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Technology Takeover and Transformation: Humans vs. Technology

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Thesis/Directed Project CAH 61000

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July 9th, 2023

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Abstract

When looking at the history of the fashion industry up to the present day, technology can easily distinguish the progress of fashion throughout the ages. The direction of this research is to gain insight and a deeper realization of how technology is taking over and transforming those in and revolving around fashion by slowly taking over and replacing human involvement or presence. Statistics and research show due to the adverse effects of COVID-19, technological development within fashion has seen a significant increase. COVID-19 was either the final push towards making technological ideas a reality or was the birth of new technological concepts in an attempt to reshape the fashion industry. Both those within the fashion industry and the fashion consumer must gain understanding of these technologies, lest they be left behind. This research specifically focuses on those working within the fashion industry and does not have as heavy of an emphasis on those outside of the industry. To gain an extensive knowledge on how we have gotten to where we are, this research will address fashion technologies from all angles, past, present, and future to see how it has come to have the potential to replace humans within the fashion industry.

Key terms: Technological development, Artificial Technology (AI), Automation, Computer Aided Design (CAD), sustainability, SMART Technology, SMART Textiles, Immersive technology

Introduction

In a world where technology consumes our daily lives, one must either keep up with the times, or be left behind. Technology is taking over jobs, textiles, traditions, and the entire industry of fashion. Humans have always had an influential role to play in the fashion industry when it comes to designing, producing, wearing garments, etc., as the sketches do not appear of thin air, nor the needle sewing completely on its own. It started with exceedingly small advancements within technology, to now consuming all aspects of fashion, so much so that a human presence within the fashion industry seems to be decreasing. Technology means change and growth towards the future. As time goes on, it is inevitable that change will occur. How that change occurs and what it looks like can be daunting, exciting, challenging, as well as evoke many other emotions within society.

Technology has a past, present, and future, and the fashion industry along with society revolves around it. That said, it is vital to understand how this technology works, functions, and how it will transform what we know to be fashion. A writer by the name of Stewart Brand put it best when he said, “Once a new technology rolls over you, if you’re not part of the steamroller, you’re a part of the road”. Could technology even have the potential to make those working within the industry nothing more than a bump in the road? Have we always been heading down this path of giving our jobs over to technology? This is exactly why there must be an awareness of it. Technology has a way of sneaking up on those who are not prepared for its arrival. Having a deep realization of the history of technology is a great start to understanding how we have gotten to the place we are now. The technology of ages past has laid the groundwork for and is

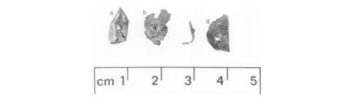
the explanation behind how far we have come. There is a reason history is taught in schools, as it brings a deeper context to the current day and age.

The History of Technology Within Fashion

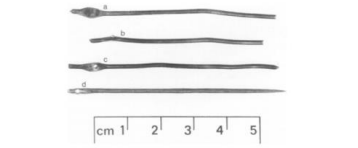
To truly recognize and understand the technology today in fashion, looking at the milestones in technology's history within the fashion industry is the best place to begin with. From the first sewing needle to the first sewing machine and beyond, the fashion industry has seen many changes in its time. When thinking about the purpose of technology, it most commonly serves as a means to speed up processes that by hand would take much longer. This is a key point and factor for understanding the "why" behind the progression of technology within the fashion industry. Yet, technology could also serve as a means of convenience, as well as a money saver and not just as a means to speed up processes. Fashion is fast-paced and demands quick reactions. Fashion and time are intertwined. The two share a connection and could be considered like soul mates in the fashion industry. Time relies on fashion to give it definition. Fashion relies on time to push innovative ideas forward. These latest concepts are now slowly taking over processes that were only ever known to be done by human hands. The day has come to dust off the history books to discover how it all started and evolved over time.

It is another hot and dry day in the ancient Middle East in which busy bodies are up and working away. A what would now be known as a sort of blacksmith, is working hard on a new invention. That blacksmith is working on the first tool that could be considered as a part of the technological development category within the realm of fashion, the sewing needle (Figure 1). The very first sewing needle was claimed to be invented by the Egyptians. The Egyptian people would take a bead of copper and begin to beat it. Once it formed the shape of a punch, they would take one end of the needle and shave it into a point. (Nunn, J., & Rowling, J. (2001)) They then would form a hole in the needle called an "eye", which allowed for thread to be looped

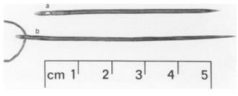
through. To get the “eye” in the needle, they first used a hammer to create an indent, in which they would then grind into a hole with stone. Though it may have looked like a tricky material to work with, once heated, the material was incredibly shapable. This tool for the Egyptians served many purposes, but the most important being sewing. These needles were believed to be best used for fabrics that were lightly woven, as they would bend under the weight of heavier materials. This little, seemingly insignificant tool to someone today, would have meant much more to those using it during this time period. Before the invention of needles, they would most likely have had extraordinarily little to any sort of way in which the garment was fastened together. Typically, people who were clothed at this time, depending on status, would take a square or rectangular cloth and drape or wrap it around themselves. Sometimes cloths were layered over one another and were held together by some form of a pin. All the frustration of folding and draping the cloths over a body, trying to get them to stay in one place, was over. They were now able to sew together cloth, which was a good first step in the right direction, in the foreshadowing of the fashion industry. Like bricks stacked up on top of one another to form a wall, technology builds on itself. This invention would be the beginning of a ripple effect in developing technology that would help produce garments.



1. (a) Work-hardened copper punch; (b) sheet of annealed copper after punching (seen from above); (c) as for (b) but seen from the side; (d) hole after broaching. All items are of copper smelted from malachite.



2. Needles under construction: (a) after formation of the flat; (b) after punching (seen from the side); (c) completed hole in flat; (d) after work-hardening and grinding.



3. (a) needle with oblong hole; (b) needle threaded.

THE EYE OF THE NEEDLE IN PREDYNASTIC EGYPT (pp. 171–2)

(BLOOMSBURY, 2015, sewing needles)

Within the same region as the first sewing needle, another tool that would help produce garments would be created. The strap looms invented by weavers within the ancient Middle East would mean progress for fabric and textile creation (Figure 2). The strap looms as one can imagine were used for weaving textiles that would be utilized for clothes, tapestries, and curtains. The yarns wrapped around the weaver's waist and then held by the loom (Bloomsbury, 2015). There was also a horizontal ground loom used to weave various fabrics. These two looms allowed for weavers to have a few different weaving tactics for cloth. They were able to experiment with which one they felt had produced better textiles. With this technology, fabrics such as flax were woven, which at the time of the Egyptians was popular. Women were often responsible for overseeing textile production, while the men would then take, wash the materials, and travel with the finished textiles to be traded. It is said that the weaving of textiles with the strap looms was somewhat complex and required skill. Now even that skill in today's society can be done by a machine easily, and with the same precision. This particular invention, just as the sewing needle, was more of an aid and a tool for speeding up processes, rather than replacing the hands producing goods. It helped quicken the processes of textile production and would also be a foundation for other textile production machines that inventors would reference.

(Bloomsbury, 2015, strap loom)

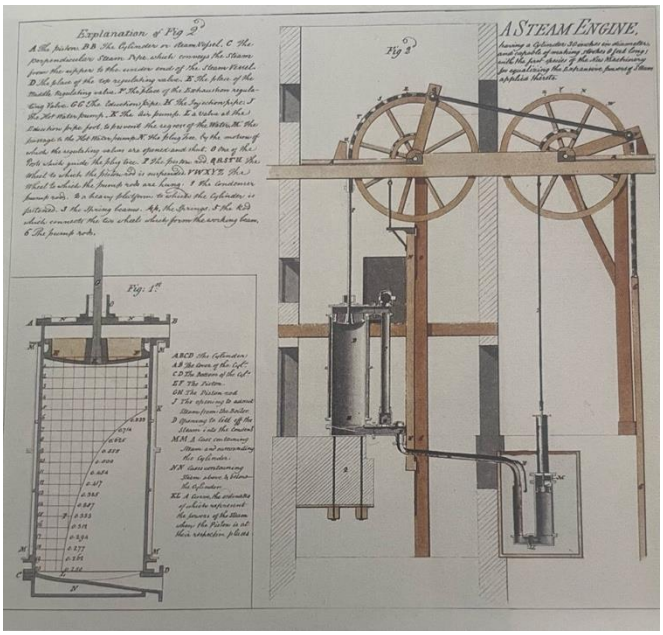
With slow progress over the years in terms of major inventions within fashion technology, there was finally a reawaking of interest in how to produce textiles more efficiently. One of the many famous inventors, Leonardo da Vinci, was claimed to have created a beautiful mechanism called treadle-powered spinning wheel. (Bloomsbury, 2015) What made this mechanism special was the fact that it was merged with a bobbin flyer. A bobbin flyer made continuous spinning possible. This mechanism helped accelerate the process of textile production as it required less processes than previous spinners. All to say, more was able to be accomplished within textile production in a shorter time span.

Around the same time period, there was also a knitting mechanism. This knitting mechanism was able to knit hosiery with little assistance. This would be life changing considering how long it would take them to knit these by hand. This, however, would not be approved for patenting from the very queen Elizabeth herself. Her reasoning behind this decision was her heart for hand knitters potentially being put out of business (Bloomsbury, 2015). Some technologies, though they may replace jobs, can also potentially create new ones. Despite being

rejected by Queen Elizabeth, this would not prevent the invention from being utilized. William Lee the inventor of this knitting machine, ended up taking his invention to France, where it would be appreciated by many (Bloomsbury, 2015). It is hard to imagine technological development being withheld in today's society, in which often the price tag is considered over the care of individuals positions within the fashion industry. Technology, however, cannot be withheld for long. Technology is a roaring lion eager to escape its cage. Today, knitting machinery is so advanced that they can produce whole garments, without requiring additional assembly. Technology such as this can both give and take away jobs.

Prior to the Spinning Jenny was the steam engine, designed to increase the speed of spinning of textiles. Per the name's suggestion, this device was powered by water (FIGURE 3). Cotton was said to be the easiest to produce of all the textiles, lowering the cost of cotton fabrics. Depending on status, this steam engine was both used in a home setting and a factory setting. There were a lot of politics surrounding this invention and it would cause tension between countries in all parts of the world. So much of what has happened back then parallels today's current situation. As factories started to pop up, inventions to encourage and promote mass production were all the more welcomed. There was a shift in the way clothing and textiles were being produced. More than likely, everything has become about money rather than the product itself. This idea can easily be seen in fast fashion. With fast fashion, there is an oversupply of what consumers can realistically consume in terms of clothing products. However, the companies know these consumers are hungry to spend money on clothes when it is cheap. It is not so much the quality that the company is concerned with, but rather the money spent by the consumer. A lot of it is a money game, which could be another explanation for how we have come to the place we are in today. Those who had a hold of this technology were getting a taste

of the potential the fashion industry could have. They were realizing how technology could help save them money on labor and save them time.



(Bloomsbury, 2015, steam engine)

Fast forward years later to another monumental technological development, which was the spinning wheel. The first spinning wheel was made up of a vertical wheel, a horizontal spindle that was parallel to the axle of the wheel, and a string that was similar to a belt, turning the spindle. (Allen, 2009) Yet this spinning wheel would not be remembered for very long. Which also can be easily said of technology turnover in today's culture as well, one example being the latest generation of iPhone. The industrial revolution brought forth many ideas and concepts for technology, some of which would be monumental moments in history. A technological emerging concept tends to bring an infectious excitement for expanding upon inventions and improving upon them. It quickly becomes a race for which inventor can create the best version and improvement of an invention.

The spinning Jenny was invented by James Hargreaves in Lancashire, who would set the tone for the industrial revolution with this technological breakthrough (Scientific American, 1904). This invention was what helped spin cotton and shape the realm of textiles in the industry. It was much faster than the original spinning wheel, as it was constructed slightly differently. The wheel went from being horizontal to vertical, also adding more spindles, increasing the production time. This spinner spun around 100 pounds of cotton in 100 days, equaling 1 pound of cotton per day. (Scientific American, 1904) This invention not only cut down on the amount of human labor involved, but also meant that labor was not as expensive. Even then inventors were finding ways to cut the amount of human interaction with production. England in implementing this invention, England would increase their productivity by 23 pounds of yarn a year, which was considered significant (Scientific American 1904). Due to Hargreaves fascination with the spinning wheel and the impact it had on the industry, it would cause a domino effect, leading many to follow in his footsteps with the advancement of technology. It stirred up intrigue and emerging technology today still inspires the next generation of inventors. For those who worked inside the fashion industry would see a change in expectations for production levels. This would also mean those who owned this invention could get by with fewer workers. The jobs that people would rely on at this time, especially women in particular, would become harder to come by. Although the jobs and working environment were horrendous, they nonetheless helped in providing a small income for families.

Even with textile production rates increasing, the actual production of clothing was relatively slow in comparison. Sure enough, after hand sewing was not meeting the demands of the people, the first attempt at a sewing machine was invented. The humble beginnings of this experiment took place in 1775 when C.F. Welsenthal sought to find a way to make the hand sewing processes less time-consuming (Gibbs, 1987). Hand sewing had its limits and garments needed

to be constructed in a timelier manner with the beginnings of the fashion industry really kicking off. Welsenthal's machine had a needle placed at the center and was pointed at both ends, unlike a normal needle that is pointed only at one end. Due to the nature of this double pointed needle, it was not necessary for the needle to turn over when sewing (Gibbs, 1987). Although this was a great initial concept, it still did not hit the target for speeding up the sewing process. A lot of inventions today are built off of older concepts and were the groundwork for more successful technologies. That is, even though it did not meet expectations, it was still considered a valuable technological building block. Little did anyone know how transformative this would be to the fashion industry and how it would shape those within it.

Identifying this unmet need for speeding up sewing processes, Thomas Saint invented what was considered the first "practical" sewing machine in the year 1790 (Bloomsbury, 2015). His machine would be considered a chain stitch and single thread machine and was good for stitching together hardier materials. Elias Howe would also have his small moment of fame inventing a sewing machine in 1846, after Thomas would lose interest in further developing his invention (Bloomsbury, 2015). Elias' machine would be the first truly successful machine. He invented his sewing machine as a lockstitch that hung vertically, instead of horizontally. It seemed as though this particular invention kept getting passed on to other inventors until it was eventually perfected. Sometimes it takes a fresh pair of eyes or a different perspective to approach a technological concept.

As it would turn out, all of these previous inventors' work would be overshadowed by the famous Isaac Singer's sewing machine made in 1851 (Figure 4). Today, it is hard to envision a sewing machine that did not look like the one produced by Singer. This invention was also a lockstitch machine, slightly different from Howe's, which would cause much tension between the two inventors' legacy. As many inventors' backgrounds, Singer had a past life of struggle

before succeeding in the invention of the Singer sewing machine. This makes his story all the more memorable. It is said that “Singer’s machine would be the first domestic appliances manufactured on a production-line basis using interchangeable parts.” (BLOOMSBURY, 2015) This meant that many of these sewing machines could be produced at once and sold at a more reasonable price. It would be the Civil War in which sewing machine purchases would skyrocket (Bloomsbury, 2015). The Singer sewing machine also contributed to manufacturing and production of mass quantities of garments, as many more learned how to use the sewing machine and became seamstresses. Singer’s machine would be one that everyone would start using in their homes, even up until the current day. After this breakthrough, there wouldn’t be many other machineries quite like it up until current technology that is surfacing.

(Magazine, S. (2015, July 14). *How singer won the sewing machine war*. Smithsonian.)

Though no monumental machinery came about for a while, many more within the fashion industry were continuing to ask questions of how they could make textiles even better. Synthetic fabrics were invented at this time such as polyester, nylon, and many others. These man-made textiles would leave the public dumbfounded as they helped serve a more functional purpose. Textiles were more than just decorative and pretty. To name a few of these textiles' there were

acrylic fibers, polyester fibers, triacetate, nylon, and much more were invented around the 1900's (Bloomsbury, 2015). What made these materials so desirable was the fact that they were more durable, washable, and overall, more user friendly. There were fabrics in the 1950's-1960's that were drip-dry, wash-and-wear, and permanent press (Bloomsbury, 2015). With these features, it was easy to appeal to the consumer. Through this breakthrough of synthetic fabrics, a pathway would be carved for inventing even more new materials and textiles in the future. Those working within the fashion industry could now see more of a diversity in what they could produce for consumers. This would make the fashion industry's working environment more competitive between other companies and businesses selling new materials. If one company had new textiles, one can bet the consumers would flock towards it. Just like today, consumer demands must be met unless a company, business or brand wants to find themselves out of business or at a loss for jobs.

With all the movement taking place within the fashion industry, everyone in and around the industry was trying to learn how to adapt to all these changes. It was in the 1980's that there was a shift in employment and technology, which forced businesses to manufacture their garments outside of their country, in typically less developed countries. (Nunn, J., & Rowling, 2002) It was this, or they were forced to update their own technology within their manufacturing processes. This was an expensive and also time-consuming option. This meant those currently employed within United States manufacturing would have to find a job elsewhere, as their jobs were being given to those overseas. This idea of mass manufacturing is what has led us to the automated sewing machine and other forms of automated manufacturing. Computer Aided Design programs have now been developed to speed up processes of pattern making, pattern grading, etc., that by human hand would take many more hours to complete. Businesses that fought integrating this technology would be trampled on and choked out as others flourished

from adapting and changing with technology. The faster one can adapt to or outsmart technology, the better the chance they will thrive and be ahead of the competition. These Computer Aided Design programs would cut down the amount of work done by hand and also cut down on materials used as well helping with the issue of waste within the fashion industry.

Even as much as 40 years ago when technology within the industry was changing, those within the industry recognized technology's power and potential early on. Even 50 years ago there was word that technology was "altering traditional industries". (Gibbs, 1987) Technology has a tendency to push boundaries and break levels of comfort. There are also events that occur within the world that in reverse push technology's boundaries. A lot of the world's historical events and tragedies have brought forth the advancement of technology. Past technologies are the steppingstones and foundation for understanding the technology which we use today and the technology which has yet to come. Throughout history, it is evident that technology has taken away more responsibility of human hand work, and given in over to machinery and tools, little by little. It has shaped the working environment for those within the industry and has changed their roles over the course of history, as it continues to do today.

THE CURRENT STATE OF TECHNOLOGY AND HOW IT SHAPES FASHION

When looking at the current state of the fashion industry, after looking at the past, a lot of movement has occurred. The global pandemic, COVID-19, shook the entire fashion industry and could very well be considered the catalyst for some of the technologies that are now being implemented amongst the fashion industry presently. Events like these accelerated the process of development of technology beyond what some have imagined would be possible. “Technology like art is a soaring exercise of the human imagination” is a statement made by Daniel Bell. With those words in mind, the human imagination will not rest and will always continue to ask how we can advance. Another quote relevant to our current technology is by Godfrey Reggio which says, “It’s not that we use technology, we live technology.” In other words, technology consumes our lives and is hard to escape or avoid. We have melded our lives together with it. It is hard to picture what life would look like void of technology. Even now, as it proceeds to consume many aspects of life, when will technology become more than a tool? Where is the line drawn as technology seeks to replace humans in the workplace? Today’s technology is heading in a direction that has never been seen before in the fashion industry.

The sewing machines of the past were so limited in what they could do. Over time, small features were added such as a zigzag stitch, to other decorative stitches, to being able to embroider, and make buttonholes. However, even the latest sewing machines are arguably not that much greater than those made 50 years ago according to some designers within the industry. The current sewing machines being sold today do not even begin to compare to the automated sewing machines coming out. Now even the latest sewing machines will more than likely be used in a home environment with sewing as a hobby or those who design couture and custom

fashion within the years to come. It will be a slow process of course, just as the famous movie store Blockbuster was switched out for Redbox across America over time.

Many of the technologies coming out that will be impacting the work environment and jobs within the industry are in relation to clothing conceptualization and production. These ideas could either make or break the fashion industry of the future. It all comes down to how these technologies plan on being utilized and what it will look like to move forward. With automating processes on the rise in many other industries, it is no surprise it has made its way to the fashion industry.

One fashion related technological advancement to come out of COVID-19 was automated sewing machines. With many dollars to spare, Wal-Mart was one of the few who had gotten their hands on a fully automated sewing machine. It all started when Walmart gave money to Georgia Institute of Tech to invent automated clothing production through sewing robots. They called these highly intelligent sewing robots, "sewbots" (Borchardt, 2016). It is said these machines are able to, "place two pattern pieces together, transport them, and sew the outside seam on jeans with the push of a button" (Borchardt, 2016). The military once they got hold of this news was more than happy to contribute funds towards the automated sewing machine as well. The reasoning behind the funds was to see that manufacturing be brought back to the United States. Manufacturing within the United States would mean independence from other countries and thus self-sufficiency. It could also mean that tension is caused between the countries with which manufacturing is being withdrawn from. This is why this topic of bringing manufacturing back to the States is a whole conversation in and of itself that is profusely debated.

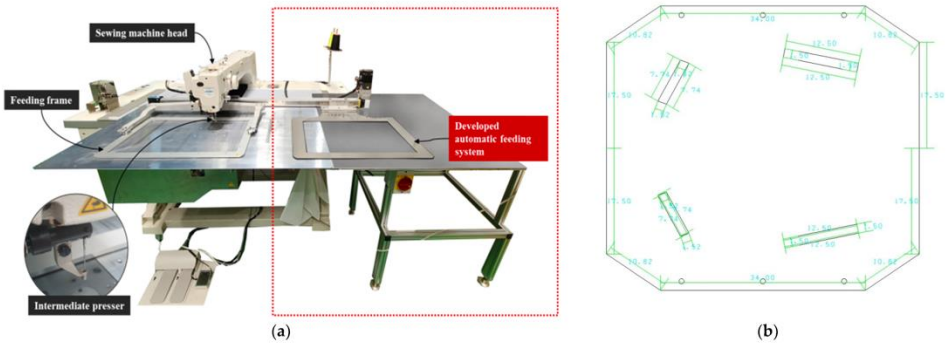
The idea behind automating processes for producing clothing is not new to the fashion industry. There is already an automated fabric cutting process, automated pocket making, and

everything and anything else that could be automated within garment construction. Yet, no one was quite ready to invest the money into automated sewing. Automated sewing was a daunting task for even the most skilled inventors and engineers. Another reason behind hesitating in this project is because it is so cheap to have clothing manufactured where labor costs are low in other countries. Yet now, there is a sort of shift and transition occurring in which cheap labor is becoming harder to find. Generations below current seamstresses from all over the world are finding ways to pursue careers outside of manufacturing. Now that the ball is rolling with automated sewing, there will be more force to switch over and convert. It is said that automation within the industry would not eliminate jobs, but instead create new ones. This statement, however, is arguable. It is said that there would be technicians and software designers needed for automation is fully integrated. However, even with some of these new jobs, there will still be a significant drop in jobs available and the presence of humans within manufacturing.

The real worry is for seamstresses going extinct, even though technicians and software designers may have a job made available for them through the integration of automated sewing. There are said to be 52,010 seamstresses currently employed in the United States (Fashion & Apparel Design, 2022). The average age of an employed seamstress is around 50 years old (Fashion & Apparel Design, 2022). This proves that there is not much of a younger generation that have the same sewing skillsets. Afterall, classes that teach sewing have been pulled from a majority of schools, such as Home Economics. Even those who do manage to pick up this skill, most seamstresses only stay 1-2 years at their job. (Fashion & Apparel Design, 2022) Seamstresses are often treated poorly, which explains their reasoning behind leaving. That being said, the future of seamstresses is not looking particularly great. It also means that automation has the perfect chance to fill this gaping hole within the industry once it crosses that bridge. There will be a demand for seamstresses and very few able to take on that position. If the amount

of seamstresses continues to drop significantly, there will be no other options than to look for solutions like automated sewing. Once this occurs, more companies and brands will want to invest in machinery like the Sewbot.

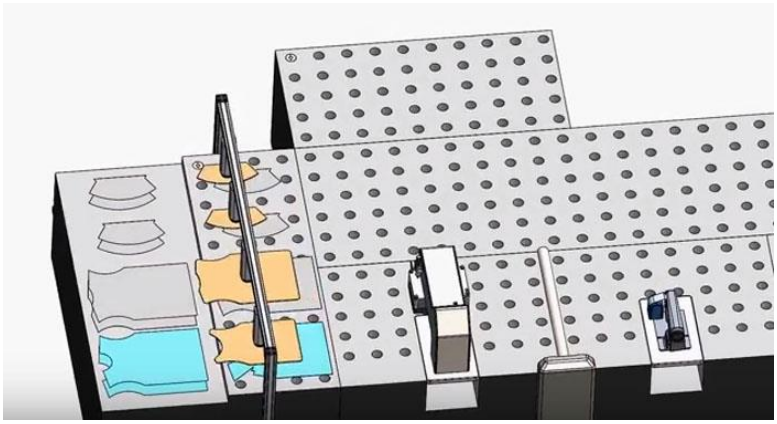
Apart from Walmart's research and money put into automated sewing machines, others within the fashion industry have also taken their turn at inventing automated sewing machinery (Figure 5). LOWRY is a fully automated sewbot with a grand investment of $1.25 million from DARPA (Sewbot, 2022). There are currently three patents and several that are pending for sewbots. This new automated sewing equipment, however, is limited to what it can do. As of now, it can piece together a basic T-shirt. This means that either research and development will have to be conducted by a number of engineers and tech specialists, or the industry won't see automation within sewing for years. At the core of this invention, software's such as Gerber technologies' Accumark files are utilized. That same data, which is used for 2D and 3D, is integrated into the file that goes right to the sewing robot. This is a great foundation, however, with the many diverse styles out in the world of fashion, these automated sewing machines would have to be programed several times over. This is another factor that suggests it will be several years before automated sewing machines can accomplish multiple distinct types of garments. Whenever they can manage to program it to be able to meet all those requirements, it will cause competition for seamstresses as well as other jobs within the industry and reshape the way in which things are manufactured in fashion.



(SewBot, 2022, Automated sewing machine)

When questioned about the quality in which these sewing robots could produce clothes, studies show that this technology can be trusted. It is said that these sewbots have better accuracy than the human eye. In fact, it tracks an exact needle placement to within 1/2 a millimeter of accuracy (SewBot, 2022). This is an exceedingly small margin of error and speaks to this technology's abilities and potential. There is a set of image processing algorithms that are used to detect each frame, where the threads are. It is said that with the, "Machine's vision and real-time analysis, the robotics then continually manipulate and adjust the fabric to be properly arranged." (Sewbot, 2022). It works similar to that of a conveyor belt in which the garment is passed down along the line to be constructed. (Figure 6) Just as seamstresses would complete different sets of tasks at a time, the garment is passed down to sewing machines that are programmed with specific tasks to complete. There is even a piece of the machinery that will pick up and place fabric, as if a seamstress themselves were moving it. A question that is bound to be asked of those who have worked with materials and understand them well, pertains to the way in which diverse materials must be handled. Recognizing that all materials are different in weight and drape (how they hang), a stiffening is used on the fabric temporarily to give the machinery a way to grip it. This helps fix the issue with the fluidity of various materials, though it may not be the best solution. There still are many questions within its functioning that need to be answered,

though manufacturers are at the edges of their seats in anticipation, waiting for promising results. Until then, seamstresses can continue to sew away unbothered.



(Sewbot, 2022, Automated Sewing Machine Conveyor)

Still skeptical of the idea of automation being integrated within a company, there have been many who have sought out answers to their itching questions about automation. To test the theory of how robots could perform within the sewing industry, an experiment was conducted. This experiment consisted of three distinct groups of seamstresses and operators in a manufacturing facility (Rashid, 2021). Test one dealt with post initial training, while test two dealt with skill retrieval assessments after what they called “retention periods”. These three groups were divided in order to experiment with the effects of zero automation, to full automation. The first group was the “Manual Machines” group known as MMG. The second group was the “Refresher Training Groups” also known as RTG. The RTG group would be the individuals in the middle of the spectrum, who handled both manual and automotive tasks. Lastly, the third group was called the “Automation” group or AG. There were 67 participants, seven of which dropped from this experiment prior to completion (Rashid, 2021). The seven that dropped out belong to unknown groups as this was not recorded in the experiment. Groups were monitored on a daily basis, as well as a weekly basis, for 12 weeks (Rashid, 2021). half of those

weeks would be spent examining production, while the other half would be examining retention. All were given both paper and dexterity development exercises included in their training. They were also given goals on a daily basis to measure successes and failures. This would help gage just how efficient each group was.

With the help of this experiment, the automation process and how it will impact the industry becomes clearer. As far as average single cycle times (ASCT), or average completion of units, the MMG participants had shown a significant decrease in ASCT. The RTG participants also showed a significant decrease in ASCT. Lastly, the AG participants showed a significant increase in ASCT. This data proves to show that there is a certain strength within automation, specifically in regard to ASCT. This is what attracts companies and businesses to this type of technology. As far as production went, MMG participants increased in production over each day from training to skill retrieval assignments However, the participants in RTG Did not show a substantial difference. The AG participants showed a significant decrease in production. Both MMG and RTG participants were able to increase their percentage of getting tasks done right the first time. Yet, AG participants were unable to achieve getting tasks right the first time. This could potentially be a concern or hurdle for those looking to integrate this technology into their manufacturing processes. Finally, dexterity was tested amongst the participants. Dexterity, within this context of fashion, would mean the skillfulness needed to complete a task well and efficiently. The MMG participants had shown a significant decrease in dexterity, while the RTG participants showed no significant difference with dexterity. However, AG participants displayed an increase in dexterity, when looking at the other two participating groups. This is another positive outcome for automation that could make a difference in deciding whether or not it is worth being utilized in manufacturing. Throughout this examination, both positive and negative outcomes in regard to automation are revealed. Though much more research could be done on

this topic and questions still unanswered, this experiment gives a good enough taste for what automation would look like taking over manufacturing and replacing human hands.

In terms of positive news that was illuded to previously, it is believed that manufacturing can be brought back to the United States. Automated sewing robots reduce the need for sewing laborers, which means less money goes into labor itself. It is said that there will be, “the labor decrease of 50- 70% compared to the workers on a conventional line” (Sewbot, 2022). This is appealing to anyone looking to manufacturer looking to save money on labor, while also being able to stamp “Made in America” on their clothing. Not only this, but the production line is increased as a human seamstress can only produce 699 T-shirts in eight hours, compared to a sewing robot that can produce 1142 T-shirts in eight hours (Sewbot, 2022). This means that manufacturing is around the same cost as it would be overseas, which is why it now can compete with prices in overseas manufacturing. With ethical and economical movements on the rise, more clothing companies have been seriously looking into other manufacturing options.

When looking for manufacturing solutions, another solution similar to that of automated sewing came into view. Evolution in St. Louis, Missouri is a manufacturing company that specializes in knitwear. This company took many risks starting up but has now been around for about 8 years and continues to grow in popularity and success. Not only are there automated sewing machines, but also automated knitting machines as well. This automation process was a bit easier to tackle than automated sewing is. It is said that “manufacturing in Asia is typically a 12-to-15-month cycle” (Vicki M. Young, 2020). This means that consumers' interest in surfacing trends die before the product can even be released. This leads to waste within “out-of-style" products that can no longer be sold. Not only this, but the cut and sew processes of manufacturing are labor intensive. This is because only one person can be operating a sewing machine at a time, as well as working on one garment at a time. Whereas it is said, “flat bed

knitting, digitize operations into an efficient and cost competitive process." (Vicki M. Young, 2020). Fewer people are required with this machinery as one person can operate multiple machines, rather than one person per machine, like manual sewing machines require. Implementing this manufacturing process within the United States also eliminates the number of samples that need to be sent back and forth between countries, which in turn cuts back on waste and heavy fees. All in all, this process is found to be more sustainable than others.

When contemplating how to achieve a better form of manufacturing, Evolution partnered with a German manufacturer called Stoll to obtain this machinery. They were the ones to create the 3D flat bed knitting machines, of which Evolution purchased 30 of. Evolution says that they have created around 50 new jobs with this form of manufacturing, of which 10 are full-time jobs. What sets them apart is their ability to react to upcoming trends quickly and meet the consumers' demands immediately. As mentioned earlier, what would take a year's worth of planning and production, now can take a few months. This means designers do not have to plan their collections so far in advance or be able to predict the future while trying to tackle the present. This dissolves a lot of issues and problems within the industry as far as sustainability goes, with being able to supply products only as they are needed. This solution is one of two. A second solution would involve much more difficulty. Conditioning and encouraging consumers to buy less or upcycle what they already have in their closet is another solution. Yet, although this would help shed a positive light on the fashion industry, the industry would also not be making as much money with this solution, which is why it is less appealing.

As companies rack their brains as to what they will do to continue to win over their consumers, they look towards other technologies that are also on the rise. It is said that the world is living in the 4th Industrial Revolution or 4IR for short. Within this 4th Industrial Revolution, there are 3 goals to address and cure concerns in the fashion industry. Many problems have been

a result of unmatched demand. Yet at the same time, there is also a problem of oversupply, in which the industry is supplying more than the consumer can consume. There also sadly is the inability to meet consumer demand correctly. How could these issues all coexist? The issue is within the fast-paced nature of trends and instant gratification, with how quickly everything comes and goes. As mentioned previously, by the time the garments get to the consumer, they are already onto the next trend, or have do not like the interpretation of the company's spin on the trend. The fashion industry is forced to take risks not knowing if the consumer will take their bait but trust past data to inform their decision making on products. Yet going with the decision informed by past data of what consumers are liking, does not always work. One suggested solution for these problems seemed to point to mass customization. The fashion industry recognizes that their prime goals are to become more environmentally sustainable, offer hyper personalization, and watch productivity.

One need that is being tested out within the fashion industry is customizable fitting to the body. A company that utilizes this technology goes by the name MTailor. Mtailor allows consumers to scan their bodies, upload them on to their mobile app, which then allows for tailored clothing (Britt, P.2022). Both the fit of the clothing article and also aspects of the color, print, etc. are customizable as well. This allows the consumer to add their own personal touch to a garment tailored to their measurements. This addresses one of the concerns listed above by the fashion industry of offering more options to customize garments. This means that the demands of consumers can finally be met and decrease waste, helping the reputation of the fashion industry recover. When the reputation of the fashion industry is recovered, those working in it can be proud of their roles within the fashion industry.

Though the fashion industry is trying to meet the needs of its consumers, it has many hurdles to overcome before it can achieve these goals. Not only this, but it will take a significant

amount of money to invest in some of these concepts. Consumers reactions will also have to be favorable enough to help them turn from their habits of spending money on fast fashion, over quality and sustainability. Fast fashion is a problem that has become increasingly harder to control, as we live in an instant gratification society. New technologies, however, are something that will always draw the attention of consumers, which continues to support the direction fashion technological development is heading in.

While the emerging machinery for constructing garments is fascinating, there are also other technological developments that are incredible and not getting the attention they deserve. Synthetic fabrics, since the time of their invention, have seen progress in small ways throughout the last half decade. Now, textiles are incorporating technology within their very being. Some of these textiles help replace the need for a physically present nurse, for patients suffering certain conditions. This is probably one of the least expected areas of the fashion industry to get a technological upgrade. How does this tie into the fashion industry working environment? Textile technology will provide new jobs within the fashion industry, for all the jobs to be taken away by automation. Textile technology will require programming and maintenance, like that of other technologies.

As the fashion industry adjusts to the implementation of automation and the challenges that come with these new technologies in producing these garments, unforeseen changes within textiles are being made as well. Just as technology is now able to produce and create garments on its own, little did anyone know that the very fabric within the garment could be an advancement in technology itself. Wearable technology is something that the fashion industry is slowly seeing rise in popularity as it hits the runways. With this in account, the fashion industry will have to adapt to this change as well. They will soon be expected to offer these textile technological features to the consumer.

Textile science and technological development has been huge with change within the industry. Smart textiles are textiles that contain certain advanced properties. E-textiles apply a conductive component to the surface through either plating, printing, coating, or other techniques. (Smart Textile Materials, 2022) Another way in which technology can be incorporated into textiles is through a fabrication process done by braiding, weaving, knitting, or after fabrication through embroidering. Smart or Intelligent textiles are textiles that are "responding or adapting to changes in the environment." (Smart Textile Materials, 2022) They also produce a response in reaction to the change in the environment or "to an external signal/input". (Smart Textile Materials, 2022) These textiles help push the industry in ways that it hasn't been pushed before. The workplace for textile manufacturing will be forever changed.

There are three separate ways in which Smart Textiles can be categorized: passive, active, and very smart/intelligent textiles. (Smart Textile Materials, 2022) Another definition for Smart Textiles are "adaptive materials that use established textile methods to integrate multifunctionalities beyond apparels." (Ruckdashel et al. Smart Textiles: A toolkit to fashion the future, 2022) This means that textiles can go beyond serving an aesthetic appeal but contribute a greater function. Most Smart Textiles incorporate one or more of these: electronic materials, conductive polymers, encapsulated phase change materials, shape memory polymers/materials, and other electronic sensors/Communication equipment. (Smart Textile Materials, 2022) Some features of smart textiles come in the form of assistive soft robotics, smart healing, and thermal comfort. The example given of the first generation of wearable motherboards is of, "sensors integrated inside garments that can detect injury and health information of the wearer and transmit such information remotely to a hospital." (Smart Textile Materials, 2022) This kind of technology has the power to change and impact lives like never before. This may be surprising to some people, as the fashion industry may not seem to be significant in the aspect of impacting

lives. How does this impact roles and the working environment within the fashion industry? Those within the fashion industry are able to check the health and wellbeing of the consumers, as well as supply a unique stylish feature through technology. This changes the roles by way of hiring those who are able to program software for these textiles.

Health and wellbeing textiles are being developed and can serve many purposes such as: shape memory, color changing fabrics, soft robotics, smart healing, and thermal comfort. These are only a few of many features of textiles that aid in health and wellbeing. Soft assistive robotics are relatively safe and possess “active and reactive compliant systems” (Ruckdashel et al. Smart Textiles: A toolkit to fashion the future, 2022). The way in which they interact with the body is something quite fascinating. With this technology, textiles can aid in helping with human applications like implants, prostheses, drug delivery, tissue engineering, and assistive devices. (Ruckdashel et al. Smart Textiles: A toolkit to fashion the future, 2022) In other words, these textiles can care for wounds and handle drug dispatching's. Not only this, but they can be used to diagnose, monitor, as well as heal. Essentially, smart textiles have the ability to identify negative bacteria “in a wound bed with a porous silicone microcavity resonator (an organic receptor attached to the resonator binds to diphosphoryl lipid A).” (Ruckdashel et al. Smart Textiles: A toolkit to fashion the future, 2022) Monitoring is then done with strain sensors and fiber probes. Though these textiles may not replace human interaction in the fashion industry, they do replace a lot of the tasks and human interactions made between the patient and the healthcare providers. With such technology available and ready to use, the health care industry has been able to provide comfort and relief for many a patient.

These textile technological advancements will be what create a crossover between the medical field and fashion, which is something utterly unique. This is one of the more positive outcomes that emerging technology will have on the working environment within the fashion

industry in terms of jobs available. There will be a brand-new department that can be added to textile manufacturing with this discovery of technological integration within textiles, one of which will consist of software designers.

The fashion industry in many aspects is seeing momentous change. Perspectives within and outside of the industry can vary with all the many departments that make up a company. An inside view as to what is going on within the industry is extremely valuable. There are well hidden secrets to the fashion industry that no one on the outside really knows about, until they get a job working in the industry themselves. A lot of the areas that were once gray on how the industry functions and thrives, become clearer the moment you take on a role within the fashion industry.

To dive deeper into the matter, an interview with Soft Surroundings' Associate Director of Technical Design, Emily Edmundson, was conducted and gave great insight into how technology is impacting the industry currently. Within this interview, Emily also explains how she feels about the future of technology and what that could potentially look like for both those working in the industry, and the consumer themselves (Emily E., personal communication, June, 2023). The importance of this interview and why it was conducted was to bring forth further clarity on the industry's current perspective on technological developments.

Soft Surroundings is a women's clothing company that has been around for 20 or more years. This company consists of multiple departments that contribute to the success of their brand. Each department has a set of jobs and tasks that are specialized according to that department. For example, the technical design department handle the communication with the manufacturers on how to properly construct a garment according to the fashion designer department's requests. All departments are vital within the company. It is hard for anyone to

imagine within these positions that there is a potential for their jobs and tasks being overtaken by technological developments. This is why it is a good reminder to ask the questions on how one can prepare for emerging technology within the fashion industry.

When picking apart what would be most relevant to the research, the first question to set the tone would be, "how has integrating technology impacted how soft surroundings functions?" Emily explained in great detail how technology most recently with events going on in today's world has impacted Soft Surroundings. She talks about a current technology in the process of being integrated within the company, though she cannot disclose exactly what that technology is. Emily said:

"Technology is so important in the apparel industry, whether it's a PLM system, Illustrator, 3D, planning tools or our website and how we communicate with our customer. Companies must adopt and integrate new software to remain current in the market. Since Covid, Soft Surroundings has put a lot of these new technologies to the side as we have focused on other areas of the business. This year, we are implementing an entire new software system that will allow all departments to have access to the same information and all functions to be able to communicate to each other. This is a 12–18-month process that we just began Phase 1 in March 2023. We are excited to see how we will be using this system in 2024." (2023)

Another important question to ask when implementing a technology is "How long does it typically take to integrate a new technology within a company? what are typical struggles that come with this?" Emily gives an estimation of a general time frame for technological implementation and reveals that it can take a while depending on what that technology is. She makes a good point that in order to reap the rewards of implementing new technologies, one must also be good at training those who will be using it. That is also another plus side to having programmable technology. She said:

"I would say typically around 6 months depending on the technology. As with any new system, the key to success is to make sure the new technology is properly rolled out to appropriate team members through a demo, training, and how-to manuals for easy reference. When onboarding new team members to make sure they are receiving the same training on the software. The

biggest struggle is the disruption in output and the validation that the information from the new technology is correct and making sure that everyone is properly trained and informed." (2023)

Another factor that must be considered when any sort of emerging technology makes itself known is how people react to it. If there is a negative response to technology, this means that it will be harder to implement and also "sell" the consumer on. It will have a devastating effect on the fashion industry if integrated technology is widely rejected. When asking, "How do people generally respond to new technology?" The way in which Emily answers explains the side of how those within a company would react. Emily stated:

"It depends on the new technology. You would hope that the new software saves either time or money. If the team can see the benefit of time saved in their day-to-day functions, then generally the response is very good. Not everyone loves change, but if you show them the benefits of the new technology and how once fully trained it will benefit them in their job, most people get pretty excited and look forward to implementing it. You will always have the late adopters who may take a little longer than others. But for the most part, if the technology will save them time and/or money most people respond well." (2023)

Not all technologies are going to be welcomed right away or be all that they are dreamt up to be. When asked, "What have been some pros and con's with new tech?," Emily responded with more pro's then con's with modern technology. She takes it from her own personal experience being within the fashion industry at Soft Surroundings. She touches on the communication aspect of it heavily being of great benefit. The downside to technology is the amount of time it takes to learn it as well as the money. She also talks about the risk of investing in new technology that does not live up to its expectations. Emily listed the pro's as:

"Better/faster ways to communicate with vendors overseas (example – we have the ability to fit virtually on Microsoft teams. If we want a quick turnaround, we will fit sample from the factory while we are here at the office instead of waiting for the sample transit time)"

"Better/faster ways to communicate to customers (can show them different ways to wear an outfit, can see what the customer responds to and send targeted messages to them in hopes they purchase) (can collect a lot of information from the customer – likes/dislikes)"

"Reduce sample rounds (example 3D Technology – after viewing image on croque, you can adjust and make changes before ever seeing a physical sample. 1st sample is in a much better place and can sometimes be approved right away)

Saves time and money." (2023)

Emily then listed the cons as:

"Takes time to learn."

"Can sometimes be more labor intensive but improves a process"

"Expensive – does the cost outweigh the benefit"

"Does not actually do what it was intended to do." (2023)

From a psychological perspective, technology often frightens, yet fascinates people. When asking Emily, "What are your thoughts on automated sewing machines, fashion ai, smart textiles, etc. and the direction fashion is heading in?," she responded with extensive insight into each category of technology. Each technology she touches on has a unique way in which it can shape those working within this industry. Whether workers within the industry like it or not, their environment and potentially their roles will be changed, though it may take time. Emily said:

Automated Sewing Machines

"Amazing in theory, but interested in the time it takes to sew each garment and how the machine handles different fabrications. Currently we design with a lot of lightweight chiffon and stretchy knit that are difficult to handle for very skilled seamstresses. I would be interested to hear more about how machines are set up to handle a variety of product and how long it would take to produce orders with thousands of units vs. a standard factory production. What is the average lead time."

Fashion AI

"This is the future of the apparel industry. Any information we can gather to know how trends are evolving, what our customer is shopping for, how and when they buy, what are they not buying. Then we can change how we are selling to them so they buy our product and may even encourage them to buy more of our product. We now have the capability to send personal emails to customers based on their shopping habits. This will be pivotal to a company's success, especially with the increase of online shopping. The other side of AI is the 3D aspect, where you can create avatars to see product virtually before seeing physical sample. You can also create floor sets and fashion shows all virtually. This could be an amazing selling feature on a company's website as well, showing you ways to style an outfit resulting in more sales. Overall, very positive and look forward to seeing how these changes the industry in even the next 5 years."

Smart Textiles

"Love the concept, not sure how affordable it will be for the mass consumer. I could see a certain customer paying the higher price point depending on what the end use is for. For example, a professional athlete may pay for smart textiles if it has some sort of performance enhancement feature. It is an interesting idea and a way to offer a unique product you will not find everywhere." (2023)

The final question of the interview is based off of Emily's own predictions. Another question Emily answered asked, "Do you believe technology is taking over and transforming the industry? Or what do you believe the future of the fashion industry will look like (20, 50, 100 years down the road)?" She talked about the aspect of sustainability and how it is really impacted the way people purchase, and how she believes that will be an even bigger factor in the future. She also talks about how she believes production will still be overseas for many years to come. Emily stated:

"I do believe Technology is transforming how we work and communicate. We are able to connect to our factories and customers in more ways than we ever have before. The future of fashion, that is a tough one. In the next 5-10 years I see the industry really look for ways to improve our impact on the environment, finding ways we can use technology to reduce sample waste. For Gen Z customers this is important to them, and they will find brands that support their beliefs. I believe we have even more ways to gather information about our customers. In 20 years, the retail space will look a lot different. People want convenience, how does that look? What is the next Amazon? As for production, I do believe that space will be slower to change. I think we will still rely heavily on overseas production for the next 20-50 years." (2023)

After interviewing Emily, there was a little more depth and perspective added to this research that was needed. She, having an insider's perspective, having to deal with a lot of technology on a daily basis, has a good understanding of how things function within a company. From what she has estimated, technology will be moving at a slower pace than what is being predicted by others. She, however, sounds excited for the potential that comes with new technology as time continues to pass. She views technology in a more positive light.

With the technology we have now, from building off of past technology, one can get a better glimpse of what the future will taste like in the next few years. The fashion industry within the future will look unrecognizable. The life of the consumer will be shaped and changed in such a way that it will be hard to look back on what it used to be, thus affecting those working within the fashion industry. Those who have jobs within the fashion industry will start experiencing modifications within their working environment. They may have to learn new skills and be trained to work with new technologies in order to stay relevant within the field. Companies will have to use great discernment in out-waying the risks and benefits of these emerging technologies. In other words, a lot will change whether or not the world is ready for it.

Smaller businesses in comparison to larger companies do not have the same ability to adapt to the emerging technology in the same ways. For example, within manufacturing, it is hard for smaller businesses to afford machinery such as the automated sewing machines. A group of researchers acknowledged that there is difficulty in technology adaptation on a smaller business scale and identified potential barriers (Zahra, Dhewanto, Utama, 2021). These barriers were listed as resistance to change, trust in technology, and willingness to try, as well as political, social, and economic uncertainty (Zahra, Dhewanto, Utama, 2021). Nothing surprisingly was mentioned about having the monetary means to adapt this technology until these researchers investigated further. Small business owners stated that the technology was simply not in their budget (Zahra, Dhewanto, Utama, 2021). Not only this, but they mentioned how they were needing individuals with higher competencies for this technology, which is why they would rather collaborate with companies who have integrated these technologies instead. Automation within these small businesses may be out of the question, but other technologies are not out of reach. One thing that is accessible to smaller businesses is the immersive technologies that are relatively less expensive and harmful to their budget. This will at the very least give

smaller businesses a means of survival until they can find other ways to make it within the industry as technology is being integrated.

The Future of Fashion

So many new changes occurring in and around one's life can leave someone feeling overwhelmed. Something that is hard to understand such as technology can also feel threatening. "If it keeps up, man will atrophy all his limbs but the push-button finger" says the architect Frank Lloyd Wright. The words of Frank Lloyd Wright are not too far off. Many tasks that were once done by humans are now most likely to be done by robots. Tools and machinery of the past are no longer appreciated as much anymore because something that works more efficiently has replaced it. How long before humans are replaced for not being as efficient as the technology they produced? Society must have had gut feelings that this would happen, after all, they make movies about robots taking over. Circling back to the purpose of technology, it essentially is designed to make things easier and to reduce the amount of work we as humans must do. Could something that makes people's jobs easy also be something that puts them out of a job years down the road? Even with AI, VR, XR, Etc., are we replacing ourselves with robots? Or replacing human interaction with robots and living a virtual life. When reading in the previous section on current technology within the industry, one can already see this coming to fruition. It may not be quite as dramatic as robots overtaking and ruling the world, but the impact technology will have, in all its many forms, will be tremendous.

When diving deeper into what jobs within the fashion industry will look like in the future, a lot can be said. It is estimated that 85% of jobs that were lost in manufacturing between the years 2000-2010, were due to productivity growth with the usage of robotics and machinery. (Sewbot, 2022) Who is to say that this will not completely take over more jobs within the fashion industry.

In fact, studies show that by 2025, global manufacturing 10-25% of tasks will be done by robots across all industries (Sewbot, 2022). Rather than addressing the issue of job loss, as one can imagine, it is more appealing to focus and discuss how manufacturers are now able to "sew local." This could potentially result in global ramifications, as manufacturing in places like Asia is a main source of economic growth. Furthermore, AI or artificial intelligence, machine learning, and cognitive computing is expected to directly impact 47% of United States' jobs. (Sewbot, 2022) These statistics are quite alarming for the average United States worker, but there are potential roadblocks to some of this technology.

When researchers dove into the matter of how people felt about all the predictions being made with new technology coming out, their response to the matter was fairly clear. When conducting research, 72% of respondents in a Eurobarometer survey agreed to the statement "robots and AI steal people's jobs" (Sewbot, 2022). This is to say that people are scared knowing that tech is on the rise. Though there may not be enough robotics and machinery to fill the amount of job capacities available within the fashion industry, the focus is on the fact these technologies even have the ability to replace humans.

The American Psychology Association did a study on how individuals felt about all the new technology being integrated into the workforce. They once again mentioned the statistics about robots replacing 47% of jobs, especially within manual labor (American Psych Association, 2022). There is a fight between opinions on whether jobs will be taken by robots, or whether there will be new jobs as a result of the technology coming out. Right now, there are around 1000 human workers for about every 1 robot. This is not a substantial number of robots to humans ratio, yet people are still terrified of the potential of that ratio changing within the near future.

According to research, even just having robotics present within a working environment causes a sense of job insecurity. The implications of robotics taking over include, “costs in the form of employee job insecurity, burnout, and incivility that must be accounted for,” (American Psych Association, 2022). This is to say, if that ratio were to rise in numbers in terms of robotics, it will not be without some form of pushback. Adapting to technologies within a working environment will not go as smoothly as companies and manufacturers would like it to. As Emily Edmondson brought up previously, it takes a lot of time being poured into training individuals and the way in which they react can determine the speed at which a technology is integrated. To quote from the American Psychology Association, “No one knows with certainty how robots will shape our future society, and that uncertainty itself can be unnerving.” Change can either bring out the best in people, or the worst. How one adapts to change can speak volumes. How these companies will approach this change in technology could have the potential to make or break them.

For some companies, that decision has already been made. It is said manufacturing innovations have already been partially integrated in countries like Germany, with the desire to start what they call “Smart” factories and automation factories. In the hopes to pursue sustainability, manufacturers are looking for ways to eliminate serious environmental problems and social costs, that are due to mass production. (Lee, S., Rho, S.H., Lee, S., Lee, j., S.W., Lim, D., & Jeong, W., 2021) However, it is quite expensive and risky to move manufacturing from places where wages are low as well as production costs. To move manufacturing to “smart” factories means many technologies are needed and digital facilities which results in a terribly slow integration process. To integrate these technologies without risk or loss of money, automation only takes over certain processes and steps for manufacturing.

Automation, though it has been praised for its ability to cut down on manufacturing time, increasing productivity, is still in its infancy. This technology is very new, and though it is believed to takeover quickly, as of now, it is unable to complete 95% of automation tasks for clothing production. (Lee, S., Rho, S.H., Lee, S., Lee, j., S.W., Lim, D., & Jeong, W., 2021) That being said, it will all come down to how fast they are able to lower that percentage. Time is either your friend, or your enemy, as many a man has said, and it is always a race in the fashion industry.

As this technology continues to ease its way in, how can one even begin to be prepared for such a transition? Future workers within the fashion industry will be a unique breed of workers. There will be a new set of skills that are required of these workers in order to adapt to an industry immersed in technology. It is said that there will be a fourth industrial revolution from, “One of the main ideas of which is accompanied by the replacement of manual labor by automated or robotic” (Odnoroh, H., 2022). This means there will be no workers who are capable of surpassing the efficiency and precision of the automated manufacturing equipment. It is said that automated labor will, “demand new professions, the readiness of skilled workers for lifelong learning or retraining.” (Odnoroh, H., 2022) What mainly will hold back seamstresses, tailors, and cutters from jobs would be their competency level, professionalism. creativity, overcoming stress, and acting well in conflict situations.

A Netflix documentary was made and found that the future of fashion could potentially lead to 3D printing clothes. This would mean that customers would not need to heavily rely on the fashion industry manufacturing clothes for them. They would be able to select the clothing item they desired and have it printed out for them. This technology would scan a person’s body measurements, and then use software that has been developed previously to construct a pattern for 3D printing, then use biodegradable materials to produce and print the garment (The future

of: Fashion, 2022). According to this documentary, the future of fashion is one that leads to customization of clothing within the home. This, however, they recognize is decades from coming into existence, though the excitement is still there.

Automation within knitting and sewing have been covered as a means of production, but one other possible means of production of clothing can be done through 3D printing. This form of production through 3D printing is also called Additive Manufacturing. Typically, this technique of production uses geometrical patterns to create the textiles to give it flexibility. Prior to this, 3D printing was formerly used or most commonly used for creating prototypes. Those who are familiar with 3D printing know that the production processes use layering techniques to produce the final product. The major roadblocks within this type of production can be seen through the issues of comfort and flexibility. Also, it is limited to what garments it can produce as of now, since there are once again a numerous amount of garment silhouettes and styles. One other main reason that could contribute to these limitations is due to the materials that are being used to create the textiles, which are then created into garments. Most of the materials used to create these textiles are not the best in terms of performance, in comparison to the textiles we have now for garments. The materials used for these textiles are thick and dense, as well as sensitive. They do not hold up well when it comes to abrasion, force, or any form of wear-and-tear. They also are finicky when it comes to changes in temperature. Another question that arises with these textiles is in regard to the care content with these 3D printed garments. How does one wash them or keep them from being damaged if they are so sensitive? Still, these questions have not stopped a growing interest that the consumer has for 3D printed clothing. While this interest is peaking, the fashion industry will continue to seek answers for the issues of 3D printing garments. In terms of manufacturing through 3D printing, it is one of the cheaper options in comparison to the automated processes previously mentioned. This is a form of manufacturing

that even the smaller businesses could potentially have access to, when competing with companies that are looking into smart factories. This could potentially save those who find themselves out of a job within the fashion industry if they want to stay within the realm of fashion.

Not only are jobs and roles such as technical designer, fashion designer, merchandising jobs, etc. changing within the fashion industry, but it also changes those who are not making or designing the clothes as well. It affects so many within the industry, though there is a heavy emphasis on those who have roles in designing and producing the clothing. Never was it expected that those whose jobs were to model or sell the clothes, be potentially handed over to technology. Yet, technology while its emerging is full of surprises and the unexpected.

Shows like Next Top Model praise the skill and dedication it takes to make it as a model in the fashion industry. Models are expected to look flawless in every single way and hold a lot of heavy expectations on their shoulders. In light of the Barbie movie coming out, one could say that models are supposed to replicate the idea and emulate Barbie herself. This concept of perfection is hard to capture, as humans are naturally flawed and go through many changes in appearance. What about supermodel robots? In Paris, France, the city known for living and breathing fashion, something never seen before came to the runway. As guests arrived for the show, they had no idea what they were about to witness. Five robots shared a runway with well-known supermodels at the Coperni fashion show, a long awaited and beloved show in Paris. Coperni is known for dazzling his audience with incorporating modern technologies and knew his audience would not be expecting this. The designer's reasoning behind this idea of having the robots come out onto the runway was to as he said, "humans and technology can live together in harmony" (Guardian, 2023, March 3). Technology and humans can live in harmony when the

technology is being used with good intentions. There is truth in this statement, but yet there is still a feeling of uncertainty when it comes to trusting robots over humans.

These robots were not modeling the clothes themselves and only carrying articles of clothing, but who is to say that there will not be robotic supermodels within the industry someday. There have already been rumors of robot super-models within the industry. There is however an issue with the mobility of robotics, as this is hard to achieve. The appeal again would be that it would cut costs within the industry if this were to happen. However, there seem to be many more hoops to job through that make this concept appears impossible. So as of now, super-models most likely have no reason to fear for their jobs being taken. Certain things just cannot be replaced by robotics, no matter how much it would cut down labor costs. The consumer would not be pleased to see clothing that they are expected to want to buy on robots that do not replicate humans. Therefore, the consumer would have to be won over by this idea from the fashion industry before it could be implemented.

As far as other roles within the fashion industry that might be in jeopardy would have to be those working on the retail side of the industry. Technology that deals with customer service has been seen slowly creeping into clothing retail. There are retail robots that can provide customers with the information that they need. Not to mention, self-checkouts are becoming more widely accepted throughout different retail spaces. It may very well be that all of customer service within the fashion industry will be handed over to robots someday. They may not greet the consumer with a friendly smile or a warm hello, but they are promised to help the consumer find what they're looking for in the most efficient way possible.

Going along with robots in retail spaces, Chatbots are also currently being introduced into the industry. This is specifically for retail purposes in helping with consumer behavior and

awareness. Chatbots have the opportunity to offer personalized care to consumers as they shop, making everything that much more efficient. For someone who has been within retail for a few years, trying to understand exactly what a customer is looking for and to offer personalized services to all customers can be challenging. Sometimes customers are not comfortable explaining exactly what it is that they are looking for, or do not know how to describe it. These Chatbots would be able to decipher more efficiently what the consumer is wanting, or maybe even perhaps finding what the consumer wasn't necessarily looking for but is drawn to. Often times the strategy of "up-saleing" is used, in which items that the customer had not initially had in mind, are added to the sale because they discover a need or want for these items. Chatbots have the potential of increasing sales averages by being able to predict these consumer behaviors. This is why it is so appealing to use these chatbots within the industry, along with not having to pay them a wage.

It is clear that there are many areas that must be addressed in the fashion industry, in order to promote it in a more positive light. One of these areas is the popular topic of sustainability and waste within the fashion industry currently. The consumer has become more concerned and aware of the environment and how it is being treated. This consciousness of the consumer prompts a reaction and response out of the fashion industry. The industry has approached this issue in different ways but is now looking to technology to help them with this problem. The fashion industry would no longer like to be known as one of the biggest pollution contributors. Rather, they hope to be at the forefront of promoting good habits for keeping this world beautiful and clean.

The issue of waste within the fashion industry, although it has been around for a while, is just within the last few years gaining recognition and further consciousness. It is said that a lot of these emerging technologies are being invented to alleviate waste and bring about sustainability.

These particular technologies are said to, “reduce online returns, educate consumers, reduce waste in design/manufacturing, and remove the need for physical items.” (Mesjar, L.,Cross,K.,Jiang,Y.Steed, J., 2023) This technology sounds grand, but any technological development takes money, consumer support, and understanding of this technology.

Sustainability takes many forms in the fashion industry, especially considering that it is the 2nd biggest pollution problem in the world. To name a few of the major ones you have: waste in production processes, waste in leftover products not sold, waste in textiles manufacturing processes, 8-10% global carbon emissions, fast fashion promoting excessive consumption, and water waste of up to 20% (Mesjar, L.,Cross,K.,Jiang,Y.Steed, J., 2023). It is said that the average American used to buy only 12 clothes a year in the 1980s, which has now rose to 68 clothes per year (The Future of: Fashion, 2022). This number shows the dramatic increase of the consumers' demand for clothing. To look at it even closer, the average American disposes around 80lbs of clothes within a year, which looking at it from a global scale is 92,000,000 tons of textiles a year (The Future of: Fashion, 2022). Once again, Covid-19 was the spark to start a flame. Due to Covid-19, the fashion industry found ways to go virtual and looked into digitizing fashion. They saw the opportunity of Augmented Reality (AR), Virtual Reality (VR), and Extended Reality (XR) to promote fashion in an immersive technical way. The industry thought that they might be able to push the idea of sustainability in this way.

AI in fashion is also becoming increasingly advanced, though it has not fully reached its potential. Consumers according to analysis have positive perspectives on AI fashion curation services. AI fashion curation services consists of shopping, platforms, and business profit. The desired intentions behind it is to promote usability, usefulness, reliability, enjoyment, and personalization. With this technology, we are currently in a 4th industrial revolution, with rumors of a 5th industrial revolution to come. The world of E-commerce fashion is said to have grown

from $481, to now having exceeded around $712 billion in the United States. (Eunjung Shin, Ha Sung Hwang, 2022) These numbers show a significant shift in the fashion industry going virtual, along with everything else.

AI has already been subtly incorporated by giving customers hints when they are online shopping, with the data that has been collected based on their personality. Hugo Boss launched an entire collection which was generated and developed solely by an AI System. Tommy Hilfiger, IBM, and the Fashion Institute of Technology collaborated with one another to create "Reimagine Retail." This will be an AI system that recognizes and identifies consumers' tastes. Recent AI concepts have been directed towards creating and establishing service robots that can aid consumers in their shopping experiences. The amount of data AI has on everyone seems as if it is almost enough to know you better than a close friend or loved one and maybe even know you better than you know yourself. Few have even looked into AI within fashion or know of its heavy presence within fashion. Yet, there is an intrigue there that cannot be ignored. Once again, this would change the working environment of the industry in a way that requires more software engineers and specialists.

There is already technology out there that is in the process of further development in which consumers are offered a virtual shopping experience. They are able to explore stores from a virtual aspect through their avatars that they can create. There are virtual fitting rooms in which they can dress up their avatars in the store's actual inventory. This allows the customer to get a feel for how it would look on their body through their created avatar before they commit and purchase a garment. These consumers are able to do this with the same technology that is used for CGI in movies (The Future of: Fashion, 2022). There is a company that is already providing a platform for this sort of technology called Auroboros. Consumers are able to buy a look and the Auroboros will virtually fit it to their bodies (The Future of: Fashion, 2022). This appeals to the

customers that dread physically trying on clothes and making a trip to the storefront. There are even rumors of glasses that will be created for the purpose of being able to view people out on the streets with their digital clothing conformed to their body (The Future of: Fashion, 2022). With this technology, consumers' behaviors are developed and shaped. Digital fashion is claimed to cut down waste by 97% (The Future of: Fashion, 2022). When the consumer is influenced and shaped, the fashion industry will be too. Workers within the industry in the future may have to adjust to working with non-tangible clothing. They may need to pick up on many new unforeseen skills to keep their jobs within the industry.

Methods and Methodologies

The methodologies used within this research were a blend of different approaches. Both qualitative and content analysis, also known as observational data, within different sections of the research were utilized. Along with those methods, it could be said that structuralism was used within the research, through trying to provide deeper context and detail within the research. The technology within this study was researched in great depth as to how it would impact the working environment of the fashion industry. Wanting to get the perspective of someone who works with technology in the industry, an interview with Emily Edmundson was conducted. This would be part of the qualitative data research. Within the quantitative research, a lot of statistical evidence supporting the thesis statement was found.

Within the section of research, structuralism is used to explore the many ways in which technology has impacted human work within the fashion industry. It was important to give those who may not be as familiar with the fashion industry some depth behind technology, with how far it has come. Throughout the paper as well, there was an attempt to use somewhat detailed observations to bring further clarity. It is mentioned throughout the paper how the technology of

the past can be seen as bricks that build off of one another. The technology we have now is all thanks to the technology that came before it.

Within the second section of research, there is a blend of qualitative and content analysis research utilized to explore the technology that is currently shaping the fashion industry, and what kind of impact that has on the environment of the fashion industry. A lot of statistics could be found on the topic in regard to the implementation of automation within the fashion industry, as well as how individuals felt about this technology being integrated into the workplace. This was done to strengthen the sort of feeling of a changing atmosphere within the fashion industry and how that was being tampered with. For my qualitative data, an interview Emily Edmondson as mentioned earlier was done. Through this interview, there was more substantial information that was added to the topic of research. The interview touched on a lot of the key points addressed throughout the research conducted.

Within my closing section of research, an exploration was done through observational data, mainly how emerging technology will impact the environment and atmosphere of the fashion industry in terms of work. A lot of the research touched on how the current technology we have today, will catapult us forward in many different areas of the fashion industry. It explores all the possibilities and "what-if's" of the future, based on what is known today. This is not concrete evidence, but mainly educated estimates and guesses on what the future of the fashion industry will look like. The research touches on manufacturing, sustainability, and immersive technologies within the fashion industry.

Results and Findings

Although the findings of this research suggest technology is changing rapidly, the predictions that are being made do not seem like they are set on a realistic timeline. The findings also suggest that automation, though it can take over many jobs within the industry, will be a much slower process of integration than what is being predicted. It appears as though there are too many obstacles yet for automation to completely take over the industry. However, at the same time, there will be gaps that need to be filled, as it is becoming increasingly harder to find seamstresses as well as other workers within the fashion industry. This could potentially mean that there are companies trying to find ways to speed up the processes of technological integration. If enough money were poured into this and there were multiple different engineers working on solving automation problems, it could lead to a faster paced integration.

Predictions Based on Results/Discussion of Results

When looking at the research completed, if given the chance to give an opinion and guess as to where the industry was heading based on this research, a lot could be said. Though the researcher is coming from an outside perspective and having only just begun to break into the industry, there has been an extensive amount of research done on the future of the fashion industry within this thesis process. By always keeping up to date with what is coming out in terms of technology, how these predictions have been made and how they have an impact on the industry can be foreshadowed. As mentioned earlier, it is crucial as someone who will be working in the industry, to have a deep knowledge and understanding of what we will be facing in the future, so that one can better prepare for what is to come.

Based on the information that has been gathered, it is predicted that most manufacturing jobs will be replaced by automation. However, it is not believed that they will be replaced as quickly as some of my research suggests, but rather that they will slowly be integrated until most of the workload is done with automation, leaving only the operators of the equipment. It is also believed that it will take longer than predicted with how expensive all this automation is to integrate. Not only cost, but it is as though it will cause a lot of tension between countries, as the United States could potentially withdraw their manufacturing from other countries and bring manufacturing back into its own borders. Though Americans would be all for bringing back manufacturing to the states, it would devastate countries that rely on manufacturing goods as a main source of economy.

It is believed that AI and other immersive technologies will increasingly become more popular and could be problematic for social interaction. Already now, there is a social disconnect

between humans, specifically in the younger generations that have been heavily influenced by technology. Social interaction has become easier online and through social media, as you are able to design and create the way you would like people to perceive you. These technologies will only continue to promote the idea of keeping to oneself if the technology is overused.

It is also believed that there will be more robotics within customer service in retail, other than the chat bots online. It is estimated that there will be robots that assist in shopping experiences within retail stores. It has already been seen from one of the local grocery stores that many go to every now and then. It is a long pole-like structure with a screen, that looks like it is attached to a rumba. It can assist customers in finding certain things, as well as checking inventory within the store. It is imagined that it will not be long until they have something similar in clothing retail stores. With the social interaction issue we are beginning to see; it would not surprise me if clothing retail stores made it as low interaction with humans as possible.

Society and the fashion industry already know that E-commerce for fashion will continue to grow as more demands are being met. It is the way that the fashion industry in terms of retail has been pushed towards through many factors, which Covid-19 helped accelerate a bit. It is believed that AI will have an even bigger role in E-commerce than it does now. Through the research, one can guess that with the technologies that we have now, they could potentially implement a software that allows customers to create themselves their own avatar, that is even more detailed than the ones previously mentioned. As an example, the CAD software CLO3, people would be able to plug in their measurements, and try on garments virtually. With these measurements, they would be more accurately able to see how these garments would fit on their body. Potentially, with the way that the industry is looking at meeting the demand for customizable garments, they could have a preset of different clothing patterns that people can pick and choose from to create their own garment. This would be a bit of a risk going through the manufacturing process if the

design did not quite turn out how the customer envisioned it. These designs would not go through their regular test runs to make sure everything looks ok.

Although it grieves seamstresses to say, it is believed that sewing is becoming more of a dying art as time continues to move forward. It is as though sewing, as automation seeks to fill the gap left by seamstresses, will become more of a hobby or special skill. The average age for a seamstress being around 50 years old says it all. Coming from sewing at a noticeably early age, it can honestly be said that it is difficult at first to get into it. Most people love the idea of being able to create, but hate taking the time to sew everything together. Sewing, pattern drafting, draping, and other design processes take patience that a lot of the next generation does not have. We are living in an instant gratification kind of world. Skills within the arts are going virtual, requiring less hands-on activities.

How Can Humans Adapt to This New Technology

What would the world look like if these predictions listed became a reality? How would we learn to adapt to this technology and avoid being left in the past? With this research, there is now an understanding of how this technology came to be and how it functions, which allows for better adaptation to it. Jobs will most likely be different than the ones society is familiar with today as roles and tasks shift. This will most likely be a slow change.

Adapting as someone within the industry will be difficult for certain, but definitely not impossible. This technology, because it is so advanced and still limited, gives those within the industry a chance to prepare themselves. As mentioned earlier on, having an understanding and knowledge of what this technology is and how it functions is the best place to start. Once the is a knowledge of what you are dealing with, one can understand how to best approach this technology.

Adapting as a consumer to the fashion industry's technological development will look much different. Consumers will need to be prepared for a switch in environment and atmosphere in terms of the future of retail storefronts. There is a good chance that technologies will be incorporated into boutiques, malls, etc. These could include robots within customer service roles, to digital smart mirrors or screens that help you select clothing. I also believe that the consumer will have to be aware of all the virtual immersive technologies out there that help with e-commerce.

In terms of fashion designers within the industry specifically, they will need more than ever to find their own niche. To compete with big companies and businesses integrating technology, they will need to find another way to reel in their consumers. They may not have all the money

for the emerging technology coming out in the industry, but they can still offer a level of customization that cannot be offered through bigger companies quite yet. Also, AI and other immersive technologies can easily be used by those who are smaller owned businesses, as this will not be as big an expense as other technologies within the industry.

Conclusion

There is much to be said about technology in the fashion industry, good or bad, but in the end, whether it is welcomed or not, it carves a way to the future. The growth of fashion technology throughout the ages only continues to show how it is consuming our lives. Society continually becomes more and more dependent upon it, day by day. Will a world like the movie Wall-e be ahead of us? A world where robots have more responsibilities and tasks to complete than humans? Or will there come a point and time where technology is acknowledged as another form of addiction that can only in moderation be ok. The fashion industry in particular looks to technology to shape it. Fashion thrives off innovation, growth, and change. That being said, it's all the more a race to see who can come up with the latest, most technologically advanced products. Whether that be smart textiles, automated sewing machines, AI, etc. Based on this research, we have a long way to go before robotics start replacing jobs. The researchers also hopes that with jobs being replaced, many new ones will come of it. These predictions, even based on research, may be wrong. Human presence in fashion could be more than just those programming robots or AI, or VR, etc. If there is one thing that technology cannot do, it is replicating the heart and soul behind the creativity of a living, breathing, human being. There is something uniquely beautiful about human hands creating something that not even the best technology can replace.

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