Reducing the spread of COVID-19 Through Elimination of Common Surfaces: Socially Distanced Dispenser

(Technical Research Project in Computer Engineering)

The Internet of Things on Future Jobs

(STS Research Paper)

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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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Approved _____ Date_11/23/2020_,
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Introduction

In the age of Covid-19, limiting the number of surfaces that are touched by multiple people is a key factor in slowing the spread. To help achieve this, the Socially Distanced Dispenser will serve as a contactless food dispenser, best deployed in a setting with many potential users such as a grocery store or a dining hall. The dispenser will take user input from a smartphone application over a secure Bluetooth connection and automatically dispense the desired amount of food, limiting the required contact for any user to receive their food to their personal smartphone.

The Socially Distanced Dispenser is an example of an Internet of Things enabled device. An everyday device such as a food dispenser that you would find in a dining hall is enhanced with internal sensors and motors and is given the capability to communicate with users' smartphones. There are much more sophisticated IoT devices than the Socially Distanced Dispenser, but the dispenser captures the spirit of IoT nonetheless. And as will be discussed in my research paper, even though the motivations behind the dispenser are pure, there is always some degree of politics involved with new technology. Operation of the dispenser requires the user to have a smartphone with Bluetooth capabilities, which means that users who do not own smartphones will not be able to enjoy the benefits of the dispenser. In this specific case, the politics and ethical concerns are not too severe. Smartphones are extremely commonplace and not being able to use the dispenser does not place users at a disadvantage, it simply means they are not able to receive the benefits. While the politics embedded in the Socially Distanced Dispenser are not as pronounced as in other IoT technologies, it still demonstrates that technologies, especially those that change how people go through their daily lives, have politics in the way that they are created, deployed, and used. One of the most pronounced areas in which said politics will be seen is the future job market, which will be the focus of my STS research. Changes in job quantity, effects on jobs for correlated with certain social groups, shifts in skill requirements, decreases or potential increases to job accessibility, the definition of a job, and many other considerations will be analyzed for my research paper.

Technical Topic

As Covid-19 has yet to be eradicated, it is important to reduce opportunities for spread as best we can. The Socially Distanced Dispenser is a new, safe way to quickly dispense food that limits surface contact with the dispenser to reduce the number of shared surfaces between users. Thus, the dispenser is best used in high traffic areas such as dining halls or grocery stores.

It consists of five main parts: a mobile application, Bluetooth connector, a microcontroller, a motor, and a physical food dispenser to store and output the desired quantity of food. The overall process of handling this device is using a mobile application to connect wirelessly to the microcontroller, which interprets the signal and instructs the motor to dispense the correct amount of food. Figure 1 illustrates this concept.

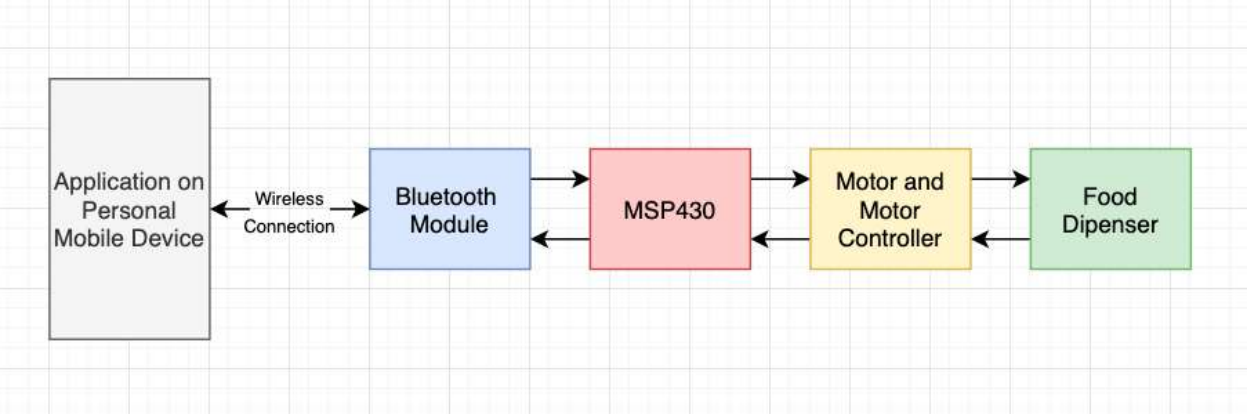

Figure 1: General Diagram (Created by Quincy Mendelson, 2020)

Mobile Application

The interface that the user interacts with is a mobile application directly on the user's device. This interface will consist of an intuitive UI that makes it easy to select how much food the user wants. The front end of the application will have a list of available options to select for food dispensing. Predetermined options disallow incorrect inputs, as well accidental or malicious inputs that could cause problems with any other parts of the Socially Distanced Dispenser. Additionally, the application confirms the user's submission to prevent accidental user inputs. The software will also contain other features such user feedback, such as if the dispenser has jammed the user can make note of this. Backend components of the application allow the user to quickly connect to the Bluetooth hardware of the machine, as well as ensure the user has a secure connection to the right device.

Bluetooth Module

This mobile application will be connected to the microcontroller via an HM-11 Bluetooth Module. This module converts the Bluetooth signal into an electrical signal that the MSP430 can interpret.

Microcontroller

In order to control how much food the dispenser will release, we are using a microcontroller connected to a motor. This controller interfaces the Bluetooth module and the motor for turning the dispenser. We have chosen to use a MSP430 for this process. From this Bluetooth signal the code in the MSP430 determines how many rotations the motor needs.

Motor

The way the food is physically dispensed is with a stepper motor. We chose a stepper motor as it can apply high torque at low speeds, which is ideal for our dispenser. This will allow careful control of how much food is let out of the container, and will mitigate the risk of jams. Stepper motors can also be

turned in precise increments, which is necessary for us to be able to provide customers with the amount of product they request.

Dispenser

The dispenser will have a clear plastic container to store the food, while keeping it visible to the consumer. The vessel is cylindrical in shape, with one opening large and the other medium. A plastic lid fits securely into the large opening, as this allows the dispenser to be refilled with food easily. The medium sized hole has an axis perpendicular to it, which holds a plastic valve. This valve effectively seals the bottom of the container when it is not rotating, but when turned about its axis allows small portions of food to fall through. The plastic container is suspended by a plastic stand to suspend it in the air. This allocates space for a medium sized bowl or other collecting object to be placed underneath on a tray. Alongside the stand is the motor, microcontroller, and Bluetooth module. The motor is in place of the manual tap and connects directly to the valve's axis and controls how much it rotates. All three of these pieces are contained in a housing unit. This unit has multiple purposes, all stemming from the need to separate these components from outside factors. It prevents environmental factors from messing with the electrical components, keeps the motor from being touched and causing interference or harm to a person, and provides a structure to suspend and keep these components alongside the container.

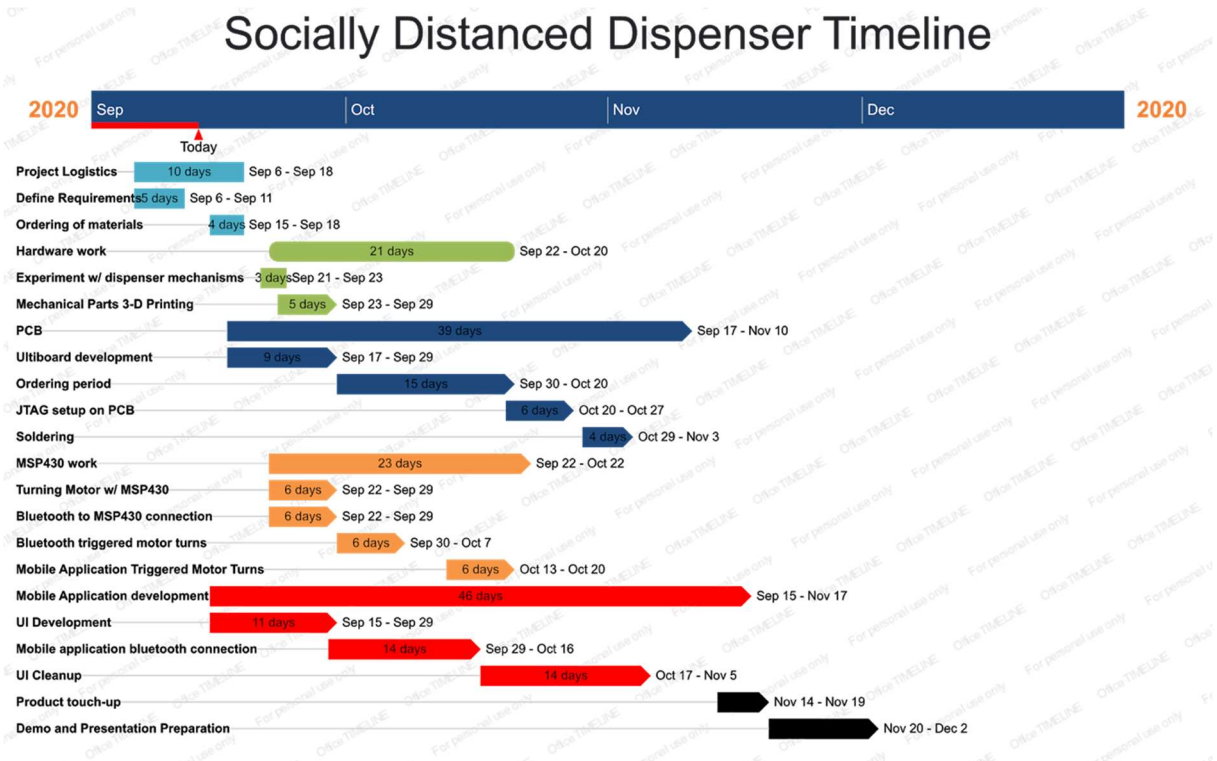

Figure 2: Socially Distanced Dispenser General Timeline

The figure above shows the general timeline that our group followed to create the dispenser.

STS Prospectus

Introduction

The Internet of Things is 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. The IoT could also drastically improve education, thus creating more pathways for underprivileged students to achieve higher education and brighter futures, creating a healthier and more accessible job market. Other considerations include how the IoT could impact a worker's daily life or how the IoT could potentially redefine what having a job and working means. The list of considerations and possibilities goes on, there is no clear cut answer as to what will happen to jobs. This, in addition to the fact that IoT impacts all of society which means many conflicting agendas will be involved, brings me to believe that the proposed research topic is a problem worthy of research.

Research Questions

Some of the specific research questions I will investigate include:

What affect will IoT have on the literal number of jobs? This question serves to provide a general trend. As stated earlier, there are many deeper, more qualitative considerations.

What kinds of jobs will be created and lost and therefore what social groups or industries will be most affected? This is one of the more qualitative considerations, as certain social groups could be disproportionately negatively affected than others.

As a follow up to the previous question, will there be certain races or social classes that are affected more than others? As seen in one case study of Winner's framework, the invention of the tomato harvester displaced many Mexican-Americans laborers. Will this cause resistance to the development to IoT technology?

Jobs are an amalgamation of tasks. As mentioned later in the literature review, Arntz and Gregory (2020) point out that it is unlikely that entire jobs will be automated, but rather certain tasks which jobs are comprised of. What kinds of jobs will be most transformed through the automation of old tasks and introduction of new tasks?

How will the IoT impact education and what does this mean for the job market? The IoT has the potential to indirectly impact jobs through other aspects of society, education being one of the more prominent ones.

How will the IoT reshape what it means to have a job and to work? Workforce management, onboarding and training, and even when, where, and how people work could all be changed.

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 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 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.

Timeline

My research milestones will be organized based on my research questions. The first milestone will be to compile and analyze information in regards to quantitative effects on jobs. The second milestone will be related to what industries and which social groups will disproportionately gain at the expense of others. The next milestone will involve education and other avenues through which the IoT can impact jobs. The last milestone will examine how the IoT could potentially reform work organization and how the definition of a job could be redefined. In regards to how time will be split up, I will focus the majority of my efforts on the second milestone, as this topic will most likely contain the most information and controversy about the ethical impact of the IoT.

Conclusion

In short, the IoT will be the world's next great revolution, and as such it will serve as an invaluable source of information on how politics and technology is intertwined. My research aims to investigate existing perceptions of the IoT, ethical implications of the IoT, and IoT technologies as forms of life with a focus on jobs. From my research, I hope to gain a deeper understanding of techno political systems and exemplify how differing social groups play roles and are affected.

Bibliography

Arntz, M., Gregory, T. and Ziehran, U., 2020. *The Risk Of Automation For Jobs In OECD Countries*. [online] OECD iLibrary. Available at: <https://read.oecd-ilibrary.org/social-issues-migration-health/the-risk-of-automation-for-jobs-in-oecd-countries_5jlz9h56dvq7-en#page1> [Accessed 25 October 2020].

Cohen, T., Stilgoe, J. and Cavoli, C., 2017. *Reframing The Governance Of Automotive Automation: Insights From UK Stakeholder Workshops*. [online] Taylor & Francis. Available at: <https://www.tandfonline.com/doi/full/10.1080/23299460.2018.1495030> [Accessed 25 October 2020].

DeFranco, J., Kassab, M. and Voas, J., 2018. *How Do You Create An Internet Of Things Workforce?*. [online] ieeeexplore.ieee.org. Available at: <https://ieeexplore.ieee.org/document/8429280> [Accessed 25 October 2020].

Frey, C. and Osborne, M., 2013. *THE FUTURE OF EMPLOYMENT: HOW SUSCEPTIBLE ARE JOBS TO COMPUTERISATION?*. [online] Oxfordmartin.ox.ac.uk. Available at:

<https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf> [Accessed 25 October 2020].

Ismail, N., 2017. *7 Industries That Will Be Radically Changed By The Iot*. [online] Information Age. Available at: <https://www.information-age.com/7-industries-will-radically-changed-iot-123467258/> [Accessed 29 October 2020].

Ma, J. and Cha, S., 2020. *A Human Data-Driven Interaction Estimation Using Iot Sensors For Workplace Design*. [online] Www-sciencedirect-com.proxy01.its.virginia.edu. Available at: <https://www-sciencedirect-com.proxy01.its.virginia.edu/science/article/pii/S0926580520309328?via%3Dihub> [Accessed 25 October 2020].

Mähler, V. and Westergren, U., 2019. *Working With Iot – A Case Study Detailing Workplace Digitalization Through Iot System Adoption*. [online] Springer Link. Available at: <https://link.springer.com/chapter/10.1007/978-3-030-15651-0_15> [Accessed 25 October 2020].

Malone, T., n.d. *How Is The Internet Changing The Way We Work?*. [online] Bbvaopenmind.com. Available at: <https://www.bbvaopenmind.com/wp-content/uploads/2014/01/BBVA-OpenMind-book-Change-19-key-essays-on-how-internet-is-changing-our-lives-Technology-Internet-Innovation.pdf> [Accessed 25 October 2020].

Marzano, G. and Lizut, J., 2018. *Labor Market Challenges In The Digital Era*. [online] researchgate. Available at: <https://www.researchgate.net/profile/Gilberto_Marzano/publication/326356473_Labor_Market_Challenges_in_the_Digital_Era/links/5b479abb0f7e9b4637d1bfec/Labor-Market-Challenges-in-the-Digital-Era.pdf> [Accessed 25 October 2020].

Shenkoya, T. and Dae-Woo, C., 2019. *Impact Of Iot On Social Innovation In Japan*. [online] Emerald.com. Available at: <https://www.emerald.com/insight/content/doi/10.1108/APJIE-06-2019-0040/full/html> [Accessed 25 October 2020].

World Economic Forum. 2016. *The Future Of Jobs*. [online] Available at: <http://reports.weforum.org/future-of-jobs-2016/> [Accessed 25 October 2020].