Automation Machining and its Effects on Blue-Collar Workers

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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

Imagine going to work each day, but instead of a traditional office building, your office is a mine shaft, construction site, or a manufacturing warehouse. These workers are rarely thought of as consumers tend to focus on the product these workers are producing. These types of workers are labeled as blue-collar workers, which typically consist of people working in positions that require manual labor located outside an office setting (Workable.com, 2023). Manufacturing work is an example of a blue-collar position, as workers are either controlling, deforming, and creating a material that will be used by another company or consumer. The industry is currently able to produce these products by using mechatronic engineering integration with machines as well as computers to help control manufacturing devices.

Mechatronics engineering combines mechanical, electrical, and computer science engineering to develop new systems that breathe life into inanimate objects. These systems involve three components: a sensor, a controller, and an actuator (Brooks and Roy, 2021). The sensor takes data from a real-world setting and sends it to a controller, and the controller then responds to the data using an actuator. An example of a mechatronic system can be seen in automatic sinks seen in bathrooms. The infrared sensor in the sink detects when there is a hand nearby. This sensor will then send a signal to a microcontroller of some type which is coded such that if a signal from the sensor is received, it sends an output signal towards the actuator (Larranaga, 2022). The actuator used in most cases is a solenoid. The solenoid is arranged such that when it is off, the electromagnet in the solenoid will block water flow (Holzner, 1992). Engaging the solenoid with an electrical signal will cause the solenoid to engage, allowing water to flow for a certain period. This simple mechatronic system helps eliminate the need to turn on

and off water, potentially saving a small office up to 3,000 gallons of water a year compared to an old mechanical lever (Martin, 2017).

Computer science helps create a larger role in these mechatronic devices as engineers can use these computers to help orchestrate different tasks or motions of a certain device. These computerized machining devices are called CNC, or computer-based numerical control, machines. To understand how these machines work, it is important to know the concept of numerical control, or NC. NC machines work by having a numerical input into a system that controls its movement or position. For instance, a controlling system could move a drill bit two inches to the left and four inches into a material to drill a series of holes in a material by using an inputted code that would be processed by a computer. All this input would have to be set into the system by the user, and it would rely on mechanical and electrical components like relay switches and hard-wired memory programs to determine confirmed positions and complete actions (Omron, 2023). The issue here was that mechanical devices can lead to system failure and systems had to be hard coded by a user. So, after a NC system is set up, it could only be used on that motion, leaving no room for variability. These troubles led to the development of numerically controlled devices that could use a computer as the controller rather than a human inputter. With a computer, workers could program whatever motions needed to manufacture a part given the proper equipment (Kief, 2012). These CNC machines are fed g-code, which is a certain type of coding language that is interpreted by the CNC machine itself. Users could manually write code for these machines, but most computer aided design (CAD) software comes with the ability to convert online models into g-code.

This helps the user not have to worry about user input or error that can come from manufacturing. However, the user can’t completely check out of the manufacturing process as

they are often required to watch and supervise the process to make sure there are no errors. These machines also tend to run for hours, basically capturing the worker in place with the machine. The goal with this machine was to make this process easier, more accurate, and more efficient. It is successful in this respect, but at what cost is it towards the workers doing the job? Are these workers truly better off if they are becoming dissatisfied with their job, depressed, or leaving because of the changing industry they are accustomed in?

. By studying the use and implementation of CNC machines in manufacturing processes, it can be seen how these types of devices are designed solely to be accurate efficient taking in no consideration of how mental health could be negatively impacted. The following section will display the current state of the manufacturing industry in respect to technological advancements as well as the state of blue-collar manufacturing work in general. Developments in the manufacturing industry and their implementation towards CNC technologies will be presented as well as some of the visible effects these changes in technologies have had on the workers. The information gathered consists of detailed information of how a CNC device has been made to change an aspect of manufacturing as well as the development of this technology into the manufacturing industry. This will be analyzed by using the configuring the user framework in which the history, design, and implementation of CNC machines will be meticulously described to see how it was created for the user as well as finding any affects it might have on the user. For the purposes of this discussion, the user is a blue-collar manufacturing worker specifically working on the assembly floor of a factory with little knowledge of the engineering behind the manufacturing process.

It will then be shown how the history of CNC devices shows how in its origin, the device was created without considering the mental health effects it could have on its user. These devices

were created in a period where they were the most effective and efficient option, and there wasn't a point of question as to how they would impact the interacting user. With the continuing advancement of this technology, it has allowed more manufacturers to use this technology because of its ability to be precise in complex manufacturing. This will show the lack of thought of the user in the development and implementation of CNC devices in which has led to the decreased mental state of blue-collar employees involved with these types of machines. An example will then be presented as to show that there is still a lack of consideration for the user in new implementations of this technology.

Literature Review

Looking at the current state of the technological advancements manufacturing industry, autonomous machines are being added to manufacturing systems with the hope of creating easier work and efficient outcomes when it tends to make these systems more complicated. These autonomous machines include micro-controllable robotics as well as CNC manufacturing machines and are used to expedite certain manufacturing processes. This exploits the use of a computer to directly control a manufacturing device rather than a group of trained workers. These systems are the key for efficiency and production in manufacturing, which helps explain the popularity of CNC machines in manufacturing scenarios (Yang, 2022). With the implementation of these newer technologies, it is expected to make the life of the worker using them easier. This isn't usually the case as many of these developments fall into the automation paradox. This paradox is the idea of bringing in a new type of autonomous technology with the goal of alleviating stress off workers tends to bring in more issues making an already easy task more difficult (Resnikoff, 2022). This added layer of difficulty can increase the amount of stress that an employee might deal with as well as slow the production of the task at hand.

The manufacturing industry has also been seen to be taking large steps towards the use of automation. Since the coronavirus pandemic, autonomy has been shown to be a useful tool for all humans. This is creating a new infrastructure between technology and humanity in which there is more reliance on automation to complete tasks that were traditionally done manually (Lin, 2022). With the rapid advancement of these types of technology as well as the public request of its nature, it is proposed that society is seeing a new industrial revolution taking the form of automation and digitalization. This integration is becoming more apparent in daily lives as new advances are constantly being made. Instead of being in a blue-collar position that was hands-on, the worker's position has become monotonous consisting of small movement or equipment checks due to these advancements in technology (Hirschi, 2018).

As the workforce has been changing to be more technologically driven, the focus is to create more technological advances rather than creating a product that benefits the user and consumer (Challenger, 2001). The assumption here is that the reason that technological developments are encouraged is that they will bring in more profit compared to a lesser technology. This drives the current state of the workforce to be more focused on STEM career paths and opportunities onto new and current workers, causing workers to enter area's they don't appreciate learning. This becomes coupled with the monotony created with their job and leads to a decrease in appreciation in their work (Hirschi, 2018). This combination of stresses creates a common theme in industry in which the career of the worker has been completely redefined by the introduction of new technology. It's with these changes that workers tend to switch career paths, create mental health struggles, or change professions altogether (Lent, 2018).

To analyze this topic, I will be using Woolgar's "Configuring the User" framework. In this work by Woolgar, a hypothetical relation between technology and writing is formed in

which technology is created and designed much like certain words are chosen to create imagery, characters, or settings for a reader. Much like a writer could choose to write a sentence with a certain tone, actors could design machines with purpose to have a certain effect on someone or something. It is important to understand that this is theoretical, but the ideas of this metaphoric relationship help analyze CNC technology such that it will expose how this technology was written for a user with no recognition of the mental health effects it might have on them.

Methods

The data and information used in this study were gathered by using an instructional book regarding the history, development, and knowledge of how a CNC machine operates. This knowledge, as well as other reports and information of CNC machines are used to examine the history of a CNC machine as well as the developments this machine that have been used in the manufacturing industry. This information was chosen through UVA's data library in attempting to find information about CNC devices, as well as their overall development and impact on the users around them. Using a CNC as a point of study allows to show one example of how manufacturing industries are more focused on a production of a device rather than the actual workers creating the device. If the focus was shifted, the satisfaction at some of these blue-collar positions could be increased. By examining the CNC machine, we can see the development of these technologies and determine what effect can be related to these developments.

The analysis of this issue will be completed by first focusing on the origin of the CNC machine and how it's become modernized in today's manufacturing industry. The focus will then shift to the current state of the manufacturing industry with the methodology as to the reason these changes are being made. This will then shift towards new innovations being made,

demonstrating where this industry is going in the future. These three settings will be all analyzed using the "Configuring the User" framework presented by Woolgar.

Analysis

It is important to understand how computer numerical controlled devices were developed to understand how this technology was written for users. The development of computer numerical control devices dates to post World War II Germany. After defeat in this war, Germany was broken and needed to be rebuilt seeing much of its cities, towns, and infrastructure were destroyed. A lack of skilled workers from the war effort led Germany to focus on the development of manual production and mechanical automatic machinery to mass produce products need to begin this rebuild. This led to the development of these type of numerical controlled (NC) technologies to the United States where it grew in large popularity, again focusing on mass production. As this type of technology made its way around the globe, Japanese industries were the first to begin to implement this technology with a computerized component. As the 1960's and 70's led to more wars and other industrialization, this new CNC manufacturing technology was quick to be researched, tested, and developed into global manufacturing plants (Kief, 2012).

By examining the history of CNC machines, it can be seen that there is no evidence of consideration of mental health of the user. Using Woolgar's framework, let's define the actors in the history of the CNC machine. When NC devices were first developed, it was in a period of German history where a technology was needed to speed up mass production while accounting for the lack of skilled workers available. German industries are the actors in this setting, and because the focus was on speed and rebuilding, the actor is writing the NC device to have these mass productive properties. Seeing that the users are unqualified manufacturing workers, NC

devices are written by actors to allow the user to become involved with the device quickly with the motivation of rebuilding and mass production in mind. It appears not that the user was neglected on purpose, but that the stress of not having quick manufacturing methods was too great and the user's mental health wasn't accounted for in the design process. Moving forward again to where the first CNC machine was implemented, a similar scenario can be applied. The actors here are Japan and Germany being leading industrial manufacturers, and they needed to keep the demand during the period of industrialization happening globally. In order to maintain this business, the actors needed the development and implementation of a new NC device. This new NC device was written to contain a computerized method of interpreting the numerical component of the machining device. This takes less responsibility on as more is being done to actively remove human interaction in the process to gain efficiency. This newly written machine again is neglecting the mental health of the user. This is creating a common theme with the CNC machine's history such that it's not that the user's mental health is being purposely neglected, but it's the lack of acknowledgment from the actor writing the technology that could be leading to the negative experiences surrounding these machines.

The reason that implementing CNC systems into these types of machines is so popular is because the ability for them to create intricate shapes and creations, even if it means a change to the worker originally trained for the old machine or an overall neglect for the position. CNC devices can use up to five-axis machining when creating products. This allows a machine to create any type of shape or part within the scope of the device (Kief, 2012). Some machines are set up so that a worker only must set up the machine and run the code to create the part. However, as mentioned earlier, this will require a technician to be available to oversee the machine as it is creating the part to ensure the process is completed as planned. CNC devices cut

down the time it takes for a part to be manufactured because all the motions are calculated and set, and this process also decreases the amount of human interaction which tends to lead to less error (Yang, 2022).

This modern-day approach using CNC machines does not take into consideration of the user's mental health and is still focusing on the technical innovations of the CNC machine. Typically, these parts are created in an assembly-line manor where a part would start on one end of a factory and end on the other end. In between would be factory workers doing one task to help create a part. For this analysis, manufacturing companies will be the actors. With a CNC machine implementation, these actors can motivate development of CNC machines into a manufacturing process. They are erasing the link between manufacturing work from the worker, leaving the assembly line obsolete as the machine can now process and complete the part with a computer-generated code. These manufacturing companies are motivated by the increased profit benefits of CNC manufacturing, leading to neglecting the mental health of the user. Instead of multiple workers completing a task at hand, this process is now written such that a singular worker is now sitting and watching a process that takes a shorter amount of time than with an original assembly line of workers. This is a clear area of displeasure in the workplace as the original job has been changed by this new technology. It can then be argued that these CNC systems were written into systems to make it easier for the user to use. The code to create the manufactured part is computed for the user, the user just must run the code. However, this tends to result back to the redefinition of a position and creates other mental health struggles that workers experience or leads to a change in professions (Lent, 2018). These new editions of these types of autonomous systems attempt to create ease, but they tend to make these systems more complicated, causing the automation paradox to appear (Resnikoff, 2022). It can continue to be

seen how there is no thought towards the user, a continuation seen in the history of the CNC machine.

CNC devices are becoming more popular especially considering the introduction of new CAD technologies in rapid prototyping and manufacturing. The following displays an example of how a new integration in CAD technologies is leading to new advancements in computer-aided machining (CAM) software (Deans, 2021). This case was presented at the DAAAM International Symposium in 2011, and it presents how a complex bottle opener design could be modeled, designed, and produced using new computer technologies. The process begins by first designing a model of the bottle opener using Inventor Professional CAD software. This model is then adjusted for manufacturing by removing unnecessary edges and accounting abnormalities in the casting process using CAM software. After the model is converted into an STL file or g-code, it can be sent to a manufacturing machine to be created. In this case, the bottle opener is converted to an STL file and then created via 3D printing. This silicon casting mold is then used to shape a cavity that can be used to create the desired part from metal (Bilek & Rokyta, 2011). This process uses digital interfaces to connect the design, modelling, and manufacturing components of the manufacturing process. It shows how these new types of manufacturing technologies can be further intertwined, leaving less for a human to do and more for a computer.

By analyzing this case, it can be shown that new advancements in technology are still not considering the mental health of the user in the design of the process, thus continuing the trend seen in the past. The actors in this case are engineers whose goal is to design rapid prototyping methods for new methods of manufacturing. These actors are using the advancements in technology to eliminate the process of needing a human interactor with the technology by rewriting the technology to be done completely on a computer. Using CAM software, users no

longer are needed to focus on technical manufacturing methods as a computer can complete it for them (Deans, 2021). CAM technologies can be integrated with CNC machines as seen with this case. Computers have the ability to convert online models into g-code, leaving a user to simply hit a button which would create a product. This rewritten process is taking more responsibility away from the user as well as neglecting how the user is to respond to this change in job description. It is this lack of awareness that can be seen in this technology's past, present, and future, continuing this trend of dissatisfaction and negative mental health effects seen on these users. It is important to understand that this study is not a new source. This type of technology existed roughly a decade ago, and it is important to keep in mind that this technology has grown significantly with the growth of its supporting technology. This case study also has no mention on the effects this new process has on the users that interact with the technology. However, it does present how each step of the process is completed which is where the analysis will be completed.

Conclusion

The focus of this study is to shed light on the difficulties of working blue-collar positions even though there are increases in technology that are attempting to make things easier. As new technology is being designed and developed to try to better certain industries, it is always important to remember the people that will be interacting with the technology as there could be side-effects of the device that go unnoticed causing potential harm to users. With the completion of this research, manufacturing engineers can use this example to attempt to spend some energy focusing on a product that takes into account the user's interaction with a new type of technology. Even if some time is spend focused on the well-being of the blue-collar worker using

the technology, it can spread a long way into increasing their well-being on a daily basis. Corporation leaders can also see that there is more to their industry than making profits as the employee force is equally as important as making a strong profit. If more companies can increase worker satisfaction in blue-collar positions, there is a chance that their profit margins will naturally increase with the satisfaction of the worker. As designers, regardless of the context, it is important to consider all interactions a piece of technology can have on not only humans, but the environment and ecosystems. With this research, readers can be enlightened by this idea to develop better products that can positively benefit all interacting users.

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