

Workforce Training and Industry 4.0 Adoption in Warehouses at SMEs

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Abstract

Consumers now have the ability to shop online from a wide variety of products with a shorter order delivery time. This puts a great pressure on the distribution centers and warehouses to increase inventory. Although increased inventory results in a shorter order fulfillment time, it causes a high inventory holding cost. To decrease the cost of operation and remain profitable, industries have invested heavily in warehouse automation. Since the inception of automation and data exchange which is commonly referred to as Industry 4.0, there has been a technological revolution in the warehousing and distribution industry.

Material handling remains one of the essential functions of the distribution, logistics and manufacturing industry. It comprises of different tasks ranging from receiving the raw material to shipping the finished goods inventory. Since material handling is labor intensive and incurs a high cost it is often a top priority when industries consider automation. In general, order picking alone accounts for 55% of the total material handling cost. Automated voice picking, virtual picking of products has the ability to decrease the cost of material handling and are easy to implement with employees who are capable of interacting and managing smart devices.

Since automation is the essence of Industry 4.0, companies are trying to adopt it to bring the costs down for receiving, sorting, picking and putting away products in a warehouse. However, the implementation of Industry 4.0 has been challenging. The main reason behind this has been the lack of readiness among the employees who have not been trained for this technological shift. Generally, data analysis, managing order pickings, and maintaining smart computers are technical requirement to adopt Industry 4.0. Insufficient training in those areas are a prime impediment for small and midsize distributors and manufactures to take a step forward towards Industry 4.0.

The purpose of this research is to understand the preparedness of the implementation of Industry 4.0 among small and midsize enterprises (SMEs). Through this research, skills such as data analysis, inventory auditing, understanding technical drawings of material handling layout were found to be critical for the implementation of Industry 4.0 among many others. A survey comprising sixteen Likert-type questions regarding these skills was drafted and was filled by thirty-three SME managers from sectors like logistics, manufacturing, distribution, and retail.

The responses were statistically analyzed and helped in mapping the skill deficit for the existing workforce. It was found out that 80% of the employers felt their workforce was not well trained for the current and expected future technological advances. It led to the conclusion that to implement even small initiatives like voice picking, virtual picking in the SMEs, necessary technical training is required for the workforce.

Introduction

For any sector, be it manufacturing, distribution, or retail, inventory has always provided the necessary cushion to deal with the uncertainty in demand. The warehousing system is an important business unit within the supply chain that enables all these sectors to respond to demand fluctuations. It encompasses two subsystems; one is inventory planning and control and the other is material handling¹. The inventory planning subsystem is concerned with building orders for the suppliers and dispatching materials to the customer wherein material handling is

more involved with transferring the goods inside the warehouse. There are different functions like labeling, breaking bulk, light assembly, order entry and fulfillment, packaging, pick and pack, and transportation arrangement necessary to carry out material handling activities². All these operations are cost intensive; the most expensive is the pick and pack process which generally constitutes about 50%-75% of the total warehousing cost³. Attempts have been made to reduce this cost and one successful method is warehouse automation. DHL, a global logistics company, claims that a self-driving robot has the ability of reducing the order cycle time by 50% and increasing the picking productivity up to 100%⁴. The definition of automation has changed over the past decade; during the era of Industry 3.0, automation referred to usage of conveyor belts, carousals, hybrid lift trucks gained momentum. These systems were well integrated into warehouse operations across different industries⁵.

However, the definition has changed with the inception of Industry 4.0. Now, automation in warehouses has become synonymous with the usage of automated guided vehicles (AGVs), automated storage and retrieval systems (AS/RS), and conveyORIZED sortation systems⁶. All these systems have increased the agility of the supply chain as it improves productivity by automating the mundane tasks like pick and pack, labeling, and order fulfillment tasks. AGVs and AS/RS also increase the throughput rate for the put-away and picking processes. This causes a reduction of inventory as the warehousing system becomes more responsive to high peaks of unknown demand. With less on-hand inventory, space required to keep finished goods reduces and space utilization increases as it can be used for other warehouse operations. Because of these cost benefits, Industry 4.0, commonly referred to Logistics 4.0 is successfully making its way into different industry sectors. Ecommerce giant Amazon heavily uses these AGVs in their fulfillment facilities to keep up with the erratic customer demand.

Logistics 4.0 is cost efficient and increases the level of service, but the total cost including the initial setup and training cost is high. This total cost is one of the most important qualifying factor which dictates the implementation of warehouse automation⁷. Many argue that the high fixed cost associated with Logistics 4.0 implementation can only be compensated for by exploiting the economies of scale. This applies directly to small and medium-sized enterprises (SMEs). Even to automate the pick and pack process, AS/RS systems are viable for distribution centers (DCs) that have stable demand, high volume of products, and less variability in the shape and size of products⁸. Other argue that SMEs have often proved that automation enhances the product quality, cost reductions and shorter lead time and beat the high setup cost⁹. With the growing economies, SMEs are also thriving, with operations functioning at a higher scale. Warehouse automation has helped to achieve high levels of speed and accuracy in warehouse operations while maintaining an acceptable cost of implementation and operation⁶.

Each organization wants to keep up with the technology but not every organization is sure how to capitalize on this opportunity. Hence, the shift from Industry 3.0 to Industry 4.0 has been rather difficult for SMEs for several reasons. Automated systems in the warehouses were improperly selected, maintained, and it was difficult to reconfigure them to meet the changing business requirement¹⁰. Therefore, to easily navigate through these challenges it is important to have a team whose skillset is aligned with the needs of Industry 4.0. The skill requirement has changed as most of warehouse operations are being physical executed by smart machines i.e. cyber physical systems. Data analysis, interaction with smart devices, packaging of bulk and individual products, are some of the essential job requirements to make an easy transition to Industry 4.0. This paper focuses on one of the major impediments SMEs face to even initiate the

adoption of Industry 4.0 in their warehouses, i.e., talent preparedness. This paper outlines the skillset necessary for Industry 4.0 and workforce readiness to embrace this technological shift.

One of the major findings through this research was that existing workforce is not ready to interface with emerging warehouse technologies and the issue was found to be more pronounced in SMEs. Hence this research will help human resource professionals understand the current workforce inefficiencies and possibly organize training in specific domains like data analysis, material handling, and other necessary skills. This research is useful from the academic perspective as it emphasizes the need to prepare future warehouse personnel and the skillsets lacking in the current workforce that can be incorporated in the curriculum to improve the employability of students and make them “industry ready”. This paper also details some of the challenges that executives from different industries like distribution, manufacturing and retail experiences when they try to implement emerging warehouse technologies. Executives provided solutions on how they see the challenges for their specific organization can be best tackled. Some managers suggest that their firm needs to attract better qualified employees by increasing the salary thresholds. IT solutions were often met with resistance as their workforce lean towards accepting paper-based solutions. Almost 65% of the managers interviewed for this research felt that in order to adopt Industry 4.0, either trained professional should be recruited, or the current workforce must be properly trained.

Literature review

Technological advancements in industry have caused significant changes in the way goods are manufactured and moved. The first industrial revolution happened when mechanical production was enabled by steam and water energy, the second one introduced electricity, and the third one introduced the use of IT and automation for line workers ¹¹. However, the fourth industrial revolution, i.e. Industry 4.0 is unique because there is the exchange of information between people, between people and objects, and between the objects themselves. This information exchange is enabled using a technology known as internet of things (IoT). IoT has been defined as the interconnection of physical objects, by equipping them with sensors, actuators, and a means to connect to the Internet ¹².

Businesses kept on adapting to the ever-changing technology. Initially barcode technology was used to identify, track and trace items. This technology was replaced by electronic tags as it minimized human intervention for tracking and identification purposes. These tags were called as RFID (Radio Frequency Identification). RFID became popular in the logistic industry during the third industrial revolution. Walmart, Target, and the US Department of Defense required suppliers to implement this technology ¹³. With this mandate it became necessary for about 43,000 suppliers for the US Department of Defense to adopt RFID technology. The complete overhaul was to save billions of dollars lost due to lack of information for the material received by the US Armed Forces. It forced thousands of suppliers to keep up with Industry 3.0 and changed the way they did business. As time went by, advancements in Information and Communication Technologies helped reduce the size of computers and improved their portability ¹⁴. This technology allowed for vast amount of data to be stored on small devices. With the inception of Industry 4.0, RFID was not only able to track and identify the items but also store comprehensive work instruction to command and record the production process ¹⁵. This proved to be very useful for a high-resolution supply chain. This RFID technology may soon become

ubiquitous in various sectors including retail, distribution and manufacturing. But a key question is whether the SMEs are ready for this change to take place?

The fourth industrial revolution provides an opportunity for innovation, growth, and competition; but there are risks for some organizations, as the roadmap to Industry 4.0 is filled with different challenges. According to a survey conducted by McKinsey, about 50% of the US Enterprises have made little or no progress towards the adoption of Industry 4.0¹⁶. Companies are worried about their ability to integrate the new technology with the existing one, and about the long-term impact these machines will have on their organization. One of the major implementation barriers noted by many executives in the survey was lack of skilled professionals. The other alternative was to partner with third partner providers. Outsourcing in general, poses several challenges for many companies¹⁷. Lack of social contract, limited commitment, and ill-defined service purchaser/service provider relationships are some of the reason why the idea to work with third party providers adds on to the difficulties faced by organizations.

An analysis carried out by Price Water Cooper (PwC) found that prior to the fourth industrial revolution, vast amounts of generated data was rarely analyzed or used for communication purposes. Data and analytics are some of the core capabilities of Industry 4.0¹⁸. Industry 4.0 has tried to eliminate the simple, routine, repetitive tasks by replacing human labor with machines. It's objective is not to replace human labor but to assist them physically as well as digitally¹⁹. Boston Consulting Group (BCG) cites the example of a German logistics company where the use of augmented reality help workers to locate items and scan bar codes. This increases process efficiency but requires extensive capabilities in IT and digital assistance systems²⁰. According to BCG, industrial job roles have evolved and require job specific dexterity such as working with robots or changing tools on machines. It also requires IT competencies that range from using spreadsheets to advanced analytical knowledge. PwC cited a lack of digital qualification among current employees as the biggest challenge for industrial leaders. The reason behind this shortfall of talent is the imbalance between the rapid shift in technology and a slow update of academic curriculum. Educational institutions have not been able to understand the skills needed for Logistics/Industry 4.0 and hence the demand for a skilled workforce remains unfulfilled.²¹

Henk and Mathias explained the knowledge accumulation gap as outlined in Figure 1, arises as humans are not able to accumulate knowledge over generations, as opposed to machines and computers that are increasingly able to do so. Academic institutions have a significant role to play in the talent pool preparation, and it is not limited to recent graduates, but can be extended to training the current workforce. Different options of continuing education will help them to be requalified and get hired. This will help close the IT skill gap and provide these potential workers with a broader skill set. According to a study carried out by Deloitte, only about 20% of the executives feel that they have a strong understanding of how Industry 4.0 will change their workforce and their organizational structure²².

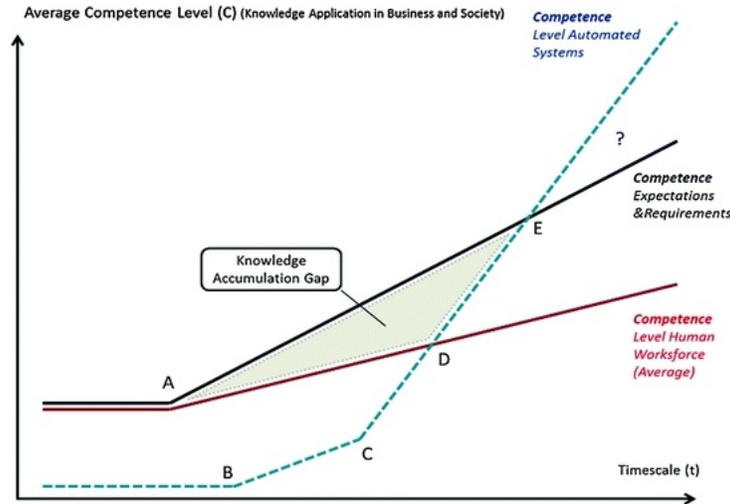


Figure 1: Competence development for human beings and computers ²³

Among different pieces of literature available and discussed so far, many studies were carried out without keeping SMEs as the sole focus of their analysis. Some research did focus on a separate analysis of workforce 4.0 where the importance for skills like collaboration, knowledge of IT, error recovery was analyzed for the SMEs. SMEs have been the backbone of US economy and employment. About 28 million SMEs accounts for more than half of US non-farm GDP ²⁴. In this paper, the objective is to identify the skill gaps in the existing workforce that inhibits industries which are often dependent on warehouses to adopt this new technology.

Methodology

A survey was conducted to determine the future needs of distribution personnel. Internet-based surveys have several advantages: they are cheaper to conduct, yield high response rates, and are faster to fill out which helps in obtaining the required information ²⁵. This survey was drafted to elicit responses from different industries like manufacturing, retail, distribution, and third-party logistics (3PL) service providers. These industries utilize different functions of warehouses to manage their supply chains. Survey was skillfully designed to aid in this research and eleven Likert-type questions were included. The interval for the scale questions was between 1-5 (“1 – Strongly Disagree, 2 – Disagree, 3 – Don’t Know, 4 – Agree, or 5 – Strongly Agree.”). This was done to better capture the variability in the responses without causing information overload for the respondent ²⁶.

The survey was sent to 56 potential respondents; 54 executives participated in the survey. Out of these 54, 31 executives were from the distribution sector, (i.e. approximately 57%), 15 executives (i.e. approximately 27%) belonged to the manufacturing sector. Participants belonging to sectors like 3PL, retail, and service providers accounted for the remaining 16% of the sample. The survey was sent out to firms located across the US, about 12% of the responses came from companies outside the US. The variability in responses make the findings applicable to most organizations who end up using warehouses, irrespective of their location as well as the sector of industry they belong to. About 65% of the executives were from a large organization having more than thousand employees and rest of the population sample were from SMEs. Table 1 provides insights on the designation of the executives who participated in the survey.

Table 1: Distribution of executive's designation who participated in the survey

Designation	Percentage Distribution
Manager	33%
Director	15%
Senior Manager	15%
Analyst / Associate	11%
Vice President	7%
President or CEO	6%
Owner	6%
C Level Executive (CIO, COO, CTO, etc.)	2%
Senior Vice President	2%
No response	4%

Most important task was to draft a survey which captured relevant questions related to workforce readiness for the adoption of Industry 4.0. Questions were created so that all the respondents should possess the same understanding of the meaning of the question²⁷. The questions were designed in such a way that executives could answer willingly and accurately. Questions were structured from the literature review which focused on the skills that should be possessed by employees whose firm is on its path to adopt Industry 4.0. For instance, AGVs used in warehouses generate a lot of data, Industry 4.0 enables the usage of this data to perform condition-based monitoring. Machine learning algorithms help predict the future state of the machine based on the machine parameters, often known as data driven prognostics²⁸. This reduces downtime of the machine and hence increases productivity. In order to leverage this opportunity, employees should be well versed with some of the common data analysis techniques.

Similarly, one of the major concerns for the employers, related to Industry 4.0, is the safety of its employees because of the increased interaction between men and machines²⁹. In order to maintain safety in the workplace and for the implementation of smart machines, it is imperative for employers to be capable of interacting and maintaining smart devices/machines. Skills such as data analysis, inventory auditing, understanding technical drawings of material handling layout, warehouse administration, and the packaging manufactured goods were critical for the implementation of Industry 4.0 among others. Keeping these skills in mind, following questions related to the workforce skill set were included in the survey:

- Ability to perform current duties (Q1)
- Well trained for technological advances expected over the medium term (5-8 years) (Q2)
- Ability to navigate future technological advances in the medium term (5-8 years) without additional training (Q3)
- Ability to use data analysis tools to properly handle order picking and staging needs. (Q4)
- Capability to interact with and maintaining smart computers, devices and objects that collect and share data [industrial internet of things -IIoT] devices (Q5)
- Capable of warehouse administration (task scheduling, record maintenance, and information coordination). (Q6)
- Capable of reading technical drawings of material handling layout designs. (Q7)
- Capability to do inventory control and auditing (Q8)

- Understanding of how to package manufactured goods for individual and bulk shipping (Q9)
- Understanding materials handling component selection, operation, and functionality (Q10)
- Understanding safety equipment and safety procedures (Q11)

In addition to the skillset related questions, participants were asked one open ended question. The open-ended question provides an opportunity to discover some of the information missing from the literature review. It also helps in getting a diverse set of responses from the participants³⁰. For the last question of the survey, executives were asked to share their personal experiences or comments which would help the researchers.

Data analysis

After the data collection, a simple statistical analysis was performed to evaluate the average and variation in each response for the 11 survey questions. The following is a brief description of statistical analysis that was performed during this research. To obtain descriptive statistics like mean, standard deviation, responses were coded on an interval scale between 1 and 5.

Table 2: Mean responses for each survey question with respect to organization size

Organization size	Mean value of the response										
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Large sized	3.70	2.85	2.39	3.21	3.12	3.61	2.85	4.06	4.06	3.76	4.52
Medium sized	3.33	2.33	2.17	2.50	3.33	3.00	1.67	3.67	4.00	4.00	4.50
Small sized	3.23	2.62	2.08	2.69	3.46	3.46	3.08	3.77	3.85	3.69	4.00

Table 2 contains the mean responses for all the survey questions based on organization sizes. In 9 out of the 11 skills listed on the survey, SMEs were found to be less competent as compared to large size organization. In Q2 and Q3 mean response was less than 3 for all organizations and it was even less in the case of SMEs as indicated in figure 2 and figure 3 respectively.

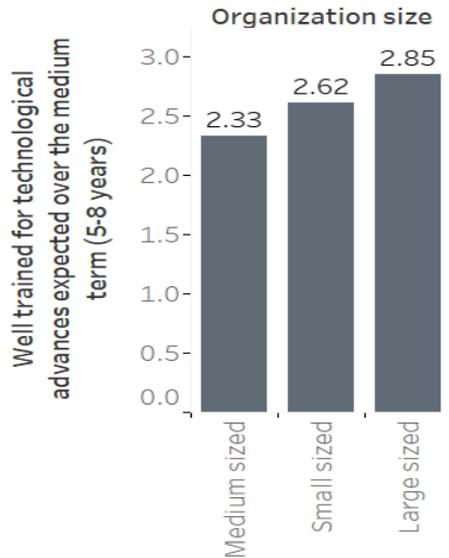


Figure 2: Mean response value for Q2 based on different organization sizes

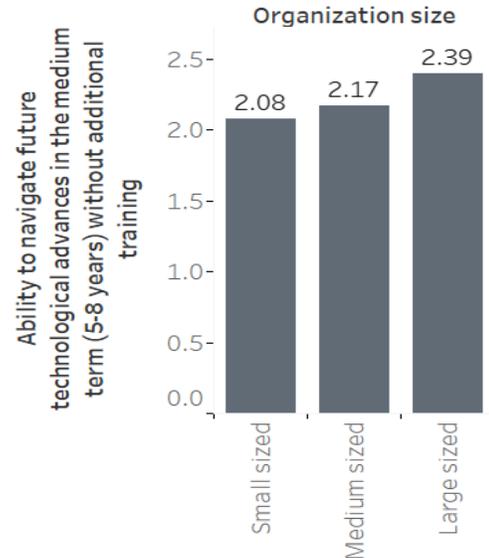


Figure 3: Mean response value for Q3 based on different organization sizes

These results provide strong evidence that employers are not confident about their workforce potential when we talk about skills like data analysis, interacting with smart devices, reading layout designs listed in question 4, 5, and 7 respectively. These skills forms the backbone of Industry 4.0 implementation and responses from question 2 and 3 suggests that without enough training it would difficult for organizations to navigate through future technological advances. Skills like inventory control, using safety equipment, packaging capabilities etc. were a part of current duties of the existing workforce. Employers were confident about these skills and answered positively in question 1, 8, and 11.

Similar analysis was performed but in this analysis, it was further bifurcated on an organization sector basis. Table 3 describes in detail the mean response value according to different sectors where warehouse plays an integral part of operations.

Table 3: Mean responses for each survey question with respect to organization sectors

Organizations	Mean value of responses										
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Distribution	3.61	2.79	2.18	2.93	3.29	3.39	2.68	3.86	4.00	3.71	4.39
Manufacturer	3.38	2.54	2.15	2.77	3.00	3.77	2.69	3.85	4.15	3.77	4.62
Retail distributor	3.25	2.75	2.75	3.00	3.00	3.25	3.00	4.50	4.00	3.75	4.00
3PL	3.00	2.00	1.50	4.00	4.00	4.00	3.00	4.50	4.00	4.00	4.00
Service providers	4.00	2.86	3.00	3.14	3.29	3.57	3.14	4.14	3.71	3.71	4.14

Response analysis about the talent preparedness and skillset was not different from the analysis done with respect to organization size. All the organization sectors were not confident about their

workforce and similar to the previous analysis, this study also revealed that without the essential training, Industry 4.0 adoption looks difficult for all organization sectors as shown in Figure 4 and Figure 5.

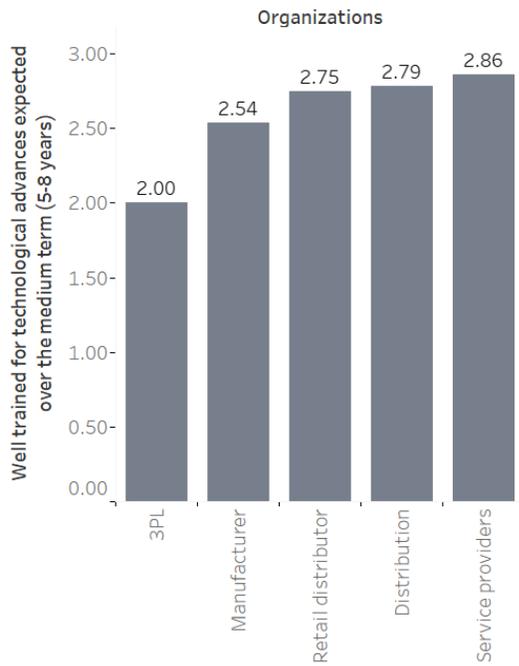


Figure 4: Mean response value for Q2 based on different organization sectors

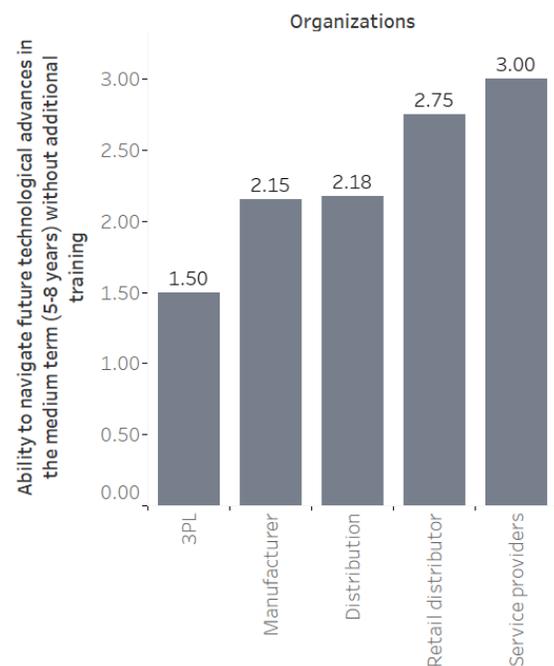


Figure 5: Mean response value for Q3 based on different organization sectors

Conclusions

Technological advances are rapidly changing various industries. This is especially true in manufacturing and distribution. The technologies and processes associated with warehouses are advancing to use some of the key technologies associated with Industry 4.0. These advances include automated guided vehicles (AGVs), automated storage and retrieval systems (AS/RS). The importance of data and communication are increasing. Unfortunately, the literature has noted that most industries are not prepared to fully incorporate and exploit these technological advances. A survey of industry executives associated with various aspects of distribution was carried out. The results of this survey confirm the findings of the extant literature. While these executives are relatively confident in the ability of their workforce to carry out current tasks, they are not confident in the ability of their employees to exploit technologies that are coming online in the next 5-8 years. This lack of confidence is more pronounced among small and medium sized employers than among larger firms. Small and medium firms are also less confident in their ability to use data to manage inventory processes. This could lead to their inability to glean the significant economic benefits associated with this technological advance.

While these results are informative, they should be viewed within some limitations. While the survey population was relatively large, it was not a random sample and the subgroups did not all have statistically significant populations. Future work will attempt to gather data from a larger group of respondents. Future work will also attempt to analyze some of the open response data

using the comparative method^{31, 32} method to provide further insights into how educational institutions can better collaborate with industry to prepare the necessary workforce to fully exploit the technological capabilities of Industry 4.0. Future work will details some explicit educational initiatives related to these goals, particularly aimed at small and medium sized enterprises.

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