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RESEARCH QUESTION

Additive Manufacturing, also known as 3D printing, is the process of producing a three dimensional product by laying successive layers of material. This additive manufacturing process differs from traditional subtractive manufacturing, which is the process of taking raw material and 'cutting', 'shaving', or 'chipping' away at it in order to achieve the final desired shape. Additive Manufacturing is a rapidly developing technology that has only recently been thrust into the global spotlight. Digital Trends, a popular technological news site has even labeling 3d Printing as "Manufacturing's big bang", destined to change society and the way we live (Digital Trends). As a result of this hype and recent attention, the goal of this project is to develop a deeper understanding of this technology by introducing the 'need to know' terminology, giving a quick overview of the production process, and lastly analyzing the contexts in which 3D printing technology was created.

An article published by the Atlantic Council highlighted the possibility of Additive Manufacturing technology to change the world's economic system, revolutionize the medical field, and possibly even benefit the environment. It is for these reasons that this project will also serve as a platform to ask, and hopefully answer, questions pertaining to the necessary policy changes and regulations needed in order to ensure that 3D printing brings the greatest good to society. This project will answer the question of 'how this technology works' while attempting to also address 'why it was created'. Our project will aim to utilize 3D printing as a case study for students of all disciplines, with the intent of answering the question: what is an interdisciplinary view of Additive Manufacturing technology?

BACKGROUND CONTEXT

In an era of rapid technological growth, it is imperative for engineers, scientist, and the general public as a whole, to fully understand the implications of this innovation. To gain this understanding, society must take a "post-humanist contextual socio--technological" approach to the relationship between technology and society. Simply put, research must be done to study not only how technology affects society, but also how society can affect technology. By providing current Lafayette students with a case study of Additive Manufacturing technology, our group aims to teach future engineers to develop a deeper understanding of technological innovation by analyzing the contexts in which a technology is created. This information would then be used to make an educated decision on whether a technology will have a positive or negative effect on the society in which it was intended. We feel that a contextually integrated understanding of Additive Manufacturing is pertinent to all Lafayette students, especially EGRS majors, because of the potential capabilities and widespread use of this technology in the future. Research in the fields of medicine, construction, food production, and manufacturing has discovered

possible revolutionary uses for Additive Manufacturing technology, with new research being conducted every day. Engineers need to be more proactive than reactive in order to properly adapt to technological innovation. To become leaders in our industries we need to leave this institution with not only technical knowledge, but a multidisciplinary understanding of technology and the impact it has on society.

METHODS

The final product for this project is a website that provides links and analysis of articles, videos, and images relating to Additive Manufacturing, which can be utilized as a case study for further discussion on the importance of contextual issues in technological development. Our group decided on a website as it is an easily accessible source of information and allows for feedback from website viewers. Our website has already attracted attention from scientists and engineers in Munich, Germany who has started a discussion relating to Additive Manufacturing in the construction industry. Our group believes that this website will continue to be viewed by people interested in Additive Manufacturing and will open discussion about this technology, between not only engineers, but people of all different backgrounds.

The method used for this project was to collect many different forms of research including: scholarly journal articles, news articles, media publications such as videos, and other websites. After this information was gathered, our group began to analyze how each source could be used to present an unbiased view of this technology. This analysis focused on societal, environmental, economical, and ethical issues surrounding 3D printing technology. After this initial research our group began to focus more on recently released news articles relating to this technology, as scholarly articles relating to this topic are uncommon at this time of its development. These news articles and other media publications were linked and incorporated into our final website in order for viewers to not only see our analysis of the source, but to also give them the opportunity to read further into a specific topic of discussion. The website is broken into many different pages including: Home, Contexts, Present and Future Applications, and Importance and Significance. Additionally, a separate page was added in order to allow viewers to start discussions and share their opinions on this technology. Lastly, a map of the website was added to the right hand column in order to allow viewers to easily navigate through the site.

This website will also serve as the platform for the 3D Printer Case Study for Lafayette College's Engineering Capstone, EGRS 451. This case study will be used to educate engineering students on methods of evaluating technologies, and allow them to be more efficient leaders as they are able to combine their understanding of ethics, engineering, and technological development. Our group hopes that this website will act as another way for students to develop a 'post humanists contextual socio-technical' understanding of technological development and an appreciation of forces external to the artifact that influence its development. The lessons learned from this Additive Manufacturing case study will also provide a base for analyzing future technological innovations. This website will serve a means to educate future students on this topic, and create a stepping stone for further research and understanding of this technology as it continues to advance and spread to different industries.

This project was aided by two of Lafayette College's faculty; Professor Nicole Crain of the Economics department, and Professor David Shulman of the Anthropology and Sociology department.

CONCLUSION AND OUTCOMES

The website which was developed as the final product of this project can be accessed at: http://sites.lafayette.edu/egrs451-sp13-heppn/

The website linked above is both informative, and demonstrative of interdisciplinary research relating to Additive Manufacturing technology. Additionally, this website is user friendly as it is easy to navigate, with a map of the website being permanently placed in the right hand column. Technological innovation is a constant part of human society; however the adoption of this technology is not. As a result, engineers and people of other disciplines must work on developing a greater understanding the contexts surrounding technological innovation in order to allow for a smoother assimilation of this technology into society. As a technology that has only recently reached the global spotlight, Additive Manufacturing has given students a case study with which they can work on being more effective leaders in an era dependant on technology. Analysis of past technologies and current technologies, such as Additive Manufacturing, will allow students to develop a deeper understanding of concepts studied throughout the Engineering Capstone course.

RECOMMENDED NEXT STEPS

The majority of the work for this project is completed, as the website's format has been developed and many articles have already been posted. However, our group does believe there is work for future students in the form of maintaining this website with links to future articles and news publications in order to document how 3D printing develops as a part of society. Society is currently witnessing the development of this technology and as a result, we are perfectly positioned to study the past development while also analyzing how this technology will continue to grow and the impact it will have on the world. One question that future students can answer, and what many current students are wondering is: Will 3D printing 'stall' and never reach its perceived potential, or will it truly become a technology to change society as we know it?

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APPENDICES

APPENDIX A

Part 1: Annotated Bibliography:

Atala, A. (2011, March). Anthony Atala: Printing a human kidney. [Video file]. Retrieve from: http://www.ted.com/talks/anthony_atala_printing_a_human_kidney.html

Anthony Atala, the director of the Wake Forest Institute of Regenerative Medicine, along with his coworkers, has spent years applying 3-D printing technology to the field of medicine. Atala highlights society's current health crisis in terms of the shortage of human organs, crediting the tremendous improvement in medicine, as people who live longer have an increased chance of organ failure. Years of research and experimentation have allowed Atala and his team to develop a 3-D printer that can print with human cells. In this video, the audience is able to see firsthand the creation of a human kidney, one of the most needed organs for organ transplants, making up nearly ninety percent of organ transplant requests. This video is a valuable example of how technology is being developed in order to fulfill a need of society, and not just because we can.

Bradshaw, S., Bowyer, A., & Haufe, P. (2010). The Intellectual property implications of low cost 3D printing. *Scripted*, 7, (1), 5–31.

3D Printing has been developing now for over 40 years. The technology has developed to point that it may soon become a household item; feasibly enabling individuals to produce anything they wanted from home if they can get a hold of the design file. The first part of the article details the possible uses of a 3D printer for individual home use. The second part of this article addresses the issues of intellectual property with 3D printing. The article examines existing legislation to foresee the possible implications of this technology on copyrighting, design protection, patents, and trademarks. At the current time this technology is not advanced enough to create a widespread readily available consumer 3D printer that would be advanced enough to infringe upon intellectual property legislations. Our group will utilize the various case studies and legislation that has been addressed to discuss and outline possible legislation or regulatory restrictions that could prevent negative consequences from further developing this technology.

Diegel, O., Singamneni, S., Reay, S., & Withell, A. (2010). Tools for Sustainable Product Design: Additive Manufacturing. *Journal of Sustainable Development*, 3, 3, 68–75.

This article highlights the benefits Additive Manufacturing (AM) will have to designers and the sustainability of their projects. The authors illustrate the principle of "triple bottom-line" ideology to address the sustainability of AM: environmental, economic, and social sustainability. The authors address the capabilities of analyzing the sustainability of a product in these areas. The methods entailed will be used to address other technologies as we compare them against 3D technology in terms of the future of manufacturing. The authors argue the concepts of design quality, mass customization, and freedom of design are leading factors that contribute to the recent and continued success of AM. Despite the positive implications of AM technology it has created complications in design, requiring designers to adhere to different set of restrictions. These restrictions will be factored into the cost of revamping manufacturing from the current processes. This article effectively addresses the broad picture of the benefits AM can have towards further sustainability but fails to acknowledge specific examples.

Foti, J., Tiffany, A., Tolstokov, I., Fabre, J., Rawat, R. (2011). The societal impacts of 3D printing. *The website all to do with 3D printing.* Retrieved from: http://madameeureka.wordpress.com/the-societal-impacts-of-3d-printing/

This source is word press site created by several individuals. These individuals come from the backgrounds of Marketbot Industries, and researchers from Washington State University and Cornell University. This section of the site discusses the societal impacts of 3D Printing technology. The source briefly mentions the implications of the near future of a printer being in the homes of the general public but spends most of its focus on the phenomenon of mass collaboration. Nike is exemplified to explain what mass collaboration is and how companies may utilize it to their benefit. If Nike needs help or feedback from consumers on how to design a certain type of shoe, through free design software and open forums on the internet, Nike can initiate a competition for the best design. Thus, society as a whole becomes the designers of the products they buy while Nike profits off this phenomenon with minimal overhead cost. This creates an entirely new dynamic of consumer producer interactions.

Gehi, M., (2012). *The Implications of 3D Printing.* Retrieved from: http://www.khouse.org/articles/2012/1078/

This article talks about the origins of 3-D printing, which started in the late 1970s as a method of creating prototypes quickly and cheaply. In the early 2000s, the significant decrease in the printer material allowed for this technology to move into different fields, such as jewelry and architecture. The article goes on to discuss the many economic, legal, and sociological implications of widespread use of this technology. Economically, 3-D printers will change the prevalent models of consumerism, as society would move from manufacturing goods to a knowledge-based economy. The article also highlights the shift

in society from the 20th century mentality of large-scale consumerism and mass production, to the 21st century mentality of small-scale productions and customization. 3-D printing technology will aid in these social and economical relationships. The article coins a term "Prosumerism" to describe the shift from a consumerism focus to a world of continuous production and consumption as 3-D printing will emphasizes societies need for instant gratification. This article shows how the transition of America's economic mentality is being supported by the possible widespread use of 3-D printing technology. The limitation of this article is that it does not take a deeper look at why this transition in economic mentality occurred during the past century.

Gibson, I., Rosen, D., Stucker, B. (2010). Development of Additive Manufacturing Technology. *Additive Manufacturing Technologies*, 1, 17-39.

This chapter discusses the key moments in the development of Additive Manufacturing technology, including improvements to computing power, reduction is mass storage costs, in addition to CAS technology. Improvements in computing power during the 1970s and 1980s allowed for computer to complete computational tasks in real-time as opposed to hours or even days. Additionally, this chapter highlights the importance of the gaming industry in the development of graphics technology to create more 'realistic' images. Additive manufacturing takes advantage of many other technologies such as: processing power, graphics capability, machine control, networking, and integration. Without developments in these technologies during the 1970s and 1980s, Additive Manufacturing would not exist in its current form. This chapter delves deeply into the technologies that made 3-D technology possible, however does not address the social-technical aspect of why this technology was created.

Gibson, I., Rosen, D., & Stucker, B. (2010). *Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing*. New York: Springer.

This book was written by three professionals who realized the rapid growth and potential of Additive Manufacturing technology (AM), and came together to create a text they hoped to become an aide to students and a supplement to the engineering curriculum. This book provides a basic overview of AM technologies as well as detailed descriptions of the various forms it has taken and the multiple industries it has been integrated into. The text concludes with how the authors foresee the future of this technology; what this technology will develop into, the products that will be developed, and its influence on business and industry. This text will serve as resource to understand the fundamentals of AM technologies. Specifically, chapter 17; the use of multiple materials in AM is the fundamental necessity for using this technology in building construction. This chapter will provide the capabilities and limitations of this process as a basis to understanding its potential in the construction industry.

Hao, L., Mellor, S., Zhang, D. (2012). Additive Manufacturing: A framework for implementation. *17th International Working Seminar on Production Economics*, 1, 133-144.

This article focuses on the implementation method of Additive Manufacturing and highlights the lack of socio-technical studies on this subject. Additive Manufacturing was originally developed to allow for economic low volume production of customized products. As a result, the dominant application of this technology is Rapid Prototyping, a useful tool in the aerospace sector. This article acknowledges that with the implementation of this technology, there will also be a cultural change in workplace practices and structure, likely in the form of new jobs and tasks for workers. This will be accompanied by a change in workplace experience and skill as there will be a need for engineers and designers who will have to adapt their knowledge and ignore many of the limitations that they experienced when only subtractive manufacturing and formative processes existed. This article also talks about how this technology will impact company operations departments, as there will need to be a need for research into planning strategies for the use of Additive manufacturing. The article concludes by stating that its limitation is that minimal research and testing had been done on the issues of AM implementation because only a small number of companies currently use the technologies. This article shows how the implementation of this technology will affect the atmosphere of the workplace and change the cultural dynamic, as there will be a need for new skills and experience.

Henke, K., & Treml, S. (2012). Wood based bulk material in 3D printing processes for applications in construction. *European Journal of Woods and Wood Products*, 71, 1, 139-141.

In this experimental study the researcher tested the capabilities of using additive technology to construct bulk wood material for construction. The researchers tested various forms of wood waste (i.e. sawdust and woodchips) bonded with gypsum, cellulose, sodium silicate, and cement. The results concluded that bulk material wood production is feasible, but not utilizable for building construction. This article does an effective job of detailing the procedure to make bulk material, but falls short in finding how to produce material acceptable for use in construction. This article serves as background to material renewal through additive manufacturing.

Hernandez, A., Wong, K. (2012). A Review of Additive Manufacturing. *International Scholarly Research Network*, 1-10.

This article discusses the origins of 3-D printing technology in the manufacturing sector as a method of rapid prototyping, and how this technology became possible as a result of other technological advances during the 1980s. These technologies included CAD, computer-aided design, CAM, computer-aided manufacturing, and CNC, computer numerical control. The article then stated that without these technologies, the printing of three-dimensional objects would not be possible. The technical contexts, which facilitated the creation of 3-D printing technology has given way to the many current uses of 3-D

printing technology. This article is limited in that it briefly mentions the contexts surrounding this technologies creation, the engineer's need for rapid prototyping, however do not go into further detail about the topic.

Huitt, W. (2007). Maslow's hierarchy of needs. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved from: http://www.edpsycinteractive.org/topics/regsys/maslow.html

Abraham Maslow's Hierarchy is a famous system of needs that describes human motivation. The four basic needs in ascending order are: Physiological: food, water shelter; Security; Social Acceptance/ Belongingness; and Self Actualization: pursuing and fulfilling our full potential. This hierarchical theory entails that a person strives to fulfill each need, but cannot go up the hierarchy until the need below it is met. This article will serve to provide further background in understanding the need for faster more effective construction in terms of providing impoverished nations with suitable housing. The author also includes other more recent theories of what the basic human need, all of which vary in some degree but have in common that a human's physiological needs are fundamental if the person is to grow/ accomplish anything.

Khoshnevis, B. (2012). *TedxTalks contour crafting*. Retrieved from: http://www.youtube.com/watch?v=JdbJP8Gxqog

This is a Tedx Talk presented by Behrokh Khoshnevis. Ted Talks are informative presentations founded upon the ideal of spreading important knowledge. The 'x' indicates that it is not an official 'Ted' presentation, but was created by an outside individual or organization. Behrokh Koshnevis is a professor of Industrial and Systems Engineering and Civil and Environmental Engineering at the University of Southern California Viterbi School of Engineering. He is also the director of the Center for Rapid Automated Fabrication Technologies and Manufacturing Engineering at the university. This presentation is about one specific area of his research and innovation, Contour Crafting; the process of using a scaled up 3d Printer to construct a building from the ground up. He justifies the need for this technology by pointing out the importance of creating adequate housing for over a billion of the people on this planet, and how as a world we need to create an environment where humanities basic needs are met. He then further elaborates on the shortcoming of current construction methods, and how these methods will not be able to provide this fundamental need. The slums that billions of people live in are described as breeding grounds for disease, crime, illiteracy, and over population, we need to address this problem. Though, conventional construction is slow, labor intensive, dangerous, and very inefficient. The technology of Contour Crafting developed by Professor Khoshnevis is a faster, more efficient, safer means of construction. He reports that a full scale Contour Crafting Printer would be able to construct a 2500 square foot home of any design in 20 hours. This is an excellent source that provides another set of contexts of 3d Printing: humanitarian needs and building construction efficiency.

McCue, T. (2011). 3D printing will transform education. *Forbes*. Retrieve from: http://www.forbes.com/sites/tjmccue/2011/11/01/3d-printing-will-transform-education/

TJ McCue in visions a future of technological revolution similar to the one my generation lived through when a computer was put on ever student's desk. The next revolution will be having a 3D printer for every student. One company, Makerbot Industries, has already done so through a test rollout in New York City. This company being part of the beginnings of this technology has also been innovators in how this technology is used creating 'crowd source solutions', which is an online community that you can upload and download designs to be printed out. This article will gear is in the direction of studying initiatives other 3D printer companies are taking to understand how these companies are shaping the future of this technology.

Nieusma, D., & Riley, D. (2010). Designs on development: engineering, globalization, and social justice. *Engineering Studies,* 2, 1, 29-59.

This article utilizes two case studies involving community development to illustrate the problematic assumptions engineers make about technology's role and their failure to grapple with economic and cultural structures in development projects. The authors were both personally involved with these case studies. This article critically analyzes their work as an opportunity to teach future generations of students, professors, and community development organizations to learn from past mistakes. The main point for this article is for engineers to focus on process over product. This idea will be utilized in questioning whether or not this a technology mankind should pursue. 3D Printing is capable of doing incredible things through additive technology, but that does not necessarily entail that this technology should continue to be developed. By analyzing the process first our group seeks to evaluate what mankind seeks to gain from a technology of this short and evaluate multiple options to develop a good rationale.

O'Neill, K. (2012). Is Technology Outmoding traditional firearms regulation? 3-D Printing, State Security, and the Need for Regulatory Foresight in Gun Policy. *Social Science research Network*. 1, 1-7.

This article talks about the ongoing debate of firearm regulation in the Supreme Court, and brings to light the fact that 3D printing technology is making many of these regulatory issues irrelevant. The article states that 3D printing is in its infancy, but its applications are extraordinary, stating that the industry is expected to reach $30 billion per year by 2020. The article states that there are already many debates of copyright or trademark infringement as a result of this technology. The article stresses the ability of this technology to be used to create firearms or other weapons. In 2011, one developer uploaded a CAD design of an AR-15 receiver, which caused many to question 3D printing capabilities and whether such technology is worth pursuing. The article states that no longer does a person need metalworking skills to create these weapons, but only a computer and CAD design. This article also mentions the importance of regulations to adapt and not become irrelevant as new technologies arise. Our group feels that this example of ethical problems, and others like it, is the reason that engineers must be taught about ethical problem solving and social justice. Engineers should also work with regulatory forces in order to limit or get rid of any negative consequences that could arise

from a new technology. The limitation of this article is that it only mentions the single problem of gun creation and fails to address all of the possible concerns that surround this technology.

Pool, S. (2012). A 21st Century Approach to Manufacturing Innovation. Retrieved from: http://scienceprogress.org/2012/08/a-21st-century-approach-to-manufacturing-innovation/

This article discusses the increasingly competitive globally economy, and states that the traditional 'linear' approach to innovation will no longer be sufficient. Economies can no longer rely on the separation of science and industry, as there is now a need for an interconnection of science, technology and industrial production. The article focuses on the need for society to develop a new model of innovation, which partners the academic and business world. Pool goes on to state that we must 'smooth' the path for new technologies such as Additive Manufacturing in order to continue recent manufacturing innovation. In order to do this, Pool argues that government intervention and funding are a feasible method of producing this pathway. Lastly, this article highlights the importance of collaboration among all innovation stakeholders and bringing research and production together. This article delves into the governmental context and the involvement of government in new technologies. This article is limited in that it does not list other possible ways that a 'smooth' pathway for 3-d printing technology or other similar technologies could be created.

Ratto, M., Ree, R., (2010). The *Materialization of Digital Information and the Digital Economy*. Retrieved from: http://webcache.googleusercontent.com/search?q=cache:rhHl0tkdMqIJ:thingtanklab.com/wp-content/uploads/2011/02/SSHRC_DigEcon_DDF.pdf+&cd=1&hl=en&ct=clnk&gl=us&client=firefox-a

This article discusses the many socioeconomic implications of 3-D printing technology, including the potential of this technology to largely impact cultural, social and political life. This 3-D printing technology has a cultural impact as is will create new spaces for fabrication as these printers become more affordable, drastically changing the relationship between producers and consumers. This technology will also create a different social atmosphere as engagement with this technology involves the dissemination of information, and human interaction. 3-D printing also allows consumers to fulfill their need for customized and individualized products or experiences. This technology also has political implications such as problems with intellectual property laws. Lastly, the article acknowledges that the current research on this 3-D technology comes from engineering and the sciences; however the research in this article expands this research into the fields of social science and humanities. This article greatly expands on the social, cultural and political consequences that 3-D technology could have on society. However this article tells that its limitation is that most research on this topic is done by engineers and scientists, limiting the available information regarding social science and humanities.

Ratto, M., Ree, R. (2012). *Materializing information: 3D printing and social change*. Retrieved from: http://firstmonday.org/ojs/index.php/fm/article/viewArticle/3968/3273

Authors, Ratto and Ree, professors at the University of Toronto, believe there is a bright future for this 3-D printing technology; however stress that more attention must be paid to the way that this technology is entering our creative environment. Ratto and Ree label 3D printing as a 'socio-technical invention', as it brings with it a new form of community exchange and cultural expression. This article reveals the many different ways that additive manufacturing technology will drastically change social dynamic. The most prominent of these changes is the explosion of 'virtual collective studios', which allow developers to showcase and sell their designs and projects. Our group views this article as an important part of the need to make society and community the center of technological development. No longer should technology be thrust into society without thought and preparation into how society will react, and what the possible consequences could be. This article is limited in that it highlights the need for further research on the topic and does not give a final recommended solution to how society should approach new technologies in the future.

Sandel, M. (2004). Embryo ethics – the moral logic of stem-cell research. *The New England Journal of Medicine.* 351, 207-209

3D Printing has the potential to revolutionize the medical industry by enabling the fabrication of human tissue and organs. 3D Printing in this purpose is an extension of current Stem Cell research; using these cell building blocks as the material to print organs and other human tissue. Thus, the potential use of 3D printing in this purpose falls under the same ethical debate of stem cell research. Critics of stem cell research make two main arguments: the destruction of embryos amounts to killing human being, and if not research still takes us down a slippery slope of dehumanizing practices. MJ Sandel uses a philosophical context to create a moral justification for the continued use of stem cells, as well as political and regulatory suggestions to account for the second argument the critics make. The points philosophical points that Sandel makes are: just because every person began as an embryo does prove that embryos are persons; and if embryos were people research would be illegal not unfunded and infertility clinics likewise. He further lists political actions that should be taken to prevent the slippery slope of research: ban human cloning; restrict commoditization of embryos; and regulate the use and supply of embryos to prevent a monopolization of stem cells.

Vance, A. (2010). 3D printing spurs a manufacturing revolution. *New York Times*. Retrieved from: http://www.nytimes.com/2010/09/14/technology/14print.html?pagewanted=all

The New York Times is a major American daily newspaper. Its popularity is mainly metropolitan United States but it is renowned across country and internationally. The author Ashlee Vance specializes in writing about business technology. The article briefly

explains what 3d Printing is and then goes on to discuss the current applications of it in various businesses. The article shows a slight bias in favor of 3d Printing only broaching the positive implications of this technology. One of the applications highlighted is using these printers to construct customized prostatic limbs. He points out that the cost would be decreased by a factor of 10 ($ 60,000 - $ 6,000) and that it would create a superior quality item. Furthermore, this technology promotes the humanitarian and economic benefits, "creat[ing] a leg that had a level of humanity" at a fraction of the cost. Vance further details the economic benefits by justifying the removal of manual labor in manufacturing, due to the fact that most jobs of these levels are outsourced. 3d Printing would create more domestic jobs of individuals working with printers as well cut the costs of shipping charges. He concludes with the social/cultural context quoting the founder of an architectural company using 3d printing, Charles Overy; "we are moving from handcraft to digital craft." The author does not comment on this potential cultural shift from this technology. This article is a great resource to understand what the public sees in mainstream media about this technology. We will use this knowledge to achieve a complete and thorough understanding of this technology.

Weinberg, M. (2010). It will be awesome if they don't screw it up: 3D printing, intellectual property, and the fight over the next great disruptive technology. *Public Knowledge.* 1- 15

The goal of this whitepaper is to prepare the 3D printing community for the roadblocks that are going to be thrown in the way of its development to slow it progress through intellectual property laws. By a thorough analysis of the current intellectual property laws in place the author hopes we will be ready to understand how companies and legislators alike will try to slow down the progress and assimilation of these printers into mainstream society. This author shows a clears bias in favor of this technology and against corporations that he foresees trying to discredit these printers. The author utilizes many real life scenarios to allude to the possible controversies that may arise in current copyrighting, patenting, and trade marking products. The author then goes on to predict how the future development of this technology will begin to slowly change our laws to incorporate future intellectual property protection. He predicts an expansion of contributory infringement on patents to go after those who enable replication of patented items; couple replacing individual unpatented parts of broken machines as piracy; and continue to expand copyright and trademark laws. The author makes many detailed and compelling arguments that are logical about the future, but are only predictions, and thus educated opinions of what the future might unfold.

Part 2: News Articles:

Hembrey, J. (2013). How exactly does 3D printing work. *CBC News,* Retrieved from: http://www.cbc.ca/news/technology/story/2013/01/23/f-3d-printing.html

LaMonica, M. (2013). Additive Manufacturing: GE, the world's largest manufacturer, is on the verge of using 3-D printing to make jet parts. *MIT Technology Review*. Retrieved from: http://www.technologyreview.com/featuredstory/513716/additive-manufacturing/

Licata, J. (2013). How 3D printing could revolutionize the solar energy industry. *The Guardian.* Retrieved from: http://www.guardian.co.uk/environment/blog/2013/feb/22/3d-printing-solar-energy-industry

Pettey, C., van der Meulen, R. (2012). Gartner's 2012 Hype Cycle for Emerging Technologies Identifies "Tipping Point" Technologies That Will Unlock Long-Awaited Technology Scenarios. *Gartner,* Retrieved from: http://www.gartner.com/newsroom/id/2124315

Staff, B. (2012). They were predicted to fail – but thank goodness they didn't. *Buzzle,* Retrieved from: http://www.buzzle.com/articles/they-were-predicted-to-fail-but-thank-goodness-they-didnt.html

Valentino-DeVries, J. (2010). From Hype to Disaster : Segway's Timeline. *The Wall Street Journal.* Retrieved from: http://blogs.wsj.com/digits/2010/09/27/from-hype-to-disaster-segways-timeline/