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ASSESSMENT OF TECHNICAL SKILLS AND THE USE TOOLS FOR INDUSTRY 4.0: A STUDY IN THE MANUFACTURING SECTOR

AVALIAÇÃO DAS COMPETÊNCIAS TÉCNICAS E O USO DE FERRAMENTAS PARA A INDÚSTRIA 4.0: UM ESTUDO NO SETOR DE MANUFATURA

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Abstract

This paper aims to identify the perception of manufacturing workers regarding the technical skills and use of industry 4.0 tools. For this purpose, we conducted a survey with 392 interviewees It was found that workers are more used to digitalization technologies and the Internet of Things, and are interested in carrying out training, including in the form of Distance Education, in the areas of basic computing, Artificial Intelligence, Cybernetic Security and Integration of Information Systems. These results support actions to improve processes and training within the scope of industry 4.0.
Keywords: Industry 4.0. Technical skills. Enabling Tools. Manufacturing Companies.

Resumo

Este artigo tem como objetivo identificar a percepção dos trabalhadores da indústria em relação às competências técnicas e ao uso das ferramentas da indústria 4.0. Para tanto, realizamos uma pesquisa com 392 entrevistados. Verificou-se que os trabalhadores estão mais habituados às tecnologias de digitalização e à Internet das Coisas, e têm interesse em realizar formação, inclusive na modalidade de Educação a Distância, nas áreas de informática básica, Inteligência Artificial, Segurança Cibernética e Integração de Sistemas de Informação. Esses resultados subsidiam ações de melhoria de processos e treinamentos no âmbito da indústria 4.0.
Palavras-chave: Indústria 4.0. Competências Técnicas. Ferramentas habilitadoras. Empresas de Manufatura.

Introduction

The fourth industrial revolution is affecting the different segments in companies related to existing processes, as well as their work tools (HERMANN et al., 2016). It is a phenomenon called industry 4.0, which is generating transformations, and which has been increasingly widespread in organizations and academia (HERMANN; PENTEK; OTTO, 2016).

The first industrial revolution introduced the mechanization of production through steam engines. In turn, the second was characterized by mass production, division of labor and the use of electrical energy, starting to integrate existing industries based on Taylorism-Fordist models of production. Later, the third encompassed electronics, the automation of production processes and the implementation of information technology. Finally, the fourth and current industrial revolution is based on technologies that make processes more autonomous and intelligent, requiring workers who have skills and competencies to understand, know how to do and want to do their tasks (YANAI et al., 2017).

For Canavarro (2019), although automation stands out in this new form of organization in the context of industry 4.0, workers must be initiative-taking so that they can seek continuous learning. Let et al. (2014) point out that the main barriers and adaptations that industries will face when entering industry 4.0 involve flexibility in production, decentralization of organizational hierarchies and resource efficiency, with an intense focus on sustainability.

In this context, the main challenges that companies will have to face on the path towards the implementation of industry 4.0 are: responding to questions of security and digital protection; standardization of communication interfaces; work processes and organization; availability of skilled workforce; training and professional development; technological base; research and investments (EUROPEAN PARLIAMENT, 2016).

According to Moreira (2020), in the context of industry 4.0, Germany, the United States and China have more advanced strategies for articulating national governments and private agents with the purpose of achieving technological monopolies that will guarantee them greater conditions for capital accumulation.

About the Brazilian reality, the National Confederation of Industry published a Special Survey on industry 4.0 in Brazil. One of the most relevant findings of the survey was the companies' low awareness of the importance of digital technologies for competitiveness (43%). Ignorance is significantly higher among small companies (57%), compared to 32% of large companies, demonstrating the distancing of the Brazilian industry from digital technologies (CNI, 2016).

Since it is related to aspects of information, data, modern technologies and procedure and management, the development of skills for industry 4.0 must have a technical, methodological, social, and personal nature, that is, know-how, linked to relationship methods and particular to the individual (SILVA; KOVALESKI; PAGANI, 2019). In this context, human-machine interactions are complementary, promoting changes in the work profile of employees and resulting in the demand for different skills (DOMBROWSKI; WAGNER, 2014).

King, Fowler and Zeithaml (2002) present a script aimed at identifying organizational competencies, where a list of relevant competencies for the segment in which the company operates must be drawn up and later select those with which the actors internal and external to the company most identify. This approach, in which the participation of internal and external professionals to the company is valued in the identification of organizational competences, is also shared by Gallon, Stillman and Coates (1995) and Boguslauskas and Kvedaraviciene (2009).

With the same aim of identifying organizational skills, Nascimento et al. (2022) when conducting a systematic review of the literature using the data base Web of Science between 2018 and 2022 found that within the scope of industry 4.0, technical skills in the use of enabling technologies such as digitization, Big Data, Internet of Things, virtual reality and augmented reality, robotics and additive manufacturing are becoming increasingly important and necessary for workers in the manufacturing industry in the context of industry 4.0.

Faced with this new scenario, it becomes significant to know the perception of those who are effectively working in industries about the use and importance of developing these technical skills for enabling technologies, arising from the current fourth industrial revolution. Likewise, it is also necessary to analyze how likely industrial workers are to participate in training related to the technologies involved in the skills.

In this search, the research problem raised in this article is: **What is the view that workers in the manufacturing industry have about the enabling tools for technical skills in Industry 4.0?**

In this way, the study is relevant to intensify the debate and demonstrate which technical skills and tools of industry 4.0 are being most used in manufacturing industries located in the Northeast region of Brazil, more specifically in the state of Pernambuco, as well as which courses are aimed to qualification in the face of the new demands of the labor market.

Theoretical frameworks

For the development of the work, it is convenient to make some comments on the challenges of industrial 4.0 in Brazil, the profile of industries in Pernambuco, as well as the competencies for manufacturing processes in industry 4.0 to understand the context in which the research is inserted.

Challenges of industry 4.0 in Brazil

Faced with encouraging prospects, the fourth industrial revolution promises greater operational efficiency, productivity gains, growth, and improved competitiveness, as well as the development of new business models, services, and products (KAGERMANN et al., 2013; KAGERMANN, 2014).

Companies in Europe, the United States and Asia are already adopting elements of industry 4.0, making their factories highly automated and profitable, in addition to being able to provide differentiated and personalized products in a mass production environment (THE BOSTON CONSULTING GROUP, 2015).

On the other hand, Moreira (2020) points out that for Brazil to be able to develop in the face of this scenario, it must face some challenges, related to investments and training, as shown in Table 1.

Table 1: Challenges for Brazil in the world of industry 4.0

Element	Strategy
Public Financing	Via development agencies and development banks, to strategic sectors for the incorporation of industry 4.0 technologies.
Training	Qualified training of specialized workforce at technical, graduate, and postgraduate levels in direct and related areas to work with the interfaces arising from industry 4.0 and its consequences, such as artificial intelligence, blockchain, 3D technology and Big Data.
Technological Environments	Consolidation of technology parks, public laboratories, and science and technology institutes in constant dialogue with universities, research and postgraduate centers and industries, promoting the overflow of academic research into applied and marketable products.

Source: Adapted from Moreira (2020).

Corroborating the theme, FIRJAN (2016) pointed out in research that the implementation of industry 4.0 in the Brazilian scenario brings challenges such as: (I) the construction of strategic policies, government incentives; (II) the meeting of entrepreneurs and managers with a proactive attitude; and (III) technological development and training of professionals, close to the industry.

The development of Industry 4.0 in Brazil depends in every way on greater knowledge on the part of companies of the gains from digitization. Since, with greater access to information, there will be less uncertainty and an effective cultural change in the company (CNI, 2016).

CNI (2016) also points out that the enabling technologies of the current industrial revolution will be the Internet of Things, the Big Data, cloud computing, advanced robotics, artificial intelligence, new materials, and new additive manufacturing technologies (3D printing) and hybrid manufacturing (additive and machining functions on the same machine).

Faced with the challenges that Brazil faces in the face of this new technological reality, the CNI (2016) created an agenda with seven priority dimensions:

1. Applications in production chains and supplier development.
2. Mechanisms to induce the adoption of modern technologies.
3. Technological development.
4. Expansion and improvement of broadband infrastructure.
5. Regulatory aspects.
6. Training of human resources.
7. Institutional articulation.

It is clear, therefore, that the training of professionals for the necessary skills is one of the items recognized as a priority for the development of Industry 4.0 in Brazil. In line with the studies by Spathet al. (2013), who point out the qualification of people as essential in industry 4.0, in view of the necessary human participation, with no total replacement of human labor by artificial intelligence or systems.

Profile of industries in Pernambuco

The state of Pernambuco, located in the Northeast region of Brazil, with 9.7 million inhabitants, is the 7th most populous state in Brazil, has an industrial Gross Domestic Product (GDP) of R$ 33.4 billion, equivalent to 2. 4% of the national industry, employing 273,972 workers in the industry, corresponding to 18% of the state's formal employment and 2.83% of the national industrial workforce. Of the total number of workers, 62.7% have completed at least high school (PORTAL DA INDÚSTRIA, 2020). The main industrial sectors in the state of Pernambuco are shown in Table 2.

Table 2: Industrial sectors of the state of Pernambuco

Sector	Percent share of the sector in the industrial GDP.
Construction	19.5%
Public utility industrial services	16.7%
Foods	13.4%
Auto-vehicles	11.1%
Petroleum products and biofuels	10.0%
chemicals	6.8%
Drinks	5.4%
non-metallic minerals	2.6%
metal products	2.3%
Electric machines and materials	2.1%
rubber and plastic material	2.0%
Metallurgy	1.2%

Pharmacists	1.1%
Cellulose and paper	1.0%
Clothing	0.7%
Furniture	0.7%
Maintenance and Repair	0.6%
Textiles	0.5%
Leather and footwear	0.4%
Extraction of non-metallic minerals	0.4%
printing and reproduction	0.4%
Machines and equipment	0.4%
Other transport equipment	0.3%
miscellaneous products	0.2%
Wood	0.2%

Source: Adapted from the Industry Portal (2020).

The state of Pernambuco also has 12,497 industrial companies, corresponding to 2.7% of the total number of companies operating in the industrial sector in Brazil. Of this amount in the state, 71.1% are classified as micro companies (with up to 9 employees), 23% as small companies (with 10 to 49 employees), 4.8% as medium-sized companies (with 50 to 249 employees) and finally, 1.2% are classified as large companies (with 250 or more employees (PORTAL DA INDÚSTRIA, 2020).

Skills for manufacturing processes in industry 4.0

Competence is the aptitude that an individual, group or organization must mobilize resources and fulfill a task or function in a specific context (STREETS et al., 2005). Dutra (2010) also emphasizes that competence is the ability to transform knowledge and skills into a given delivery.

With a focus on human work in industry 4.0, Hecklau et al. (2016) highlight that the main skills will be of a technical, methodological, social, and personal nature, as shown in Table 3.

Table 3 -Skills for manufacturing processes in industry 4.0

Skills	Description
Technical skills	refer to innovative knowledge, increasingly related to IT, automation programming and data analysis.
The methodological skills	include skills to deal with situations and problems, such as conflict resolution, creativity and decision making.
Personal skills	include individual values, motivations, and attitudes. Among them, you can find flexibility, motivation to learn and ability to work under pressure.
Interpersonal skills	represent social skills and abilities to communicate and cooperate with others, such as networking skills, leadership skills and the ability to work in a team.

Source: Adapted from Hecklau et al. (2016).

On the other hand, Rüßmann et al. (2015) emphasize that with the intensification of the use of technologies integrated into the digital environment, human skills for the development of software and Information Technology (IT) skills will be required by manufacturing workers in industry 4.0.

Gebhardt, Grimm and Neugebauer (2015) highlight the importance of IT skills and interdisciplinary human thinking as basic curriculum elements for people in industry 4.0.

In this context, the Industry Portal (2020) highlights the role of the Nacional Service of Industrial Training (Senai) in professional training that meets the demands of an industry focused on competitiveness, productivity, and innovation. Furthermore, in partnership with the Ministry of Foreign Affairs, Senai has training centers for workforce in 5 countries: the Republic of Cabo Verde, Guinea Bissau, Guatemala, Paraguay, and the Democratic Republic of Timor-Leste. In addition to these, Haiti, Mozambique, Peru, Jamaica, São Tomé, and Príncipe are also developing similar programs.

In the context of the fourth industrial revolution, since 2018 Senai has been advancing in the professional market through the creation of platforms related to enabling tools in industry 4.0 applied to education, technology, and innovation. Within its catalog of courses, 11 are related to industry 4.0, according to the list of improvement courses for industry 4.0 contained in Table 4.

Table 4 -Improvement Courses in Industry 4.0 offered by Senai.

Course / Hours	Course objectives
Advanced Industry: connecting concepts in practice. (40h)	• Understand the concepts of Advanced Industry. • Simulate the insertion of intelligence and connectivity in the manufacturing process of a product based on free platforms and/or open source (SCADABr, Arduino, IDE, Android Applications) and open hardware (Arduino), based on the development of autonomous systems developed in mini production workshops.
Exploring Big Data (56h)	• Understand what it is Big Data and its importance. • Know tools and trends of the Big Data.
Mobile Programming for Internet of Things (40h)	• Develop a mobile application that interacts with other devices, in the concept of Internet of Things. • Knowing the main tools, communication protocols, programming languages and electronic devices used in projects in the area.
Cyber Security (54h)	• Understand cybersecurity concepts. • Know the cyber security challenges in the current world context.
Artificial Intelligence (48h)	• Provide participants with the necessary knowledge of Artificial Intelligence to build an intelligent system and realize applications.
Integration of Intelligent Production Systems (60h)	• Provide participants with knowledge to intelligently integrate production systems that provide supervision of processes and data, generating an increase in the company's productivity and competitiveness.
Applied Collaborative Robotics (60h)	• Work on knowledge about collaborative robotic cell projects, with the aim of integrating robots into a network and with other automation systems.
Cloud computing: Architecture and Applications (48h)	• Work knowledge for deployment and management of cloud computing platform. • Knowing about memory and storage capacity of computers and servers, whether shared and/or interconnected through the Internet.
Applied Additive Manufacturing (48h)	• Know about the additive production process (3D printing), its variables and different applications in the areas of product development.
Development of Applications in Virtual and Augmented Reality (40h)	• Learn about creating simulations and applications in virtual and augmented reality, using Unity3D software and the SDK.
Unraveling Industry 4.0 (20h)	• Introducing Industry 4.0, providing the conceptual basis of enabling technologies that support advanced manufacturing.

Source: Adapted from the Industry Portal (2020).

In this way, the worker's technical skills and qualifications have become the key to success in an innovative factory, where the employee is the protagonist of industry 4.0, motivating governments, educational institutions, and industries to collaborate in training and development of the workforce. (GEHRKE et al., 2015).

Methodological procedures

Bearing in mind the evaluation of the perception of workers in the manufacturing industry in Pernambuco/Northeast of Brazil on the use of the main technologies related to technical competences to work in the 4.0 industry, in terms of its nature, this is applied research, being descriptive in terms of your objective. Gil (1996, p. 46) teaches that “descriptive research aims at describing the characteristics of a given population or phenomenon, and aims to survey the opinions, attitudes and beliefs of a population”. Furthermore, in the quest to obtain information about the opinions of workers through a questionnaire, the research method is a quantitative approach, the type of Survey.

To meet the study proposal, the research construct was elaborated, which, according to Cooper and Schindler (2016), can be defined as an abstract idea created especially for a given study. The research construct is presented in Table 5. This instrument was the basis for the elaboration of the assertions applied to workers in the manufacturing industries of Pernambuco.

Table 5: construct gives Search.

2nd section	Category	Researched aspect	Theoretical basis
	Technical Skills for Industry 4.0	Digitization: Application 1 (A1): To replace physical documents with digital ones. Application 2 (A2): For cloud storage (Google Drive, Dropbox etc.) Application 3 (A3): For dissemination by digital marketing.	Avila-Gutierrez et al. (2021); Baethge-Kinsky (2020); Carlsson et al. (2022); Chong et al. (2018); Cimini et al. (2020); Kaasinen et al. (2021); Fight et al. (2020); Maliszewska and Kłos (2019); Marinas and hasl. (2021); Pattanapairoj et al. (2021); Rangraz and Pareto (2021); Romero et al. (2021); Spöttl e Windelband (2021); Placierska et al. (2021); Sun et al. (2018); Terkowsky et al. (2019).
		Big Data: Application 4 (A4): To collect data over time and make decisions (Google Analytics, Clear Story Data e IBM Watson Analytics).	
		Internet of Things: Application 5 (A5): To replace labor in repetitive processes. Application 6 (A6): To reduce urgent maintenance on machines. Application 7 (A7): To monitor equipment productivity. Application 8 (A8): To monitor processes.	
		Virtual Reality and Augmented Reality: Application 9 (A9): For training and simulations in factories. Application 10 (A10): For equipment maintenance. Application 11 (A11): For production remote control.	
		robotics: Application 12 (A12): For automating tasks.	
		Additive Manufacturing: Application 13 (A13): For handling a 3D printer.	
3rd section	Impacts on professional performance	Opinion regarding the need to take courses or training focused on the use of technologies from industry 4.0 for better professional performance.	Hermann et al., (2015), WEF (2016) and Gehrke et al. (2015).
	Interest in training offers	Opinion regarding the interest in holding courses aimed at Industry 4.0.	Industry Portal (2022)

Source: Adapted from Birth et al. (2022)

To collect the responses was used a structured electronic questionnaire with multiple-choice answers and in the form of a five- and seven-level Likert scale to assess the degree of agreement or disagreement with the statement, subdivided into three sections: (1) characterization of the profile; (2) degree of use and knowledge about technologies related to technical skills for industry 4.0; (3) willingness to participate in courses and training focused on the technologies in question.

The questionnaire was generated by the free tool online Google Forms. Through this system, responses were automatically submitted to the researchers.

A pre-test was conducted with three employees who work at the auxiliary, analyst, and coordination levels in the manufacturing industry of Pernambuco to validate the electronic questionnaire. The pre-test was conducted between 08/18/2022 and 08/24/2022.

Once the validation was completed, the survey was conducted with workers in the manufacturing industry based in the state of Pernambuco. The dissemination of the research to the target audience was conducted through the publication of a link on social networks (LinkedIn, Instagram, and Facebook), sending a link to industry groups and the National Service of Industrial Training (Senai) on WhatsApp and face-to-face dissemination in some industries in the Metropolitan Region of Recife. The questionnaire was available from August 26, 2022, on January 31, 2023, obtaining a probabilistic sample of 392 valid respondents, collected for convenience.

For data analysis, the answers related to the objective questions were exported to Excel and imported to SPSS with the aim of processing and carrying out descriptive statistics: percentages, frequency, mean, mode, median and factor analysis, performing a quantitative analysis for this, data the fact that the opinions of workers in manufacturing industries operating in the state of Pernambuco/Northeast Brazil were statistically quantified.

Results

In this chapter, information is presented regarding the perception of workers in manufacturing industries, based in the state of Pernambuco/Northeast of Brazil, regarding technical skills and use of industry 4.0 tools, in terms of profile characterization, degree of use and knowledge about technologies related to technical skills for industry 4.0 and willingness to participate in courses and training focused on the technologies in question.

Profile of respondents

To outline a profile of the interviewees, information was collected on age group, gender, level of education, time working in the industry, industrial sector, company size, position, and the city in the state of Pernambuco in which the interviewed public works, according to shown in Table 6.

Table 6: Profile of respondents

Feature	Frequency	percentage
Age		
18 to 25 years old	139	35.5%
26 to 30 years old	63	16.1%
31 to 35 years old	51	13.0%
36 to 40 years old	68	17.3%
41 to 45 years old	31	7.9%
46 to 50 years old	32	8.2%
51 to 55 years old	8	2.0%
Gender		
Masculine	236	60.2%
Feminine	154	39.3%
I do not wish to declare	2	0.5%
Education level		
Elementary Complete	2	0.5%
Medium Incomplete	2	0.5%
High School Complete	66	16.8%
Incomplete Technician	14	3.6%
Complete Technician	96	24.5%
Incomplete graduation	83	21.2%
Completed graduation	94	24.0%
Specialization/MBA Incomplete	7	1.8%

Specialization/Full MBA	23	5.9%
Incomplete Master's/Doctorate	0	0.0%
Full Master's/Doctorate	5	1.3%
Time working in the industry		
Less than 1 year	124	31.6%
Between 1 and 5 years	102	26.0%
Between 5 and 10 years	79	20.2%
Over 10 years	87	22.2%
Industrial sector		
Foods	142	36.2%
Drinks	63	16.1%
Rubber and Plastic Material	12	3.1%
Construction	25	6.4%
Derived from Petroleum and Biofuel	4	1.0%
Pharmaceutical	13	3.3%
Electric Machines and Materials	6	1.5%
Furniture	11	2.8%
chemicals	14	3.6%
Public Utility Industrial Services	34	8.7%
Auto-vehicles	7	1.8%
Clothing	25	6.4%
Metallurgical	12	3.1%
Other Sectors	24	6.0%
Company size		
Microenterprise (up to 19 employees)	71	18.1%
Small Company (from 20 to 99 employees)	79	20.1%
Medium Size (from 100 to 499 employees)	108	27.6%
Large Size (more than 500 employees)	134	34.2%
Office		
Assistant / Assistant / Technician	253	64.5%
Analyst	93	23.7%
Supervisor / Coordinator	32	8.2%
Manager / Director / President	14	3.6%

When analyzing the age group profile of the public interviewed in the survey, the majority is between 18 and 25 years old with 139 respondents, representing 35.5% of the sample. Followed by the public aged 36 to 40 with 68 respondents, representing 17.3% of the sample. The results demonstrate greater adherence of the young public. As for gender, most of the public surveyed is composed of males with 236 respondents and a relevant percentage of 60.2%. While the self-declared female respondents total exactly 154 respondents, equivalent to 39.3%.

In relation to the level of education, the result is quite balanced, with a majority of 24.5% having a Complete Technician, which corresponds to 96 respondents, followed by 24% with a Complete Graduation, which corresponds to 94 respondents. Among those interviewed, most of the public is between Technical and Undergraduate education in the complete categories.

About the time working in the industry, 124 respondents reported that they have been working in the industry for less than 1 year, which represents 31.6% of the sample. 102 of them are between 1 to 5 years whose percentage is 26%. The result demonstrates that most respondents are recently working in the industry.

Regarding the industrial sector, the ones with the most significant values were the food sector which had the highest volume of respondents with a quantitative result of 142, which represents 36.2% of the sample, followed by the beverage sector with 63 respondents which represents 16.1%. It is noteworthy that the 13 industrial sectors with the highest percentage shares of the sector in the industrial GDP of the state of Pernambuco, present in the Table 1, presented respondents. However, the sample shows greater adherence of the public that works in the food sector.

About the size of the company, 134 reported composing teams from large companies with a percentage of 34.2%, then 108 are from medium-sized industries, representing 27.6% of the sample, 79 are from small-sized industries, representing 20.1 % and finally 71 respondents are from micro-enterprises, which represents 18.1%. A balanced percentage, but with greater emphasis on respondents who work in large industries.

Regarding the position, 253 respondents claim to be an Assistant, Assistant or Technician, which represents 64.5%, followed by 93 respondents who function as Analysts, representing a percentage of 23.7%. Having the sample covered all levels, especially the operational level positions in the industries.

Regarding the city where they work, the survey received the participation of workers who work in 28 cities in the state of Pernambuco, with the most relevant being the 116 respondents who work in the State Capital, Recife, which represents 29.6% of the sample.

Considering the research with a non-probabilistic sample and for convenience, the numbers show greater adherence of the public aged 18 to 25 years, male, with Complete Technical training, inserted in the industry for less than 1 year, with greater activity in the sector of food, in large industries with more than 500 employees, working as Auxiliary, Assistant or Technician, in the city of Recife/PE.

Technical skills for industry 4.0

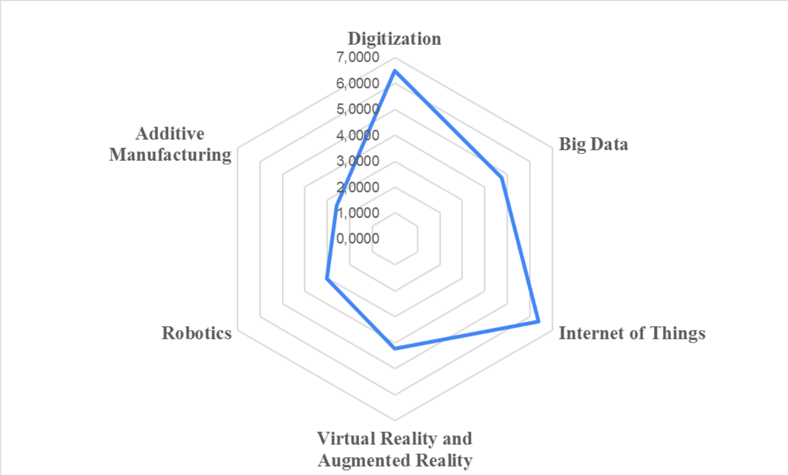
The Technical Skills for industry 4.0 were analyzed through the use and applicability of digitization technologies by respondents, Big Data, Internet of Things, Virtual Reality and Augmented Reality, Robotics and Additive Manufacturing, through a Likert scale that allowed the variability of levels between 1 in situations where the respondent totally disagrees that he uses or applies the technology and 7 indicating that he agrees fully making use and application of technology in your industry.

Measuring the degree of applicability of the technology provides an indication of the attributes in which respondents have greater and lesser understanding of importance and use, guiding suggestions for priority qualifications to expand preparation to work in Industry 4.0. In this context, the arithmetic mean, mode and median of the answers in the technological categories will numerically represent the level of applicability of the technologies that enable technical competences for industry 4.0 (I4.0) and will be established in Table 7, complemented by the radar graph of the averages for the referred technologies, as shown in Figure 1.

Table 7: Mean, mode and median of technology categories for I4.0

Technological Categories	Average	Fashion	Median
Digitization	6.4923	7	7
Big Data	4.7385	7	6
Internet of Things	6.3823	7	7
Virtual Reality and Augmented Reality	4.2321	7	5
Robotics	3.0357	1	1
Additive Manufacturing	2.6020	1	1

Figure 1: Radar graph of the averages for the technological categories of I4.0



In general, the comparison of the results of the technological categories visualized in Table 3 and in Figure 1 indicate that the respondents are more used to digitalization technologies with the highest average (6.4923), mode (7) and median (7), as well as the Internet of Things with the second highest average (6.3823), mode (7) and median (7), confirming that the use and application of these technologies in their work environment is more plausible. While the technologies of Big Data and Virtual Reality and Augmented Reality presented similar values in relation to their average (4.7385 and 4.2321, respectively), mode (7) and median (6 and 5, respectively), indicating a certain use of technologies, but with potential of better development.

On the other hand, the Robotics and Additive Manufacturing technologies obtained the lowest mean values, 3.0357 and 2.6020, respectively, as well as the mode and median value of 1, completely disagreeing with the use and application in their industrial work environment.

Therefore, the results presented are encouraging as they point to a direction of Pernambuco industries towards technologies arising from the fourth industrial revolution, as highlighted by studies by Chon get al, (2018), Baethge-Kinsky (2020), Pattanapairoj et al. (2021), Marinas et al. (2021), Avila-Gutierrez et al. (2021).et al. (2021), Carlsson et al. (2022) that reinforce the need for a basic understanding of I4.0 technologies, such as: digitization, internet of things, robotics and big data, combined with the ability to communicate and work as a team so that industries can adapt to this new reality.

In this context, we also sought to detail the result of the mean, mode and median of each application in the set of six technologies in evidence in this study, presented below:

Digitization

In addition to the physical and virtual resources necessary for the transition to industry 4.0, workers in manufacturing companies must have specific digital skills for new advanced production technologies (MARINAS et al., 2021). Table 8 presents the result of mean, mode and median for the application of digitization technology listed by the authors:

Table 8: Mean, mode and median for digitization technology.

Applications		Average	Fashion	Median
(A1)	I think it is necessary to seek knowledge about digital technologies and apply them in the work environment.	6.8367	7	7
	I increasingly replace the use of physical documents with virtual documents in my work.	6.4362	7	7
(A2)	I have the ability to create, edit and publish content in a virtual environment.	6.2066	7	7
	I use providers to store my work files in the cloud (Example: Google Drive, Dropbox etc.).	6.4439	7	7
(A3)	I use digital marketing tools to access and disseminate information	6.3827	7	7

	about my work (Example: email, WhatsApp, intranet, internet, etc.).			
	I find it easy to navigate, search and understand subjects related to my work in the virtual environment (Example: email, WhatsApp, videos, and social networks).	6.6480	7	7

In view of the data obtained in the survey, it is observed that the digitalization technology is the most present in the work environment of the respondents who participated in this sample, since Table 4 shows that the average was above 6.2 and well close to 7, referring to the options "partially agree" and "totally agree", leading to the thought that participants are aware of the need to seek knowledge about digital technologies and apply them in the work environment, which obtained the highest average (6 ,8367). Similarly, another topic related to the ease of navigating, researching, and understanding subjects related to my work in the virtual environment (Example: e-mail, WhatsApp, videos, and social networks) obtained the second highest average (6.6480)

From a more practical perspective of the work, very high average values (6.4439) were pointed out for the use of providers for storing work files in the cloud (Example: Google Drive, Dropbox etc.) and an average of 6.3827 for the use of digital marketing tools to access and disseminate information about your work (Example: email, WhatsApp, intranet, internet, etc.). Values that may have been influenced by the increase in remote work and adaptation of companies during the most critical period of the Covid-19 pandemic. However, the ability to create, edit and publish content in a virtual environment had the lowest average of the group (6.2066), pointing out that training is still needed in this regard for greater security in digitalization technology.

The mode and median for all applications were 7, which corresponds to "I totally agree", demonstrating that among the sample represented in this research, the most marked option is the one that is exactly in the middle of a data set, when they are ordered, is the one where respondents realize the importance of using digitization technology in their work environment. Thus, respondents claim to use digitization tools, but do not feel empowered to effectively use them for creation.

Marinas et al. (2021) when estimating standards both for the adoption of new technologies in European manufacturing companies, and for the readiness of human resources for new technological challenges, pointed out that Romania is lagging in the adoption of industry 4.0 technologies compared to other countries Europe, a reality that can be considered close to that of Brazil. However, they also pointed out in their studies that less developed countries have the chance to skip certain stages of the transition to industry 4.0, promoting smart policies to take advantage of their digitalization potential.

Big data

Park et al. (2017), conceptualize Big Data as a set of data processed with analytical technology, including unstructured data and without compatible formats, such as social network data, blog, news, and others. All this information can contribute to strategic planning and decision making in companies. Table 9 presents the result of mean, mode and median for the application of the technology of Big Data Listed by the authors:

Table 9: Mean, mode, and median for technology Big Data

applications		Average	Fashion	Median
(A4)	In my daily activity I use tools to collect data over time and make decisions for the best performance of my work (Example: Google Analytics, Clearstory Data, and IBM Watson Analytics).	3.9515	1	4
	I realize that the rise of virtual work requires increased security to protect personal data and privacy.	5.5255	7	7

However, the research data shown in Table 5 reveal that this technology is still not being used effectively, with an average of 3.9515 referring to the options "indifferent (neutral)" and "disagree" for use in the daily activity of tools to collect data over time and make decisions for better job performance

(Example: Google Analytics, Clearstory Data e IBM Watson Analytics). Furthermore, the mode for this same application was 1, referring to "totally disagree" and the median was 4, corresponding to neutrality.

Therefore, the perception of respondents in relation to greater security to protect personal data and privacy in the face of the increase in virtual work presented an average of 5.5255, within the option "I agree," as well as an average and median value of 7, representing a "totally agree". Therefore, the respondents are aware of the large amount of data involved in the company's operations and the importance of its security, however, they still do not use the tools of the Big Data in everyday work.

Corroborating the theme, the results of the study by Pattanapairoj et al. (2021) reveal that the first most important indicators for the employment of graduates are knowledge of the industry 4.0 strategy and the knowledge that students must have developed is the collaboration of humans and robots, Big Data Analytics, real-time data usage and database decision making.

Internet of things

According to Magrani (2018), the Internet of Things (IoT) is the environment of physical objects connected to the internet, through embedded sensors, creating an omnipresent computational system, introducing functional resources, and facilitating the daily lives of people and companies. Table 10 presents the result of mean, mode and median for the application of Internet of Things technology listed by the authors:

Table 10: Mean, mode and median for IoT technology.

Applications		Average	Fashion	Median
(A5)	I believe that the integration of Artificial Intelligence in my work environment improves my results.	6.4821	7	7
	I observe repetitive tasks in my work that could be facilitated with the use of technology.	6.5995	7	7
(A6)	I observe in my work that the use of a system would reduce urgent maintenance on the machines.	6.3597	7	7
	I want to increase the use of technological tools to improve my professional skills.	6.6378	7	7
(A7)	In my work, I use a system to monitor the productivity of equipment.	5.9541	7	7
	I need to improve my knowledge and use of technology to apply it in my work environment.	6.5612	7	7
(A8)	I have all my activities monitored by a system.	5.7449	7	7
	I believe that technology can promote the process improvements I need in my work environment.	6.7194	7	7

The research revealed that the Internet of Things (IoT) technology is the second most present technology in the industries of the respondents who participated in this sample, since Table 6 shows that the average was between 5.7 and 6.7, with between the "agree" and "totally agree" options, demonstrating that respondents believe that technology can promote improvements in processes that they need in the work environment, which obtained the highest average (6.7194). Very similar in mean values, other topics related to perception and desire also obtained an average close to the maximum value of 7, which corresponds to "I totally agree", such as the desire to increase the use of technological tools to improve professional skills (6.6378); observes repetitive tasks at work that could be facilitated with the use of technology (6.5995); need to improve knowledge and use of technology to apply it in the work environment (6.5612); believes that the integration of Artificial Intelligence in the work environment improves its results (6.4821); notes in the work that the use of a system would reduce urgent maintenance on machines (6.3597).

On the other hand, the practical aspects of this technology showed a sharp drop in the value of the averages, where the use of a system at work to monitor the productivity of the equipment obtained an average of 5.9541 and having all activities monitored by a system, an average of 5.7449.

The mode and median for all applications were 7, which corresponds to "I totally agree", showing that, despite the perception that respondents have of the importance of such technology, it is still Training work is needed in this regard for greater integration between physical objects connected to the internet for greater productivity, according to studies presented by SUN et al. (2018) who analyzed the implementation of an indoor location system using devices Bluetooth on the factory floor as part of an enterprise IoT platform, enabling better location of workers and machines.

Virtual reality and augmented reality

Virtual Reality (VR) is defined by Jerald (2015) as a computationally generated digital environment that can be interactively experienced as if it were real. In turn, Augmented Reality (AR) is a system that supplements the real world with virtual objects generated by computer, seeming to coexist in the same space, applying to all the senses, including hearing, touch, and smell. The main goal of VR is to use technology to replace reality whereas the main goal of AR is to improve reality (TORI et al., 2020).

Table 11 presents the result of mean, mode and median for the application of Virtual Reality and Augmented Reality technology listed by the authors:

Table 11: Mean, mode and median for Virtual Reality and Augmented Reality technology.

applications		Average	Fashion	Median
(A9)	I am prepared for increased virtual work, for example with virtual glasses.	4.1122	7	4
	I often conduct, including in the last year, training, and simulations at the factory, with virtual reality glasses.	2.6556	1	1
(A10)	I use augmented reality equipment to perform equipment maintenance.	2.8087	1	1
	I believe that my work environment needs qualification and training to increase knowledge of technologies.	5.3929	7	7
(A11)	I can conduct my activity remotely (outside the company) through technology.	4.4719	7	6
	I believe that it is necessary to implement new and/or improve existing technological tools within my work environment to conduct remote work.	5.9515	7	7

Kaasinen et al. (2021) point to a new profile of industrial workers in the context of I4.0, the "Operator 4.0", who are intelligent and skilled operators of the future who find in handling augmented reality and virtual reality the means for training and operation virtual factories. However, the survey data shown in Table 7 once again show that the respondents have a perception of the benefits of these technologies for their work, but there is still no effective exploration.

The highest average for the application of Virtual Reality and Augmented Reality technologies was 5.9515, referring to the belief that it is necessary to implement new and/or improve existing technological tools within the work environment to perform remote work. It is noticed that although the most used technology is digitalization, which was possibly driven by remote work during the pandemic period, there is still room for the development of new tools. In this same line of thought, the belief that the work environment needs qualification and training to increase knowledge of technologies presented an average of 5.3929. For both applications, the mode and the median were 7, corresponding to the agreement with what the respondents pointed out.

Still on the perspective of remote work, the possibility of performing the professional activity remotely (outside the company) through technology presented an average of4.4719, referring to the neutrality option, but its mode and median presented values of 7 and 6, respectively, pointing to a certain agreement with the remote work format, which is also evident, when analyzing the data in detail, that such values are indicated by respondents who exercise their functions in administrative activities within industries.

Another point to be highlighted in the data analysis refers to the use of virtual glasses, in which the respondents indicated an average of 4,1122 as to being prepared for increased virtual work, such as, for example, with virtual glasses, representing the option of "indifference (neutrality)", with the median following the same value group (4). However, the mode of this application reached a value of 7, related more to the use of these glasses in personal and leisure activities than in professional practice.

Corroborating with the theme, Sun et al. (2018) very appropriately highlighted in their studies on competences for I4.0 the use of Smart Glasses that render good portability, sensor technology, connectivity, and operational handling, being able to provide information, instructions, and tutorials on a head-mounted monitor while the employee can keep his hands on the job. However, respondents had an average of 2.8087 and 2.6556, for the use of augmented reality equipment to conduct equipment maintenance and the frequent performance, including in the last year, of training and simulations at the factory, with virtual reality glasses, respectively, representing the "partially disagree" option. Taking the value of 1 as the mode and median of these practical applications of virtual glasses, representing the "totally disagree" option.

In view of the above, one can see the potential that Virtual Reality and Augmented Reality have in the Pernambuco industries participating in this sample, which, when performing a detailed analysis of the data, it was observed that the use of virtual glasses is stronger in the Automotive Vehicle industries, which represented only 1.8% of the total number of respondents in this survey, thus showing potential use for other industrial sectors.

Robotics

Autonomous, intelligent or collaborative robots have already been used long before the arrival of the fourth industrial revolution in some industries to perform simple or complex tasks, however, after the arrival of industry 4.0, they have become more independent, cooperative and flexible, having an exponential increase in its abilities over its predecessors, even making decisions without human intervention (ALBERTIN et al., 2017). Table 12 presents the result of mean, mode and median for the application of Robotics technology listed by the authors:

Table 12: Mean, mode and median for robotics technology.

applications		Average	Fashion	Median
(A12)	I conduct my tasks together with robots.	2.5255	1	1
	I observe that my company uses robots to perform some tasks.	3.5459	1	3

Source: The authors (2023).

In line with the results obtained in Virtual Reality and Augmented Reality technology, Robotics presented values at much lower levels, according to data presented in Table 8. In this aspect, the performance of tasks together with robots presented an average of2.5255, which represents the option "partially disagree", similarly, the mode and median presented the value 1, which represents the option "completely disagree". With such characteristics, the perception that the company where he works uses robots to perform some tasks presented a higher average (3.5459), even so, it remained in the "disagree" option, as did the median value of 3. Finally, the mode followed the trend of this technology with a value of 1.

In this way, robotics technology, despite being derived from other industrial revolutions, still has potential for development and application in the industries participating in this research. As pointed out by Rangraz and Pareto (2021), who reported in their studies a transformation process for industry 4.0 that was conducted in a small manufacturing company in Sweden, where automated assembly lines, industrial robots, codes, and algorithms replaced the previous manual configuration, highlighting that today's small factories need to consider industry 4.0, especially robotics technology, to remain competitive in the market.

Additive Manufacturing

Additive manufacturing is a term used to refer to the technologies used in the manufacture of physical objects through data sources created in computational design systems, not being restricted simply to the production of models, but also to the final manufacture of products (GIORDANO; ZANCU; RODRIGUES, 2016). Table 9 presents the result of mean, mode and median for the application of Additive Manufacturing technology listed by the authors:

Table 9: Mean, mode and median for Additive Manufacturing technology.

Applications		Average	Fashion	Median
(A13)	I use 3D printer in my professional activity.	2.1811	1	1
	I realize that a 3D printer would help in the execution of my work.	3.0230	1	1

Source: The authors (2023).

Such technologies showed the lowest values of the research in the analysis of applications, as shown in Table 9, where the average use of the 3D printer in the professional activities of the respondents presented the value of 2.1811, representing the option "partially disagree", equitably, the perception that a 3D printer would assist in the execution of the work presented an average of 3.0230, representing the “disagree” option.

Furthermore, the mode and median of this technology presented the value 1, representing the option “totally disagree”. Evidencing, therefore, that despite all the potential of this technology, according to studies by Gao et al. (2015) who point out that additive manufacturing is prepared to cause a revolution in the way products are designed, manufactured, and distributed to end users, in the industries participating in the study its potential has not yet been explored.

On these aspects, Romero et al. (2021) pointed out the need for training also in Educational Institutions for the use of Additive Manufacturing in the wood industry sector in 9 different countries of the European Union (Bulgaria, France, Germany, Italy, Slovenia, Spain, Sweden, Poland and United Kingdom United).

Factor Analysis

Using the factorial analysis technique, the existence of dimensions underlying the variables that could synthesize, summarize the information contained therein was examined, giving the analysis or interpretation of the sample data a better understanding. For this, factor analysis was performed by calculating the correlations between the technology application variables, as can be seen in Table 10.

Table 10: Correlation Matrix

Variables	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
A1	1	.260	.292	-.113	.340	.281	.104	.093	-.048	-.124	-.046	-.113	-.144
A2	.260	1	.486	.092	.400	.403	.419	.381	-.028	-.040	.014	-.052	.006
A3	.292	.486	1	-.008	.310	.493	.352	.312	.020	-.064	-.002	-.037	-.028
A4	-.113	.092	-.008	1	-.047	.013	-.039	-.051	.650	.428	.389	.426	.439
A5	.340	.400	.310	-.047	1	.395	.281	.217	.002	-.110	.128	-.065	.001
A6	.281	.403	.493	.013	.395	1	.412	.359	.007	-.057	-.039	-.024	-.034

A7	.104	.419	.352	-.039	.281	.412	1	.676	-.006	.130	.031	.058	.099
A8	.093	.381	.312	-.051	.217	.359	.676	1	.029	.148	.058	.087	.109
A9	-.048	-.028	.020	.650	.002	.007	-.006	.029	1	.479	.425	.417	.387
A10	-.124	-.040	-.064	.428	-.110	-.057	.130	.148	.479	1	.356	.640	.662
A11	-.046	.014	-.002	.389	.128	-.039	.031	.058	.425	.356	1	.319	.367
A12	-.113	-.052	-.037	.426	-.065	-.024	.058	.087	.417	.640	.319	1	.786
A13	-.144	.006	-.028	.439	.001	-.034	.099	.109	.387	.662	.367	.786	1

Source: The authors (2023).

The results suggest that the data for this factor analysis have a fit-to-data fit (Kaiser-Meyer-Olkin Measure of Sampling Adequacy - KMO = 0.830) of 83% on a scale of 0 to 100%. Continuing with the analysis, it is noted that the highest correlation coefficients were between the variables of Application 12 (A12): For automating tasks with Application 13 (A13): For handling a 3D printer, with 0.786; from Application 7 (A7): To monitor equipment productivity with Application 8 (A8): To monitor processes, with 0.676; and Application 10 (A10): For maintenance of equipment with the Application 13 (A13): For handling a 3D printer, with 0.662.

Furthermore, the analysis of the relationship between the applications of technologies and the component to which they are linked was carried out, in the following sequence: 1 – Totally Disagree, 2 – Partially Disagree, 3 – Disagree, 4 – Indifferent (neutral), 5 – Agree, 6 – Partially Agree, 7 – Totally Agree, shown in Table 11.

Table 11: Pattern Matrix

Application	Component						
	1	2	3	4	5	6	7
A3. I find it easy to navigate, search and understand subjects related to my work in the virtual environment (Example: email, WhatsApp, videos, and social networks).	.842						
A2. I use providers to store my work files in the cloud (Example: Google Drive, Dropbox etc.).	.808						
A3. I use digital marketing tools to access and disseminate information about my work (Example: email, WhatsApp, intranet, internet, etc.).	.769						
A6. I observe in my work that the use of a system would reduce urgent maintenance on the machines.	.626						
A2. I have the ability to create, edit and publish content in a virtual environment.	.579						
A5. I observe repetitive tasks in my work that could be facilitated with the use of technology.	.410						
A13. I use 3D printer in my professional activity.		.917					
A12. I conduct my tasks together with robots.		.900					
A13. I realize that a 3D printer would help in the execution of my work.		.780					
A10. I use augmented reality equipment to perform equipment maintenance.		.745					
A9. I often conduct, including in the last year, training, and simulations at the factory, with virtual reality glasses.		.674					
A11. I believe that it is necessary to implement new and/or improve existing technological tools within my work environment to conduct remote work.			.822				
A4. I realize that the rise of virtual work requires increased security to protect personal data and privacy.			.762				
A9. I am prepared for increased virtual work, for example with virtual glasses.			.621				
A10. I believe that my work environment needs qualification and training to increase knowledge of technologies.			.621				
A4. In my daily activity I use tools to collect data over time and make decisions for the best performance of my work (Example:			.585				

Google Analytics, Clear Story Data, and IBM Watson Analytics).							
A8. I believe that technology can promote the process improvements I need in my work environment.				.757			
A7. I need to improve my knowledge and use of technology to apply it in my work environment.				.725			
A6. I want to increase the use of technological tools to improve my professional skills.				.523			
A11. I can conduct my activity remotely (outside the company) through technology.					.693		
A12. I observe that my company uses robots to perform some tasks.					-.679		
A5. I believe that the integration of Artificial Intelligence in my work environment improves my results.						.731	
TO 1. I increasingly replace the use of physical documents with virtual documents in my work.						.682	
TO 1. I think it is necessary to seek knowledge about digital technologies and apply them in the work environment.						.585	
A8. I have all my activities monitored by a system.							-.720
A7. In my work, I use a system to monitor the productivity of equipment.							-.617

In view of the analysis of Table 11, it is possible to perceive a tendency of total agreement of the respondents in relation to the desire to increase the use of technological tools to improve their professional skills, having the conviction that it is necessary to seek knowledge about digital technologies and apply them in the work environment, bearing in mind the increasing substitution of the use of physical documents for virtual documents. Still believing that the integration of Artificial Intelligence in the work environment will improve its results.

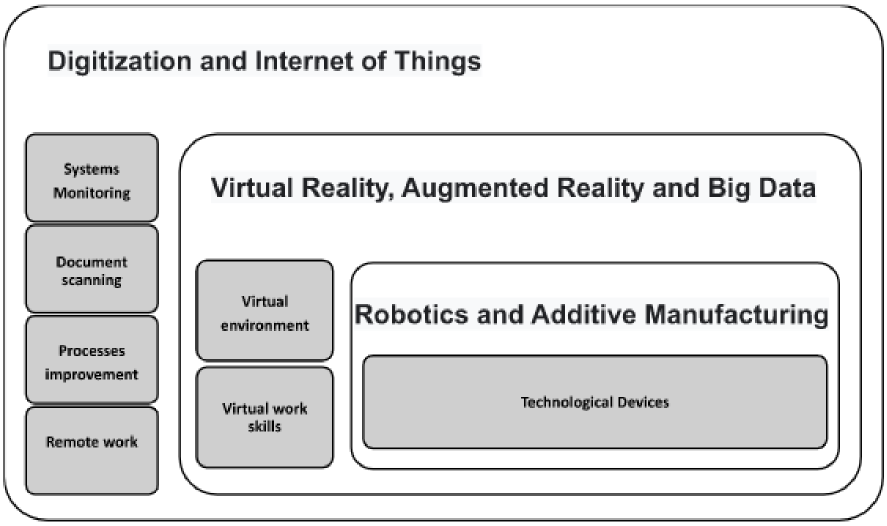
Through the data evidenced in the factorial analysis, it was possible to establish the correlation of the 6 guiding technologies of this study, distributed in 26 applications, according to the systematic review of the literature carried out by Nascimento et al. (2022), directing a set of skills for industry 4.0 into 07 components, as shown in Table 12 and Figure 2.

Table 12: Skills in the technology categories of I4.0

Components	Skills to be developed
1 – Virtual Environment	Create, edit, and publish content in a virtual environment (email, WhatsApp, intranet, and social networks), storing them in the cloud (Google Drive, Dropbox).
2 - Technological Devices	Use virtual reality glasses, robots, and 3D printer.
3 – Training for virtual work	Training focused on virtual work technologies, security, and data analysis (Google Analytics, Clearstory Data, and IBM Watson Analytics).
4 – Process improvement	Adaptation of technology to the needs of each company.
5 – Remote work	Use virtual tools to conduct work remotely.
6 – Digitization of documents	Replace the use of physical documents with virtual documents, integrating artificial intelligence.
7 – Systems Monitoring	Use a system to monitor the work and monitor the productivity of the equipment.

Source: The authors (2023).

Figure 2: Correlation of skills with I4.0 technologies



Training for industry 4.0

To understand the perception of respondents in relation to training for industry 4.0, information was collected on taking a basic computer course, the need to take courses or training focused on the use of technologies from industry 4.0 for better professional performance, as well as adaptability to teaching remotely and which courses in the industry 4.0 area most arouse interest, as shown in Table 13.

Table 13: Perception of respondents about training for I4.0

Feature	Frequency	percentage
Completed basic computer course		
Yes, recently.	112	28.6%
Yes, but it has been a long time and I am interested in updating myself.	114	29.1%
Yes, but it has been a long time and I am not interested in redoing it.	94	24.0%
No, and I am interested in doing so.	57	14.5%
No, and I have no interest in doing so.	15	3.8%
Realizes the need to conduct courses or training focused on the use of technologies from industry 4.0 for better professional performance		
totally disagree	2	0.5%
I disagree	5	1.3%
I do not agree nor disagree	34	8.7%
I agree	152	38.8%
I totally agree	199	50.8%
Is adept at the teaching-learning process in the EAD format (Distance Education)		
totally disagree	10	2.6%
I disagree	20	5.1%
I do not agree nor disagree	72	18.4%
I agree	142	36.2%
I totally agree	148	37.8%
Courses aimed at industry 4.0, offered by Senai, which is interested. (you can select up to 03 course options)		
Unraveling industry 4.0	125	11.1%
Advanced Industry: connecting concepts in practice	116	10.3%
Exploring Big Data	96	8.6%
Mobile Programming for Internet of Things	80	7.1%
Cyber Security	152	13.5%

Artificial intelligence	174	15.5%
Integration of Intelligent Production Systems	126	11.2%
Applied Collaborative Robotics	107	9.5%
Cloud computing: Architecture and Applications	61	5.4%
Applied Additive Manufacturing (3D Printer)	70	6.2%
I am not interested in taking a course	15	1.3%

The studies by Silva, Kovaleski and Pagani (2019) pointed out that qualification for industry 4.0 must occur mainly through training people through integrated training in technical laboratories equipped with appropriate technologies (hardware and software). In this regard, this study sought to initially understand the basic training of the interviewees in terms of basic computer training, where 114 respondents, representing 29.1% of the sample, stated that they had already taken a basic computer course, but that they wanted to become to update. Followed by 112 respondents, representing 28.6%, who said they had taken the course recently and then 94 respondents, representing 24%, who reported that they had taken the course a long time ago and that they are not interested in retaking it. However, 94 respondents, representing 14.5% stated that they had not yet taken a basic computer course and that they are interested in doing so. Finally, 15 respondents, representing 3.8%, said they had not taken the course and had no interest in taking it. The results demonstrate that most of the interviewees are interested in updating their basic computer skills.

When asked if they perceived the need to take courses or training focused on the use of technologies from industry 4.0 for a better professional performance, 199 respondents, representing 50.8% of the sample, stated that they totally agree, as well as 152 respondents, representing 38.8% agree with such need. In contrast, 34 respondents, representing 8.7% neither agree nor disagree, while 5 respondents, representing 1.3% disagree, followed by 2 respondents, representing 0.5%, who strongly disagree. The sample represents a significant amount of those who perceive the need to take a course aimed at Industry 4.0.

Distance Education in Brazil is officially defined in Decree nº 5.622 of December 19, 2005, as an educational modality in which the didactic-pedagogical mediation in the teaching and learning processes occurs with the use of information and communication means and technologies, with students and teachers developing educational activities in various places or times (BRASIL, 2005). Regarding this educational aspect, the interviewees were asked if they were adept at this teaching-learning modality, where 148, representing 37.8%, responded that they completely agreed, followed by 142 respondents, representing 36.2% who said they agreed. In turn, 72, 20 and 10 respondents, representing 18.4%, 5.1% and 2.6% are not so used to this new modality, so much so that they said they neither agree nor disagree, as well as disagree and totally disagree, respectively. It is noticed that among the interviewees, the majority is adept at distance learning (EAD).

With regard to the improvement courses for industry 4.0 offered by Senai, according to the Industry Portal (2020), detailed in Table 3 above, where respondents could select up to 03 (three) course options of their interest, the most chosen were Artificial Intelligence with 174 choices, representing 15.5%, followed by Cybersecurity with 152 choices, representing 13.5% and very close to the courses Integration of Intelligent Production Systems and Unraveling Industry 4.0, with 126 and 125 choices, representing 11 .2% and 11.1%, respectively. A data to be highlighted is the choice of 15 respondents regarding the lack of interest in taking courses, representing 1.3% of the choices, which can be associated with the 15 respondents who did not take and are not interested in taking the computer course. With a more detailed analysis of the results, it was related that these respondents are those between the ages of 46 and 55, therefore, employees in the higher age group are not very conducive to taking courses. However, most respondents are interested in taking courses aimed at Industry 4.0.

Thus, in relation to training for industry 4.0, it was possible to identify that the interviewees are interested in updating themselves in the basic computer course, being supporters of Distance Education (EAD), in the same way that they perceive the importance of training for this new industrial revolution, having a greater interest in courses on Artificial Intelligence, Cybersecurity and Integration of Intelligent Production Systems.

Final considerations

Industry 4.0 technologies influence human-machine interaction, also changing the demands faced by employees. For this reason, the professional routine is characterized by tasks that are less manual and more directed towards the coordination and monitoring of intelligent systems (HEINDL et al., 2016).

The results obtained indicate that the age group between 46 and 55 years old does not show great propensity for taking courses, although most of the respondents express interest in participating in programs related to Industry 4.0. This finding is aligned with the concerns raised by FIRJAN (2016), who emphasized the need for development and training of professionals close to the industry for the successful implementation of Industry 4.0 in Brazil. Furthermore, the research reveals that the workers recognize the importance of integrating technologies, such as artificial intelligence, for improving outcomes and optimizing repetitive tasks. This perception is consistent with the discussions of Gebhardt, Grimm and Neugebauer (2015) on the impacts of technological innovations on work and vocational education, highlighting the need for preparation and constant updating of professionals to deal with the demands of Industry 4.0.

The research results indicate that Distance Education (DE) is a well-accepted teaching modality by the industry workers, with most of the respondents showing interest in participating in courses related to Industry 4.0. This perception is in line with the discussions of Baethge-Kinsky (2020) on the importance of continuous education and the development of digital skills for the adaptation of workers to the changes brought by Industry 4.0. Moreover, the choice of the most sought-after courses by the respondents, such as Artificial Intelligence and Cybersecurity, reinforces the need for training in emerging technology areas, as discussed by Ávila-Gutiérrez, Aguayo-González, and Lama-Ruiz (2021). These authors highlight the importance of using advanced technologies, such as machine learning models and sensors, for the development of intelligent systems in Industry 4.0. Given the above, in the light of the theory researched and the verification and analysis of the results presented by the 392 respondents, the main contribution of this article is the possibility of being used for a diagnosis of competences to support improvement actions for the industries of Pernambuco, directing them as to the technologies to be adopted and the direction of the appropriate qualification courses to its employees, in the same way, which courses the educational institutions can offer based on the interest of the workers of the industries of Pernambuco. From a methodological point of view, the study contributes with the application of a quantitative approach to measuring technical skills for manufacturing processes in the context of industry 4.0.

The factor analysis performed in the research allowed to identify the main technical competencies demanded by the industry workers for the implementation of Industry 4.0. The competencies most valued by the respondents are those related to the digitalization and automation of processes, such as the use of modeling and simulation software, programming of systems and control of automated processes. These results are consistent with the discussions of Gebhardt, Grimm and Neugebauer (2015) on the importance of training in digital technologies and automation for the adaptation of workers to the changes brought by Industry 4.0. Furthermore, the emphasis given by the respondents to the competencies related to communication and teamwork, such as the ability to collaborate in interdisciplinary projects and to communicate with different areas of the company, reinforces the importance of developing socio-emotional skills for Industry 4.0, as discussed by Ávila-Gutiérrez, Aguayo-González and Lama-Ruiz (2021).

As limitations, there is the fact that a non-probabilistic sample was used for convenience, not allowing the generalization of the results. In addition, the distribution of the sample in some industrial comparison segments was not proportional. There were also difficulties related to the participation of micro-enterprises, which have the highest number in the state (71.1%) but represented only 18.1% of the sample.

As an agenda for future research, it is recommended to investigate, from the point of view of directors, how educational institutions are preparing students for the skills most demanded by industries; the perception of manufacturing workers from other states in Brazil or countries that are at the same level as Brazil and draw a comparison with this study; the permanence of remote work in industries after the pandemic period; the importance of using virtual glasses to improve industrial processes and which technology from industry 4.0 has the greatest impact on industrial performance.

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