The Internet of Things on Future Jobs

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

The Internet of Things is a quickly developing concept that will become the backbone of society in the near future. Just as the Internet did in the late 1900's and early 2000's, the Internet of Things will revolutionize the day-to-day life for all of society. For more context, the Internet of Things is a paradigm in which everyday devices from phones and laptops to cars and refrigerators exchange information and interact with each other through wireless sensors. For example, as a person drives home in their car, their car detects they are within 5 miles of their house so it notifies the smart home system to turn on the air conditioning. The Internet of Things (which will be referred to as the IoT hereafter) can be applied to essentially every aspect of society and will forever change many industries such as Farming, Advertising, Retail, Manufacturing, and plenty more (Ismail, 2017). As a result of this widespread impact, the automation and connectivity that the IoT would bring will make many lives easier, but it will also have a drastic impact on the job market. The IoT could potentially create more jobs than it destroys in a quantitative sense, but the types of jobs that are created will be vastly different than pre-existing ones, thus requiring extreme change or compromise for those whose occupations are displaced or reformed. Therefore, some social groups might be able to take advantage of new occupations while other groups might not be able to afford to ("The Future of Jobs", 2016). On the other hand, there is the possibility that the IoT will destroy more jobs than it will create and simply displace thousands of workers with little room for compromise. Beyond simple quantitative concerns, the IoT will have profound effects on the contents of a job and the daily lives of workforce members. For some members, their daily tasks may become easier and more enjoyable. For others, increased technology could mean an invasion of privacy or riddance of ingrained routines leading to uncomfortableness or worse performance. The list of considerations

and possibilities goes on, there is no clear cut answer as to what will happen. Whether or not an IoT technology will be socio-technically successful and how the IoT will impact the job market as a whole comes down to the amount of care engineers put in ethical design, as will be further discussed later on.

Literature Review

The question of how new technology and automation will impact workers' livelihoods and job security is an age old controversy. With the IoT gaining more and more traction, new fears/hopes have arisen in response. Some believe that the new technologies will better our lives and introduce new jobs, others believe that the new technologies will take more jobs away than it will produce and alienate entire social groups. The following review of literature confirms that there are many differing opinions and justifications for either side of the argument and that the question of how the IoT will impact jobs is not simply a yes/no question. There are many complicated issues beyond the effect on the quantitative job count and many potential consequences that disproportionately benefit certain social groups and harm others.

To start out with the potential quantitative effects of IoT on the job market, Frey and Osborne (2015) attempt to estimate the number of jobs that are vulnerable to automation and what industries and income brackets are most likely to be negatively affected. They reach their conclusions through a combination of pre-existing literature and machine learning algorithms trained on verified occupational data. The results of their research are bleak, resulting in fear for the future. However, there are some limitations to their models and their approach, one of them being that there are many more factors than simple probability and technological advancement that play a part in job automation. Policy, economic conditions, and activism from labor unions

will all play a significant role in automation, but they are not considered in the model. Thus, this source can potentially be used as a loose estimate for certain industries and as a reference for potential general trends, but it cannot be referenced as a guaranteed outcome.

Arntz and Gregory (2020) attempt to address some of the aforementioned shortcomings of Frey and Osborne through introducing a finer-grained filter to Frey and Osborne's models and conducting individual surveys. One of the most important critiques the authors make on Frey and Osborne's findings is that occupations are made up of many tasks. Some tasks are automatable and some are not. Thus, they claim that Frey and Osborne's model is too eager when deciding if a job is at risk of automation or not, since their model too easily groups many different types of tasks without considering the implication of doing so. This source can be used as an opposing view to the nay-sayers of IoT. It doesn't claim that IoT will benefit the job market, but it does provide evidence that perhaps the negative affect will not be as bad as some believe.

In opposition to Frey and Osborne, Shenkoya and Woo (2019) claim that integrating the Internet of Things into society will have a quantitatively positive impact on job opportunities. The authors reach their conclusion through the use of statistical models trained on economic information from Japan. While the findings of this study have a positive outlook and the mathematical calculations themselves are valid, the study makes a lot of assumptions that would drastically affect the study. For example, the study makes the assumption that "the number of households with internet access is a representation of the diffusion of the IoT". This assumption too loosely defines the Internet of Things and thus gives too much credit to the IoT for observed positive effects. That's not to say that the entire study is invalid, but rather that the results of the study cannot be taken as gospel. Instead, I will most likely use this source to show that there are

many differing opinions and that no one group has the definitive answers as to how the IoT will affect our future.

One aspect of how IoT can affect the workplace beyond simple quantitative estimates is how IoT could potentially impact the quality of life for a worker. In their report, Ma and Cha (2020) introduce a new framework for estimating and recording interactions between workers in certain locations in hopes of allowing future workspaces to be built keeping said interactions in mind. If the workspace itself is designed while considering when, where, and how workers interact with each other, a much more worker-friendly and encouraging environment can be constructed. There are a few limitations with the authors' study, however. The human interactors that were used in the study were few in number and the correctness of the framework hovers around 77%, so the study cannot be considered perfect and completely indicative of the future. However, as technology improves and research in the IoT area becomes more popular, perhaps the techniques in this study will be refined and eventually result in a solidified product that benefits the workplace experience.

Another potential aspect of the job force that IoT could impact is how companies are organized. A long time ago, there was just the CEO. Then came a CFO. Not too long after that, the CTO was introduced. As industries and how we do business evolves, companies have adapted and reorganized their corporate hierarches to embrace changes. Malone (2014) discusses the potential decentralization of corporate hierarchy and the benefits/shortcomings that come with it. He mainly justifies his conclusions through the use of historical analysis, which could be seen as a pitfall for the article. Historical precedent does not guarantee that contemporary developments will play out the same way, and he does not provide much more evidence to

support his claims. However, I can still use this source to investigate how IoT could potentially reconfigure order and power within the workplace in the context of Winner's theory.

There is more to the story than just quantitative changes to job count. We must also consider the qualitative changes of the job market, which the report from the World Economic Forum discusses ("The Future of Jobs", 2016). The report mentions how certain industries, such as Computer Engineering and Mathematics, will see tremendous growth while low-skilled jobs will likely suffer from great job loss. Deeper consequences such as widening of the gender gap and the strengthening of the middle class are also discussed. The report takes many social consequences into consideration, so this will be one of my strongest resources when discussing how social relationships are configured in Winner's theory.

In response to the World Economic Forum's report, Marzano and Lizut (2018) conducted research and claim that some of the issues mentioned in the World Economic Forum's report could potentially be addressed by the educational system. The authors came to their conclusion based on literature analysis of a multitude of sources including reports from international organizations. From these sources, they identified several trends in future desired skills and potential new positions and titles. The main criticism I have is that the article concludes with the proclamation that IoT could potentially be used to improve the educational system which, in turn, will prepare future generations better for the IoT and ensure that the shift in the job market towards high-skilled jobs can be accounted for. However, it does not provide any suggested methods to do so. The research merely identifies the issue and a potential Relevant Social Group that can be recruited into the system as decision makers, but ends there.

An article written by DeFranco et al. (2018) picks up where Marzano and Lizut left off and proposes more grounded and specific actions the educational system can take to adapt to

upcoming changes. It proposes specific curriculum such as “learning to design embedded cyber-physical systems with real-time behavior” and “design and prototype an ambient intelligence system”. The only criticism that I have is that DeFranco’s article only addresses actions that higher education, namely college, should take in the form of specific curriculum. There is no mention of earlier education. This article, combined with Marzano and Lizut’s research, provide a fairly comprehensive defense for the potentially profound impact the educational system can have on addressing the predicted job imbalance.

Mähler and Westergren (2019) conducted a study in which the IoT was introduced into a few controlled workplaces. The results they found varied greatly. One workplace found that management greatly benefitted from the new technology and that future hiring and employee management would become much more streamlined. Another workplace, however, found that the new technology increased stress and self-doubt in employees, which could potentially lead to degraded performance and other long-term issues. This study is a great resource through which I can investigate how new IoT technology impacts workers and exists as a form of life. The only critique for this study is that the workplaces that were used in the study were all part of the same industry. This was most likely an intentional decision to eliminate as many unnecessary variables as possible and to keep the differing workplaces similar, but I’m sure a workplace from a different industry would provide valuable information as well.

Cohen and Cavoli (2017) wrote an article in which they discuss responsible governance for emerging social technical systems with a focus on autonomous vehicles. The article mentions the politics behind IoT related technologies and how as of now, technology companies have the most power in decision making. It would be difficult for government bodies to assert themselves and establish regulation and monitor the progression of new technology due to the overwhelming

power that technology companies have. However, this article doesn't mention too much about one of the most important stakeholders, the end users. In fact, this article is a little guilty of excluding the end user themselves. In their stakeholder workshop and interviews, government officials, private firms, and researchers made up the majority of attendees. Very few, if any, normal citizens/end users attended. This goes to show that certain stakeholders are considered more important and are included more in decision making than others and that there is a large degree of politics involved in integrating the IoT into our society.

As seen in the aforementioned literature, there has been lots of discussion regarding potential effects and consequences for the job market if we embrace the IoT. However, solidified, over-arching articles that take all these differing views into account to investigate what integrating the IoT would truly mean for the job market are far and few between. Thus, further research into how all these differing opinions relate to and affect each other is needed. In addition, there are certainly aspects related to the IoT that will need to be further investigated that were not listed in this literature review.

STS Framework and Method

The socio-technical framework that will be used to investigate the aforementioned research questions is Winner's Theory in which technology has politics. The reasoning for choosing this framework is that while the motivations behind the IoT may be neutral, there are politics embedded in IoT technologies. As such, there are many parallels between Winner's Theory and my Research Questions.

As mentioned in the Literature Review, certain groups are included in the decision making of how IoT technology is developed and governed while others are excluded (normal

citizens/end users in the study from the Literature Review). One of the core focuses of Winner's Theory is studying which groups have control over the decision making for a technology. My Research Questions also focus on how the lives of different social groups, races, and classes will be affected, which is another tenet of Winner's framework (technologies as forms of life). Another significant parallel I see between Winner's Theory and my Research Questions is the consideration of how IoT technologies could possibly reconfigure the organization of the workplace and how workforce relationships could be redefined. The hierarchy of power within a company and the relationships between workers, managers, and executives could be completely overturned by IoT technologies. The considerations I'm interested in investigating are covered well by Winner's Theory. Thus, it is the perfect framework to use for my studies.

The ethical framework that will be used to discuss findings will be Mediation Theory. Mediation Theory views technology not simply as functional artifacts, but as artifacts that serve as analogs to human-world relationships. For example, an iPhone is not viewed simply as a device for communication, but also as a device that defines how humans interact with the rest of the world and shapes people's perceptions of society. An iPhone may drastically affect the lives of different social groups in various ways, thus, a large degree of responsibility is placed on the designers to consider how their product will shape society. This framework fits well with my research as the IoT is a new, developing technology that will certainly change human-world relationships and will change how humans perceive society.

The methodology through which I plan to collect data will be document analysis and ethical assessment of prior literature, surveys, and interviews. Sources that I plan to pull information from include reports from international organizations such as OECD, available databases such as UVA's library and IEEE, and less formal online sources such as forums and

blogs to ascertain popular perception. Data I aim to collect include number and types of jobs likely to be created and destroyed (and therefore which social groups and industries will benefit and which will suffer), through what avenues can the IoT take to impact jobs, and preliminary results on how IoT has changed workers' lives. Possible sources of bias include authors' culture, educational level, profession, and wealth. I will handle these biases by investigating the perspectives of authors with differing biases and backgrounds and by analyzing what they focus on and what they omit.

Data Analysis

As The World Economic Forum discusses in their report, there will be a significant shift in the content and nature of new jobs ("The Future of Jobs", 2016). And as said in the Literature Review, the report mentions how certain industries, such as Computer Engineering and Mathematics, will see tremendous growth while low-tech jobs, such as Maintenance and Sales, will likely suffer from great job loss. In the context of Winner's Theory, this disproportionate growth pattern is not the primary ideology behind IoT technologies. IoT technologies are, ideally, meant to improve life for all of society by providing new and improved ways to connect with one another and interface with technology. But as a result of the perceived benefits that the IoT brings, certain job industries and thus social classes will suffer. The report itself claims that potential "widening of the gender gap" and "strengthening of the middle class" are possible outcomes. Furthermore, it is important to note that the industries that drive the development and deployment of IoT technology are mostly technical fields such as Computer Engineering, Mathematics, etc. Industries such as Construction, Manufacturing, and Administration that will suffer have little to no say in the design or deployment of IoT technologies. The political

implications that arise from this are significant. Those who benefit make essentially all of the decisions while those who stand to lose are excluded from the decision making process. Such an imbalance could lead to social reconfiguration, a change in societal values leaning towards technology-based industries over human/artistic industries, or even social unrest. Even if the quantitative number of jobs increases as a result of the integration of the IoT, the aforementioned politics may lead to a negative outcome for the job market.

The discussion of World Economic Forum's report was mainly conjecture based on industry trends and future prediction. A concrete case study will now be discussed. One prevalent hope for the IoT is how it could improve the average workday for a worker. As mentioned in the Literature Review, Mähler and Westergren (2019) conducted a study based in the U.S in which the IoT was introduced into a few controlled workplaces. The workplace that will be discussed in detail is CleanCo. At CleanCo, sensors were placed on various dispensers and would notify cleaners when they needed to be refilled or maintained. Team leaders also had the ability to give cleaners new plans, send cleaners direct messages, and access statistics regarding specific sensors. The intention behind the sensor system was to increase efficiency for cleaners, increase coherence between cleaners and team leaders, and just in general to improve a workday for all parties. Not all parties at CleanCo had the same, positive response, however. While the team leaders all found the IoT system to be greatly beneficial since it granted them greater amounts of information and control, some of the cleaners found the sensor system to be stressful and harmful to their work. Knowing that team leaders could see everything that they were or were not doing was uncomfortable, and occasionally, cleaners found that team leaders were assigning them too much work through the system and were becoming exhausted. This disparity in perception of the system strays from the system's underlying purpose. As opposed to

improving the workday for all parties, the system benefitted one party and worsened conditions for the other. The shortcomings of the system likely stem from the fact that it was designed with purely practical performance in mind. The design aimed to be as responsive, intuitive, and efficient as possible. However, the sensor system seems to fail to consider the human side of things. The sensor system provides increased information and statistics to the decision makers, the team leaders, but not to the cleaners, who are certainly a relevant social group in the CleanCo hierarchy. For the cleaners, the sensor system essentially just provides a better way to receive instructions. Features that allow cleaners to request lighter workloads or communicate with other cleaners to promote cooperation are not included. Here, we can see that the tenet of Winner's Theory that focuses on who should be involved in decision making processes failed to be adequately considered in the design process. Thus, scenarios where the cleaners become stressed and team leaders overwork and exhaust their workers become possible. Another possible factor resulting in the partial failure of this IoT system is the fact that it is being deployed in a relatively low-tech scenario. Prior to the system, the cleaners and team leaders relied on technology to a much smaller degree. The introduction of IoT technology into CleanCo was abrupt, and combined with the fact that advanced technology was barely present to begin with, the deployment of the IoT system resulted in a rough transition that disproportionately negatively affected the low-level cleaners. As a result of the system, the pre-existing relationship between team leaders and cleaners was overturned, apparently for the worse. Prior to the implementation of the system, cleaners had greater degrees of freedom and were able to formulate their own routes and plans. After the IoT technology was introduced, team leaders began to exert more control over the cleaners and specifically tell cleaners what to do, resulting in reported cases of increased tension in the team leader-cleaner relationship. An interesting note that Mähler and

Westergren point out is that when team leaders were interviewed about that shortcomings of the system, they attribute the issues not to the system, but to the cleaners. The cleaners were said to not have the "proper mindset" to use the system to its fullest. This improper mindset ideology was also found in the other workplaces for the study, which indicates a major disconnect between the team leaders and cleaners and thus a strong possibility for negative consequences in the future, specifically concerning the relationships between the levels of hierarchy within the cleaning companies. Further ethical implications regarding this case study will be discussed later in the Discussion section. Case studies such as CleanCo show that even if the intentions behind the design for an IoT system are pure, a plethora of non-technical, social factors can lead to misuse or negative outcomes for the system. In this specific study, there was a significant imbalance in the power delegated to certain users resulting in skewed decision making abilities and weakening of relationships in the system even though the system aimed to promote the exact opposite.

For a different cultural perspective, a case study for the IoT in a Chinese industry will now be analyzed. In this case study conducted Yang et al. (2020), an AI-based technology produced by Celefish was introduced to the Chinese fish farming industry. The AI system's goals included supporting collaboration between members of the fish industry, enhancing performance of all members in the industry (from small fish farmers to larger businesses), and promoting cooperative innovation within the industry. And similar to the previous case study, the industry in which new IoT technology is being introduced is relatively low-tech. Yang et al. mention that many small-scale fish farmers simply rely on their "breeding experience" when it comes to things such as managing oxygen enrichment and feeding quantity. Unlike the previous case study carried out by Mähler and Westergren, however, there were no significant cases of the

system failing or harming specific groups. The results of this case study resulted in both a technical success, said success including reduced costs of fish farming as well as mitigated risks involved with breeding processes, and a sociotechnical success. Both large scale businesses and small scale farmers benefited from Celefish's IoT system, there were no significant cases of certain groups being disproportionately negatively impacted as seen in CleanCo's case study. This success on both fronts shows that IoT technologies can indeed be the positive boon to industry that designers intend for, but in order to ensure that the underlying politics of the IoT technology do not favor certain groups over others, special care and perhaps a different design mindset are required. As mentioned earlier, when it came to designing this IoT system, the designers at Celefish moved forward with a mindset focused on not only technical capabilities, but also sociotechnical concerns such as improving communication and cooperative innovation between members of the industry. And unlike the system in Mähler and Westergren's case study, Celefish's system does not try to solve everything for the end users, it acknowledges that it "cannot independently provide all the products and services for fish farmers". Rather, it cooperates with suppliers, farmers, banks, and other members of the industry to form a cooperative network that promotes sharing of technology, sharing of resources, and evolution of the industry. In addition, CleanCo's system placed a large emphasis on differentiating cleaners from team leaders, whereas Celefish's system treats all users as equal, important members of the industry. Differentiating between users and treating them differently based on their status is not an inherently unethical practice, but it should be done with care and should ensure that no one social group has too much or too little power. In the case of CleanCo, it seems as if the system favors functionality for team leaders much more than functionality for cleaners. This differing, more people-focused ideology behind the technical designs of Celefish's system played a

significant role in its success as compared to CleanCo's system. The technology actively attempts to "involve more stakeholders" and create a sustainable business environment. Case studies such as Celefish's AI system show that careful consideration for both technical and social concerns at all phases of development and deployment are important for the long-term successful integration of an IoT system.

Discussion

As seen in the case studies, the introduction of IoT technology, especially into low-tech industries, can have a profound effect on all aspects of the industry, not just technical. In CleanCo's case study, what could be considered as technical improvement could be seen, but numerous social shortcomings arose from their system. Mediation Theory touches on some of the potential reasons why CleanCo's system failed to meet its design goals. The system integrated into CleanCo's workplaces mediated the team leaders' abilities to track and command cleaners much more so than it mediated the cleaner's ability to communicate. Thus, the resulting human-world relation concerning how cleaners, the IoT, and team leaders and the system fell short of the designers' intended relationship. New technological systems, especially IoT technologies, must put significant amounts of thought into ensuring that the resulting behavioral effects do not deviate too far from expectations. In CleanCo's case, pre-installation negotiation between cleaners and team leaders regarding boundaries or more consideration for two-way communication or cooperation between cleaners could have potentially gone a long way in supporting a more successful system. In Celefish's system, a large portion of the technical design revolved around ensuring that as many stakeholders as possible were involved and that they all were able to share resources and interface with the IoT system to as much of a degree as they

wanted to. As a result, Celefish's system enjoyed much more success. It would be fair to say that the ethical responsibilities that we engineers are responsible for when it comes to designing and deploying these systems were much more accounted for in the Chinese case study. Perhaps this could be attributed to differing cultural values between the U.S and China such as the contrast between individualism and collectivism, but regardless of culture, members of the job force deserve to be treated with a common, basic level of respect. As engineers that create these technologies that serve as mediators, we need to ensure that no matter how technically powerful a new technology is, it must adhere to basic qualities that the human side of the technology require. The IoT will certainly have the capability to redefine future work whether it be the number of jobs, content of jobs, or job policy. And as technology continues to lead policy, an extremely large amount of responsibility is involved in designing and deploying the IoT.

As seen in case studies such as CleanCo and the U.S trucking industry, resistance to the IoT will be significant. This resistance can partly be attributed to the fact that many low-tech workers are simply not equipped for a transition to more advanced technology or feel as if they will be completely replaced. Many in the trucking industry fear that "automated driving systems could replace many driving jobs in the near future" ("Driverless Truck Protest Organizer Warns of "Devastation of Millions of Jobs"", 2021). Existing stakeholders in the trucking industry see IoT technology and automation as entities that will completely replace them, unlike in the Celefish case study where IoT technology served as mediators between stakeholders, not as replacements. One route that IoT developers can take to help assuage these concerns is education. The IoT has the potential to drastically improve education as mentioned in the Literature Review sections for DeFranco, Marzano, and Lizut. Teaching low-tech workforce members to understand IoT technology and how to use it could alleviate fear, and adding IoT-

friendly curriculum to public education in general can help underprivileged students achieve higher education and brighter futures, creating a healthier and more accessible job market. That being said, even with IoT-enhanced education, the engineer's responsibility to ensure that new technology does not unintentionally alienate groups such as trucking industry workers is still present.

Conclusion

Existing literature that discusses potential quantitative and occasionally qualitative impacts the IoT can have on jobs cover a wide range of research, but there is a significant gap in literature examining the sociotechnical side of things. Hopefully, this paper has helped fill some of that gap. Two case studies from differing backgrounds and cultures and their outcomes were contextualized through Winner's Theory and the ethical implications that come from said case studies were discussed using Mediation Theory. And from this analysis, it can be seen that the manner in which the IoT will impact jobs as a whole is not a black and white question. Politics are involved, important social groups can potentially be excluded in the decision making processes, social relationships and corporate hierarches could be completely reconfigured for better or worse, and even quantitative impacts such as job count will be inconsistent across social classes. A large factor that determines whether or not a technology positively or negatively affects the job market/workplace lies in the amount of ethical care placed into the design of said technology. Thus, it is up to the engineers creating and integrating these new IoT technologies to acknowledge the potential social impacts that may arise from their designs and implement ethical practices at all stages of development.

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