THE MAKER MOVEMENT AND 3D PRINTING: A CRITIQUE

A Thesis
Presented to the
Faculty of
San Diego State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Sociology

by
Kathryn M. Durant
Summer 2016
SAN DIEGO STATE UNIVERSITY

The Undersigned Faculty Committee Approves the

Thesis of Kathryn M. Durant:

The Maker Movement and 3D Printing: A Critique

Michael James Roberts, Chair
Department of Sociology

Paul Thomas Semm
Department of Sociology

Thomas Weston
Department of Philosophy

May 19, 2015
Approval Date
DEDICATION

For David, for everything.
(and for Fröön)
ABSTRACT OF THESIS

The Maker Movement and 3D Printing: A Critique
by
Kathryn M. Durant
Master of Arts in Sociology
San Diego State University, 2016

We live in a world where technological progress is a norm of society. Technology and its effects cannot be separated from what it means to be human. This is why it is important to understand why despite this relationship technology is still considered to be a neutral influence on society. For this thesis I review the technology of 3D printing and the users of this technology that are part of the Maker Movement community to better understand this neutral stance. From the Maker community I find that the members are also anti-government when it comes to policies or regulation of 3D printing because they feel that it will stall its progress. I critique their neutrality and anti-policy stance from the standpoint of historical theorists of technology such as Karl Marx, The Frankfurt School and Martin Heidegger and modern day theorist Harry Braverman, Sandra Harding and Andrew Feenberg. What I find is that the rational, or quantifying method, of how we experience nature and ourselves is why we view technological progress as neutral or deterministic to society. I also find a lack of connection between the innovators of technology such as 3D printing and those that create policies about technology in different political and social institutions. The issue that I find from this research is that most users of technology have little or no control over how technology is designed and how it can best function for all members of society and those that are in control cannot separate innovation from the capitalistic global economy.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT .................................................. v</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS ........................................... vii</td>
</tr>
<tr>
<td>CHAPTER</td>
</tr>
<tr>
<td>1 INTRODUCTION .................................................. 1</td>
</tr>
<tr>
<td>2 LITERATURE REVIEW .......................................... 13</td>
</tr>
<tr>
<td>3 ADDITIVE MANUFACTURING VS. MAKER MOVEMENT .......... 44</td>
</tr>
<tr>
<td>4 CRITIQUE OF MAKER MOVEMENT IDEOLOGY ................ 53</td>
</tr>
<tr>
<td>5 CONCLUSION .................................................... 64</td>
</tr>
<tr>
<td>REFERENCES ........................................................ 69</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I would like to thank all of the professors that I had the pleasure of learning from these past two years, not only for sharing their impressive knowledge and passion, but for their “realness.” Special thanks to the “realest” of them all, Professor Roberts, for giving me the direction and support I needed to expand upon what was just a small idea in my mind.
CHAPTER 1
INTRODUCTION

3D printing is an emerging technology that has been hailed as the technology that will bring on a third industrial revolution. It is also considered the most disruptive technology of the century. With such extreme implications it is important to understand why society is willing to accept this new process for printing materials. The methods to regulate or protect the users of this technology have yet to be developed. As with technologies that have come before 3D printing, it has become commonplace for society to accept the risk of technological development and have faith they will provide a better quality of life. This has become a common ideology of technology because in society we see technology as neutral and believe that we as a society are in control of our technologies. We live in a rational society where the values of science and technology and the efficacies they provide have become commonplace. The issue is that because we live in a capitalistic society these values reflect the interest of a small section of the population. Although it is true that the design of a technology can be influenced by the demands of the market, the choices of technological development usually benefit those with the most capital. It is hard to argue that technology is neutral when viewed from the perspective of who has access to its design, but as a consumer of technology it seems like we must simply accept the technology that is given to us and learn to adapt our lives around it.
I recently had an experience with a relatively new kind of 3D printing technology. This experience was overall a very positive one until I had the time to stop and think about it more objectively. It’s not a secret that everyone hates going to the dentist, generally it is an anxiety inducing painful experience. I had to have a tooth replaced with a crown, something that most people will need in their lifetime. It was the second time within a year I needed one but the second experience was much different then the first. During my first experience, part of the procedure was that I had to have a physical mold made of my tooth and then this mold was sent out to a dental lab. In the mean time I was sent home with a temporary crown to wait two weeks for my permanent crown. Unfortunately, the temporary crown fell out before my scheduled appointment and I had to go back and have it glued back in before the permanent one was ready. It took a total of three anxiety-inducing appointments to get my permanent crown as well as time out of my busy schedule. The second time I needed a crown; my same dentist had just added a 3D printer to her office. I was told to expect a two-hour appointment time and only one appointment. When I arrived they removed my old filing and scanned my damaged tooth with a handheld scanner and the images immediately came up on a computer. The dentist showed me as she edited the images and then sent them to the 3D printer out in the hallway. This took about forty-five minutes. I was then told I was free for the next thirty minutes it would take to print the crown. They were excited to show me the machine that was prominently displayed out in the hallway and I watched as the machine made my replacement tooth with great speed and efficiency. The crown printing process is different then other 3D printing processes. Instead of a building the crown in layers, it takes a block of material and two programed robot arms with lasers cut out the crown from a block of dental material. Once it was finished, I had my permanent crown in
place and left the office within twenty minutes with no additional appointment needed. How could I not be happy with this new technology that saved me additional appointments and anxiety while costing me the same as the previous crown? Instead of leaving the dental office with only my normal sense of relief, I was also excited to tell people about my cool experience. It was not until the excitement wore off that I was able to critically think about my experience. I started thinking about the ramifications at the dental lab that had made my previous crown and the people that worked there who had been replaced by this machine. Initially I was more concerned with my own benefits so I did not wonder what type of work would they do now? They have been trained to work in a dental lab and I imagine they thought that they would be secure in their jobs due to their level of skill. There are also the people that drive or are part of the process of transferring my crown to the dentist that would no longer be needed. Perhaps the people that designed them were only thinking of the benefit of efficiency for the patient and the dental office. I use my personal example to point out why it is important to understand the history and theory of technology to better grasp why most consumers think that technology is neutral and have taken a deterministic view of the effects of technology on society.

**Scope and Significance**

Like all technologies, 3D printing did not just spring up overnight. It has a history of development that relied on previous technologies for its creation. Like any technology, there are people that want to make a profit from its use and people that value it as a way to express their creativity and interests. 3D printing, otherwise known as “additive manufacturing” was first developed in 1986 at the University of Texas by Carl Deckard and Joe Beaman and was immediately acclaimed to be a revolutionary technology (Lipson and Kurman 2013:9). It has
not been until this century with the advancement in the digital age and the affordability of home computing and the Internet that its use has become more widespread. People have been using 3D printing for years in different types of industry and home use. From the manufacture of custom parts for the aerospace industry to the antique part needed for home appliances (Lipson and Kurman 2013:33). The “additive manufacturing” process involves the method of printing material in layers and as the layers stack on top of each other form objects of three dimensions. The term “manufactured” refers to the fact that the process can be repeated and is systematic (Lipson and Kurman 2013:65). What makes this a unique process is the ability to print in several types of materials such as plastic, steel, food and living cells. In additional to the materials, you need to have the software to design the object, the 3D printer and a computer. It can print complex interlocking structures and combine materials to produce objects that otherwise would have not been possible to make out of conventional materials. (McCutcheon 2014:221). “Additive manufacturing” is different then the current type of manufacturing done today. The more conventional type used is the “subtractive” type of manufacturing. This process is when you start with raw materials that are cut away or shaped into objects. This requires more waste and storage compared to “additive” manufacturing because additive can be done as on-demand and is a more custom way of manufacturing then “subtractive” (Prince 2014:40). Once you have the design file, a computer-aided design or CAD file that you can download from the Internet, additional software turns the file into a printable file and that design in then sent to the printer. Some companies are sharing their files and designs for free and eliminating the need to be a software developer or designer to print an object. You can also send your design file to a
company that will print for you if you do not have access to a printer or material needed to print.

The field of 3D printing has expanded immensely since the early 2000’s with two different paths or philosophies about what it will mean to society. Like many technologies before it, a conflict has emerged about the possible positive and negative effects about its place in society and who should be in control. The conflict can be seen in two very different fields interested in the development of 3D printing: those looking to profit and those looking to create. It has become part of a new movement of artisan manufactures and designers called the Maker Movement as well as of great interest to corporations hoping to have the next big medical invention. Ethical issues that surround the manufacturing of 3D objects are developing as quickly as the technology. Beyond items for home use, the medicine and science fields’ research output has tripled in the last 10 years. Just a few years after the invention of 3D printing, Wake Forest Institute of Regenerative Medicine printed 3D scaffolding for organ augmentation (Prince 2014:40). Headlines today tell of companies such as San Diego based Organovo leading the way in 3D human tissue printing and they are telling the world it is only a matter of time before you can get a replacement organ printed to your needs (Fischer 2013:27). Organovo made an announcement in December 2014 that they are teaming up with Yale medical research to 3D print organs for transplant and the organs will be made from the patient’s own cells therefore reducing the failure rate. The short-term goal is to develop organs that can assist with failing ones instead of replacing them altogether. Also, they will work together to develop transplantable blood vessels, lung tissue and bone (Brewster 2014).
This is the kind of headlines that we love to hear, the possibility that technology can save us from death but at the same time it is unchartered territory and there is no way we know where it will lead. Also what the headlines fail to mention are the issues of classism and racism. That these organs will be available first to those that live in first world countries and can afford the highest level of health care. Organs will be for sale and companies such as Organovo will want to make as much profit as possible on their invention. Although these printed body parts are far in the future, Organovo announced in November 2014 the commercial release of their™ Human Liver Tissue to be used for preclinical drug discovery (Renard 2014). The goal is to accelerate the drug making process and develop treatments for disease faster and at a lower cost. With a claim like that how can we not be excited by the possibilities and should we not assume that these companies are only looking out for our best interest if they want to cure diseases? Other advancements have been made in the field of prosthetics and medical implants. Before the ability to 3D print a prosthetic, the manufacture of a custom prosthetic was too expensive for most patients, especially children who could quickly outgrow the prosthetic and need it continually replaced. Now a 3D scan and print of a prosthetic can be done in one day with moving parts and because it is made of inexpensive material can be cheaply reprinted over and over until it is fully fitted to the user. As I mentioned, dental prosthetics such as crown and implants are already printed daily at dental offices around the country. This saves the patient time and stress as they leave the office the same day with their permanent replacement tooth while creating other unforeseen problems as it eliminates skilled jobs. Other daily items printed are bandages (containing living cells), bones, ears and exoskeletons. Scientists at MIT are working on prosthetic sockets that can be customized to the limb and will be lower cost to manufacture than the current type being
used (Sharma 2014:32). It seems like daily there is a news article about a life being improved by 3D printing a custom replacement bone such as a jaw or trachea. There are still technical challenges in 3D printing such as slow printing speeds and the home based models only can print in plastic (McCutcheon 2014:242) but it has the potential to becoming the most disruptive technology in modern society. I have read several article that call 3D printing disruptive, otherwise known as unsettling and troublesome, yet there is nothing that has said about stopping its development only what we should get ready for in the future.

Other social issues surrounding 3D printing are the materials it uses. As it is mostly plastic manufacturing there is a concern for the environment as we will rely on plastic more heavily and it is unclear what type of emissions the manufacturing process gives off from the plastic (Gilpin 2014). Another possible area of disruption is the ability to manufacture guns and drugs. Already we have seen that the desire to print guns is driving the innovation of 3D printing. In only two years the evolution of 3D printing a gun moved from improbable to reality (McCutcheon 2014:227). It is the recreational gun user that has made the software accessible on the Internet where it can be downloaded to make unregistered weapons without a license. These enthusiasts claim it is within their civil rights to print the guns and there is a divide between those that believe that the 3D printing of guns is within their Constitutional rights and those that believe it to be a threat to public safety (McCutcheon 2014). The challenge is that the blueprints for the guns that are printed out of plastic “can be used by anyone to print rough, disposable and shoddy guns, than be recycled into a flower vase” (Johnson 2013:343). There is currently no regulation of 3D printing in the home and the concern is that historically lawmakers are slow to move on regulation of fast developing new technologies. Other potential problems include the manufacturing of 3D drugs. A scientist in
Glasgow created a prototype for patients to print their own medicine using a chemical blueprint provided by their pharmacists (Gilpin 2014). This raises the concern of the criminal trading of these chemical blueprints and the illegal manufacture of these drugs for sale.

**Subculture**

In contradiction to those looking to profit off of 3D printing such as the medical industry and criminals, there is a movement of user that see it as an adventure, the Maker Movement. The movement is based on the experience of creating customized objects and the satisfaction in knowing that you are the designer and the manufacturer of the objects. The Maker Movement is being praised as the start of the new industrial revolution and many of its members are using 3D printing to make their creations (Anderson 2012:41). Unlike the first and second industrial revolutions, when you had to have large amounts of capital to bring your idea to the market, today with the 3D printer members of this movement believe anyone will be able to develop and manufacture from their printer at home. With “additive manufacturing” the cost is the same to make one item or many different types of items. What used to require a factory and the cost of labor to run the factory will be replaced by small and medium size businesses that require fewer workers and instead of mass production it will be the specialization of production, manufacturing to the custom need of the consumer (Whadcock, 2012). The ideology of Maker Movement depends upon the narrative of giving everyone the chance to become an entrepreneur right from his or her home office or garage. All you need is a home computer and the Web and “would-be entrepreneurs and inventors are no longer at the mercy of large companies to manufacture their ideas” (Anderson 2012:18). Today there are thousands of “makerspaces” throughout the world, with Shanghai being the leader in building these spaces that provide for a rental fee the space and the
equipment needed for shared production. Libraries have embraced the technology and created Maker Spaces in the hope of drawing in new patrons. The 3D printers have given them a new service to offer that is creative and educational. This would not be possible without the invention of the desktop versions of 3D printers and the lower cost brought on by competition of the manufacturers of the machines. The Makers see the future of 3D printing as a way to provide access to the average person to the world of manufacturing without asking, will those in control of manufacturing allow this and what about all the people that rely on manufacturing as a job

**Methods**

For this research project I used a combination of research methods. For the first part of the project I used participant observation and in-depth interviews. These methods were used to better understand how the different types of users perceive 3D printing. I chose two different settings to try and capture how the perception of 3D printing varies between student users and entrepreneurs.

The second part of my methods is a theoretical approach to better qualify the discussions that surround 3D printing and other technologies and to provide a more historical perspective on the demand and acceptance of such technologies into modern day society. I include the philosophies of Adorno, Horkheimer and Marcuse who were members of The Frankfurt School, the school of thought that developed Critical Theory, and Marx who was the basis for their common theoretical analysis. I also include Heidegger for his criticism of technology and its control over nature. I also felt it important to provide two critiques of Marx’s theory on technology by Braverman and Feenberg as well a more modern day critique of technoscience from the feminist perspective as theorized by Sandra Harding.
Purpose of Thesis

The purpose of this thesis is an examination of 3D printing from three different theoretical perspectives on technology. This study will look at the users of this technology to better understand for what purpose they currently use 3D printing and if they believe it to be neutral or have no effect on society. It is important to understand the controversy surrounding this technology as well as look at how its development is enframed within our capitalistic economy and our culture. Looking to the future this study will try to understand the possible disruptions of 3D printing and to theorize why we are willing to accept it and all modern technologies even in the face of possible harm to our ourselves and our jobs. The intention of this study is to research 3D printing and the potential of this revolutionary new fast developing technology. As with any revolution, in the quest to use this technology to end poverty, improve the environment and create new medical marvels, there are also negative side effects.

The philosophies of technology separate themselves into two very different areas of thought. Instrumental theorists assume technology is relatively neutral in terms of its application; it is the most common theory of technology. It assumes that people think they have control over technology they develop and that this control allows them to put it to a positive use or a negative use. The lack of concern by the Maker Movement about 3D printing a gun is the same issue as all guns from this neutral perspective, “guns don’t kill people, people kill people”, therefore all guns should be considered neutral. Other problems that this perspective make easy to ignore are when technologies create unemployment as in the case of auto manufacturing or cause harm to the environment.
On the other side are the Substantive theorists, such as Heidegger (1977), whom in *The Question Concerning Technology*, argued that technology controls and shapes all aspects of our social world. Technology has changed our view of nature. We see it as something to be ordered and controlled and this has caused humanity to lose the essence of technology and this according to Heidegger is cause for man to also lose his essence. The danger is “the threat to man does not come in the first instance from the potentially lethal machines and apparatus of technology. The actual threat has already affected man in his essence” (Heidegger 1977:28). It does not matter if as the Maker’s believe that 3D printers are neutral, we are already “enframed” by technology.

There is a third philosophy of technology, the Critical Theory of technology. Philosophers of this theory include from The Frankfurt School: Adorno, Horkheimer, and Marcuse. The Frankfurt School argued that although technology is not neutral, reverting back to nature or a time without technology is not feasible. Technology can no longer be separated from society. Marx (1973) wrote in *Grundreisse* of the possibility of technology having a liberating potential from the standpoint of the workplace. If workers are able to demand better working conditions in conjunction with the advancement of automation at work then they could achieve at the very least a reduction in working hours. Braverman critiques Marx theory by addressing the issue of “de-skilling” from automation and its continued effect on alienation in the workplace.

Andrew Feenberg (2002) is the most modern theorist of the Critical Theory of Technology and in his *Transforming Technology: A Critical Theory Revisited*, he combines Instrumental and Substantive theories to argue that technology is a way of life in modern society and is not neutral, but controlled by the elite. His theory rejects the fatalism of
Substantive theory while also arguing that technology is not deterministic, “thus critical theory agrees with instrumentation in refusing fatalism. It does not despair in the face of the triumph of technology, nor does it call for a renewal of the human spirit from a realm beyond society such as religion or nature” (Feenberg 2002:14). The average citizen does not have much influence in how technologies are developed and we no longer can separate what it means to be human from our technology in modern society, so for the critical theorists we must develop a way for collective social action when it comes to our technologies. This critical perspective on technology looks to history to better understand our willingness to accept technology as a social force. Since the Enlightenment, society has embraced the quantification of nature and mankind. This has been propelled by a revolution in science, which has resulted in a switch from a religious control over society to a scientific or rational control as Weber (1930) discusses in *The Protestant Work Ethic and the Spirit of Capitalism* and *Science as a Vocation*. To understand the importance of the role of technology in society it is necessary to question how rationality has affected what it means to be human (Weber 2004).
CHAPTER 2

LITERATURE REVIEW

Interest in 3D printing technology is not only in the area of science and technology but also of interest to the fields of economics, law, the environment and sustainability. I reviewed articles about the development of 3D printing, its uses and the concerns regarding this technology. To better understand why 3D printing technology is an important development to society it is necessary to discuss different theories of technology. Through this literature review I will also discuss the different theories of technology and how they can be used to interrupt 3D printing as well as how society views its benefits and negative outcomes that arise as it develops. Two studies in this review discuss the possibility of ownership of production moving into the hands of anyone that can afford a 3D printer and has access to the free software available on the Internet (Pearce 2012; Pearce et al., 2010). Further discussion about this free software will be about the controversy surrounding free software in connection to the manufacturing of unregistered guns and focusing on the concerns with the legality of this type of manufacturing. Also, I will review the different products currently available in the field of medicine as well as a look to the future of 3D printing and a time when it will be as common as an MP3 music file to own and use and what that might mean to the current business structure of the economy and those that rely on mass production for their income.
As of now, 3D printing’s proposed success has been in the production of the single unit, low volume and highly customized good (Petrick and Simpson 2013:12). The idea is that anyone will be able to design and manufacture anything they can dream up quickly and cheaply thus changing the nature of design. Despite the media hype, as the use of 3D printing spreads, we find there is a gap in the experiences of those that use it based on their level of expertise. What is found is a technical ambivalence by entry-level 3D printing users as it is being introduced to the public. This alludes to the idea that the lack of interest and inspiration will stall 3D printings emergence as the “next industrial revolution” (Bosqué 2014:579). The current mode of mass production requires a factory and the labor force of the factory to produce just one prototype and if that prototype is a failure than large amounts of capital are at risk. Products can now be designed and produced locally and companies such as UPS and Staples already offer 3D printing services at some of their stores (Petrick and Simpson 2013:14) but there will still be a need for mass production. Despite the efficiency of 3D printing it is unlikely that this type of production will disappear due to the large amount capital that has been invested. Access to a 3D printer is still in the hands of the advantaged, especially those who are technical, making the average person at a disadvantage when it comes to the possibilities of 3D printing.

**The Maker Movement**

The Maker’s of today’s Maker Movement have focused their do-it-yourself, or DIY attitude on technology and how they can adapt different technologies to fit their imaginations. 3D printing is just one of the technologies they are attracted to because they crave tools of production and find pleasure in solving concrete problems on the spot (Lipson and Kurman 2013:48). A connection for the desire to innovate can be found between those
that use 3D printing as members of the Maker Movement and those that use it as a form of commercial use or “additive manufacturing”, the difference is Makers want to share their creativity and “additive manufacturers” are in it for profit. One company in particular, the RepRap project, represents the Maker Movement’s ideology of 3D printing. They claim that not only are you able to download their for printing objects for free using open source appropriate technology or OSAT, you can also download free software to print another RepRap 3D printer from your existing one. To understand the importance of OSAT, according to one study, OSAT provides free access to the software and this plus the availability of inexpensive computing “has made a new means of open design capable of accelerating self-directed sustainable development” (Pearce et al., 2010:17). RepRap’s 3D model printer is self-sustainable to the point of not only making its software free but the printer can also make 48% of its own components (Pearce 2012:427). The importance of this, according to 3D printing users and designers, is the end of intellectual property that restricts access to technology for the less privileged and creating sustainability in local communities with access to a 3D printer and the Internet. An example of sustainability for a rural village community would be the need for a part for a water pump. They will have the ability to print out and replace the part in the same day without relying on the obstacle of transporting the item to the village. As OSAT and 3D continue to develop together Maker’s believe that a technological revolution is possible, a revolution where home users and technical savvy people will work together without the control of Intellectual Property. The hope is that without the control of Intellectual Property new designs can focus on creating equality in society and not on profit. The ability to save lives in developing countries through open sourced software will become more assessable (Pearce 2012:428).
The underlining problem of the OSAT culture is that it exists within the capitalistic world economy. We already have the means to create equality in the world but because those that hold the capital are not willing to use it for this purpose. Inequality continues despite technological advancements. A leading 3D printing company, MakerBot, is an example of what happens when the ideology of OSAT meets capitalism. When MakerBot first began in 2009, their philosophy was one of open sharing of software designs and open source hardware. The three men who started the company met at a “hackerspace” in the New York City DIY community. They developed a 3D printer based on the RepRap project design and had open software accessibility through their online site Thingiverse. The purpose of the Thingiverse site was to create a community where anyone could build upon MakerBot designs or create their own by allowing people to hack their codes and improve the quality and function of their machines. Their motto, like that of all the Maker community, was that the sharing of software and hardware designs would only improve the overall development of the 3D printing community. Less then three years later, after gaining much success and developing several 3D printers, their newest machine was brought to the market with a closed source or trade secret design. One of the three developers that started MakerBot had since been forced out of the company because he disagreed with the decision. MakerBot stated that the change was needed to become a more professional business and later that year they patented several of the designs that the Maker community had help create for them. This decision destroyed the loyalty of the Maker community who stated that MakerBot had stolen their designs for profit and had turned their back on the community that had built them (West and Kuk 2015:9).
A current trend in 3D printing design is to make it more marketable to consumers by making the experience as “user-friendly” as possible. Some of the smaller companies making the 3D printing machines, that are newer and own less patents, are doing this by leaving their designs as open source so that anyone can adapt or modify them for free to fit their printing needs. What makes this “user-friendly” is that without knowing any aspect of software design that is needed to print objects, users are able to borrow and tweak existing free software designs for their own purpose. There is a growing debate about what this “de-skilling” of the functions of 3D printing will mean to the future growth of the industry. If the development potential of 3D printing is what makes it so unique, the fact that there is a separation between those that truly understand the technology and those that do not, limit the potential of what can be created (Bosqué 2014:579).

**Critique of Instrumental Theory**

Today’s capitalistic society is technological and the two cannot be separated. The market, products and processes of technology create the social forces that determine our way of life. It is easier to imagine your life with the additions of new technologies such as 3D printing then it is to imagine a life without technology. Considering that our way of life is shaped by technology and the modern science that has brought us all these new technologies, it is important to think about the philosophy of technology and traditional theory. The rise of rational society can be attributed to traditional theory and the distinction made between theory and praxis to explain facts through universal laws. This technique of validating a theory, that is must pass empirical confirmation, has lead us away from praxis. Creating a society where scientific truth or falsehood is used as a measure for all things including
human behavior and because of this, the most universal philosophy of technology is one of neutrality and determinism, Instrumental Theory.

To better understand the development of 3D printing and its appeal as a technology that will add value to society it is important to understand how technology is experienced in society. Modern society, like our tools, is shaped by instrumental rationality. This rationality focuses on the most efficient and cost effective means to achieve a specific end. Instrumental rationality uses reason only as a tool to reach the goals, not to say which goals are right or necessary. It is more concerned with the answer as to “how” goals can be reached in society through technological developments then the “why.” What is missed by not asking the “why” is how are these developments improving the human condition. This can be seen not only in our technological developments but also in our institutions and social relationships. Andrew Feenberg calls this modern social structure a “social rationality”; the application of rationality is so prevalent it shapes even our social life (Feenberg 2002:166). Max Weber’s theorized that our rationalization stems from the domination of people by bureaucracy and our systems of rationalization are born from the Protestant work ethic. Protestants emerged from Calvinism and Calvin was said to encourage people to attain wealth to prove that they were worth saving by God. This was to be done through hard work and the embracing of frugality to build more wealth, essentially embracing capitalism. This required the implementation of different systems to measure and factor wealth, bureaucratic systems. As these became more efficient or rational it allowed for a faster attainment of wealth and better chance of salvation. In Western capitalist societies we are trapped and controlled by our bureaucracy or in an “Iron Cage”. Capitalism thrives on rationality by creating a more efficient and replaceable workforce that paves the way for more profit for the capitalist
ensuring they remain at the top of the social hierarchy. Essentially rational society helps to maintain the hierarchy. Weber writes, “the capitalistic economy of the present day is an immense cosmos into which the individual is born, and which presents itself to him, at least as an individual, as an unalterable order of things in which he must live. It forces the individual, in so far as he is involved in the system of market relationships, to conform to capitalistic rules of action” (1930:19). Our conformity is why the most accepted theory of technology is still one of neutrality or determinism. We accept this theory because our culture is based on the belief of the value of efficiency.

The neutrality of technology stems from the ideology that technologies are “tools” waiting to be used. Viewed as neutral or instrumental, these tools are deemed indifferent to their end use. This concept is also known as the “common sense” view of technology because it makes sense to society. This indifference gives technology the appearance of being very different from social institutions such as politics and policies as well as religious institutions. In social applications this neutral view can be attributed to the “rationality” of technology. Rationality implies universality therefore the idea that technology can easily transfer from one society to the next is acceptable. Rationality equates measurement and measurements of technology can be applied to any social context despite the fact that the society in place might disagree on political or religious grounds to the technology being introduced. The Instrumental view of technology provides the framework for technological advances even if concerns and tensions are brought up from social or political institutions.

**Critique of Substantive Theory**

Substantive theorists think technology is anything but neutral and contend that through the continued quantification of society we are losing our humanity as we become
more instrumental and like the tools we create. They maintain that technology is not neutral, but has a substantive value bias that can differ from the intended impact of the technology. Philosophers such as Jacques Ellul and Martin Heidegger argue that technology is a “new cultural system that restructures the entire social world as an object of control” (Feenberg 2002:7). According to Substantive theorists, it can be argued that technoscience has become a social practice to rationalize people and nature and only by eliminating rationalization can we end the transformation of all objects into a means for an end and develop a new social practice that does not embrace domination as it’s narrative. The way we use our technology is part of how we determine our humanness. It cannot be separated from our culture or society because technology has become what we structure our cultural identity and society around. At the far end of this theory is the view that the only way to gain back control of our humanness is to revert back to the era of craftsmen before modern technology. In The Question Concerning Technology, Heidegger (1977) asks how do we obtain a “free relationship” to modern technology? We have become controlled by our rationality or “enframed” as Heidegger writes; that is why technology cannot be viewed as neutral (1977:15). Modern technology he argues is bringing about the decline of modern civilization because we view nature as raw material for the purpose of technical transformation and this detached perception has blocked the true essence of technology. Until the essence of technology is revealed we will continue to treat human capabilities as an instrument for production and workers as a human resource to be arranged and distributed to the detriment of humanity (Blitz 2014:68). Although this theory of technology is not the norm and may seem extreme because society is not going to give up its technology, a less rational society would allow for a greater connection to nature and perhaps to ourselves. It is our enframing
by technology and rationalization that allows the continued domination of nature and the environment. Feenberg argues,

Heidegger agrees that technology is relentlessly overtaking us. We are engaged, he claims, in the transformation of the entire world, ourselves included, into “standing reserves,” raw materials to be mobilized in technical processes. Heidegger asserts that the technical restructuring of modern societies is rooted in a nihilistic will to power, a degradation of man and Being to the level of mere objects. (2002:7)

Another way to view the Substantive theory it to see it as a movement toward a more “common sense” society or “informal rationality” that does not see our environment as raw material waiting for action and instead adds value to informal thinking and individual experiences.

The Frankfurt School

The origin of Feenberg’s Critical Theory of technology can be found in the Frankfurt School. This group of philosophers originally went by the name The Frankfurt Institute for Social Research, it essentially was a school of social theory that looked to build upon and critique traditional theory to find a cultural system not based on capitalism and with the aim of further developing Marxist studies (Tar 1977). Critical theory provides a specific interpretation of Marxist philosophy and reinterprets some of its central economic and political notions such as commodification, reification, fetishization and critique of mass culture.

As Hitler came to power the school was forced to move, as several members were Jewish and feared for their lives, they eventually settled at Columbia University, New York under the name The Frankfurt School. Through their work one can see the influence WWII and the holocaust had on them. As Hitler attempted to eliminate the Jewish culture through the mass murder, these philosophers argued that science and technology was leading to the
destruction of humanity. Two of the members of the Frankfurt School, Theodor W. Adorno and Max Horkheimer, argued that our technological age is our new despotism. Despite how we have been socialized, the age of Enlightenment has not delivered us freedom. Instead of being dominated by the rule of the church and religion we are ruled by reason and this has taken away our ability to question the meaning of science and technology.

The Age of Enlightenment movement in Europe during the 18th century was mainly a philosophical movement that was based on reason as opposed to the dominant beliefs of the time that were established on religious traditions. It was a time of the awakening of scientific discourse led not only by those that studied science but also the main philosophers of the time such as Bacon, Descartes, Voltaire and Kant. The importance of the Enlightenment was the move to separate society from the domination of the Roman Catholic Church by applying empiricism and reason to the religious and political authority of the era. The overall objective of the Enlightenment was one of democracy, individual freedom such as free speech and thought, and scientific progress. This movement, which has brought us, our modern Western culture and reverence for science and technology has also led us to sacrifice in our desire to free ourselves from the authoritarianism of religion and myth through reason.

In the Dialectic of Enlightenment, Horkheimer and Adorno (1987) argue that the Enlightenment has led society back to barbarism. Instead of creating a more democratic and free existence it has created a different form of domination, one of fear of the unknown. “For enlightenment, anything which does not conform to the standard of calculability and utility must be viewed with suspicion” (Horkheimer and Adorno 1987:3). Man believes that this era of knowledge is freeing him from the fear of the past mythology during which he felt under the control of the gods but the fear is instead replaced by a fear of anything that cannot be
calculated or is not part of the modern language. We see our world through our language and if language cannot explain the world then we distrust what cannot be explained. Before the Enlightenment we were mastered by the sacred symbols of the priests and today it is by the symbols that represent the ruling class or those with the most capital. There is nothing neutral about these symbols that depict that the attainment of wealth is essential. These symbols create fear and those in charge of technology, the elite, control alienation and the measure or instruments used to define these symbols. These elites believe that thought is an instrument and there is no need for reflection without it being measureable and useful. We have become out of touch with the idea of the natural world and therefore ourselves, as we are nature. Our fetish of commodities has furthered our separation from nature as we have come to value material wealth over knowledge. Horkheimer and Adorno (1987) write: myth is Enlightenment and Enlightenment reverts to mythology, unable to escape. Essentially the Enlightenment is the disenchantment of the world by doing away with myths. All power is given to knowledge, which uses science and technology to debunk myth. “But the more the illusion of magic vanishes, the more implacably repetition, in the guise of regularity, imprisons human beings in the cycle now objectified in the laws of nature, to which they believe they owe their security as free subjects. The principle of immanence, the explanation of every event as repetition, which enlightenment upholds against mythical imagination, is that of myth itself” (Horkheimer and Adorno 1987:8).

Horkheimer and Adorno (1987) argued that this as a return to barbarism, as subjective reasoning overshadows objective reasoning. The efficiency of reason does not allow for ideas, theory or meditation because anything that cannot be measured is considered
not of value because it has no activity. Subjective reason finds “its worth is determined by the operational value for the domination of men and nature” (Tar 1977:84).

Technology through its domination and control of nature by exploitation uses formulas and math to systematically reduce all things to facts. Through our bureaucratic management of people and the division of labor society it is making humans subservient to technology in the same way there were previously subservient to mythical gods or the religious state. This is how enlightenment reverts to mythology. Nature and man as objects are manipulated by technology. This technology requires the conformity of the model and individuals are forced to conform to a model that is mastered by reason, “by relating every existing thing to every other” (Horkheimer and Adorno 1987:8). Ideas are rejected that cannot be mastered and our individuality is subject to suspicion and anything that cannot conform is met with fear and oppression.

The instruments of technology give us a feeling of self preservation as they at the same time take away or feelings of self. We are more automated as we rely on these instruments to create a secure fearless society but truly they are dominating and have given us a fear of the irrational. The victims of this are people and any ideas of an “irrational” quality. This can include a technological advancement that does not work within the framework of capitalism. We hear every day of inventions that would be useful and not destructive to the environment or the worker but the market does not embrace these products because there is too much capital at stake for those in control so they are willing to destroy each other and the environment for profit.

Instrumental theorist’s view that technology is outside of social context then it has no value and is neither good nor bad. This fits within the worldview of that a rational way of
life is necessary for efficacy and control. Therefore technology will always lead to progress despite the setbacks or disasters that may occur during the quest to better the human race. Social values should be distinct from scientific research because trying to put upon science and technology social values would be detrimental to the empiricism or facts of science and technology. As a result of this ideology, neutral theorists believe that when a technology inflicts harm upon society that it is irrelevant in the sense that the harm is separate from the need to progress science and technology, like a side effect that cannot be helped or stopped. These theorists can say the same when a technology imparts good onto society.

Horkheimer, who was the director of The Frankfurt School, developed critical theory as a critique of traditional theory from an ethical standpoint. Traditional theory was a result of the Enlightenment influenced by Descartes and Husserl, and he felt was a “bourgeois” theory. This theory views only facts as knowledge and is applied to natural objects as well as non-living nature. As they developed the Critical Theory of society, the Frankfurt School theorized that in order to find the essence of society you must include history and an ontological relationship between the individual and the reflection of the humanity and culture of society (Taylor 1977:158). It is the combination of the individual and the group not one without the other. For man to be emancipated does not mean he is emancipated from society and therefore the Substantive theory of technology, that we should revert to nature, is not a path to emancipation because technology is part of society. There needs to be a theory on how humans can have freedom, technology and a society together. This theory has to include a connection to nature, of man forming a relationship with nature that is not one of domination, Critical theory is opposed to the traditional concept of theory that the individual must “accept” the basic conditions of their existence as it was given to them. Unlike
Traditional theory it considers the “dysfunctional” aspect of our capitalistic society and how it is connected to the way our social structures are organized. Critical Theory addresses the needs of the individual not just the social structure. It looks to a future of a society of free men, one where the work process and production benefits the interest of all classes. The members of The Frankfurt School understood that intellectuals are not outside of history or social processes therefore knowledge can only be obtained within a society and is dependent on it and that is why a Critical Theory of society is necessary.

Rationality can be seen in all aspects of society, it does not matter what type of society we have, socialist or capitalist, “in arguing that the liberation of humanity and the liberation of nature are connected, the Frankfurt School also addressed the fear that socialism might simply universalize the Promethean technicism of modern capitalism” (Feenberg 2002:14). Until we address the issues of social rationality society we will continue to be biased. Due to the influence of the Enlightenment we have created a culture where rationality is beyond criticism and art and creativity is met with skepticism, therefore any changes in society are not acceptable unless they can be measured and factored.

Herbert Marcuse was a member of The Frankfurt School who came to fame in the late 1960’s and the 1970’s and like Marx argued that capitalism and the objects it produces continue to alienate and dehumanize those that produce them. He expanded on this theory by stating that it is a connection between science, technology and capitalism that had created a system of domination. Where as Marx saw the system of domination stemming from the mode of production, Marcuse wrote that modern capitalism had created false needs and false consciousness geared to consumption of commodities. It has created the one-dimensional man living in a one-dimensional society who can only recognize themselves in their
commodities. The very mechanism, which ties the individual to her society, has changed and social control is anchored in the new needs that it has produced. Most important of all, the pressure of consumerism had led to the total integration of the working class into the capitalist system. As part of capitalism he argued that technological developments are based on the political and cultural system set in place by the primary actors that hold the positions of power and because of this technology cannot be seen as determinate or neutral. Returning to a pre-industrial society will not change the relationship with technology either; we must look to a less rationalized society. Marcuse saw this as a society that values art much the same way as we value reason thus creating a world filled with different values (Feenberg 2013:608). Marcuse’s point of view stems from the historical period during which he wrote. It was the counter-culture movement of the late 1960’s, a movement that was against the established rational system and instead embraced creativity and alternative thinking. The Maker Movement of today is a reflection of this era; their manifesto states “making is fundamental to what it means to be human. We must make, create, and express ourselves to feel whole” (Hatch 2013:1).

Modern science and technology, according to Marcuse, cannot be seen as separate because technology uses developments in science to dominate and instrumentalize nature and further control society. Technical rationality stems from the processes of capitalism, which is based on this domination of nature. Unlike other promenade members of The Frankfurt School, Marcuse offers an alternative rationality by considering the existential character of technicity that he claims is currently blocked by capitalism (Feenberg 2013:608). Technology must not be seen as neutral but as ambivalent and as an alternative path to the realm of freedom. We can redesign our technology as a solution to anxiety and our pacification of life.
The solution is a new social development of technology created to enhance enjoyment and meet all our essential needs.

Marcuse’s “one-dimensionality” derives from our experience of living in a capitalistic society. Our capitalistic society quantifies every aspect of daily life; at the workplace, in our entertainment and with our fetishism of commodities. He argues that rationality was necessary and instrumental to life and that machines are not the cause of our domination. It is how we experience machines and technology and how we can no longer recognize ourselves outside of the system. Marcuse writes that technology and its design have the possibility to serve all of society and not just the interests of capitalism. What is needed is a “materialization of values”. He writes, “the critique of technology aims neither at a romantic regression nor at a spiritual restoration of ‘values.’ The oppressive features of technological society are not due to excessive materialism and technicism. On the contrary, it seem that the causes of the trouble are rather in the arrest of materialism and technological rationality, that is to say, in the restraints imposed on the materialization of values” (Feenberg 2013:613). What is needed is a fundamental change on the value of the design of technology that includes human potential and no longer promotes the domination of nature. A technological revolution is needed to realize a free society.

**Braverman**

3D printing is being called the next industrial revolution because of its possible disruption to our current structure of manufacturing. To put this in perspective, the first industrial revolution replaced the era of artisan and craftsmen who produced locally made goods by bringing in the era of mass production and machinery and a globalized marketplace. According to Braverman, the detrimental effects of machinery derive
exclusively from the social relations under which the technology has been developed and put to use.

The success of the Industrial Revolution was dependent on the invention of machinery that improved capacity and allowed for the fastest output speed. It also required the cheapest labor, which was often child labor, to maximize profits for the owner of production. This era perpetuated the elimination of the craftsman by dividing the labor process resulting in the “de-skilling” of the worker and giving the capitalist full control over the production process. One of the earliest innovative principles of the capitalist mode of production was in manufacturing and the division of labor (Braverman 1974:70). Through the division of labor, special knowledge was reduced to simple labor, leaving the laborer powerless to control his position and always fearful of being replaced for a lower wageworker.

Braverman (1974) argued in *Labor and Money Capital* that the labor process of postmodern society, despite the rapid development of science and technology, is still as alienating as during Marx’s era of the industrial revolution. He showed how jobs throughout the 20th century progressively required less and less skill while continually growing the profits of the capitalists. Our post-modern society continues to be one of alienation, resentment and anxiety in the workplace, despite our “developed” capitalistic economy. Unlike Marx’s prediction, we are still working long hours and are as disconnected from the products we produce. Due to the division of labor and the increase in the bureaucracy at the workplace, we have lost the ability to understand or relate to what our co-worker’s duties on the job involve. The degradation and elimination of the skilled worker has left behind a workforce that lacks confidence to revolt against the conditions of capitalism. We are told
that the future is moving toward one filled with highly skilled and educated workers but in reality there are few spaces for this level of worker to exist in capitalism (Wardel, Steiger, and Melksins 1999).

The monopoly that we see today of wealth relies on the uneducated and unskilled laborer who feels too empty, and the importance of this is according to Braverman, is this emptiness or vacuum in people’s lives more then ever shapes their existence. The division of labor does require a certain amount of skilled labor but it is organized in such a hierarchical manner that the level or time of the simple laborer is worth nothing, while the few skilled laborers at the highest level are experiencing a totally different sphere of what it means to “work”. This separation transfers to all aspect of life not just at the workplace.

It can be argued that without the connection to craft, de-skilling is what keeps capitalism alive. Hobbyists who use technology are outside of the sphere of employment and enjoy a space where they can maneuver with more freedom then in an employed status. Their contributions from the hobbyist community Braverman believes can lead to a utopian promise of automation,

The re-unified process in which the execution of all the steps is built into the working mechanism of a single machine would seem not to render it suitable for a collective of associated producers, none of whom need spend all of their lives at any single function and all of whom can participate in the engineering, design, improvement, repair and operation of these ever more productive machines. (Söderberg 2013:136).

In our advanced technological society the worker still feels alienated from their occupation. Technology may help create a new mode of production, where the distribution of knowledge about training of production is available to everyone at the workplace but all that is produced is still going to be owned by the same capitalists, so is a socialist economy the answer? Braverman writes that the social division of labor is what divides society into
different occupations and the division of labor within the workplace is what takes those occupation and reduces the workers, who hold these positions, to powerless cogs in the machine, “while the social division of labor subdivides society, the detailed division of labor subdivides *humans*, and while the subdivision of society may enhance the individual and the species, the subdivision of the individual, when carried on without regard to human capabilities and needs, is a crime against the person and against humanity” (1974:73).

**Marx**

Marx recognized that the new system of mass production, as nature was massively being converted to capital, resulted in the workers becoming alienated from their work and themselves. The type of work needed for mass production requires little skill or contact with the raw material in which these commodities begin, this is in contrast to the previous era where skilled craftsman would work with the raw materials all the way through to the final completed product. This separation from nature gave rise to a new type of consciousness where the relations between people started to appear as the same exchange value as the objects they produced. As the labor became more external to the worker it no longer related to their intrinsic nature. Without this relation to his work he does not affirm himself but denies himself, he does not feel content but feels unhappy, he does not develop freely his physical and mental energy but destroys his body and mind. The worker then can only be himself outside of work and work he feels outside himself. He feels at home when he is not working and when he is working he does not feel at home. His labor is therefore not voluntary but has become forced labor (Marx 1976:165).

The separation of people form their “species-being” as Marx refers to consciousness is the social theory of alienation. Marx argued that for humans to overcome this alienation we
as a society need to remove ourselves from the mode of production and only then will we be free. To better understand how we have come as a society to develop a machine such as the 3D printer, a machine that’s main objective is to quickly and efficiently create any object at the click of a button, it is important to look to Marx. In the Grundrisse, he writes that we are dependent on our technology and therefore we will continue to develop more technology (Marx 1973:704). It is through the use of technology and machines that man will be freed from this forced labor, as automation replaces workers.

Marx theorized that technology or automation in the workplace could potentially lead to the emancipation of the worker, leaving them in control of their workday and able to demand fewer working hours and better pay (1973:701). He also saw the progress of technology and science within the means of production as the end of capitalism.

In machinery, the appropriation of living labour by capital achieves a direct reality in this respect as well: It is, firstly, the analysis and application of mechanical and chemical laws, arising directly out of science, which enables the machine to perform the same labour as that previously performed by the worker. However, the development of machinery along this path occurs only when large industry has already reached a higher stage, and all the sciences have been pressed into the service of capital; and when, secondly, the available machinery itself already provides great capabilities. Invention then becomes a business, and the application of science to direct production itself becomes a prospect which determines and solicits it. But this is not the road along which machinery, by and large, arose, and even less the road on which it progresses in detail. This road is, rather, dissection [Analyse] – through the division of labour, which gradually transforms the workers’ operations into more and more mechanical ones, so that at a certain point a mechanism can step into their places. (See under economy of power.) Thus, the specific mode of working here appears directly as becoming transferred from the worker to capital in the form of the machine, and his own labour capacity devalued thereby. Hence the workers’ struggle against machinery. What was the living worker’s activity becomes the activity of the machine. Thus the appropriation of labour by capital confronts the worker in a coarsely sensuous form; capital absorbs labour into itself – ‘as though its body were by love possessed’ (Marx 1973:703).

Capitalism cannot be sustained by machines and automation of the workplace.
Profit for capitalists can only be attained through the extra labor of the human worker, their surplus labor. Surplus labor is the amount of labor worked in addition to the necessary labor time and is how profit is created. Without surplus labor the cost of the commodities cannot be met and then surpassed, this is what adds value to the objects being produced or the profit. The more the capitalist can reduce the necessary labor time of the workers the more profit can be generated. The capitalist through the automation of the workplace therefore believes they are maximizing profit through automation because it reduces necessary labor time. What they do not realize is that capitalism relies on the formula of the difference between necessary labor time and surplus labor to prosper. They see automation used in conjunction with workers labor hours as creating better productivity with necessary labor time and creating profit and because of this the capitalist will continue to purchase more technology in order to make the production process even more efficient.

Marx understood that this drive for efficiency in the workplace, through the incorporation of automation, would lead to the failure of capitalism. Capitalism and profit require the difference of necessary labor time and surplus labor time; this is how profit is created within capitalism. The more technology that is introduced the less labor needed and therefore the capitalistic system breaks down. When Marx (1973) states, “production based upon exchange value breaks down,” it is the formula of necessary labor time to surplus labor that has broken down and with it so will capitalism. What Marx imagined from this breakdown was an economy where the machines would do most of the work and the laborers became the watchman of the machines. As watchman they would no longer feel alienated but instead they would feel in control of their work. The machines would create shorter working days and safer working conditions by doing the work creating “the free development of
individualities and hence not the reduction of necessary labour time so as to posit surplus labour, but rather the general reduction of the necessary labour of society to a minimum, which then corresponds to the artistic, scientific etc. development of the individuals in the time set free, and with the means created, for all of them” (Marx 1973:706). It is not until workers in conjunction with the machines demand these conditions that as Marx theorized would it allow freedoms from the social theory of alienation and the elimination of work and allow people to enjoy more free time and develop a different consciousness, one that values leisure time over work.

In response workers must demand to work fewer hours of work thus creating a system where human labor is no longer considered the measurement of wealth.

In fact, the realm of freedom actually begins only where labour which is determined by necessity and mundane considerations ceases; thus in the very nature of things it lies beyond the sphere of actual material production. Just as the savage must wrestle with Nature to satisfy his wants, to maintain and reproduce life, so must civilized man, and he must do so in all social formations and under all possible modes of production. With his development this realm of physical necessity expands as a result of his wants; but, at the same time, the forces of production which satisfy these wants also increases. Freedom in this field can only consist in socialized man, the associated producers, rationality regulating their interchange with Nature, bringing it under their common control, instead of being ruled by it as by the blind forces of Nature; and achieving this with the least expenditure of energy and under conditions most favorable to, and worthy of, their human nature. But it nonetheless still remains a realm of necessity. Beyond it begins that development of human energy which is an end in itself, the true realm of freedom, which, however, can blossom forth only with the realm of necessity as its basis. The shortening of the working day is its basic prerequisite. (Marx, Engels and Tucker 1978:441)

Technology today evolves within capitalism and as Marx stated is therefore contingent on class power. Instead of allowing the evolution of technology to become more universal it is through social processes and the capitalistic structure of the world market that certain technologies are desired and developed over others. Technology may shorten the
length of the working day but overall it is the capitalists that gain the most due to the de-skilling of the worker by technology and a further undermining of their power in determining what technologies work best for all classes.

**Heidegger**

Substantive theorists of technology argue that through the use of technology we are destroying nature and along with it the human species. Heidegger (1977) *The Question Concerning Technology* wants to understand how as a society we can obtain a “free relationship” to technology. He argues that technology is not equivalent to the essence of technology and we need to look at what is it that all technology has in common. We need to ask what is meaning of technology because every time we introduce a new technology into society we change our trajectory to some extent. Therefore, “we ask the question concerning technology when we ask what it is” (Heidegger 1977:4).

In modernity, human activity is largely understood in terms of a means to an end so though the use of technology we have made human activity instrumental or a tool. We use this tool as a “will to mastery” and what we choose to master is nature and due to causality we master ourselves. Heidegger (1977) argues that creating more technology is not the answer and that when you look at modern technology it has created an even more convoluted and complex relationship between humans and nature then anytime in history.

According to Feenberg, “Heidegger condemns modern society as nihilistic and attempts to conceive a philosophical alternative to autonomy” (2002:162). Modern technology Heidegger writes “challenges forth” nature to yield the maximum possible for the least amount of expense or effort. Unlike the traditional craftsman who’s work is to reveal his object by handling its transformation from raw material to object from start to finish, the
modern user of technology is transforming technology by ordering it. As we master nature or unlock the energy that is concealed in nature we are transforming and storing this energy to unlock more energy. Due to the efficiency of modern technology it has the ability to create a “standing reserve” of products. The objects in “standing reserve” become something that we take for granted and rely on in such a manner that it no longer is an object or has value or meaning. We believe we are in control of technology but humans too have become “standing reserve” as we are at the mercy of our technology because to maintain the “standing reserve” we have become involved in a continuous process of regulations and rules. The “gathering together” of nature and man to form objects that become not objects but “standing reserve” is what Heidegger calls “enframing”. This allows only revealing the “standing reserve” of technology and not it’s essence. The essence can be revealed only if humans step outside of technology by examining the rising of technology and the ordering of nature instead of standing in reverence and awe of technology, “because the essence of technology is nothing technological, essential reflection upon technology and decisive confrontation with it must happen in a realm that is, on the one hand, akin to the essence of technology and, on the other, fundamentally different from it” (Heidegger 1977:35). Heidegger’s hope it that by looking toward art we can recapture things that produce meaning.

Critical Theory of Technology

A third philosophy of technology based on Andrew Feenberg’s critique of the Instrumental and Substantative theories of technology is the Critical theory of technology. Feenberg’s philosophy of technology would argue that we value technologies such as 3D printing in our society because of its potential benefits to society and this value comes from past “experiences” of how other technologies that are similar have proven to be both
beneficial or detrimental. 3D printing technology is an example of the connection to our value of capitalism and the production of goods and our cultural value of efficiency.

Technology is part of our social behavior and has become a way of life so it is important to understand what is the effect of technology on society today. Andrew Feenberg (2002) argues that as technology shapes our human behavior we shape technology. He looks to understand, what does this casual relationship mean to what it is to be human and how can we use technology to attain a freer society? Through a Critical theory of technology, Feenberg rejects the neutrality of technology and argues instead for a theory that would look to solve these issues with democratic socialism (Feenberg 2002:137). If technology is a culture of domination as Heidegger argues, then if we move toward or away from technology, back to primitive living, we are still under the domination of technology. Both theories see “technology as destiny” and if that is the case then humanity is already beyond help. Feenberg discusses that our dominant technological rationality can be seen neither as neutral nor substantive but a combination of ideologies and techniques in what he calls “technical codes”. These codes include the history and background of the values, assumptions, definitions and roles that guide technological design. Through the use of technical codes we can determine what technical decisions should be mediated by all members of society through a democratic process and that modern technology and culture are not opposed or should not be considered a “trade-off”. A “trade-off” is when a technology such as the automobile has become more then just a necessity but also part of the culture. We as a society have to set aside important environmental issues such as air quality and the destruction of the environment for the development of roadways in exchange for efficiency. We are enframed within social values of technology because technology is the principle form
of power in society and that is why we need to have a critical point of view of technology (Feenberg 2002:15). Although technical codes can be socially specified to embody the norms of society and therefore be considered as socially constructed, social forces can push to change the development of artifacts in a way that makes them more beneficial for all aspects of the social world. Feenberg argues that because the dominant form of technological design benefits the values and interests of the ruling class a different technological culture cannot emerge until capitalism is no longer in control of social forces, “technology is a two-sided phenomenon: on the one hand, there is the operator; on the other, the object. Where both operator and object are human beings, technical action is an exercise of power” (2002:16). Instead a social democracy with new forms of control “from below” is needed that includes “the vocational investment of technical subjects and their work, collegial forms of self-organization, and the technical integration of a wide range of life enhancing values, beyond the mere pursuit of profit for power” (Feenberg 2002:35). Until we are able to expand on this, issues such as making 3D printing more accessible to all members of society and making the use of 3D printing sustainable for the planet will not be addressed by those in control who are interested in maintaining their capital.

The Critical Theory of technology according to Feenberg addresses the problems of technology globally wherever it appears and however the power struggle that unfolds. Feenberg argues that political choices are embedded into technology during the design process and these choices favor specific interests and specific ideas of those that hold the highest position in society. When the design process of a technological advancement is complete what is lost to the users is the history of the details or “value-laden choices” that lead to that final design, so instead of addressing the issue of technology as neutral or
deterministic we need to look at providing a path to the design of technologies that is more
democratic and more reflective of the values of all members of society.

Feenberg writes that Marx alluded to the idea that technology is contingent on social
relations and therefore should be understood in social terms and not as deterministic and that
the social terms in a capitalistic economy require the design of technology to reflect the
requirements needed for the capitalists to maintain control. Marx envisioned, under a
socialist economy, a different type of technological development, therefore he understood
that technology is political and the economic system it’s developed within is the most
influential part of the design. In Marx’s socialist society, wealth would be determined not by
the ownership of production but by the value of the human experience. He envisioned that as
workers become more knowledgeable through the incorporation of technology their value
and power would increase. Instead of being trained in only one small aspect of the job, the
workers will be fit for a variety of tasks and their relationship to production will change.
Marx believed that this would lead to a more socialist economy that would end the
competition of labor and capital for control of economic resources.

In a critique of Marx’s theory, Feenberg argues that Marx did not understand the
importance of politics when talking about technology. In modern society the struggle is no
longer a class issue but a technical political struggle. It is no longer a struggle between
capital and the mode of production but one of social control from modern bureaucracy or
rationalization. These institutions that include at their highest level our political institution
have become the new bourgeois. The issue is that the line of who is in control and who is not
in control has become blurred due to a never-ending system of processes. This makes it
difficult for the workers to ban together and revolt because it is unclear whom they are revolting against.

Bureaucracy has become a way of life, as Feenberg reflects on Weber (1930) rationalism goes beyond capitalism to all part of human activity and “the critical theory of technology attempts to address these problems by following technical struggles wherever they appear and analyzing the role of power in these struggles” (Feenberg 2009:216). Therefore a critique of rationality must be included when criticizing modern technology and society. We must look beyond the discussion of capitalism verses socialism and instead move toward a “social democracy”. A system that is able to work within capitalism because it is the dominant economic system in place but allows for more democratic policies in not only in the workplace but also in technology, as they can no longer be seen as separate.

Harding

Sandra Harding in her critique of feminism and technoscience writes that because science and technology are rational and factual, where as social theory is philosophical and metaphysical, it creates a separation between society and science and also protects science from being criticized. Due to this the defenders of the theory of neutrality of scientific facts are immune from social influences, “that logic and scientific method will in the long run winnow out the factual from the social in the results if scientific research” (Harding 1986:40). She argues in *The Science Question in Feminism*, that the development of technology and science and its domination of nature is embedded within patriarchy and discusses what this gender discrimination means to the development of science.
When critiquing the natural sciences from a feminist standpoint she notes that our culture is one of scientific rationality that goes beyond how we perceive our public institution and has become a way to view all even aspects of life including our private lives,

during the last century, the social use of science has shifted: formerly an occasional assistant, it has become the direct generator of economic, political, and social accumulation and control. Now we can see that the hope to “dominate nature” for the betterment of the species has become the effort to gain unequal access to nature’s resources for purposes of social domination. (Harding 1986:16)

In the past scientific developments were in control of anyone who had the genius, funding and time to develop their thoughts. Today research is expected to have immediate results that will create profit for the “vast industrialized empires” that have invested in the research to maintain social control. It is rare for research to be done just for the sake of knowledge and not materialism.

Harding writes the feminist standpoint, that is subjugated, will add a new viewpoint to the critique of theoretical framework and therefore will formulate new questions about science providing a more complete and less perverse understanding. As it stands now, with the domination of males in science, it leads to “underheroization” in science and what it creates is research that is sexist and biased and these biases help maintain the domination for men not only in the field of science and technology but through all aspects of social life. According to Harding, critiques of the viewpoint that science is sexist also make the mistake in assuming that the act of science and technology is “value-free”, meaning without the influences of social forces. The social forces that mediate science along with its misogyny create the path of a science that is oppressive to women as well as being racist and classist.

With a greater female perspective in the theories of science and technology it is reasonable to argue that knowledge and observation would create a more objective science.
Not only would we formulate new questions about science, but also the developments from the questions would create a more socially progressive society. One issue to be addressed is that women are not drawn to the fields of science and technology. Harding sees this lack of diversity as part of,

the division of labor by gender in the larger society and the gender symbolism in which science participates are equally responsible for the small number of women in science and for the fact that girls usually do not want to develop the skills and behaviors considered necessary for success in science. Until both the “emotional labor” and the “intellectual and manual labor” of housework and childcare are perceived as desirable human activities for all men, the “intellectual and manual labor” of science and public like will not be perceived as potentially desirable activities for all women. The equity recommendations, moreover, ask women to exchange major aspects of their gender identity for the masculine version- without prescribing a similar “degendering” process for men. (1986:53)

If women were as equal in number as men in the fields of science and technology, the impact and force of capitalism on research and application would still be the difficult to overcome. Those that can afford to fund research and have lawyers to create patents on the research will still be in control of the end product, therefore it would still be in the control of the privileged white male enterprise. Would a socialist economy be the answer for equality in technological development? Harding would argue that not until we create a less patriarchal rational society could we achieve some form of equality. How can the influence of feminism in science and technology take us down this path? When society compares women to men, women are seen as more irrational, subjective and cultural. How can these values be reflected in science and technology and therefore considered values of equal importance as rationality in society? Harding writes that the only way to change the trajectory of gendered biased empiricism is to look to the history of traditional empiricism in the same manner as men have in the past. It is also important to understand the relevance of the science question in feminism as to how it fits into the history of the feminist movement. Only when you
understand the roots of female empiricism will you be able to grasp how it will change science and technology or influence rationality.

In the end, Harding is suggesting that the best course to the feminist question in science is to remember that science is not the absolute answer and that feminism is part of an ever-changing history. She writes of acceptance of a “world hidden from the consciousness of science- the world of emotions, feelings, political values; of the individual and collective unconscious; of social and historical particularity explored by novels, drama, poetry, music, and art- within which we all live most of our waking and dreaming hours under constant threat of its increasing infusion by scientific rationality” (Harding 1986:245). The feminist question in science can be the agent to merging these two worlds, leading to a less rationalistic society.
CHAPTER 3

ADDITIVE MANUFACTURING VS. MAKER MOVEMENT

Part of the excitement that surrounds 3D printing is its ambiguous potential. There is a sense of wonderment followed by some fear. The reason that there seems to be a mix of emotions is because we do not feel in control of the fate of 3D printing. Most people have heard of it at this point but they do not understand how it works or what the likely outcomes will be from its inclusion into our technical world. According to Feenberg, “this ambivalence of technology is distinguished from neutrality by the role it attributes to social values in the design, and not merely the use, of technical systems. On this view technology is not a destiny but a scene of the struggle. It is a social battlefield, or perhaps a better metaphor would be a “parliament of things” in which civilization alternatives contend” (Feenberg 2002).

Some of the fear expressed by society has been due to the possibility of the 3D printing of weapons and also illegal drugs. As of now we do not have any clear policies or procedures to protect ourselves from the negative effects of this technology and one of the reasons is that technology, because it is viewed as neutral and deterministic, is seen only as a means to an end. As humans, when we have a problem we want to solve it. So we use technology to master nature and solve our problems or to satisfy our curiosity often without considering the possible negative aspects. What is missing is an ontological view of technology that understands that it is not the technology that is dangerous but the true
essence of technology that is not revealed to us (Heidegger 1977:6). 3D printing also has been hailed as the next Industrial Revolution and when people hear this statement I do not think anyone has a clear vision of what that statement truly means. Even those taking this stand do not really understand how we will evolve out of mass production. Those that are currently in control of production will fight to stay in control because they own all the capital power and will not give it up. Without regulations and policies in place those that are at the bottom level of production will be without jobs and more dependent on their governments to live. They will fall further under the domination of the elite class and their oppressed state will continue in a new unthought-of manners (Braverman 1974). Those who have access to education and training on 3D printers in schools and libraries are already set apart from those that currently do the work of mass production, who will never have the same opportunity to train in this new emerging field, and will remain subordinated in a capitalistic system.

As part of my research I visited two relatively different Maker Spaces in San Diego and observed 3D printing. I was able to speak with those interested in using this technology to gain an understanding of its different functions. I included those that viewed themselves as hobbyist along with those that used 3D printing as part of their profession. The first Maker Space I visited is on the SDSU campus at the library and is the newest space at the library. Volunteer students who are mainly from the Engineering department manage it. All the volunteers are men. The other space was FabLab, a Maker Space in downtown San Diego. FabLab is a mixture of entrepreneurs and hobbyists wanting to share their ideas. I found it to be an informal setting that lends itself to a community feeling. I was able to setup several in-depth interviews of those that I observed and from these interviews I was able to dig deeper
into how the participants became interested in 3D printing, if they planned to profit from it, and if they viewed themselves as an innovator or inventor.

From my background review on 3D printing I read several articles stating that 3D printing was going to change our manufacturing process, but what I learned from those that I interviewed is that the process of 3D printing has a long way to go before it will achieve this title. The machines are slow to print, problematic to use and the material is limited to mainly plastic parts. Where it does seem to stand out is the ability to quicken the design and manufacturing process because you can now imagine an idea, print it out and hold it in your hand to see what changes need to be made all in one day.

Jack, a retired mechanical engineer I interviewed was very excited about this,

I think the key thing that it adds is the ability to create and invent is to physically realize your invention so you can physically see and try it out as a physical devise and innovate on that. It's one thing to see it and make drawings until the cows come home but until you are able to physically realize it and test it, you don't know anything about it or how it will work out. (pers. comm.)

When I asked the interviewees from my research project if they thought 3D printing, from their experiences, was neutral in society most of the respondents agreed with the idea of neutrality. Brad, a first engineering student at SDSU when asked if 3D technology is neutral said,

Neutral as in neither good or evil? Um, ya but some people are not neutral. I mean it’s a fabrication tool; they are neither good or bad. I guess, really the deciding factor would be the availability. I guess that is what I go with, powerful but neutral. (pers. comm.)

Brad believes 3D printing technology is powerful and he also had this to say when I asked it he thought there should government regulation of 3D printing.

I don't know how this would be different. I guess you regulate the sale of 3D printers but again people can produce them on their own. It's kinda difficult to
regulate. I am not sure. Right now there isn't really a need for regulation. If you look at these things and they are not competing with industry. The guns are not at all threatening. (pers. comm.)

Doug, who older and a professional engineer, was also against regulation,

People should be able to make whatever they want. Um, now I know the government like to regulate stuff, keep track of things that are quote dangerous and there is the lines that are going to get drawn just like the 3D printing of guns. Right, I don’t like that. I don’t like the government there and the cooperate feeds the government for control. (pers. comm.)

The idea of neutrality to those interviewed went along with the attitude that regulation by the government was intrusive to the possibilities of the design and also that there are few risks involved with 3D technology. As Jack, a retired engineer and a Maker, stated when asked about risks to society,

Well I think the risk is a society willing to suppress 3D printing and throwing the baby out with the bath water.” I don't think that society [sic] use or adoption of 3D printing poses a risk to society, I think it is the other way. (pers. comm.)

When users of 3D printing were asked directly about the possible negative aspects of 3D printing, such as the ability to print undetectable and easily replaceable guns, they thought that it made sense that people would try to do destructive things with the technology but also were concerned with the idea of having too much regulation or restriction of this technology by the government. The social value of safety to them would be detrimental to the progress of this technology. It does not concern them that this would be an issue for society in the face of progress.

When I asked Jake about what he thought about the ability to print a gun, he had this to say,

It’s an interesting thing. I personally do not favor it. I’m pretty much a pacifist but beyond that the technical challenge of it is significant. And the things we will learn trying to do it are significant. And I mean when Congress get involved and starts making laws you know its messed up. Congress should just stay out of the technical. (pers. comm.)
The demand for efficacy and progress in society is the reason that those in the Maker Movement cannot see some aspects of 3D printing as harmful and why they are indifferent or even against political regulation or policy that could possible dissuade from the advancement of 3D printing and technology in general. Instrumental theorist would argue that humans are in control of their technology, that we rule over it and therefore it can only benefit us as it is merely at tool. Although opposed to regulation from the government, what the users are missing is that our values are rooted in a capitalistic economy that already regulates this technology.

In the case of 3D printing of handguns there are no current regulations regarding the ban or manufacturing of these weapons or on the 3D printers. There are laws in place for current models of handguns that could carry over to the 3D printed version. The Brady Handgun Violence Prevention Act of 1993 was implemented to keep guns from prohibited purchasers by running background checks at the time of purchase and the Undeletable Firearms Act of 1988 prohibits the manufacture, transportation or possession of any firearm that may go unnoticed by X-ray machines or metal detectors (McCutcheon 2014:231). The issues of controlling a 3D printed firearm produced at home are that it would not be a registered weapon and the owner of the weapon would not be on record as a gun owner. Additionally, it would not require a background check to obtain and being made out of plastic they are undetectable by X-ray machines. Furthermore gun advocates and the NRA would support the printing of these guns based on their second amendment rights, the right to private gun ownership and the freedom to bear arms (Johnson 2013:346). One possible way to regulate the printing of 3D guns would be to regulate the printers; this would bypass the very controversial gun law issues. Laser printers are currently under government regulation
to prohibit the printing of counterfeit money and other government documents (McCutcheon 2014:243). An option would be to regulate not only the purchase of 3D printers but also the material used in printing and the files needed for the design. Regulation of an uploaded file proved to be an issue recently for the Liberator, a gun that was 3D printed and its software was made free and available on the Internet for anyone to download. After the Sandy Hook Elementary shootings the developer voluntarily removed the software files from the Internet but the file had been downloaded 100,000 times and although YouTube removed a video of the Liberator being tested but the video showed back up on the Internet within hours (McCutcheon 2014:245).

The concern the respondents had over the control of 3D printing not only came from government policies or regulations but from the three largest 3D printing corporations that have put patents on the processes and parts of the printers.

As Mark a 4th year SDSU engineering student stated:

In 3D printing now they (companies) are just getting the patents and that’s all they are trying to do, they are not trying to advance the technology so they are buying up all these patents and not allowing sharing of them. They are putting really high price tags on them so that these companies, like start ups, can’t use the new technology that they are coming up with. (pers. comm)

From those I interviewed I learned that the value for 3D printing in society came from the innovation and the sharing of knowledge about it.

Tiffany a jewlery designer valued:

Well, I think with the Maker Movement it’s more of a DYI- do it yourself. So it kind of encourages people to take on the tool and ideas and go for it. And they are not so much discouraged if you fail or not. Um, courage? I don’t know, like experimentation? (pers. comm.)

Mark, an engineering student when I asked about the printing of guns thought the sharing of the information was important but not for everyone,
I know it should be regulated to some extent I think. The design parts of 3D printed guns should kinda be withheld from the general public so they don’t get ahold of them. I feel like keep sharing everything not keep it withheld. That’s silly I think. I think it is one of the best ideas for this generation. (pers. comm.)

The topic of medical advancements in 3D printing were both marveled and disconcerting to respondents but regulating them did not come up during the interviews.

Tiffany was cautious on this issue:

That’s also a very interesting topic, it not just that people will be able to 3D print their organs but the opposite side of the spectrum is that people that will not feel comfortable about playing God. A controversial topic.”

“I think people will be more protective about what is the right thing to do and what is more human than artificial. The doom, you become dependent on the technology that we are experimenting. (pers. comm.)

Despite an overall neutral view of technology, from my interviews of the users of 3D printing I found they were putting different social values on 3D printing. This included a wide range of social values such as profit, creativity and collaboration. I often detected excitement in their voices as they told me how they saw 3D printing as unique in its ability to produce difficult objects and push innovation even as they seemed unclear what these transformations or objects might come to be. In a sense the printers were almost mystical in what they could produce. Upon further research I found that enthusiasts believe that 3D printers will be able to print materials that behave in different ways then are available today due to the ability to combine materials in a more complex manner that will “defy understanding” (Lipson and Kurman 2013:82). One study stated that despite all our technological advances, nature is still better then humans or computers at re-creating itself but the future of 3D printers offers research scientists the possibility of capturing and simulating the human body from digital to printed human tissue (Lipson and Kurman 2013:122).
Of those I interviewed all either identified with being a Maker or knew about the Maker Movement. The Makers overall agreed that 3D printing was an important part of their community and that being a Maker gave them a sense of belonging and a way to express their passions.

Jack had only positive things to say about the Makers,

I think it’s wonderful, I think it’s really exciting. But, it’s defiantly a group that wants to try things, who like to experiment, who like to play. I think it’s going to be another technical boom particularly in the U.S. but all over the world really. (pers. comm.)

One passion was keeping 3D printing technology as public domain that would be kept open and available for sharing, or as an “open-source” technology. When one user spoke about being part of the Maker Movement and about 3D printing, she had this to say,

Umm, I first became interested in the Maker Movement, first they are very friendly in the way because they're they support various types of Makers. You could be a computer engineer or computer software programmer or you can be an artist and utilize 3D printed components into another body of work or you could just be a hobbyist and have a 3D printer in your garage. So there is a variety of people but the one commonality we share is that we like to share what it is that we are passionate about and there is an open community in that and that's why I became interested because not only are they very friendly but they are willing to share information about how they come about making their own work or what kind of program they use of making things better. (pers. comm.)

When looking to the future of 3D printing, it is predicted we will have the ability to make and print materials within materials and these materials will be of properties not yet imagined even by material scientists. It is predicated that, “we will gain the ability to program materials to function in desired ways. We will move from printing passive parts and materials to printing integrated, active systems that can sense and react, compute and behave.” (Lipson and Kurman 2013:266). In a sense we will be able to print parts that act human.
Of those interviewed only one person did not view 3D printing as neutral but as a risk for the future of humanity. Tabitha was the only female as well as the only artist I interviewed. When asked about what 3D printing can add to society she said,

I guess just like how humans have doubt in technology. The doom, you become dependent on the technology that we are experimenting. (pers. comm.)

Despite this Tabitha thought we were still in control of the fate of 3D printing, for now,

I think right now we are in control of it until in advances so far ahead, its like AI and they are going to be responding back and than we might not be in control in the end. But I think the human tendency is to try and keep it within our own control. Ya, I think we are in control. (pers. comm.)

She was also concerned with the fact that 3D printed objects are made mostly of plastic that is not eco-friendly. Despite the possibilities of what can be printed and the hope of innovative objects, these objects start out as a detriment to humanity because they are causing harm to the environment. If technologies such as 3D printing were understood not as neutral or deterministic but in social, cultural and political terms then their effectiveness could be momentous. This is why a Critical Theory of technology is so important as Feenberg argues that technology and culture cannot be separated and because of this we need a way for a better democratic discussion of probable progress of technologies. This is the only way to guarantee that technologies are created with social justice and freedom of the individual included in the process. Technology today is in the hands of the elite, those that control the Western world and through globalization are working toward control of all cultures and societies by imparting capitalism on them and creating a homogenous world. 3D printing and Makerspaces have taken ahold all over the world with China embracing it with the most Makerspaces then any country yet the freedom that Maker’s believe they are achieving from 3D printing cannot be truly achieved within our rationalistic society.
CHAPTER 4
CRITIQUE OF THE MAKER MOVEMENT

IDEALOGY

Philosophers of technology argue that Marx’s theory of science and technology could be seen as neutral or Instrumental. Today technology evolves within capitalism and as Marx stated is therefore contingent on class power. Technology may improve the laborers working day but overall it is the capitalists that gain the most due to the de-skilling of the workforce by technology and a further undermining of their power in determining what technologies work best for all classes. Instead of allowing the evolution of technology to become more universal it is through social processes and the capitalistic structure of the world market that certain technologies are desired and developed over others.

The members of the Maker Movement are do-it-yourselfers who like to connect and share their innovations. Three characteristic of the Maker Movement that have lead to its transformation in recent years is the ability to use digital desktop tools to create designs, their culture of sharing made possible through online communities, and the development of the common design file that has made it easy to send designs for fabrication (Anderson 2012:21). Technology has made it possible for these tinkers and innovators to move out of their garages and into the public sphere. They think of their network of technologies as merely tools waiting to be enlisted for their creativity, therefore it is not surprising that they think that technology should be viewed as neutral, or Instrumental. Through their use of 3D printers as
a tool they envision a world where anyone can become an entrepreneur as long as they have the skills and the right equipment. They do this without critically thinking about the capitalistic system that is in place to prevent them from succeeding. They envision themselves as smart people who can change the world with their tools and like most users of technology have little idea of what that really entails. Makers see their tools as indifferent from their end use because they use a mix of tools to create. How can you pick out one of the tools and say it is not neutral? This subculture, like many subcultures, view themselves as outside of societies political and social institutions, so any concerns that their innovations may cause for these institutions is not a factor for them when creating their designs. Makers tend to come from the world of science and engineering. These are considered the most rational of all institutions. Their rational background is another reason that they view machines such as 3D printers as neutral. Although they consider themselves as creative they are unaware of how this rationality is shaping their decisions as they create.

The Third Industrial Revolution, a combination of the digital age and personal manufacturing, is also being claimed at the industrialization of the Maker Movement. Through the use of tools such as 3D printing they argue that we will move from an economy of mass production and factories to custom manufacturing by small businesses owners and entrepreneurs.

These “regular folks” will create this Third Industrial Revolution by working from the bottom-up using their skills. It is easy to make such a blanket statement when you view technology as neutral. This allows the Makers to easily explain away the issue of the major unemployment around the world that would happen if mass production were to end. Certainly these small business owners are not going to have the capacity to employ all those
that lose their jobs. From their privileged perspective they think everyone has the same chance of becoming one of these entrepreneurs. The people most affected do not have access to computers and the Internet. The factory workers in China would be the most at risk yet China is where you will find the most Makerspaces and their State Council funds them.

Environmental issues, especially the issue of plastic manufacturing, have come up often in my research on 3D printing. Not only is waste an issue as the plastic does not decompose but there are toxic fumes that are released during the printing process. These fumes have been known to cause pulmonary problems such as bronchitis and asthma and the effect is more significant on children. The solution that is offered is to make sure that you are printing in a well-ventilated space, not that we should eliminate printing with plastics. There has been some innovation done on printing objects made from sand and using solar energy to print, but plastic is the main market that 3D printing has been developed on and those that manufacture the plastic will want to make sure that this method is preferred. On a more positive note, moving from mass production to custom manufacturing could be beneficial for the environment. When items are mass-produced they have to be shipped and be stored before they are purchased and with mass production there is the waste from items that society does not want. Custom manufacturing or made to order items would eliminate the need for storage and waste. The negative effects on the environment from transportation of objects also could be kept to a minimum if you are able to print your objects in your own home.

There are other counter-culture movements that are interested in 3D printing to further their cause. The Maker community with their enthusiasm for technology views it as an individualistic way to express their creativity and have given little thought to what if any political agenda should be attached to 3D printing. In fact they are often anti-government
when it comes to technological regulation. On other side of this can be found the liberal
democratic political imaginary, those who look at this technology with fear and want to put
in place laws and regulations to control the manufacturing of 3D printed items (Fordyce
2015:4). The Maker’s idealistic world of a 3D printing also includes outliers such as white
supremacist hoping to print mass weaponry to protect themselves from blacks that have been
unable to afford a gun before but will now be able to print one cheaply. The unique capacities
of 3D printing that are fantasied by the Maker community and other sub-cultures are quickly
creating concern about how to regulate this technology. The challenge is the printing is
mainly done at an individual level and in the privacy of a home, an area where no one wants
government to have more access.

The reality is that Makers tend to be affluent white males with backgrounds in
Engineering. They exist in a technological world where although they hold power over the
design of the technologies we all end up using, they are still under the control of capitalism.
They feel as if they are just “tinkering” around with ideas but their ideas are limited to what
will benefit capitalism. Therefore their ideology of sharing and improving on each other’s
designs to create the newest innovations is the perfect set up for capitalists to come in and
steal their ideas, make them their own and continue to profit. The ability of the RepRap
printer to self-replicate making them freely available to everyone does not address the issue
of sourcing the materials needed to print. There will still be a need for plastic, metal or
whatever new materials are invented to make the printers and print objects.

**Braverman**

According to Braverman (1974), the de-skilling or division of labor at the workplace
is fundamental to capitalism. Labor power, when reduced to simple labor, benefits those that
purchase the labor because it is cheaper and they have more control. Without skills the
workers do not have any bargaining power to demand better working conditions (Braverman
1974:82). In the case of 3D printing, the demand to make them “user-friendly” and the
software designs free to download is only making it easier for the industry to profit. They
have access to innovation that they did not have to pay for (Söderberg 2013:135). It is the
same argument Harry Braverman has made about machine developments of the past, if
machines are designed in such way that the users or workers can easily be replaced by those
with even less training, the power of the user or worker to make demands of those that
control the machines is diminished (Söderberg 2013:133). In the case of the Maker
community and their vision of an open source platform their “user-friendly” designs will
allow those with commercial use and profits in mind to take control of how the machines are
designed and what they will be used for.

As 3D printers become a more household item the level of craft or skill needed to
produce a product will be lost. The details needed on how the object are designed and the
process of how the machines are built and function will be know only by a small number of
3D printer users, most users will have limited knowledge. The issue is that without this
knowledge the users will feel alienated from the processes of 3D printers and will be forced
to rely on those that do. If 3D printers are being hailed as the next Industrial Revolution then
this imbalance in power is not any different then when Braverman was writing about the
factories of the 1970’s. Automation instead of creating a balance between the management
and the workers created greater inequality as worker became un-skilled and replaceable.

Most of those that I interviewed for this research project were engineers, who are
skilled in writing the software that is needed to design 3D printed objects, and also on how to
build their own machines. During my interviews the issue of people losing their jobs due to their expected change from mass production to customized production did not come up. This is a reflection of the social division of labor that Braverman states is an important principle of the capitalist mode of production. This social division of labor is an important factor in determining the rate of technological development, the extent of stratification and inequality, and the degree for sociocultural solidarity. The question did not come up because these Engineers are not concerned with job loss, they assume that anyone can learn the skills it takes to created the software for the 3D printers and become engineers like themselves. They are at the top of the social stratification of 3D printing and because of this are unable to reflect on what it means to be at the bottom and at risk of losing your job.

Heidegger

Heidegger (1977) writes that bringing-forth is when something concealed becomes unconcealed, as when a craftsman reveals the object of their craft. Modern technology has a different mode of unconcealment or revealing that Heidegger calls challenging-forth. The difference is that the craftsman and his skill are an important element in the process of revealing their objects and challenging-forth is when humans control the process of revealing by ordering nature. Although there has been some controversy about the effect 3D printing will have on the environment a larger issue are the unknown impacts of this technology as it develops. This is what Heidegger would call the danger of this technology. 3D printing technology can be viewed as a “standing reserve” for future technological breakthroughs that are obscured or not revealed to us.

The Makers because they are enframed by technology cannot see how they are being ordered and controlled; they see the development of 3D printing as deterministic. They do
not stop to question if their continued innovation will in the end create a world that is better or worse to live in. They can only see the need to preserve in their quest to print body parts or make objects out of materials that have never been combined or do not even exist because the ordering or manipulation of nature by technology is the only reality they know. Their social world is one of rationality and calculation and therefore does not allow them to ask what is the value of what we are creating. They cannot understand the essence of 3D printing because unlike the craftsman of the pre-modernization era, who was essential to the creation of objects, 3D printers are essential for the Makers to create so they does not have a free relationship to their craft.

The statement that we will one day be able to print replacement body parts from a Substantive point of view is the ultimate control of nature by science. By believing that humans can essentially become immortal by replacing our body parts is a reflection of our rationalization of humanity. Feenberg argues that what Heidegger fails to understand is that by moving away from technology we are still under its control or enframed so he will not be able to understand its true essence. Instead what he offers is the need to develop policies about technology that open up the possibilities to create a free society.

**The Frankfurt School**

The Frankfurt School of philosophy would argue that because 3D printing is based on science and science is a part of the forces of productions, it cannot be sustainable because it is enveloped within the capitalistic system of society (Tar 1977:30). The belief that 3D printing will revolutionize production and become the next Industrial Revolution is still based on the ideology of capitalism therefore that is where 3D printing will remain. There will not be any sort of emancipation or realm of freedom that will be seen through the use of
3D printing because 3D printing is based on science and “science is part of the forces of production” (Tarr 1977:30).

Mass production and fetishism of commodities is the result of Industrialization in today’s society. In the case of 3D printing or “additive manufacturing” its relevance is one of technological advancement and consumerism. The attainment of objects is what is valued in our capitalistic society; therefore the force of consumerism is a force that determines the design of technology. Development is divided by the social structure and this influences how research and development proceeds and leaves in control of certain interests. 3D printing plays right into Adorno and Horkheimer’s theory that we are creating a new type of domination and fear of the unknown in society. We still fear the possible developments in 3D printing because the idea of printing body parts or creating unknown materials seems mystical and magical. How is this different then when we existed in a barbarous state? It is still fear of the unknown. Although the processes of 3D printing require formulas and calculations that represent our rationality, we are still afraid of its possibilities. 3D printers are symbols that represent the elite in society, our scientists and engineers, those that we deem in control of our future and therefore we accept our fear of its unknown prospects.

As Marcuse writes, we have become inseparable from our commodities as we separate ourselves further from nature. The Makers, despite coming from a creative background and viewing themselves as a counter-culture are still under the control of the fetishism of commodities and therefore they automatically gear their creativity in such a manner. Not until we find value outside of materialistic pursuits will we be able to use technology such as 3D printers to stop the domination of nature and achieve a free society.
Harding

3D printing fits in with the demand for immediate results from research and development that we expect from our modern rational society. You can conceive of an idea, print it and hold it in your hand all in one day. Due to its ability to combine materials like never before in history it has the ability to quickly realize new combinations of nature and determine if they are useful.

Like most technology I found from my research and interviews that 3D printing is a male dominated field. For my in-depth interviews I interviewed only one female and she was also the only artist. Her perspective on the future of 3D printing differed from the male interviewees, who were all some type of engineer. She did not think that 3D printing was neutral but posed risks to society. She was concerned that we have become too dependent on technology and expressed feelings of doom about the medical possibilities of 3D printing. Sandra Harding criticizes the development of science, that due to its lack of female perspective it continues to perpetuate oppression in society and in 3D printing I saw not only a lack of female perspective but also the male users were from an educated backgrounds and were all white.

When doing my participant observation on 3D printing and the Maker Movement, not only were most of the participant male but also all of the trainers were men. The issue is that this male domination does not allow space for females to act in a feminine manner, meaning that we would frame our questions or concerns about 3D printing in such a manner that would be best accepted by the male engineers who are in control of the teaching. Women are not as socialized to speak in technical terms and this makes us refrain from engaging in technical conversations, this translates to the design of machines, such as 3D printers, to be
male dominated and controlled by a language that may be intimidating thus keeping women from engaging in 3D printing altogether.

**Marx**

Marx would be concerned with how the Makers can use 3D printing to improve the conditions of workers globally. Instead of seeing themselves as outside of the norms of society they must learn to work together with political and social institutions to create a process where the elimination of jobs by 3D printing coincides with shorter work weeks and also allow for the same amount of compensation. According to Marx this is the only possible under a new cultural system that is not dominated by capitalism. We need a new culture that does not alienate the worker. In the case of 3D printers, this means that its users must be trained on all aspects of the machines. Instead of creating a “user-friendly” or click and print culture around it there needs to be available the training on the software and hardware of the machines on a global scale. Only then will the workers not feel alienated by the technology but will be able to join in the conversation as to how future developments in 3D printing will create a culture of working less and improve our overall quality of life. By using the Makers counter-culture ideology its users can find a way to combat the domination of capitalism to create technology that allows more freedom to develop a new consciousness.

**Feenberg**

To the Maker Movement, the 3D printer is viewed as simply a tool standing by waiting to be used. It is therefore neutral because it has no value or purpose unless it is in use. Its application only has meaning based on the social structure within which it is used to produce goods. The social forces within which the printer exists will determine what is printed, it will depend on the objects that are valued by the society and it’s culture. If you
move the printer from one society to another it itself, as only a tool, it has no value until it is decided what to print. This ideology that the 3D printer is universal is its function as a tool and independent of what it produces is why its users do not view this technology as a threat to society. It is simply a means to an end.

It can also be argued that the features of the design of a technological artifacts such as the 3D printer reflect the culture and values of the society they are developed within, then in modern society, scientists can only work to develop new science and technologies that are within the cultural norms and fit within the political structure and therefore cannot be viewed as neutral (Aronowitz 1988:524).

By participating in The Maker Movement people become connected to what they produce and to each other as a community. Feenberg points out that social groups form around technologies and their social identities become one with the technology. Feenberg also writes that a fundamental issue of capitalism is the separation of labor, consumption and social decision making (2002:185). The Maker Movement is a way of being connected at all levels of production. What needs to happen in a further connection of the Maker Movement to the different institutions that will be effected by their developments. If they continue to develop without providing solutions to the possible negative effects of their creations then society will continue on its same path of being dominated by capitalism and rationality. They must step outside of their neutral stance on technology and accept that 3D printing is part of our social behavior and therefore needs to be shaped in such a manner that it includes the values of all members of our global society.
CHAPTER 5

CONCLUSION

3D printing despite all the controversy and hype that surrounds it is simply one more technological innovation introduced at one point in time. It’s abilities will be developed upon in the future to create more technology that will create the same story of controversy. This is why it is important to ask what, as a society, what do we want our technologies to provide for us? In order for this to happen we must critically think about not only the future of technology but also its history. As a society we need a plan to make the design and development of technology reflective of the needs of all society and not just those with the most capital.

The Maker Movement views themselves as a DIY community. They are people who use technologies such as 3D printing to create a culture based on craftsmanship, sharing and innovation. They emphasis OSAT to improve upon the innovations of other members, not in the drive for profit, but for the betterment of society. What we also find within this community is an underlying narrative of anti-government views. There tends to be an individualistic ideology with disregard for the rules and regulations of different political and social institutions. Contradiction like these are the reason that Feenberg argues that there needs to be a “radical democratic politics of technology”. The design choice process of technologies must include subjugated actors, meaning that it cannot only be in the hands of
the elite. This inclusion would help shape technological design process toward the needs of many.

To further understand what policy issues and government control 3D printing will face through its development it is important to look at similar disruptive technologies and the challenges they faced. Napstar was the first company to provide a service for downloading and sharing new smaller music files, the MP3. This service would have not been possible without combined development of the invention of the MP3 and the improved speed and connection of Internet services. When Napstar developed their software there were no policies in place against the sharing of music files and they were quickly sued “for the direct copyright infringements of its users and for committing contributory copy-right infringement” (Rayburn 2001:1). They were sued by the Big Five music distributors, which owned 80% of the music rights, and were able to shut them down. Following the lawsuit a new policy was implemented in 1998, the Digital Millennium Copyright Act (DMCA), in an effort to better tailor copyright law to new developments in technology. This act could apply to 3D printed software that is shared without the consent of the developer on the Internet. In an attempt to stop illegal downloading of files on the Internet there have been attempts to “watermark” the files with the information of the original owner but all attempts have easily been hacked by software developers (Rayburn 2001:9). With the digital revolution and the ability to download any music from your home computer the need to drive to the store to buy a CD disappeared taking the music stores with it. Some benefits that were unforeseeable with the invention on the MP3 were the consumers having free market access to suppliers and the lower cost to the industry and consumers by reducing transportation and physical distribution costs. Risks were the illegal redistribution of music files and the loss in profit to the Big Five
(Bockstedt, Kauffman and Riggins 2006:13). After the invention of Napstar, artists were able to produce and distribute their music without the control of a big corporation; 3D printing provides the designer of a product the same freedom. In order for a corporation to maintain some control they will have to look to create new specialized experiences for consumers. This example of Napstar and the music industry shows that without policies put in place the creativeness of MP3 technology was attacked by those in the control of the mode of production of music and the designers of 3D printing are facing the same issue as the biggest manufactures of 3D printers are controlling the innovation with patents (Klaiber 2014:63). By applying for patents on material composition and scan recognition software these companies are slowing innovation not only in 3D printing technology but other technologies that could benefit from these products, all in the name of profit.

The Maker community wants to maximize autonomy by not only taking an anti-government stance but also an anti-corporation. Marx would be in favor of this stance. Corporations control not only our economy and workers but also the amount of leisure time society has by demanding a forty-hour or more workweek. The promise of the 3D printer, of eliminating mass production and factory jobs, could lead to the emancipation of the worker. The issue is that as the technology develops and takes over the work, the workers must be in step with the development and demand shorter working hours. The Makers are helping to create this environment, where the control of technology and design in is the hands of artist and the modern day craftsman, but without Feenberg’s radical democratic policies put in place the control is being taken out of the hands of the Makers and put back into control of the corporations. 3D printing in conjunction with these new polices that address the issue of patenting by large corporations and allow a space where this technology can continue to
develop without the need to profit first could lead to more leisure time as Marx envisioned. Through the increase and advances in laborsaving technologies, working hours will decrease and this will translate to more production for the capitalists and a reduction in working hours.

Feenberg’s (2010) summary on the philosophies of technology, the “Ten Paradoxes of Technology,” reflects on how we perceive technology in society and how most of our perceptions are not true. Our technology is perceived as disconnected from its past, meaning that as we use our technology we seldom have an idea of where the designs came from and who is in charge of the decisions that determined the designs. We tend to just accept the features “as is” and make the best of incorporating new technologies into our lives. This lack of knowledge and understanding has become part of our culture of technology. This culture only rejects technology when social groups form around them to shape their designs. If the technologies are generally doing a good job and have proven themselves to be efficient enough then as a society we do not ask for any design modifications. The Makers see themselves as a social group and they want to share their knowledge of 3D printing so that others can help shape it design. If this social culture can be maintained through its development, 3D printing may be able to bridge the gap between the producers of technology and its consumers.

What we need to critically think about is how design modifications have already occurred behind the scenes and how these modifications are meant to benefit the owners of enterprise and their investors not the users who are the victims of poor design. Shortcut and modifications are made that might reduces the safety of the design, but cost analysis will determine that these shortcuts are more necessary to the bottom line of profit and the damages can be figured out at a later time.
Today, at this point in the history of technology, I feel we are experiencing a change in the technology-society relationship. Society is demanding technological developments in response to our environmental crisis. The hurdles these demands face can be seen in demands from the past of technology. We already have the technology to solve world problems such as starvation but it is due to capitalism and bureaucracy that people still starve and die every day.

If we take away capitalism and replace it with a social democracy it may open the technological avenue to solving such world problems but it will not solve the issue of our rational society. We cannot live without our science and technology so how do we make sure that it does not swallow up what the essence of being human means? In this time of crisis for our planet I agree with Feenberg, Heidegger and Marcuse that we must look to art and the salvation of nature to protect what it means to be human.
REFERENCES


