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Industrial Distribution and Warehousing in Industry 4.0 era: A survey

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Abstract

Industry 4.0, represented by accelerated innovative technologies such as automation, big data and data analysis has started to change the way industries conduct their operations and helped them grow their productivity. It is also causing several irreversible shifts in most of the job structure, exacerbating the rift between workforce capabilities and the expectations of the employers. In this industrial revolution, the ability to anticipate future changes in employment trends and the knowledge to adapt to those changes is a necessity in helping organizations to stay competitive and productive. In other words, companies need to focus on two aspects 1- technical aspects of change (technological advancements and computerization) and 2- the people-related aspects (educating and growing the workforce skills). Limited availability of research on both aspects, specifically educating aspects such as the skills/ capabilities of the workforce and the available job training curriculum, in the industrial distribution industry and especially warehousing has drawn our attention for doing this research.

Regarding Small and Mid-size Enterprises (SME), Koshal et al., 2019 outlines some of the results obtained from a survey comprising sixteen Likert-type questions, gathered from 56 potential respondents from industries such as manufacturing, retail, distribution and third-party organizations. Results show a lack of confidence in executives with regards to employees' preparedness for future technological advancements and the available training. They offered collecting open response data to provide further information on the role educational institutions play in better preparing the future workforce. Furthermore, Xie et al.,2020 provides us with a systematic review of the available literature on how to train and prepare a specific population, warehouse workers, in the face of industry 4.0.

In this work, we have investigated the impact of industry 4.0 on the industrial distribution industry and warehousing, as a heart of the company's operations. We have targeted different Business-to-business sectors located across the USA and conducted interviews with 22 individuals from CEO positions down to warehouse/operations managers. Common technologies identified in these industries included but not limited to, barcoding through Radio Frequency (RF) handlers, Enterprise Resource Planning (ERP), Robotic Process Automation (RPA), followed by the use of machine learning and artificial intelligence for process automations.

According to the previous related works, we will explore our factual interview data on addressing challenges faced by warehouses' managers and employees with regard to using future automation and designing training and educational programs that will address both technical and professional skills of these workforce of the future.

Introduction

Industrial revolutions can bring recession, policy and legislation changes, and technological advancements. These effects have continuously changed the job profiles of the future workforce, introducing new skills and capabilities required for workforce development [1], which may cause significant labor gaps in the job market. Industry 4.0, a phenomenon powered by several forces such as the Internet of Things (IoT), cyber-physical systems, cloud computing, big data, and data analytics have been triggered by the fourth industrial revolution [2]. According to Weyer et al., 2015, Industry 4.0 represents three specifications including intelligent products, intelligent machines, and augmented operators [3]. There are some social benefits as well as drawbacks with this industrial revolution, benefits are defined as having more knowledgeable and motivated employees, offering higher wages, and the use of motivational programs by employers; drawbacks being discussed include job loss, lack of educational competencies, as well as employee's resistance to change [4]. The COVID-19 pandemic is a good illustration of the huge demand for digitalization in an effort to reduce the effects of working remotely due to physical distancing. Fine et al., 2020 reported 195 million job losses in the world job market [5], with an increase of 20% of cybersecurity engineers and 12% of net developers reported by Perry et al., 2020 [6]. Industrial distribution and warehousing are a sector that is constantly being digitized due to the high demand of customers and the request to follow their purchases from the time orders are being placed until the time they are available in their hands. This further proves the need for this sector to become more updated on technological advancements including intelligent logistics of material in the supply chain, automatic material handling using robots and cobots, and advanced Enterprise Resource Planning (ERP).

As we are stepping into a highly computerized future for industry, research needs to investigate the effects of Industry 4.0 on this sector in an effort to prepare workers through identifying the necessary capabilities and the required training. This study has two advantages*: 1- Identifying the challenges and experiences of industrial distribution managers and employees in the Industry 4.0 context. 2- Identifying skills/capabilities and training, seeing fit from their perspective.*

Literature review

Industry 4.0 is being used equivalently as a term to define digitalization which is based on the IoT [7]. To stay profitable and cost-effective, industries have invested heavily in warehouse automation [8]. Although a survey conducted by McKinsey illustrates 50 % of the US institutions have made small to no improvement in adopting Industry 4.0 [9].

Many studies have addressed the influence of Industry 4.0 and the impact of the upcoming technological advancements on the future of industry and the workforce, including deficiencies in workforce skills, lack of appropriate training programs, and educational degrees. For example, Koshal et al., 2019 declared the need for technical training even on small initiatives like voice picking and virtual picking in the warehouses of Small and Mid-size Enterprises (SMEs) [6]. Despite its negative impacts, significant positive impacts of industry 4.0 have been observed through advancements in computer networks and IoT which bring flexibility in the

manufacturing processes, enabling companies to respond to ever-changing customer demands and quality requirements, which may not be achieved otherwise [10].

Through interviews with 41 representatives of German manufacturing plants to understand barriers to implementing Industry 4.0, Müller 2019 found that “employee acceptance” was being mentioned as the most important concern with reasons such as fear of job losses, fear of not being able to comply with new technology due to low skill and no experience [7]. Lack of competencies, cooperation, and strategy were big concerns following employee acceptance. In conclusion, Intensive training and education need to address Industry 4.0 know-how and the required workforce skills. Using a grounded theory approach, Qiu et al., 2021 investigated the impact of Industry 4.0 on 13 participants from industrial distribution and warehousing with12 of them being in management positions [11]. While exploring workers' and managers' perceptions of the industry 4.0, five specific themes emerged from their study, including lack of support at both company and society levels, employees’ preparedness for the upcoming technology, employees’ motivation to learn, perceived technological changes, and required skills/capabilities. Lack of training and the educational opportunities to help adapt the workforce to new technologies was further discussed, which sheds light on the necessity of research to be explored on skills and educational training at industrial distribution and the warehousing level. Moreover, it has been brought up that effective communication channels with higher education institutions would need to be made for warehousing and industrial distribution [12]. Aligned with making these communication channels, new job profiles of the future need to be identified. Defining new job profiles and finding qualified personnel has been challenging for companies [13]. Human resources and human capital management has been challenging in finding and retaining qualified personnel [14]. Lack of digital and analytical skills among employees has been mentioned as the biggest challenge for industrial leaders, which is the result of the fast-paced technological advancements and the not so updated training curriculums. Some applications of Ground theory approach on focus group studies has also been investigated by researchers [24-26] showing the usefulness of this method in providing trustworthy insights regards to human behavior.

With regard to Benešová et al., 2017 , Industry 4.0 focuses more on advancing the workforce's skills, rather than making employees jobless [15]. In a recent study, human skills required for a successful implementation of Industry 4.0 in the manufacturing industry were found in a total of 23 dimensions, identified to be categorized in three criteria cognitive, emotional, and behavioral [16]. Based on a survey with 11 experts of manufacturing organizations and through the Analytic Hierarchy Process (AHP) method for data gathered in extensive literature reviews, cognitive skills were identified as the most important human skill followed by emotional and behavioral skills. Cognitive category is being defined by problem solving, critical thinking and creativity skills that are using existing knowledge to solve new and unidentified problems industry 4.0 brings. In emotional category, this study ranks emotional intelligence, judgment and decision-making skills higher than sustainable mindset and teamwork skills. Moreover, behavioral category puts emphasis on people management skills that makes organizational culture and thus helping employees meet their job expectations through learning and growing within the company.

The list of available competencies and the corresponding teaching methods is extensive and hard to select, for this reason, a Multi-Criteria Decision Making (MCDM) model was introduced

to choose the best teaching methodologies for industry 4.0 [17]. Criteria of their model are selected as available skills and competencies (25 skills) found in literature, alternatives of their model are the teaching methodologies used in engineering courses (18 teaching methods). In this study, they presented an efficient model, namely Educational Test Bed 4.0, to identify the main skills and the corresponding training curriculum in undergraduate engineering courses. Through questionnaires distributed to 7 managers from local companies, weights have been identified for each criterion that shows the relevance of that skill to the training alternatives. Next, using the fuzzy Simple Additive Weight (SAW) method, training alternatives are being analyzed to find the best teaching methodology for industry 4.0. Most effective teaching methodologies identified as Project-Based learning, University/Industry partnership, Multi-disciplinary network, followed by the Flipped classroom.

Three factors defining workforce readiness in logistics organizations within the Industry 4.0 era have been mentioned as organizational, behavioral, and technological factors. Using the AHP method, organizational factors have been identified as the most important factor, with subfactors of "training employee", "top management support", "commitment" and "organizational culture" as the most important ones [18].

Methodology

Study design and procedure

To address the goals of this study, we conducted semi-structured interviews as the primary source of data. Interviewees were chosen using a convenience sampling method with 15 managers and 15 workers, working in the warehousing and industrial distribution sectors with at least 5 years of experience. Through our interview questions, we have explored the opinions, challenges, improvements, and skills of those workers due to Industry 4.0 technologies. Lack of prior systematic knowledge in the effects of Industry 4.0 on industrial distribution and warehousing has been a motivating factor to adopt a grounded theory approach to further analyze the interviews [19]. Having the interviewee's permission, interviews were conducted and recorded using the Zoom application. Zoom automatically transcribes the interviews and provides a text file of the transcribed context. As we found lots of mistakes in automatic Zoom transcriptions, personal transcriptions of the interviews were done by two researchers, requiring us to listen carefully several times to each transcript and correct parts of the Zoom transcripts. Qualitative content analysis, in-depth analysis of the transcribed interviews, were conducted by a researcher, during and after transcriptions of the interviews. While doing a content analysis of the transcripts, we inductively categorized and counted frequencies of answers to each of the questions, thereby defining the themes of our study. For triangulation purposes, we have checked and confirmed our results with related literature reviews [7], [17], [18], [21-22], resulting in identifying necessary skills and training for industry 4.0 technologies currently being used or will be used in the future of industrial distribution and warehousing.

Sample description

To identify challenges facing industrial distribution amidst Industry 4.0 implementation and to provide necessary skill sets and training, thirty representatives from industrial distribution and

warehousing were selected. Sample selection was done selectively, according to the previous experience of the researchers who worked with participants' companies. All the companies are within the US, ranging from industrial distribution industries such as industrial gas and welding supplies distribution to power supplies distribution, industrial distributors of hydraulic, pneumatic, and chemical distribution. Selected companies were located in the states of New York, Illinois, Pennsylvania, Louisiana, Georgia, Florida, Arkansas, and Houston. From 30 selected samples, we were able to interview 13 managers and 9 employees, the rest of them were either not available or not interested in being interviewed. In general, the respondents included 23% female and 77% male. This sample selection prevents the limitations of the previous study [7], as most of the sample was constituted of top managers with almost none of them being employees working in the warehousing sector. This way, our results provide equal insights from workers in different posts and positions in the industrial distribution and warehousing section. Titles included CEO, Vice President, President, and director positions OR warehouse management, operations management, shipping supervisor, and logistics coordinator.

Findings

Through in-depth analysis of the interviews, innovations that are currently planned or are being planned for integration into the industrial distribution and warehousing workplace were identified. Almost 38% of these innovations were identified as process automation using Artificial Intelligence (AI) and Machine Learning (ML), 19% for Robotic Process Automation (RPA), and 14 % for tracking and tracing platforms to meet customers' needs. At least 28% of the responses were upgrading the ERP system which requires using big data and data analytics to eliminate errors in the receiving and the shipping process. Six participants were using "Barcode scanning using RF handlers" through their warehouse management system. Improving the infrastructure of the company was also pointed out by three of the participants which shows the importance of the company's infrastructure such as tools for remote work, use of new lighting systems, new tools/equipment such as forklifts and RF handlers.

Several themes emerged in response to the existence of psychological barriers of Industry 4.0 innovations, such as employees' fear of losing their jobs from upcoming technologies, fear of making mistakes and being replaceable with technologies, insufficient competencies, and the lack of trust in keeping up with expected productivity metrics [23]. As some interviewees said *"people don't like change, fear of making mistakes"*, and another one said *"if you have a machine or some kind of cobat doing all the work for you and you're tasked with basically babysitting the cobot, it is hard to stay focused on that since workers are used to move and handle things manually"*

A variety of skills and training that exist or need to be cultivated in the industrial distribution/ warehouse were brought up by all participants. Skills were identified as:
general project management, computer skills such as Excel, some level of SQL and Tableau, data analyst skills, IT knowledge, critical thinking, problem solving, ability to understand basic instructions, technical and organizational skills, attention to details, continuous improvement mindset of applying process automation in business rules, and being open and eager to accept technology. One manager's response was different from others saying *"Not much change in skills like scanners for barcoding, still going to be some manual process. it's the same skills,*

it's the same capabilities, it's just the process is being developed". And two workers said *"Very basic skills: using RF scanners and learning how to use software such as headsets. Not much skills, training is still required".*

Pieces of training mentioned by participants of the study are industrial manufacturing technician certificates which touch on business-related, lean, quality, and also other topics such as mechanical, electronics, and robotics. Fleet AI training, which involves managing and analyzing big data from both company and customers to help fleet routing optimization using a learnable system (machine learning on big data). Training on being Agile on lean concepts for those with IT or a data analyst background; one manager said: *"ERP experts have to learn more about RPA technologies and to integrate them in ERP"*. Other training needs include different software languages training for RPA development, ERP, and System Application and Products (SAP), health and safety training, hands-on (very basic) training in the warehouse including driving, picking, and packing activities.

Discussions

Employees' lack of preparedness and acceptance to confront Industry 4.0 technologies is one of the most important reasons that caused psychological barriers to Industry 4.0, which has been mentioned in some research studies [7], [11]. Making people comfortable with technology, training them, showing them how technology will accelerate their job performance with less effort were the most highlighted responses in preventing psychological barriers. Surprisingly, companies with a greater number of young employees were not worried about psychological barriers as they believed that younger generations are embracing technology and will adapt to change faster than older ones.

Although managers of our sample study accepted and talked about existing psychological barriers, their first responses were mostly toward economic barriers of finding qualified personnel that they can afford while transitioning from traditional warehouses to automated ones. One top manager said *"I am in a midsize company competing with larger retailers and distribution centers for people because they can pay an extra dollar or dollar and half. As we are automating warehouses, we need to give people professional benefits and status to maintain them, otherwise, we are going to have a whole lot of unemployed people".*

Erol et al., 2016 introduces "Industry 4.0" as a phenomenon that needs increasing workers' creativity, innovation, and communication skills, as automated systems are going to be replaced by day-to-day activities [20]. Upon this, they have defined three categories for workforce competencies: personal, professional, and social competencies. Self-efficacy, personal responsibility, critical thinking, adaptability, strong analytical thinking, and the ability to change (continuous improvement mindset) are examples of the personal competencies which we observed numerous times in this study. Workers in the warehouse were all motivated and welcome to change. Learning more, being profitable and comfortable with technology was being observed in all of their answers. In response to "How motivated are you to expand your knowledge and skills with respect to new technology"? one employee said *"I am extremely motivated with continuous improvement, how we all get better at things that are more profitable*" and the other said *"Personally everything that represents a benefit in the future is worthwhile to*

do an investment of time. So, if I know that X, Y training will have me to maybe do my work in a much more efficient way, will make me more suitable for the future of the job market, I am always open to it." A thought-provoking comment from one manager was *"warehouse workforce are hands-on learners, if technology is slowing them down they become frustrated".*

Examples of professional skills have also been observed throughout this study. Among which are data analysis, problem-solving, basic knowledge of tools and software such as headset and scanners for warehouse barcoding, knowledge of ERP systems especially SAP to facilitate information flow across organizations, IT knowledge, data visualization, computer typing skills, data management skills such as Tableau and SQL and general project management skills. Social competencies that include communication, cooperation, teamwork, and leadership skills were the skill set that was least observed in this study; as one interviewee recommended the importance of group work, saying "being in a competitive group to look for new technologies". Meaning that cooperation and teamwork tend to make you more aware of the future of work and technologies.

Concerning the questions of, is external professional development available for leadership to support them in preparing for shifts in the future of work? Except for one manager that said *"I'm not aware of any, I haven't really seen anything that I'm particularly aware of"*, all other managers believed that they have roundtable discussions and professional teams coming to help their leadership, however, they were not sure if employee collaboration or empowering employees' component for future of work was the topic of those discussions. one said, *'' We do talk a lot about the future of work in the new operations roundtables, the biggest thing that we tend to be all fixated on right now it's just finding Labor*". One manager said *"we've sent a lot of people to different programs throughout the company. Our company has sponsored over 20 individuals to get their master's. Getting accreditations for different types of software's and programs".*

Conclusion

In this study, as in Gupta et al., 2021, we believe that three factors of Organizational, Behavioral, and Technological need to be measured to identify the workforce preparedness in wake of Industry 4.0 [18]. The organization's vision for long-term adoption of Industry 4.0 needs to be addressed which requires top management support and commitment towards developing a culture of process digitalization. Therefore, defining an action plan and preparing top managers would be recommended as the first steps to take in adopting Industry 4.0.

Despite their work, for the behavioral category, we suggest putting the workforce's awareness towards technological innovations as the most important factor followed by building competency and training on functional skills development. The reason is that, if the workforce is not aware of those technological improvements and doesn't see the benefits of having an automated workplace, they will be less likely to be interested in learning and developing skills. Since in this study, we observed that the workforce is interested in taking up to three hours per week of class on their own time if the training is aligned with their goals and helps them improve themselves professionally. Personal and social competencies such as adaptability to change, critical thinking, creativity, cooperation, communication, leadership skills, and thinking at the organization level

could be used to gauge organizational and behavioral factors. With regards to technological factors, there is a need to integrate different platforms of industrial distribution and warehousing systems such as integration of ERP and RPA systems, followed by cloud computing, resource sharing, and data storage. Integrating supplier and customer platforms and real-time location monitoring such as fleet AI management are the other important technological needs of the logistics and industrial distribution sector. Professional competencies such as computer programming/ IT knowledge, digital skills, interdisciplinary knowledge, and problem-solving are needed for the technological category.

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