new realms to explore areas of research missed by earlier authors, and a number of new schools of thought have arisen. Through studying and comparing several micro-systems of innovation by looking at makerspaces, we can address the hypotheses posed by the authors of these new theories. This chapter will tell three short interconnected stories about innovation, born from the observations and findings of this research project. One of the stories is of the makerspaces as innovation systems, a second is of the archetypes of innovation, and a third of the other factors present and observed during this research project, grouped together in a critical study of the maker movement.

At the outset of this project, the initial question asked: ‘how do subjective elements influence knowledge transfer that occurs in communication networks present during the innovation of a new technology at a makerspace?’. Further to that, three key gaps were identified in the relevant innovation literature that this research looked to address: the transfer of

ideas during the development of a new technology; the sources of inspiration and new knowledge for their project; and the role of the makerspace as a third place that enables collaboration. Before we can address innovation in the context of makerspaces and these research questions, a summary of the current theories of innovation are in order.

9.1 Makerspaces as Innovation Systems

In the current era, the main schools⁵³ (areas of research or paradigms) of innovation theory are: the current neo-Schumpeterian school approaches focused on systems and networks; the user innovation school of open, user-driven, and democratized innovation; the soft innovation school focused on aesthetics and the cultural industries; and the common innovation paradigm, for projects undertaken for personal use outside of traditional national accounts. Each examines innovation across a wide number of categories, including technology, products, processes, and organization. Researchers at these theoretical schools are all attempting to address the question of innovation from different angles. Each area has a different take on the processes by which innovation occurs.

What these schools of theory do have in common is their focus on the challenges of studying innovation in the current era. They are designed and developed around gaps in the literature, which understood innovation in the context of national systems of innovation, but may no longer be well suited to the current challenges in an era of transformative change. The theoretical schools speak to a system of innovation in aggregate, but what they do not speak to is the micro-level descriptions of how innovation actually takes place. That is where the qualitative analysis and the on-site fieldwork conducted by this study comes in to play. Based on the

⁵³ These may be grouped by area of research, paradigm, or fundamental assumptions.

observations that took place and the analysis of those findings according to the observed archetypes of innovation, a study of makerspaces allows for an investigation into the communication processes that occur within innovation systems.

9.1.1 The Four Schools, Revisited

The current school of neo-Schumpeterian theories draw on previous work on systems, networks, diffusion, and evolutionary economics. The school focuses on these dynamic systems and the cumulative network effects that impact them (p.55). These networks are of actors and linkages in a globalized system, and the key actor in the network is the entrepreneur whose influence is measured by their centrality. Within the current neo-Schumpeterian school, the underlying principles are largely the same as earlier neo-Schumpeterian theories, with more advanced tools at their disposal. The firm still has a role in the neo-Schumpeterian school, where they monitor new science, look to consumers for sources of dissatisfaction, and combine flows of information and new ideas into new successful innovations. Diffusion is one of the methods by which information about innovations is dispersed to the market, and there are a number of factors that can impact adoption and uptake.

The user innovation school includes four related theories – open, user, user-driven, and democratized – all of which include the user as a link in the chain in the creation of an innovation. These theories differ in their focus and to the degree of agency they ascribe to the user, but they have sufficient features in common to form a school. The theories are drawn intellectually from the earlier neo-Schumpeterian approaches, yet expand the breadth of where innovations come from. For example, open innovation is focused on the firm, and the inter- and intra-firm processes that lead to the development of innovations in an organization. The user is the driver of innovation in the system, through the feedback from users to the firm, not just as a

source of information, but also as an innovator themselves. In this fashion, the users are collaborators – working hand in hand with companies as new products and processes are brought to market.

Soft innovation theories also expand the scope of where innovation may come from and occur, looking to the arts and creative industries as both a source and destination for innovation. The soft innovation school focuses on the bidirectional flows between technology products and the creative industries via certain subjective elements, including product aesthetics. According to this school, innovation occurs in goods and services that impact aesthetic and intellectual appeal, both of which are subjective elements. Research based on soft innovation uses market spending and other quantifiable metrics to determine the impact of these creative industries, but these may not be sufficient given the subjective nature of the field. Drawing on traditional metrics in a new realm, the soft innovation school has much in common with neo-Schumpeterian approaches in assuming the innovation spreads via processes of diffusion.

Common innovation is a paradigm within the incipient innovation literature, and it addresses the sources and context of innovation for items that may be left off the national accounts. What the incipient theories attempt to understand with respect to innovation is the missing residual factor in innovation theory, and capture how people really interact during the process of innovation. Much of what common innovation looks at are the cumulative effects of the value chain, effects that can exceed the value of the initial market transaction, and may not leave a paper trail to be captured by systems of national accounts.

9.1.2 Makerspaces and Innovation

By analyzing the archetypes of innovation as observed at the makerspaces, some statements can be made about the validity of the various schools of innovation theories. The

makerspaces function as different micro-systems of innovation – different beehives, as it were – each with different processes and archetypes present, but the makerspaces in *aggregate* share significant commonalities that they can comment back on theories of innovation as a whole. The question is to what extent do the observations of makerspaces confirm or disconfirm the theories of innovation. Where are makerspaces situated with respect to the innovation literature?

Overall, makerspaces provide some degree of positive confirmation for the various theories of innovation. Proponents of any given theory could find evidence for the validity of their theory at a makerspace. Each of the theories has elements which are congruous with the essential elements of a makerspace, and addressed the elements identified as archetypes in some way. Proponents of each theory could claim “success”. However, the truth is that no single theory captures everything about the makerspaces, or how they function as a locus of innovation (or within a micro-system of innovation).

Neo-Schumpeterian school theories will find the makerspaces as dynamics sites where key entrepreneurs function in a network of interrelated dependencies, exerting a control or shaping effect on the trajectory of the innovation. They can exert an influence on the makerspace itself, through innovating in the organizational forms that the makerspaces employ. Inventions that are worked on at makerspace evolve through the repeated iterative development of projects by the makers according to the materials and tools they have on hand. The makers are enmeshed within global supply chains for these projects, drawing on tools and raw materials as varied as micro-controllers and aluminum to use within the makerspace for the crafting of their projects. The makers can function as entrepreneurs, individually and collectively. In these roles, makers monitor and share new research and science gleaned from external sources, and combine and synthesize new ideas and information about their projects on a continual basis. This

information is fed back to the maker community as a whole. This can be done during various events, demonstrations, and displays of their work, or during the repeated development of the artifact at a given makerspace. This process highlights the process of diffusion in a near textbook example. However, firms have much less of an impact than traditionally expected, in some instances being almost completely absent. The makers are fulfilling a function, individually and collectively, that often seeks to address a lack of a given product or service in the marketplace, where products that the users need are not being developed⁵⁴.

Similarly, academics deploying theories of the user innovation school can find credence for the theories at the makerspaces. The makers are developing products that do not exist, whether for the hobbyist (at Protospace), the Need Knowers (at TOM), or for incipient and emerging technologies (the wearable technologies at A/F33). However, the feedback loop is cut short, as innovations are rarely if ever communicated back to the firm directly from the users. There is feedback to equipment manufacturers, as evidenced by the dialogue that members of Protospace had with Trotec following the makerspace's purchase of a new laser cutter. However, many of the projects are bespoke: one-off creations that satisfy the needs of a limited audience, and while there can be some generation of new innovations that feedback to industry, it is more likely that the maker will use the makerspace to engage in entrepreneurial activities on their own⁵⁵.

Proponents of the soft innovation school would find much within the makerspaces to confirm their theories, with the bi-directional path between technology and aesthetics evident in

⁵⁴ This can be most clearly seen with TOM and the work by the makers on behalf of the need knowers/

⁵⁵ This was witnessed at TOM, Archeloft, and Fuse33.

all three of the makerspaces to a certain degree. The archetype of the marketeur fulfills a function similar to that of an entrepreneur in a social network market. Additionally, subjective elements had a large influence in all three observed makerspaces, serving as a shared language and source of inspiration for the makers. There were direct feedbacks to the creative industries, as the events of the wearable technology fashion shows drew a significant audience and national and international interest. The makerspaces all had connections to art schools and colleges, and several of the major maker-related events in the area were arts-driven. Makers saw subjective elements like aesthetic details as a necessary (albeit final or last minute) component in the work that was conducted on a maker project. Subjective elements are key components for maker engagement, and were mentioned or observed at all sites as a point of engagement for new and prospective makers, assisting in attraction and retention. However, it can be difficult to confirm the findings for proponents of soft innovation, as the work that takes place at a makerspace was difficult to quantify with much of it not showing up in any market measures. This does not disconfirm the theoretical assumptions of the soft innovation school, but rather merely highlights the need for alternative methods when examining innovation within this field. One highlight for proponents of this school is the prevalence of the subjective elements in the language and works of the makers. Soft innovation occurs; it just cannot be measured as expected.

The theory of common innovation saw the greatest amount of confirmation in the observations at the makerspaces. In most areas that common innovation identifies for a contribution to the common good – health, arts, science, education, etc. – there was a significant amount of work occurring at a makerspace. Each maker had personal reasons for joining a makerspace or undertaking a project there, and these often were for small projects of personal significance. However, the aggregate of all these small tasks was the development of a large link

in the value chain. Elements of innovative activity occur constantly at the makerspaces, whereby ordinary individuals could pursue projects that contributed to the common wealth. Other areas that saw a positive influence from the activities of a makerspace include skill building, active learning, and the definite benefits that arise.

Within the makerspaces, there is a drive for education, training, and experimentation, due in part to their position at the edge of both old and new technologies, and both industrial and hobbyist production. By occupying this intersection, makerspaces offer support for certain instances of Swann's (2015) Common Innovation framework. When it does occur, common innovation is prevalent at makerspaces and within the maker movement. By allowing room for hobbyists and tinkerers to satisfy "small" or personal needs and maybe gain some skills training, the spaces provide an opportunity for growth, for useful functions to occur in a space of openness and availability, where tools and resources are at hand to help work on users' projects. Can a "new industrial revolution" truly grow out of a subcultural hobby movement to the extent that it transforms entire industries, research and development, and production? Perhaps not. However, the benefits of users working on their personal projects are real, to the extent that it develops new skills, fosters community, and allows these selfsame users to address their personal needs, all factors that contribute to the real wealth as described by Swann (2015).

The other instance supporting of common innovation is the knowledge transfer that occurs via the doing; the active learning that happens in the interface between self, community, and object. The long-term effects of this active learning may be commonly known or understood in the field of education, but it is not prevalent in the innovation literature. However, the learning never stops at a makerspace. The implications of the availability and growth of

makerspaces on adult learning, invention, and innovation, as well as on skills development and retention are key.

The other key factor is the contribution to the common good. There are a number of defined goods or benefits from makerspaces, making as a practice, and the maker community writ large. Foremost of these are the direct benefits derived for all those involved in the Tikkun Olam Makers Makeathon events. These benefits include: the utility gained by the need-knowers (the persons with disabilities and their caregivers) in alleviating the particular problem they were facing; the practical employment of real world skills by the teams (mostly engineering students and graduates, who commented how the practical aspects of their engagement at a 72-hour boot camp exceeded the learning during their undergraduate coursework); and the community formation that coalesced to support, drive, maintain, and grow the TOM Calgary program through the process of launching and running an annual event like the Makeathon.

The defined benefit in skills training can also be seen as one of the primary benefits of a makerspace like Protospace. The revenue listed from the classes they offer was small relative to their total operating costs, but it constituted a large amount of the weekly presence at the site, and led to new skills development by many of the members. This was key in matters of knowledge transfer and communication. Even though innovations may not arise from the skills training, it is necessary for the continued function of the space. The skills development aspect of makerspaces presents an opportunity for policy makers, funders, and investment (see ‘Opportunities’ in Chapter 10, below).

Finally, the last defined benefit would be the creation of new technologies and development of new industry and capacity. This can be seen in the Archeloft/Fuse33 space, and their involvement with the local development of wearable technology fashions, and the

associated shows and exhibitions. This has allowed Calgary as a location to position itself within a nascent industry and gain a footing internationally. The long-term impacts of this skills development remain to be seen, but it does show promise. All told, these defined benefits dovetail in some instances with the common innovation framework as laid out in Chapter 3.

9.2 Archetypes of Innovation

While the discussion chapter provided a direct comparison of the various archetypes of innovation discovered amongst the case studies, the purpose of revisiting them here is to connect those selfsame archetypes back to the theories of innovation and situate them in the post-Schumpeterian era (Hawkins & Davis, 2012) of ‘transformative change’ (Schot & Steinmueller, 2018) that typifies those theories today. To review, the broad categories of archetypes of innovation that were explored were those of the people, the artifacts, the rules, and the governance structures, with the archetypes within each category dependent on the makerspace under observation. Given that archetypes have been used to discuss innovation since its inception (with both the *entrepreneur* and the *firm* appearing in archetypal form in the early literature), an evaluation of archetypes present at a makerspace may turn up some new information.

The archetypal artifact is the project – embodied elements of craft, technique, and practice – followed by the tools used to create them and the media from which they are constructed. The archetypal rules are the codified elements of the social contract, or the more concretely manifested rules of occupational health and safety or similar regulatory agencies. Similarly, archetypal governance structures are both intrinsic and extrinsic to the makerspace in which the above people, artifacts, and rules are situated.

Recall that the process, source, and context model categorizes the innovation theory based on where the theory situates innovation (p.58). Process-oriented theories assume the source of innovation is static, and question the underlying dynamics (p.60); source-oriented and context-oriented theories do the opposite and use traditional metrics on alternative sectors of the economy (p.61,62). Makerspaces cut across these boundaries, allowing for instances from all three categories to be seen functioning in the wild. The exemplars of process-oriented theories – the open innovation models and user-driven innovation models of innovation – show up directly within the makerspaces. The idea that these spaces end up as a crucible of invention and innovation seems borne out if we look at them through the lens of these theories directly, even though this is contested by the concept of a ‘sadness factory’ (see p. 191, below). The network effects studied during the second phase of innovation research, refined into collaborative innovation networks, directly appears within the spaces. The makerspaces function as if the theories of innovation were made manifest and summoned into being. The underlying ideas behind many of the theories find validation with the spaces. Archetypes of innovation that have been with the field since its inception, such as the entrepreneur and the firm, find new company from the makerspaces. Looking for common archetypes present across the makerspaces, several candidates appear: the personas of the maker and the marketeur, and the structure of software model influence.

9.2.1 Makers

Makers are crafters, creators, builders and inventors, working on solutions to personal problems by combining old and new technologies and tools when building personal and group projects. Regardless of whether they identify as makers or not, the members are the archetypal people present in the makerspaces. They range from the casual or curious to the dedicated

members and volunteers whose continued efforts are integral to the ongoing presence and continuance of the space. The makers have a vast range of skills, experience, knowledge, and degree of commitment, and may or may not fully buy in to the underlying ideology as espoused in the maker literature, but through their participation in the community they come to represent a new innovative archetype. They are not inventors per se, though they may engage in inventive activity. Nor are they scientists or researchers, specifically. But they do engage in the continual iterative process of making things, and *making things work*, and by so doing are continually contributing to innovation. They are not the only source of innovation at makerspaces, however. Another interesting actor was revealed: the *marketeur*.

9.2.2 Marketeurs

Within the direct comparison of the archetypes in the case studies was the revelation of a variant of the Schumpeterian entrepreneur, dubbed the Marketeur in recognition of the function that they serve in the market. The marketeur fulfills traditional entrepreneurial functions in engendering risk in others (Hawkins & Davis, 2012), as well as creating or founding a social network market (Potts et al., 2008), manifested as a makerspace in these instances. In each of the cases studied an individual (or group) fulfilling this archetype was present in the makerspace, in its design, inception, or day-to-day operations. The presence of the marketeur can also be seen in external examples of makerspaces (Rubenstein et al., 2018). In the cases observed, some of the marketeurs have moved on to other endeavors, acting as a serial entrepreneur, but the impact of their presence has been felt, in that the particular instantiation of the makerspace would not exist without their inception.

The marketeur can be identified by the functions they fulfill and the characteristics they include. The former includes the formation of new markets, networks, or forms of organization

within the community, the bringing of something new to the world, offering a service for it, and then attracting customers, subscribers, members, etc. They are also heavily involved in the formation of networks. Calling them a ‘Networkteur’ might be more appropriate: they reach out and form these connections. Another defining feature is their transitory nature: sometimes they move on, either from the specific instance or from the community altogether, though three of the four individuals who fit this role within the sample did stay within the community at large, even though they had shifted their position within it (J0, J1-151, 155).

9.2.3 Software Model Influence

Each of the observed makerspaces had different patterns of operating, administration, and funding, and these were tied to the underlying ideology of the space. In each instance, this tied back to a mode of development and distribution that can be seen in the computer software industry. This is what I have termed ‘software model influence’: the role that development on digital goods has on material practices and processes. What can be seen with software model influence is that ideology is embedded within the makerspace. It manifests itself, in the rules, the structures, and the practices of the makers themselves. Whether a given space has a community development model or a more corporate-like structure has a tangible impact on the operation of the space. Moreover, this also impacts the subjective elements of the space, the *feel* of it. This can speak directly to the audience that each is trying to attract and maintain, as the spaces are continually managing recruitment and churn, and this can lead to a degree of self-selection amongst the larger maker community or population of potential makers within the municipality.

9.3 Critical Maker Studies

In addition to the observations that are linked directly back to the innovation literature, a number of other findings come out of the fieldwork that do not fit neatly within the established framework. Regardless of whether these findings are related to the processes of communication or to the ethnographic fieldwork conducted during this project, they contribute directly to knowledge in the field, as this is one of the earlier studies of makerspaces in Canada and one of few comparative studies on makerspaces overall. What these additional findings have in common is their coming together from a critical perspective on the field of makerspaces, which I liken here to a Critical Maker Studies. These findings include the challenge of maker engagement, the process of disillusionment dubbed ‘the sadness factory’ by one of the makers, and the branded anti-consumerism that is enrolled and adopted by a number of followers of the maker ethos. These shall be handled as a subset of the critical maker studies, which follows below.

With the makerspaces’ strong ties to the hacker subculture and ICTs, the early literature on the topic has drawn heavily on similar work written on these subjects, and the tenets of technological utopianism that can be seen early in the hype cycle (Flew & Smith, 2018) of a new technology can be seen within the early literature on the maker movement as well. Therefore, a position of critical engagement and evaluation with both the literature and the maker movement is necessary, and this position is what is being termed ‘critical maker studies’. There is an abundance of hype in earlier literature about makerspaces (e.g. Anderson, 2012), and the stance of critical maker studies is not to say that this hype is unwarranted, but rather that current publications on makerspaces are following the same path as earlier publications about the potential of the internet. Twenty years later, some of the glowing predictions from the 1990s

about the internet's transformative capacity are warranted, and occasionally modest compared to what has actually come to pass. However, the downsides, costs, and externalities go far beyond what even the critics argued (May, 2002). This is part and parcel of any technological hype cycle, and so too with the Maker Movement. A critical perspective of makerspaces must treat them as it would any other new technology: address the potential critical downsides, while not limiting interest, excitement, or engagement with that new technology.

Critical Maker Studies is born from the current literature on makerspaces, which initially followed the utopian trend of the technological hype cycle. Within this literature, there has now been a shift to a more questioning stance in academia (Braybrooke & Smith, 2018). Perhaps the next wave of research will continue this trend, but for now it is just beginning. The criteria for a critical maker studies will necessarily derive from other critical studies of technology, couched within the sociotechnical literature that exists within the field of 'Science Studies'. A number of basic assumptions inform these criteria: power relations are socially and historically constituted, facts are linked to values and ideology, relationships are often mediated by capitalist production and consumption, and certain groups may enjoy privileged positions, among others. (Denzin & Lincoln, 2011). Re-examining maker literature and projects from this viewpoint can illuminate the impacts and effects of an uncritical stance. If much of the maker literature follows a utopian vision of technology and its use similar to early writing on the internet, what happens if the assumptions of the utopians is incorrect? How much money and resources could be misallocated in the pursuit of this vision. Is it even achievable, or desired? What would be the long-term effects of mass deployment of 3D printing technologies (for example)? These questions need to be addressed by a critical maker studies.

9.3.1 Maker ‘Engagement’

Critical theory is often used for a reading of media and understanding the underlying power relationships that are inherent within it. A critical perspective on technology will also touch on the media surrounding a given technology. As a necessary component of critical maker studies, the maker literature generated by and written for the maker market is one of the key media requiring analysis and critical evaluation. These media are used in attracting new entrants to the community, functioning as advertising and enrollment for the movement, the spaces, the projects, and the possibilities. These media, and the critical appraisal of them, highlight the communicative elements and cultural components of the maker movement.

Within the makerspace, engagement often occurs via maker media, as it is the subjective elements that attract the attention of the new and prospective users, and draw them in to the space, the display booth at the event, or towards the movement overall. This happens at two levels: at the first level, maker-related media – created either by or for makers – may be a source of influence: of projects, of goals, and of specific design elements; at the second level, the subjective elements of existing projects within the spaces become aspirational objects, imbued with the projections of the audience as an attainable, achievable goal. The process of engagement occurs via a communicative act. Marketing for the maker community: it is all *makerting*, basically.

9.3.2 ‘The sadness factory’

One of the downsides of the maker movement is the hard realization that new or prospective members come to realize about the projects: that despite the availability and increased ease of use of the tools, it still takes time, effort, dedication, and skill to make something that matches the dreams or the plans as proposed or seen. One of the participants at

Protospace dubbed it ‘the sadness factory’. The dreams and expectations of a makerspace cannot meet the realities that one faces once working within it. Yes, interesting things can be done with the new tools: 3D printing, fabricating, laser cutting, robotics, etc., but the realities of the use of new technology are often dashed on the rocks of high expectations. It takes a lot of use and practice to be efficient with any new technology, and many of the tools of a modern makerspace are effectively prototypes themselves. They have not been rationalized, and have not yet been turned into ‘devices’ following Borgmann’s device paradigm (1984). Maker projects (and makerspaces) have a lot of rough edges, and can require technical skill and ingenuity just to make work.⁵⁶⁵⁷ As the maker market has matured and grown a number of those rough edges have been sanded off, and off the shelf kits now have incredible abilities (p.28). But at the end of the day if you want to make something cool you may have to do a lot of hacking on your own. The makerspace provides tools and resources, but making still requires a lot of effort. This is somewhat elided in the maker literature to date; making is made to seem easier (and thus more revolutionary) than it is. The maker media is a key contributor to the sadness factory: it contributes to the hype celebrating the successes, providing excitement and enthusiasm, but ignoring the failures, issues and problems.

Finally, one of the key effects of the makerspace as a sadness factory is that it leads to a high degree of churn within the makerspaces, with annual turnover being as high as 20% in the case of Protospace, and an undocumented (but high) percentage with TOM Calgary as well. This may be similar to turnover and retention patterns in other subscription-based service

⁵⁶ This can be seen with the challenges faced by the TOM project teams where off-the shelf solutions were either employed or discarded, depending on their suitability and ease of adaptation during the 72-event.

⁵⁷ Development teams at the MakeFashion events found integrating the electronics with the clothing one of the more challenging aspects. As the technologies improved, the scope of what they could create expanded.

industries (like health clubs, meetups, etc.). The challenge it represents for the makerspaces is the need to constantly acquire those new members at a replacement level, as current budgets are dependent on the revenue stream provided by that user base. For example, after two years of operation, Fuse33 had not yet reached their goal of 200 regular monthly members that they needed to sustainably run the makerspace. The revenue issue reoccurs in other areas, as mentioned above with software model influence (p. 188), but issues of attraction, churn and retention can be described in terms of maker engagement.

9.3.3 Branded anti-consumerism

Within the maker movement and maker identity is an underlying tension between two groups: the DIY, Do-it-yourself, build it yourself, make-it yourself ethos, the ideology behind Protospace's 'Do-ocracy', the openness of TOM's approach to finding non-market solutions for its need-knowers; and the branded identity of 'Makers' fostered by O'Reilly Publishing, Make Media, and others. This former group include key anti-consumerist elements, those that reject big box stores, online marketing and the like, versus those that want to sell indicators of identity to the first group. The latter saw the development of the former, and that they represented an attractive market segment (largely WEIRD) that would be resistant to marketing. This tension can be described as "branded anti-consumerism". With the strong ties to identity, and the need for new tools, consumables, and projects, in which the tools and projects themselves can act as a form of conspicuous consumption within the community, makerspaces can represent a form of mercantile wealth, a revenue-generating prospect for those industries that can cater to this market segment.

Chapter 10: Conclusion

Makerspaces ultimately are social places of work and craft, where a community coalesces based on individual needs and group goals, and where skills needed for creating and innovation in digital and material media are combined and developed. What the makerspaces offer for research is a living lab for studying innovation, communication, and community, and the interactions of all three. Conducting ethnographic fieldwork at a makerspace to uncover the community and the practices that take place has occurred in previous work (Moilanen, 2012b; Troxler, 2010; van Holm, 2017); undertaking a comparative analysis of makerspaces reveals more going on than appears on the surface, discovering new archetypes of innovation and uncovering the impact of media, individuals, and ideology on the development, spread, and continuance of the makerspaces. The case study approach was able to provide a significant amount of detail on the people, projects, and processes across each of the three makerspaces observed, and this informed the discussion of makerspaces with respect to innovation systems, archetypes, and a call for a critical appraisal of the maker literature. This in turn led to significant and relevant findings that contribute in several areas, including innovation and communications. This chapter brings these elements together and identifies the contributions of this research, the opportunities for future work, and speculates on what the future lies in store for makerspaces and the field.

10.1 Summary of Findings

The research in the previous chapter outlined three broad areas of findings for this research. Within the first area, makerspaces function as a micro-system of innovation for more than just technical change, but also in business models, processes, organization, and outcomes.

They are sites of knowledge transfer and communication. The makerspaces provide a vehicle by which to discuss the very concept of innovation as it is understood by examining them with the various theories that currently make up the major schools of innovation thought. The second area of findings is with the archetypes of innovation that are present. Building on earlier archetypes of innovation like the entrepreneur and the firm, we discuss three novel archetypes of innovation – the maker, the marketeur, and the software model – that come into the light when examining the makerspace. The third area is the development of a critical maker studies, including the recognition of the processes of maker engagement, the process of disillusionment dubbed ‘the sadness factory’, and the role of branded anti-consumerism and anti-consumption through consumption. Each of these finding areas represents an avenue that could be further explored, suggesting the wealth of opportunities that exist within a nascent field of makerspace research.

10.2 Contributions

This work has drawn on many fields and disciplines, but it is firmly situated in the fields of innovation and communication, and it contributes to knowledge in both areas. First, it contributes to the recognition for and development of a critical appraisal of the maker movement, the maker spaces, and the maker media as a whole. Initial work has begun in this area, but it has not yet coalesced into a formal program or been identified as such either. That proposal – Critical Maker Studies – is here, and its contribution to communication studies (and to the sociotechnical literature to a lesser extent) is new to the field and the realm.

The second substantive set of contributions comes to the study of innovation. There is no set “theory of innovation”, but a number of common themes emerge. The incipient literature on

innovation is discussing the issues that led Schot and Steinmueller (2018) to frame the era as one of “transformative change”, but as yet a theory of this era has not yet coalesced. This work contributes to the theory of this era by expanding the concept of innovation, away from the firm and towards the street, recognizing the role of individuals and communities outside the core activities of corporate research and development and “triple helix” pathways of industry, government and universities can lead to a more fulsome understanding of the processes by which innovation actually occurs. Schot and Steinmueller "The development and implementation of transformative policy requires a new knowledge base." (2018, p. 1564). We argue here that makerspaces are a component in the building of that knowledge base.

We contribute to innovation research by identifying new archetypes in the innovation process including: 1) the maker as an archetype, building, fabricating, and working on projects along and in groups; 2) the Marketeur as an actor, and their role in the formation of makerspaces, and other similar social network markets, and 3) the structural role of Software Model Influence, the impact of digital models of development and distribution on the physical realm. In addition, this work has taken the lead in undertaking qualitative, ethnographic work on the practices of a makerspace and understanding it as a *site* of innovation, and that the characteristics of these sites can impact the very processes of innovation. These contributions are all indicative of the relevance of the work. Coupled with the findings, there is an opportunity to conduct further research. The makerspace as it is presented as a site of citizen innovation is something that is not present in the mainstream innovation literature. While there are similar archetypal forms that fit within the industrial R&D structure that are discussed, like R&D labs, startups and skunkworks, the makerspace is not present in the incipient literature either.

10.3 Opportunities

Opportunities exist for further research in multiple areas. Demographic work already exists that studies the constituents of makerspaces, and qualitative work is beginning to be done about their experiences and practices. An opportunity for long-term work on the effects and outcomes of makerspaces, on the community, on the people, on the industry(s), and on innovation practices, is something that now exists. This longitudinal work needs to be taken with a critical perspective, as noted above, but the current framework and growing networks of makerspaces means the opportunity is there.

Opportunities also exist in makerspace-related policy, which includes the broader impacts of DIY culture and peer production. With a number of OECD nations looking to provide funding to makerspaces, understanding the policy implications of these sites is key. Both the EU and Canada are involved in current funding programs for innovation like Horizon 2020 and the CFI (Canadian Foundation for Innovation), respectively, providing opportunities. These opportunities could include funding for development, and contributions to allow for education and skills-based active learning. The self-directed method of the makerspaces allows those interested individuals to undertake new skills development that sits outside traditional public funded schools, post-secondary, or adult education paradigms. Makerspaces also speak to a need for those who chafe at the institutional frameworks of those other delivery methods. The skills that are developed at makerspaces are ultimately those "bridging skills" (Schot & Steinmueller, 2018, p. 1564) required to form the new governance structures, like those required by large international programs.

The Horizon 2020 project is an EU Framework Programme for Research and Innovation currently committed to spending €80 billion from 2014 to 2020 ("Horizon 2020," n.d.) across its

three “pillars” of ‘Excellent Science’, ‘Industrial Leadership’, and ‘Societal Challenges’. The amount of investment is proposed to increase to €100 billion for the upcoming period from 2012 to 2027 (“Horizon Europe”, n.d.). Makerspaces are a small component of innovation, but they represent an area that bridges the three pillars of the EU’s Horizon initiative, connecting all three, and providing a space where citizens can develop the bridging skills that are required to navigate these challenge areas.

Within the Canadian context, the CFI (Canadian Foundation for Innovation) has a plan for “\$763 million over the next five years and \$462 million per year starting in 2023-24” (innovation.ca, 2019). Combined with the investment from the Canadian government through the Innovation and Skills Plan in the 2017 Budget (Government of Canada, 2017), and administered by the ISED (Innovation, Science, and Economic Development Canada), there is a real investment in the programs for the future. Makerspaces are only one component of that, to be sure, but they highlight the challenges of these solutions that are built on older paradigms of innovation and development, and function as a bridge between the various disciplines.

Finally, additional work can look at areas of research that are adjacent to the makerspaces. Their role in the bridging of digital and material interfaces, with wearable technologies and various Internet of Things projects that makers were observed to engage in may be of interest with respect to emerging areas of technology. These are the margins where the greatest opportunity currently lies. The makerspaces networks: the maker-adjacent pathways and avenues to the market that the makers use is also of interest. Many of these are digital, or social networks, like Kickstarter, etsy, Thingiverse, etc. What is missing in the literature on these areas, and what are the next steps that the makers need to pursue? Are these new and original as well or merely existing and under-recognized?

One way to think about where makerspace research can go is to compare it to the areas for new research. Schot and Steinmueller's (2018) era of "transformative change" is compared with the EU's Horizon 2020 initiative. In this transformative era, innovation is needed to address goals of sustainability, reduced income equality and full and productive employment, but for the EU, the Horizon 2020 blueprint is in the direct pursuit of technologies to offset the externalities caused by earlier waves of innovation. Makerspaces may not function at the high level of national systems of innovation, but by allowing ordinary citizens to research and innovate with projects that matter deeply to them, or to simply follow their interest and work and experiment with new tools and technologies, and more importantly, share and develop a community (and personal skills) around those tools, they may serve to achieve the goals of policy without being directly guided by it. For national policy, providing gentle guidance for makers may be more fruitful than explicit directives in research areas.

10.4 Next Steps

Expanding the scope of the research conducted in this dissertation – more makerspaces, more cities, more nations – could allow for the further development of a typology of the makerspaces. As the scope and scale of the research increases, there is a trend to look for other information in the aggregate data – as scaling is always an issue with qualitative work, no matter how many grad students may be so employed. The impact of aggregate makerspace data on innovation studies may allow for a contribution to that literature on its own (quantitative) terms. A short exploratory study that examines which factors can meaningfully be gathered from a makerspace is academic work that could be undertaken in a short timeframe.

During the course of the analysis, a number of new or parallel avenues for further research have also come to light. Engaging with literatures outside the scope of this project has potential. Engaging with the field of disability studies, to evaluate the influence of TOM and similar projects globally – both in the short and long term – could be undertaken. During the TOM gala Dr. John Bertram suggested that the impacts of makerspaces were real, but long term engagement, and the continuity of the TOM project and what is needed to drive it further is necessary and current. Similarly, ancillary effects of the makerspaces on certain populations that access them, notably at Protospace with the retirees and unemployed, and what the skill building and active community means for the members could also be explored. This research suggests that there are positive impacts for the members in having a third place outside of work and home where they can go and work on projects for personal use. In addition to the basic function as a third place, it was observed that the makerspaces share many of the same functions and challenges as other service or hobby-oriented businesses, like gyms and internet cafes, including issues of membership churn and retention, and a comparative analysis with any existing research on these industries could be fruitful for understanding future challenges for the makerspace as a concept. The makerspace's particular institutional function as a technology incubator or accelerator for firms looking to get their start could be examined in depth. Finally, the role of the entrepreneur archetype at makerspaces and the particular forms it takes, both traditionally and as the marketeur, warrants further exploration based on the initial findings.

Finally, the publication of the findings of this dissertation, either together or separately, in journals focused on the various fields of inquiry is important. The findings on innovation theory make contributions to the literature, both in what makerspaces have to say confirming and disconfirming current-era innovation theories, as well as the role of ethnographic fieldwork in

the study of innovation as was conducted here. The field of sociotechnical studies also publishes significant amounts of material on makerspaces and related technologies, and this work could contribute there. Finally, the broad umbrella of cultural and media studies is an avenue for an investigation of the maker-produced and maker-consumed literature, literature that has a broad influence in the engagement and enrolment of individuals into the movement, but lacks a critical appraisal. There is an opportunity to publish on makerspaces, and the volume of material in the field has increased in the last three years.

10.5 The Challenge of Making, Revisited

Making, makers, and makerspaces are not uncontested. As Braybrooke and Smith (2018) note, the political is still present in makerspaces, and the need for a critical appraisal of them was stressed in this document as ‘the challenge of making’ (Chapter 2, p.32). To that end, here are four challenge areas that need to be addressed in future research, some of which were only touched on here, but where the research will necessarily take other forms going forward.

1. To what extent are makerspaces leading to a “new industrial revolution” or “second machine age”? Or are they just a hobby-space? Is it an actual transformative post-industrial movement, or just a clubhouse for grownups?
2. What institutional and policy supports are needed if the makerspaces are part of the path to this second machine age?
3. What are the interconnections between firms and makerspaces, and how do they fit within the larger economy? More econometric data is needed here, and this may be difficult as many of the activities of makerspaces may fall outside the system of national accounts (Swann, 2015).

4. What does the makerspace tell us about knowledge flows, innovation, and lifelong learning? As a site of study, it is close to the ground of citizen innovation. What more can it tell us as a site of study?

These questions, and others that will arise, represent the next steps in research on makerspaces.

These are not research questions for the current project, but they can guide further research to be done, both in Canada and abroad.

10.6 The Future of Making

Making as a practice and makerspaces as a site for creating and innovation are becoming more widespread and widely recognized in society as a whole. The collective tools, spaces, and practices are spreading out along the adoption curve (Rogers, 1983), moving out of the hands of the innovators and early adopters into the broader population. Early uptakes of makerspaces by universities, colleges, public libraries and K-12 schools will introduce the ideas by craft to a larger population at a young age, who may take the practices in unexpected directions. This increased adoption will result in increased growth for maker-related goods and services, including the media as well as for the service provided by the makerspaces themselves. Drawing on the observations here, and casting this line of inquiry into the future allows for some speculation on the future of makerspaces and research.

One of the key areas of growth in the makerspaces has been the continued development of the tools and equipment used. During the course of this study alone the fabrication tools that are often associated with makerspaces have increased in capacity, capability, reliability, and usability. This has resulted in makers being able to build things quicker and more consistently,

with less waste and fewer abandoned projects. This resulting turn-around has opened up the field to new entrants with new ideas. The designers working on wearable technologies like those at Fuse33 for the MakeFashion show are able to use the increased battery life, improved sensors, and lighter components to increase the range of work they showcase.

This increased accessibility also expands the range of places where makerspaces or the tools may be used. Makerspace-related tools have been dropping in price and increasing in capability such that some models of 3D printers and laser cutters are within the range and budget of the home hobbyist. More sources of plans and .stl files are available, both freely and via digital distribution networks such as Kickstarter, IndieGoGo, and DriveThruRPG. As the tools and materials become more mainstream, the public awareness and familiarity will rise, and we will see an increase in the options available as more firms and entrepreneurs court this market. However, as this research has shown, it is the community and the network that is critical in the use and adoption of these new tools and practices.

The final area of speculation draws on one of the continual sources of ideas for incipient innovations: that of science fiction literature. As some of the tools that are embedded within the makerspaces draw varied sources for inspiration, with the replicators and communicators of *Star Trek* finding their way into modern household items from printers and smartphones, through to Virtual Reality rooms and the like, the sources of inspiration can hint at what may happen as peer production and making increases in popularity. The funding is there, the drive is there, the tools exist. What remains to be seen is how the tools and practices of making and makerspaces craft our future.

Appendix A: Detailed Methodology

A.1 Journals

A series of six notebooks was used for observations and contemporaneous note-taking:

- Journal 0 (J0) is the collected observations taken in the run-up to the project.
- Journal 1 (J1) was a large moleskin, used for detailed work on the dissertation.
- Journal 2 (J2) is a medium unlined Moleskin, for observation during 2016.
- Journal 3 (J3) is the same as J2, for observation during 2017.
- Journal 4 (J4) is the same as J2, for observation during 2018.
- Journal 4 (J5) is a small unlined Moleskin for observation during 4S Barcelona 2016.
- Journal 5 (J6) is a small Mead notebook used for notation during MakeFashion 2017.
- Folio 1 (F1) is instructional materials for course participants at Protospace.
- Folio 2 (F2) is a collection of materials collected from the 2017 YYCMiniMakerFaire.
- Folio 3 (F3) is a collection of materials collected from the 2017 MakeFashion show.
- Archives (A1-A3) are the folders for the collected audio and video, one for each case.

Audio and video was recorded on a succession of devices throughout the duration of the study, including an Olympus pocket recorder and an OnePlus5 smartphone. Pictures were taken with an Olympus digital camera, used from September 2016 to July 2017, and a OnePlus 5 Smartphone used from August 2017 to the end of the study.

A.2 Numbering

References to the journals is conducted in the XX.NNN format, where XX is the alphanumeric Journal or Archive number as identified above, and NNN is the page reference in the journal. Leading zeroes are used for consistency in formatting.

Appendix B: Timeline of Fieldwork

Date	Event/Location	Starting Page
2016-10-26	TOM Calgary	J1-053
2016-10-31	TOM interview #1	J1-055
2016-11-07	TOM Interview #2	J1-058
2016-11-09	Archeloft Site Visit	J2-047
2016-11-09	Archeloft Interviews	J1-061
2016-11-11	TOM Interview #3	J1-064
2016-11-30	TOM Developers meeting	J1-067
2016-11-28	EVDS Walkthrough – U of C	J1-068
2017-01-16	TOM Interview #4	J1-072
2017-02-07	Protospace New Member Orientation	J1-077
2017-02-16	Protospace Members Meeting	J1-080
2017-02-18	Protospace Monthly Cleanup	J1-081
2017-03-21	Maker Community of Practice	J1-082
2017-03-25	Protospace Lathe instruction	J1-084
2017-04-01	MakeFashion YYC 2017	J1-091
2017-04-08	Protospace Lathe instruction	J1-093
2017-05-06	Protospace Laser Cutter	J1-110
2017-05-13	Protospace Laser Cutter part 2	J1-123
2017-06-20	Protospace Site visit	J1-133
2017-06-22	Protospace Monthly members meeting	J1-134
2017-06-24	Protospace AGM	J1-135
2017-07-11	Protospace monthly meeting	J1-135
2017-07-18	Protospace Interviews	J1-139
2017-07-20	Protospace Interviews	J1-146
2017-08-22	Protospace Site visit	J1-147
2017-08-26	TOM 2017 Makeathon	J1-149
2017-08-27	TOM 2017 Makeathon Gala	J1-155
2017-09-05	Protospace	J1-161
2017-10-19	Protospace monthly meeting	J1-165
2019-01-19	Fuse 33 welding class	J1-169
2016-11-28	EVDS Community of Practice – U of C	J2-052
2017-12-02	Fuse33 Grand opening	J2-135
2018-05-01	Protospace Tour lead	J3-036
2018-05-08	Protospace visit and interviews	J3-050
2018-06-05	Reflection	J3-082
2018-07-26	Innovation Policy	J3-101
2016-08-31	4S EASST 2016	J5-010

Table 3: Journal Entries

References

- Aliverti, P., & Maietta, A. (2015). *The Maker's Manual: A Practical Guide to the New Industrial Revolution* (1 edition; P. D. Justo, Ed.). San Francisco, CA: Maker Media, Inc.
- Ames, M. G., Lindtner, S., Bardzell, S., Bardzell, J., Nguyen, L., Ahmed, S. I., ... Dourish, P. (2018). Making or making do? Challenging the mythologies of making and hacking. *The Journal of Peer Production*, 1(12). Retrieved from /issues/issue-12-makerspaces-and-institutions/varia-2/making-or-making-do/
- Andari, R. (2007). *Staying Ahead: The economic performance of the UK's creative industries*. Retrieved from http://www.theworkfoundation.com/assets/docs/publications/176_stayingahead.pdf
- Anderson, C. (2006). *The Long Tail: Why the Future of Business Is Selling Less of More*. New York: Hachette Books.
- Anderson, C. (2012). *Makers: The New Industrial Revolution*. Toronto: Signal.
- Anderson, C. (2013). From Maker Movement to New Industrial Revolution. *Popular Mechanics*, 190(11), 66–68.
- Arthur, W. B. (2007). The structure of invention. *Research Policy*, 36(2), 274–287. <https://doi.org/10.1016/j.respol.2006.11.005>
- Atkinson, P., Coffey, A., Delamont, S., Lofland, J., & Lofland, L. (2001). *Handbook of Ethnography*. Retrieved from <http://knowledge.sagepub.com/view/handbook-of-ethnography/SAGE.xml>
- Augsdorfer, P. (2005). Bootlegging and path dependency. *Research Policy*, 34(1), 1–11. <https://doi.org/10.1016/j.respol.2004.09.010>

- Bakhshi, H., & McVittie, E. (2009). Creative supply-chain linkages and innovation: Do the creative industries stimulate business innovation in the wider economy? *Innovation: Management, Policy & Practice*, 11(2), 169–189. <https://doi.org/10.5172/impp.11.2.169>
- Baumol, W. J. (2003). Innovations and growth: Two common misapprehensions. *Journal of Policy Modeling*, 25(5), 435–444. [https://doi.org/10.1016/S0161-8938\(03\)00038-3](https://doi.org/10.1016/S0161-8938(03)00038-3)
- Becker, M. H. (1970). Sociometric Location and Innovativeness: Reformulation and Extension of the Diffusion Model. *American Sociological Review*, 35(2), 267–282. <https://doi.org/10.2307/2093205>
- Benefits. (n.d.). Retrieved November 3, 2018, from Maker Faire website: <https://makerfaire.com/global/benefits/>
- Benkler, Y. (2006). *The Wealth of Networks: how social production transforms markets and freedom*. New Haven CT: Yale University Press.
- Blankenship, L. (1986, January 8). Hacker Manifesto (The Conscience of a Hacker). Retrieved June 26, 2017, from <http://www.phrack.org/archives/issues/7/3.txt>
- Boeva, J., & Chies, B. (2016). Yet Another Industrial Revolution—A Dialogue on Tensions in Digital Fabrication. *EASST Review*, 35(4). Retrieved from <https://easst.net/article/yet-another-industrial-revolution-a-dialogue-on-tensions-in-digital-fabrication/>
- Bogost, I. (2012). *Alien phenomenology, or, What it's like to be a thing*. Minneapolis: University of Minnesota Press.
- Böhmer, A. I., Beckmann, A., & Lindemann, U. (2015). Open Innovation Ecosystem—Makerspaces within an Agile Innovation Process. *Proceedings of ISPIM Conferences*, 1–11. Retrieved from bth.

- Booth, D. (2010). *Peer production and software: What Mozilla has to teach government*. Cambridge, Mass.: MIT Press.
- Borgmann, A. (1984). *Technology and the character of contemporary life: A philosophical inquiry*. Chicago: University of Chicago Press.
- Braybrooke, K., & Smith, A. (2018). Liberatory technologies for whom? Exploring a new generation of makerspaces defined by institutional encounters. *The Journal of Peer Production*, (12). Retrieved from /issues/issue-12-makerspaces-and-institutions/editors-introduction/
- Bruyn, S. (1970). The New Empiricists: The Participant Observer and Phenomenologist. In W. J. Filstead (Ed.), *Qualitative Methodology: Firsthand Involvement with the Social World* (Second, pp. 283–287). Chicago: Markham Pub. Co.
- Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work Progress And Prosperity In A Time Of Brilliant Technologies*. New York: WW Norton.
- Bucciarelli, L. L. (1984). Reflective practice in engineering design. *Design Studies*, 5(3), 185–190. [https://doi.org/10.1016/0142-694X\(84\)90012-7](https://doi.org/10.1016/0142-694X(84)90012-7)
- Bucciarelli, L. L. (1988). An ethnographic perspective on engineering design. *Design Studies*, 9(3), 159–168. [https://doi.org/10.1016/0142-694X\(88\)90045-2](https://doi.org/10.1016/0142-694X(88)90045-2)
- Busch, O. V. (2012). Molecular management: Protocols in the maker culture. *Creative Industries Journal*, 5(1/2), 55–68. https://doi.org/10.1386/cij.5.1-2.55_1
- Byrne, B. (2012). Qualitative Interviewing. In C. Seale (Ed.), *Researching Society and Culture* (3rd ed.). Thousand Oaks, CA: Sage Publications.
- Callon, M. (1986). Some elements of a Sociology of Translation: Domestication of the scallops and fishermen of St Brieuc Bay. In J. Law (Ed.), *Power, action and belief: A new*

- sociology of knowledge?* (pp. 196–223). Retrieved from https://bscw.uni-wuppertal.de/pub/nj_bscw.cgi/d8022008/Callon_SociologyTranslation.pdf
- Capdevila, I. (2014). Different Entrepreneurial Approaches in Localized Spaces of Collaborative Innovation. *Available at SSRN 2533448*. Retrieved from http://papers.ssrn.com/sol3/Papers.cfm?abstract_id=2533448
- Cautela, C., Deserti, A., Rizzo, F., & Zurlo, F. (2014). Design and Innovation: How Many Ways? *Design Issues*, 30(1), 3–6. https://doi.org/10.1162/DESI_a_00244
- Cavalcanti, G. (2013). Is it a Hackerspace, Makerspace, TechShop, or FabLab. *Make*, May, 22.
- Caves, R. E. (2000). *Creative industries: Contracts between art and commerce*. Cambridge ; London: Harvard University Press.
- CBC News. (2016, July 18). Alberta’s recession “one of the most severe” in its history, report says. Retrieved January 22, 2019, from CBC website: <https://www.cbc.ca/news/canada/calgary/td-economics-report-alberta-recession-gdp-forecast-1.3684056>
- Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business School Press.
- Coase, R. H. (1937). The Nature of the Firm. *Economica*, 4(16), 386–405. <https://doi.org/10.2307/2626876>
- coons, ginger. (2018). Can one size fit one? A prospect for humane custom production. *The Journal of Peer Production*, 1(12). Retrieved from /issues/issue-12-makerspaces-and-institutions/peer-reviewed-papers/can-one-size-fit-one/
- Crawford, M. (2010). *Shop Class as Soulcraft: An Inquiry into the Value of Work* (Reprint edition). New York: Penguin Books.

- Crawford, M. (2016). *The World Beyond Your Head: On Becoming An Individual In An Age Of Distraction*. Toronto: Penguin Canada.
- Cunningham, S. (2011). Paul Stoneman- Soft Innovation, economics, product aesthetics and creative industries.pdf. *Journal of Cultural Economics*, (35), 241–245.
<https://doi.org/10.1007/s10824-011-9141-7>
- DeFeo, C., Harding, J., & Wood, R. (2016). User Communities and the “Dark Energy” of Open Innovation. *Proceedings of the European Conference on Innovation & Entrepreneurship*, 913–920.
- Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011). *The SAGE Handbook of Qualitative Research*. SAGE.
- Denzin, N. K., & Lincoln, Y. S. (2018). *The Sage handbook of qualitative research* (Fifth edition.). Los Angeles: Sage.
- Dougherty, D. (2005). Maker Friendly. *Make*, 7.
- Edmondson, A. C. (2016, June 1). Wicked-Problem Solvers. Retrieved December 30, 2016, from Harvard Business Review website: <https://hbr.org/2016/06/wicked-problem-solvers>
- Eisenhart, M. A. (1988). The Ethnographic Research Tradition and Mathematics Education Research. *Journal for Research in Mathematics Education*, 19(2), 99–114.
<https://doi.org/10.2307/749405>
- Eltham, B. (2013). Three arguments against ‘soft innovation’: Towards a richer understanding of cultural innovation. *International Journal of Cultural Policy*, 19(5), 537–556.
<https://doi.org/10.1080/10286632.2012.658044>

- Eskelinen, J., Garcia Robles, A., Lindy, I., Marsh, J., & Muent-Kunigami, A. (2015). *Citizen-Driven Innovation: A Guidebook for City Mayors and Public Administrators*. Retrieved from <https://openknowledge.worldbank.org/handle/10986/21984>
- Fallows, J. (2012, November 28). Mr. China Comes to America. Retrieved October 21, 2018, from The Atlantic website: <https://www.theatlantic.com/magazine/archive/2012/12/mr-china-comes-to-america/309160/>
- Fallows, J. (2016). Why the Maker Movement Matters: Part 1, the Tools Revolution. *The Atlantic*. Retrieved from <https://www.theatlantic.com/business/archive/2016/06/why-the-maker-movement-matters-part-1-the-tools-revolution/485720/>
- Fixson, S., & Marion, T. (2014). The Segmentation of Innovation: How Digital Design, Rapid Prototyping, and a Sharing Culture are changing the NPD Landscape. *Technology, Operations & Information Management Working Papers*. Retrieved from <http://digitalknowledge.babson.edu/toimwp/6>
- Flew, T., & Smith, R. (2018). *New Media: An Introduction, Third Canadian Edition*. Oxford University Press.
- Frauenfelder, M. (Ed.). (2007). *The Best of Make: 75 Projects from the Pages of Make* (1 edition). Beijing: Maker Media, Inc.
- Freeman, C. (1994). The economics of technical change. *Cambridge Journal of Economics*, 18(5), 463–514.
- Freeman, C., & Soete, L. (1997). *The Economics of Industrial Innovation*. Cambridge: The MIT Press.
- Gaddis, J. L. (2002). *The Landscape of History: How Historians Map the Past*. New York: Oxford University Press.

- Gault, F. (2010). *Innovation strategies for a global economy: Development, implementation, measurement and management*. Cheltenham; Northampton, MA; Ottawa: Edward Elgar; International Development Research Centre.
- Gershenfeld, N. A. (2005). *Fab: The coming revolution on your desktop--from personal computers to personal fabrication*. New York: Basic Books.
- Ginsburgh, V., & Throsby, C. D. (2006). *Handbook of the economics of art and culture* (1st ed). Amsterdam ; Boston [Mass.]: Elsevier North-Holland.
- Gloor, P. A. (2006). *Swarm creativity: Competitive advantage through collaborative innovation networks*. New York: Oxford University Press.
- Gloor, P. A., Paasivaara, M., Schoder, D., & Willems, P. (2007). Finding collaborative innovation networks through correlating performance with social network structure. *International Journal of Production Research*, 46(5), 1357–1371.
<https://doi.org/10.1080/00207540701224582>
- Goetz, J., & LeCompte, M. (1984). *Ethnography and qualitative design in educational research*. New York: Academic Press.
- Government of Canada, D. of F. (2017, March 22). Budget 2017: Chapter 1 - Skills, Innovation and Middle Class Jobs. Retrieved September 25, 2019, from <https://www.budget.gc.ca/2017/docs/plan/chap-01-en.html>
- Graham, S. J. H., & Mowery, D. C. (2006). The Use of Intellectual Property in Software: Implications for Open Innovation. In H. W. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open innovation: Researching a new paradigm*. Oxford; New York: Oxford University Press.
- Hackerspaces.org. (n.d.). Retrieved June 29, 2017, from <http://www.hackerspaces.org/>

- Haddon, L. (2002). Information and communication technologies and the role of consumers in innovation. In A. McMeekin, Green, Ken, & Tomlinson, Mark (Eds.), *Innovation by Demand: An Interdisciplinary Approach to the Study of Demand and Its Role in Innovation*. Retrieved from <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10078502>
- Hammersley, M. (1992). *What's Wrong With Ethnography? – Methodological Explorations*. London: Routledge.
- Han, S.-Y., Yoo, J., Zo, H., & Ciganek, A. P. (2017). Understanding makerspace continuance: A self-determination perspective. *Telematics and Informatics*, 34(4), 184–195.
<https://doi.org/10.1016/j.tele.2017.02.003>
- Harkness, D. E. (2007). *The Jewel house: Elizabethan London and the scientific revolution*. New Haven: Yale University Press.
- Harman, G. (2009). *Prince of networks: Bruno Latour and metaphysics*. Prahran, Vic.: Re.press.
- Hatch, M. (2013). *The Maker Movement Manifesto: Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers* (1 edition). New York: McGraw-Hill.
- Hawkins, R. (2012). *Looking at Innovation from a Uniquely Canadian Perspective The Case for a New Alliance of Practice, Policy and Scholarship*. Retrieved from <http://www.issp.uottawa.ca/eng/pdf/HawkinsPaper.pdf>
- Hawkins, R., & Davis, C. H. (2012). Innovation and experience goods: A critical appraisal of a missing dimension in innovation theory. *Prometheus*, 30(3), 235–259.
<https://doi.org/10.1080/08109028.2012.716224>
- Hebdige, D. (1981). *Subculture: The Meaning of Style* (1 edition). London ; New York: Routledge.

- Henrich, J., Heine, S., & Norenzayan, A. (2010). The Weirdest People in the World? *RatSWD*, (139). <http://dx.doi.org/10.2139/ssrn.1601785>
- Hess, K. (1979). *Community technology*. Harper & Row.
- Heyink, J. W., & Tymstra, T.J. (1993). The Function of Qualitative Research. *Social Indicators Research*, 29(3), 291–305. Retrieved from JSTOR.
- Hill. (2016, September 16). Innovation Archetypes: What kind of innovator are you? Retrieved May 8, 2019, from The Future Shapers website: <https://thefutureshapers.com/innovation-archetypes-kind-innovator/>
- Himanen, P., Torvalds, L., & Castells, M. (2001). *The Hacker Ethic: And the Spirit of the Information Age*. New York: Random House.
- Holman, W. (2015). Makerspace: Towards a New Civic Infrastructure. *Places Journal*. <https://doi.org/10.22269/151130>
- Holt, M., & Braun, E. (2012, February 16). *Hacking Reality: The Hackerspace Project and the Farming of Innovation*. Presented at the Online Lifeline Conference 2012, Valdosta State University. Retrieved from <http://vtext.valdosta.edu:8080/xmlui/handle/10428/1076>
- Horizon 2020 [Text]. (n.d.). Retrieved September 25, 2019, from Horizon 2020—European Commission website: <https://ec.europa.eu/programmes/horizon2020/en>
- Horizon Europe—The next research and innovation framework programme [Text]. (n.d.). Retrieved September 25, 2019, from European Commission—European Commission website: https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en

- Hui, J. S., & Gerber, E. M. (2017). Developing Makerspaces As Sites of Entrepreneurship. *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, 2023–2038. <https://doi.org/10.1145/2998181.2998264>
- Innis, H. (1999). *The Bias of Communication*. University of Toronto Press.
- innovation.ca. (2019, March 13). Government of Canada investing in Canadian researchers to make world-class discoveries. Retrieved September 25, 2019, from <https://www.innovation.ca/about/nouvelles/government-canada-investing-canadian-researchers-make-world-class-discoveries>
- Jewkes, J., Sawers, D., & Stillerman, R. (1969). *The Sources of Invention* (Second, Ed.). New York: Norton.
- Kanter, R. M. (1988). Three Tiers for Innovation Research. *Communication Research*, 15(5), 509–523. <https://doi.org/10.1177/009365088015005001>
- Kelty, C. (2005). Geeks, Social Imaginaries, and Recursive Publics. *Cultural Anthropology*, 20(2), 185–214. <https://doi.org/10.1525/can.2005.20.2.185>
- Kidder, L. H., & Judd, C. (1986). *Research Methods in Social Relations* (Fifth Edition). Holt Rhinehart and Winston.
- Kim, B. (2016). Building Blocks of an Innovation Space. *Library Journal*, 141(3), 42–43. Retrieved from bth.
- Kuhn, T. S. (1996). *The structure of scientific revolutions*. Chicago: The University of Chicago Press.
- Lang, D. (2013). *Zero to Maker*. Retrieved from <http://proquest.safaribooksonline.com.ezproxy.lib.ucalgary.ca/book/small-business-and-entrepreneurship/9781449356422>

- Langford, C. H., & Josty, P. (2015). *2014 GEM Alberta Report*. Retrieved from Global Entrepreneurship Monitor website: <https://www.gemconsortium.org/report/49186>
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford; New York: Oxford University Press.
- Law, J. (1992). Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. *Systems Practice*, 5(4), 379–393. <https://doi.org/10.1007/BF01059830>
- Levy, S. (1984). *Hackers: Heroes of the computer revolution* (1st ed). Garden City, N.Y.: Anchor Press.
- Levy, S. (2010). *Hackers: Heroes of the Computer Revolution - 25th Anniversary Edition*. O'Reilly Media, Inc.
- Lindtner, S. (2012). Remaking Creativity & Innovation: China's nascent DIY maker & hackerspace community. *New Media and Cultural Transformation: Film, TV, Game, and Digital Communication*. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.452.520&rep=rep1&type=pdf>
- Link, A. N., & Siegel, D. S. (2007). *Innovation, entrepreneurship, and technological change*. Oxford: Oxford University Press.
- Lundvall, B.-Å. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter Publishers.
- Malinowski, B. (2013). *Argonauts of the Western Pacific: An Account of Native Enterprise and Adventure in the Archipelagoes of Melanesian New Guinea, Enhanced Edition*. Waveland Press.

- Maxigas. (2012). Hacklabs and hackerspaces – tracing two genealogies » The Journal of Peer Production. *Journal of Peer Production*, (2). Retrieved from /issues/issue-2/peer-reviewed-papers/hacklabs-and-hackerspaces/
- May, C. (2002). *The Information Society: A sceptical view*. Cambridge UK: Polity Press.
- Mazzucato, M. (2015). *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (Revised edition). New York: PublicAffairs.
- McCracken, H. (2015, April 29). Maker Faire Founder Dale Dougherty On The Past, Present, And Online Future Of The Maker Movement. Retrieved April 30, 2015, from Fast Company website: <http://www.fastcompany.com/3045505/maker-faire-founder-dale-dougherty-on-the-past-present-and-online-future-of-the-maker-moveme>
- McCue, T. J. (2015, July 21). 3D Printing Is Changing the Way We Think. Retrieved December 30, 2016, from Harvard Business Review website: <https://hbr.org/2015/07/3d-printing-is-changing-the-way-we-think>
- McMeekin, A., Green, K., Tomlinson, M., & Walsh, V. (Eds.). (2002). *Innovation by Demand: An Interdisciplinary Approach to the Study of Demand and Its Role in Innovation*. Retrieved from <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10078502>
- Moilanen, J. (2012a). Emerging Hackerspaces – Peer-Production Generation. In I. Hammouda, B. Lundell, T. Mikkonen, & W. Scacchi (Eds.), *Open Source Systems: Long-Term Sustainability* (pp. 94–111). Retrieved from http://link.springer.com.ezproxy.lib.ucalgary.ca/chapter/10.1007/978-3-642-33442-9_7
- Moilanen, J. (2012b). Emerging hackerspaces–peer-production generation. *IFIP International Conference on Open Source Systems*, 94–111. Retrieved from http://link.springer.com/chapter/10.1007/978-3-642-33442-9_7

- Mokyr, J. (1990). *The lever of riches: Technological creativity and economic progress*. New York: Oxford University Press.
- Mortara, L., & Parisot, N. G. (2016). Through entrepreneurs' eyes: The Fab-spaces constellation. *International Journal of Production Research*, 54(23), 7158–7180.
<https://doi.org/10.1080/00207543.2016.1198505>
- Mozur, P. (2014, August 21). Chinese Gadgets Signal New Era of Innovation. *Wall Street Journal*. Retrieved from <http://www.wsj.com/articles/chinese-gadgets-signal-new-era-of-innovation-1408658443>
- Müller, K., Rammer, C., & Trüby, J. (2009). The role of creative industries in industrial innovation. *Innovation : Management, Policy & Practice*, 11(2), 148–168.
- Mythbusters*. (2003). Silver Spring, Maryland: Discovery.
- Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, Mass.: Belknap Press of Harvard University Press.
- New Yankee Workshop*. (1989). Arlington, Virginia: PBS.
- Noble, D. F. (1984). *Forces of Production: A Social History of Industrial Automation*. New York: Knopf.
- Norman, D. A. (1990). *The design of everyday things* (1st Doubleday/Currency ed). New York: Doubleday/Currency.
- Oakley, K. (2009). The disappearing arts: Creativity and innovation after the creative industries. *International Journal of Cultural Policy*, 15(4), 403–413.
<https://doi.org/10.1080/10286630902856721>
- OECD. (2002). *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*. Retrieved from

<http://www.oecdbookshop.org/oecd/display.asp?LANG=EN&SF1=DI&ST1=5LMQCR2K61KL>

OECD. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (3rd ed.). Retrieved from <http://www.oecd-ilibrary.org/content/book/9789264013100-en>

Parks, B. (2005). *Makers: All Kinds of People Making Amazing Things In Their Backyard, Basement or Garage* (1 edition). Sebastopol, CA: Maker Media, Inc.

Penrose, E. (1959). *The Theory of the Growth of the Firm*. Oxford University Press.

Peters, J. D. (2015). *The Marvelous Clouds: Toward a Philosophy of Elemental Media*. Chicago ; London: University Of Chicago Press.

Potts, J. (2009). Why creative industries matter to economic evolution. *Economics of Innovation and New Technology*, 18(7), 663–673. <https://doi.org/10.1080/10438590802564592>

Potts, J., & Cunningham, S. (2008). Four models of the creative industries. *International Journal of Cultural Policy*, 14(3), 233–247. <https://doi.org/10.1080/10286630802281780>

Potts, J., Cunningham, S., Hartley, J., & Ormerod, P. (2008). Social network markets: A new definition of the creative industries. *Journal of Cultural Economics*, 32(3), 167–185. <https://doi.org/10.1007/s10824-008-9066-y>

Print me a phone. (2012, July 28). *The Economist*. Retrieved from <http://www.economist.com/node/21559593>

Putnam, R. D. (2001). *Bowling Alone* (1st edition). Simon & Schuster.

Raymond, E. S. (1999). *The Cathedral & the Bazaar*. Retrieved from <http://shop.oreilly.com/product/9780596001087.do>

Robertson, E. D. (2010). *Hacker Spaces: User-Led Innovation and Economic Development*. Retrieved from <https://smartech.gatech.edu/handle/1853/35792>

- Rogers, E. M. (1983). *Diffusion of Innovations* (Third). New York: Free Press.
- Roma, A. D., Minenna, V., & Scarcelli, A. (2017). Fab Labs. New hubs for socialization and innovation. *The Design Journal*, 20(sup1), S3152–S3161.
<https://doi.org/10.1080/14606925.2017.1352821>
- Rosenberg, N. (1982). *Inside the black box: Technology and economics*. Cambridge: Cambridge University Press.
- Rubenstein, M., Linder, B., & Taha, K. (2018). The distorting effect of money, and other lessons learned by a makerspace funder. *The Journal of Peer Production*, 1(12). Retrieved from /issues/issue-12-makerspaces-and-institutions/practitioner-reflections/the-distorting-effect-of-money/
- Rushkoff, D. (2011). *Program or Be Programmed: Ten Commands for a Digital Age*. Berkeley, CA: Soft Skull Press.
- Ruttan, V. (1959). Usher and Schumpeter on Invention, Innovation, and Technological Change. *The Quarterly Journal of Economics*, 73(4), 596–606.
- Savage, N. (2013). Backing creativity. *Communications of the ACM*, 56(7), 20–21.
- Schot, J., & Steinmueller, E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, 47(9), 1554–1567.
<https://doi.org/10.1016/j.respol.2018.08.011>
- Schumpeter, J. A. (1934). *The Theory of Economic Development*. Retrieved from <http://www.hup.harvard.edu/catalog.php?isbn=9780674879904>
- Schumpeter, J. A. (1939). *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*. Martino Pub.

Schumpeter, J. A. (1962). *Capitalism, socialism and democracy* (First Harper Torchbook ed).

New York: Harper & Row.

Seale, C. (2012). *Researching society and culture*. London: SAGE.

Sennett, R. (2008). *The craftsman*. London; New York: Allen Lane.

Shannon, C. E., & Weaver, W. (1963). *The Mathematical Theory of Communication*. University of Illinois Press.

Shusterman, R. (2006). The Aesthetic. *Theory, Culture & Society*, 23(2–3), 237–243.

<https://doi.org/10.1177/0263276406062680>

Signal, J. (n.d.). *Becoming Makers: Hackerspace Member Habits, Values, and Identities image*.

Retrieved from <http://peerproduction.net/issues/issue-5-shared-machine-shops/peer-reviewed-articles/becoming-makers-hackerspace-member-habits-values-and-identities/>

Silverman, D. (1993). *Interpreting Qualitative Data: Methods for analysing talk, text, and interaction*. Thousand Oaks, CA: SAGE Publications Ltd.

Smith, A. (2014). Technology Networks for Socially Useful Production » The Journal of Peer Production. *Journal of Peer Production*, (5). Retrieved from [/issues/issue-5-shared-machine-shops/peer-reviewed-articles/technology-networks-for-socially-useful-production/](http://peerproduction.net/issues/issue-5-shared-machine-shops/peer-reviewed-articles/technology-networks-for-socially-useful-production/)

Sousa, C. (2012). Using social network analysis to study entrepreneurship: Methodological issues. In I. Salavisa Lança & M. Fontes (Eds.), *Social networks, innovation and the knowledge economy*. London; New York: Routledge.

Sousa, C., Salavisa Lança, I., & Fontes, M. (2012). Comparing sectoral network in software and biotechnology. In I. Salavisa Lança & M. Fontes (Eds.), *Social networks, innovation and the knowledge economy*. London; New York: Routledge.

Sterling, B. (1993). *The Hacker Crackdown: Law And Disorder On The Electronic Frontier*

(Reprint edition). New York etc.: Bantam.

Stoneman, P. (2008). *Soft Innovation: Changes In Product Aesthetics And Aesthetic Products*.

Presented at the Royal Economic Society Annual Conference. Retrieved from

<https://research.mbs.ac.uk/INNOVATION/Portals/0/docs/seminar/Stonemansoftinnovationpaper.pdf>

Stoneman, P. (2010). *Soft Innovation: Economics, product aesthetics, and the creative industries*. Oxford: Oxford University Press.

Swann, G. M. P. (2009). *The Economics of Innovation: And introduction*. Cheltenham UK:

Edward Elgar.

Swann, G. M. P. (2015). *Common Innovation*. Retrieved from [http://www.e-](http://www.e-elgar.com/shop/common-innovation?__website=us_warehouse)

[elgar.com/shop/common-innovation?__website=us_warehouse](http://www.e-elgar.com/shop/common-innovation?__website=us_warehouse)

Taylor, P. A. (2005). From hackers to hacktivists: Speed bumps on the global superhighway?

New Media & Society, 7(5), 625–646. <https://doi.org/10.1177/1461444805056009>

Thomas, D. (2003). *Hacker Culture* (1 edition). Univ Of Minnesota Press.

Tierney, J. (2015a, April 17). How Makerspaces Help Local Economies. Retrieved May 2, 2015,

from <http://www.theatlantic.com/technology/archive/2015/04/makerspaces-are-remaking-local-economies/390807/>

Tierney, J. (2015b, April 20). Makerspaces and Morality—The Atlantic. Retrieved April 30,

2015, from The Atlantic website:

<http://www.theatlantic.com/technology/archive/2015/04/the-dilemmas-of-maker-culture/390891/>

- Troxler, P. (2010, October 8). *Commons-based Peer-Production of Physical Goods: Is there Room for a Hybrid Innovation Ecology?* Presented at the The 3rd Free Culture Research Conference, Berlin.
- Troxler, P., & Wolf, P. (2010). Bending the Rules. The Fab Lab Innovation Ecology. *11th International CINET Conference, Zurich, Switzerland, 5–7*. Retrieved from http://square-1.eu/site/wp-content/uploads/2010/09/TroxlerWolf2010_BendingTheRules_FablabInnovationEcology_pub.pdf
- Usher, A. P. (1962). *A History of mechanical inventions* (Rev. ed). Cambridge, Mass.: Harvard University Press.
- Utterback, J. M. (2006). *Design-inspired innovation*. Hackensack, NJ: World Scientific Pub.
- van Holm, E. J. (2017). Makerspaces and Local Economic Development. *Economic Development Quarterly*, 31(2), 164–173. <https://doi.org/10.1177/0891242417690604>
- von Hippel, E. (1986). Lead Users: A Source of Novel Product Concepts. *Management Science*, 32(7), 791–805.
- von Hippel, E. (1988). *The Sources of Innovation*. New York: Oxford University Press.
- von Hippel, E. (1994). “Sticky Information” and the Locus of Problem Solving: Implications for Innovation. *Management Science*, 40(4), 429–439.
- von Hippel, E. (2005). *Democratizing Innovation*. Cambridge: The MIT Press.
- von Hippel, E., & von Krogh, G. (2003). Open Source Software and the “Private-Collective” Innovation Model: Issues for Organization Science. *Organization Science*, 14(2), 209–223. <https://doi.org/10.1287/orsc.14.2.209.14992>

- Waldman, L. (2014, September 29). Coming Soon to the Library: Humanoid Robots. *Wall Street Journal*. Retrieved from <http://www.wsj.com/articles/coming-soon-to-the-library-humanoid-robots-1412015687>
- Walter-Herrmann, J., & Büching, C. (2013). *FabLab: Of machines, makers and inventors*. Bielefeld: Transcript.
- Wang, F., Wang, W., Wilson, S., & Ahmed, N. (2016). The State of Library Makerspaces. *International Journal of Librarianship*, 1(1), 2–16.
- Wark, M. (2004). *Hacker Manifesto*. Retrieved from <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10312824>
- Wolfe, D., & Holbrook, J. A. (2000). *Innovation, institutions and territory: Regional innovation systems in Canada*. John Deutsch Institute for the Study of Public Policy.
- Yin, R. K. (2009). *Case Study Research: Design and Methods*. SAGE.
- Zubairi, A. (2018, August 28). Calgary converting economic downturn into tech opportunity. Retrieved January 22, 2019, from BetaKit website: <https://betakit.com/calgary-converting-economic-downturn-into-tech-opportunity/>