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INDUSTRY 4.0 AND HUMAN CAPITAL 4.0: A BEHAVIOURAL COMPETENCY MODEL

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SOMMARIO

Lo scopo di questa tesi è quello di valutare il quoziente digitale delle imprese operanti in Industria 4.0, indipendentemente dal loro business o settore di appartenenza, attraverso la creazione di un nuovo modello di competenze incentrato esclusivamente sulle *soft skills*.

Il primo capitolo della tesi introduce il lettore al concetto di "Industria 4.0", chiarendone il significato ed evidenziandone le caratteristiche principali. Il secondo capitolo, invece, si concentra sul concetto di "skill": nello specifico, la differenza fra competenze tecniche e trasversali, nonché il loro legame con Industria 4.0. Nel terzo ed ultimo capitolo, il modello viene sviluppato e presentato. Attraverso una rigorosa ed estesa analisi di testi ed articoli accademici, nonché una serie di interviste a professori universitari e manager di startup, piccole-medie imprese e multinazionali, si giunge a tratteggiare la figura della risorsa umana ideale in Industria 4.0: un esperto in ambito informatico che, attraverso le sue eccellenti capacità empatiche e comunicative, è in grado di lavorare e guidare gruppi eterogenei di professionisti, organizzare e modificare la propria attività lavorativa sulla base delle priorità che emergono giornalmente, costruire e mantenere solide relazioni inter ed intra aziendali, anticipare e risolvere problematiche grazie ad una mentalità flessibile, creativa e pro-attiva, nonché continuare a studiare ed aggiornarsi nel corso del tempo per migliorare costantemente le proprie capacità e competenze.

INTRODUCTION

Industry 4.0 has completely changed the way businesses are settled, organized, and led. In recent years, especially the last decade, numerous and revolutionary technologies - such as, autonomous robots, CPS and IoT - have been introduced in organizations, thus changing drastically their structure and how employees perform their activities.

This thesis aims at defining how firms can not only survive but also drive this technological revolution by introducing a Human Capital competency model that measures their digital readiness: more specifically, by defining what are the main soft skills - or, behavioral competencies - that employees should have in such new environment.

Due to the complexity of the 4.0 revolution, this competency model required an extensive and solid groundwork. Therefore, throughout three chapters, the reader will acknowledge various topics: first of all, the concept of Industry 4.0. The thesis will indeed start with an historical excursus that takes him throughout all the industrial revolutions and, by describing each of them and their main characteristics, it will shed light on how the fourth industrial revolution started and what its main features are. Then, the concept of "Industry 4.0" will be described, along with the most appropriate definition for the purpose of this study. Once this phenomenon has been defined, the thesis will go through its core characteristics: in particular, by describing the "Digital Transformation" phenomenon, its main

technological pillars will be presented and explained. The first chapter will be then concluded with an analysis of the impact that Industry 4.0 has on the organizational structure and on the employees, laying therefore the foundations to the second and third chapters.

If the first chapter aimed at introducing the reader to the fourth industrial revolution, chapter 2 identifies its impact over the workforce through an analysis that focuses on the "skill" concept. More specifically, the second chapter starts by determining the most appropriate definition of the "skill" term for the purpose of this research. Then, after having explained how skills can be further divided into hard and soft ones, the chapter will start deepening the importance of soft skills in Industry 4.0, by explaining why they should be considered as crucial for the survival and success of both employers and employees. Thanks to the literature review that has been carried throughout the whole second chapter, this central part of the thesis will be concluded with a list of the 10 main behavioral competencies - or, soft skills - that should characterize the 4.0 employee and with a section that explains how it is possible to develop them.

The thesis will be concluded with a third chapter that, thanks to the research held in the previous parts and to some interviews to HR and business leaders, will generate the output that was discussed at the beginning of this introduction: a new competency model for industry 4.0.

CHAPTER 1: INDUSTRY 4.0, A PROTEAN AND REVOLUTIONARY PHENOMENON

Over the last decade, the term "Industry 4.0" has become a key topic of discussion and analysis among the scholars, whose studies have brought forth an extraordinary interest about its impact over society. More specifically, academics have highlighted the high complexity of this phenomenon, which is characterized by certain technologies that have completely altered the way firms conduct their businesses. This, in turn, has reflected on the organizational structure, which has to be modified in order to address properly the opportunities and the challenges linked with the 4.0 revolution and on the workforce, which now has to quickly adapt to this new and complicated environment. Because of such intricacy, it seems appropriate to dedicate this chapter exclusively on identifying and describing the industry 4.0's phenomenon. Therefore, throughout various sections, its main aspects will be analyzed and studied.

In particular, the first part will be dedicated to the genesis of this protean and revolutionary phenomenon: thanks to an historical excursus that will go through all the industrial revolutions and their key features, the reader will acknowledge how the humankind managed to arrive to the fourth industrial revolution. Then, there will be a focus on the "Industry 4.0" term and, among the numerous definitions that have been proposed over the last decade, it will be indicated the most appropriate one for the purpose of this thesis. The second part, instead, will be dedicated to the

core concepts of Industry 4.0: from the definition of the “Digital Transformation” phenomenon, through the description of its key technologies and their potential usage, to then conclude with an examination over the 4.0 main critical aspects.

Once its definition has been identified, and its main characteristics outlined, it will be finally possible to move deeper into the 4.0 revolution and analyze its impact over the organization and the workforce.

The third part, then, will focus on how the organizations are changing in the 4.0 context: what is the organizational setup in this new environment? how does the role of employees change? These are some of the questions that will be addressed over this section. This first chapter will then be concluded with a fourth paragraph that aims at understanding how important the role of worker is to foster a successful digital transformation.

1.1: A "4.0" BACKGROUND

The phenomenon of industry 4.0 has such wide and complex applications that it is required, not become dispersive and rough, to identify a specific perimeter. This is why, first of all, it has to be described the historical context that has brought to the 4.0's revolution birth and identified its most appropriate meaning for the purpose of this thesis.

1.1.1: The Fourth industrial revolution

Throughout history, mankind had the chance to see four events that have shaped radically its evolution: the industrial revolutions. The first industrial revolution takes place in Great Britain between 1750 and 1840, and it can be considered as "*one of the most distinguished turning points in human history"*[1]. The main reason behind this statement is that the first industrial revolution marks the starting point of a transition from an anthropocentric working method, based upon human and animal technologies, into a more schematic and efficient one, based on machine tools. The most important one, was the steam engine: made of iron, and fueled by coal, this invention represented the foundation stone of the modern era; "*The steam engine unlocked the mass production of goods and services on a scale beyond the wildest dreams of the preindustrial era. Modern energy fueled every aspect of the economic takeoff*"[2]. The second industrial revolution takes place approximately thirty years after the end of the first one, between 1870 and 1914[3].

[1] H. Mohajan, "*The First Industrial Revolution: Creation of a New Global Human Era*", Journal of Social Sciences and Humanities, Vol. 5, No. 4, 2019, pp. 377-387.
[2] J.D. Sachs, "*The End of Poverty; How We Can Make it Happen in Our Lifetime*" The Penguin Press, 2015, pp. 49.
[3] Joel Mokyr, "*The Second Industrial Revolution, 1870-1914*", August 1998.

Developed mainly in Europe and USA, this revolution is characterized by two key elements: the usage of chemicals and electrical energy in place of steam, and the spread of mass production. The third industrial revolution is particularly interesting because of its link with industry 4.0: it began in the 1960s, and it was triggered by "*the development of semiconductors, mainframe computing (1960s), personal computing (1970s and 80s) and the internet (1990s)*"[4], and this is why it is usually referred as the "computer" or "digital" revolution. At the core of all these innovations, there are the so-called Advanced Manufacturing Technologies (AMTs), a group of computer-based technologies used to control manufacturing activities that grant the benefit of flexibility and efficiency to end-users.[5] The link between the third and the fourth industrial revolution lies within the AMTs themselves: indeed, it has been noticed that "*the adoption of AMTs in connected environments triggers the Fourth Industrial Revolution because it allows the receipt of different information from various sources and the production of few items in a reduced time. Therefore, the shift to the fourth industrial revolution seems to be enabled by a factory that has already passed through the challenges of the third industrial revolution, since AMTs can facilitate the adoption of Cyber-Physical Systems (CPS)*"[6], which represent one of the core elements of Industry 4.0. From early 2000s, Society entered into a new phase, the so-called Fourth Industrial Revolution. This term was officially introduced by the founder and president of the World Economic Forum, Klaus Schwab[7], who wrote a report in order to introduce

[4,7] Klaus Schwab, "*The Fourth Industrial Revolution*", World Economic Forum, 2016, pp. 11.
[5] McDermott, Stock, "*Organizational culture and advanced manufacturing technology implementation*", Journal of Operations Management, 1999, pp. 521.
[6] L. Agostini, A. Nosella, "*The adoption of Industry 4.0 technologies in SMEs: results of an international study*", Management Decisions, August 2019, pp.3

and describe a new era of changings due to this phenomenon. The fourth industrial revolution is "*characterized by a much more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence and machine learning*."[8] From its analysis, it is clear that Schwab too sees a link between the third and the fourth industrial revolutions, highlighting the fact that also the latter one is based on digital technologies, but that their complexity has increased so much that the societies and the global economy have to change accordingly to it if they went to address it properly.

Before defining the "Industry 4.0"'s term, it might be worth noticing that there are two characteristics that make the fourth industrial revolution unique compared to the other ones. It is not from the increased levels of productivity and efficiency that it is possible to see how special this phenomenon is - indeed all the industrial revolutions are based on new technologies that somehow transform the working methods, granting obviously higher standards than before - but from:

- A wider radius, that involves countless areas such as nanotechnology, quantum computing and gene sequencing.
- The level of diffusion of the new technologies, which is higher and wider than before. Some of the core technologies of the first industrial revolution took more than a century to spread across Europe, whereas the second and third industrial revolutions have involved barely half of the world population. On the other hand, the core technologies of the fourth industrial

[8] Klaus Schwab, "*The Fourth Industrial Revolution*", World Economic Forum, 2016, pp. 12.

revolution are spreading incredibly fast globally, spotting an important discontinuity sign over the previous ones.

This second characteristic shall be now further analyzed, to avoid possible misunderstandings. Declaring that the spread of the 4.0 technologies is way faster than it used to be with the ones of the previous industrial revolutions does not mean that firms have already evolved to a 4.0 paradigm nor that they are ready to start this kind of evolution process. A study from Ślusarczyk[9] has pointed out that level of preparation of enterprises to Industry 4.0 is lower than expected: in the USA and Germany, about 70% of Firms feel well prepared for this new revolution, whereas in Japan this percentage drops drastically to the 35%. This surprising result could be explained by slightly different perceptions of the idea of "Industry 4.0" – whose definition, as it will be highlighted in the next section, might be vague – or by the fact that in Japan higher requirements were settled to be considered ready to face the 4.0 revolution, since it seems "*unlikely that enterprises from Japan are at a much lower level of technological development than their counterparts from Germany and United States"*[10]. Those percentages tend to get much lower when analyzing which 4.0 technologies have already been implemented. For instance, in the USA and Poland only about the 25% of firms already use autonomous robots, and "*only slightly over 20% of enterprises understand well in what way new technologies will change their labor force and organizational structure. A similar percentage of the respondents are aware of the impact of new technologies on the*

[9,10] Ślusarczyk B., "*Industry 4.0 – Are We Ready?*", Polish Journal of Management Studies, 2018, pp. 232-248.

change in the way of delivering goods and services by them. Only 16% of enterprises know how to integrate own solutions with the external infrastructure and only 8% possess strong business grounds for the applied new technological solutions"[11]. Furthermore, those problems are enhanced in SMEs, especially in countries like Italy[12]: the "Osservatorio of Digital Innovation" of the Polytechnic University of Milan has pointed out that only the 10% of SMEs use big data and that the 61% of the SMEs' entrepreneurs has never heard about the application of IoT solutions for Industry 4.0.

Once the 4.0 background has finally being stated, and the differences between the Fourth industrial revolution and the previous ones understood, it is possible to move forward and introduce the concept of Industry 4.0.

[11] Ślusarczyk B., "*Industry 4.0 – Are We Ready?*", Polish Journal of Management Studies, 2018, pp. 239.

[12] source: https://www.innovationpost.it/2020/02/12/i-numeri-parlano-chiaro-nelle-pmi-italiane-manca-ancora-una-reale-volonta-di-innovare/

1.1.2: Definition of "4.0"

Literature[13] agrees on setting 2011 as the birth date of "Industry 4.0": indeed, this term was used for the first time during the Hanover Fair in November 2011, to point out the *"high-tech strategy for 2020"*[14] of the German government.

Although everyone seems to recognize this starting point from an historical point of view, there is no such harmony on identifying its definition. Certainly, the common point is represented by the technocentrism of this phenomenon: indeed, literature[15] grounds its definition on some emerging technologies – that will be analyzed in the second paragraph – such as Big Data, Internet of Things, Simulation, Autonomous Robot, Cyber-Physical Systems, Cloud Computing, Virtual Reality, Machine-to-Machine communication, and Cyber Security.

However, its protean essence makes impossible to set a unique meaning, contributing to the diffusion of countless definitions. For instance, some scholars define it as a sort of "umbrella term"[16] to identify a new era based on some core elements such as Cyber-Physical Systems (CPS), Internet of Things (IoT) or Big Data. Others[17] describe it as an environment surrounded by smart and connected devices that make the manufacturing processes automated, or as a paradigm "based

[13] "*Industry 4.0: Industrial Revolution of the 21st Century*", Springer International Publishing AG, part of Springer Nature 2019, pp 5.
[14] K. Zhou, T. Liu and L. Zhou, "*Industry 4.0: Towards Future Industrial Opportunities and Challenges*", International Conference on Fuzzy Systems and Knowledge Discovery, 2016, pp. 2147.
[15] A. Moeuf et al., "*Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs*", International Journal of Production Research, vol. 58, n. 5, 2019, pp. 1384-1400.
[16] A.C. Pereira, F. Romero, "*A review of the meanings and the implications of the industry 4.0 concept*", Procedia Manufacturing 13, 2017, pp. 1206–1214.
[17] F. Longo, A. Padovano and S. Umbrello, "*Value-oriented and ethical technology engineering in Industry 5.0: a human-centric perspective for the design of the Factory of the Future*", Applied Sciences, 10(12), 2020, pp. 2.

on the horizontal and vertical integration of production systems driven by real-time data interchange and flexible manufacturing to enable customized production"[18]. According to Brettel at al., this term describes a new manufacturing landscape that heavily relies on "*intelligent products and production processes*"[19]. Another definition has been given by Wolter, who stated that "*Industry 4.0 stands for an interactive networking between analogue production and the digital world. This transformation includes elements such as big data, autonomously operating systems, Cloud computing, social media, mobile and self-learning systems*."[20]

However, considering the aim of this study, the term Industry 4.0 will be defined as "*utilizing the power of communications technology and innovative inventions to boost the development of the manufacturing industry*"[21], as Kagermann suggested when introducing the concept of Industrie 4.0 for the first time in 2013.

[18] M. Piccarozzi, B. Aquilani, C. Gatti, "I*ndustry 4.0 in management studies: A systematic literature review*", 2018, pp. 1.
[19] M. Brettel, N. Friederichsen, M. Keller, M. Rosenberg, "*How Virtualization, Decentralization and Network Building Change the Manufacturing Landscape: An Industry 4.0 Perspective*", International Journal of Information and Communication Engineering, 2014, pp. 38.
[20] Wolter, M.I. et al., "*Industry 4.0 and the consequences for labour market and economy: scenario calculations in line with the BIBB-IAB qualifications and occupational field projections*", IAB – Forschungsbericht, 2015, pp. 11.
[21] Shu Ing Tay, Lee Te Chuan, A.H. Nor Aziati and Ahmad Nur Aizat Ahmad, "*An Overview of Industry 4.0: Definition, Components, and Government Initiatives*", Journal of Advanced Research in Dynamical and Control Systems, 2018, pp. 1381.

1.2: EVOLVING TO "4.0"

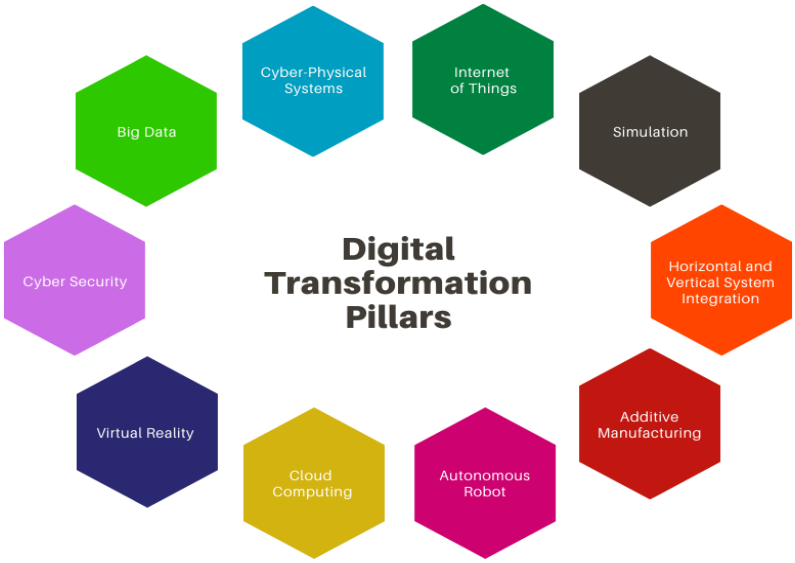
The evolution to a "4.0" paradigm is not an issue that can be taken for granted: because of its extreme complexity and the countless aspects of the organizational environment affected, it is necessary to understand what actually entails this evolution. In the first paragraph, some of the core elements that can be found in the 4.0 environment have been described – such as IoT and CPS – without defining and analyzing them. The purpose of this paragraph, therefore, is to describe the "4.0" core aspects, or the basic elements of the Digital Transformation, by clarifying their meaning and contexts of application. Then, there will be a focus on the main and most essential critical aspects of the 4.0 revolution, so that the reader will have the chance to understand properly what may be the possible disadvantages and advantages that an organization could incur into during the 4.0 transition.

1.2.1: Digital Transformation

The term "Digital Transformation" has been widely analyzed, although its definition tends to be vague. Some scholars would describe it as the insertion of new digital technologies that aims at enhancing the performance of the organizational processes[22], but others – as it will be clear at the end of this section - believe in a much deeper and important meaning. First of all, in this section the main factors that are the basis of the so-called "Digital Transformation" will be analyzed. Among all the new digital technologies, as it is possible to see in Figure 1[23], the Digital Transformation's phenomenon is characterized by 10 main "pillars":

[22] C. Taurion, G.L. Jamil, H.F.B. Tadeu and A.L. Duarte, "*Digital Transformation: Digital Maturity Applied to Study Brazilian Perspective for Industry 4.0*", Best Practices in Manufacturing Processes, Springer, 2019.
[23] Figure 1: Author's elaboration, based on BCG report

Figure 1



1) **Cyber-Physical Systems**: they "*consist of digital integrations with physical processes, where integrated computers and networks monitor and control physical processes*"[24]. A CPS is used to form a Cyber-Physical Production System, "*which connects virtual space with the physical world, to enable equipment in a smart factory to be more intelligent, thus creating better production conditions enabling smart production.*"[25]

2) **Internet of Things**: "*an emerging global, Internet-based information service architecture facilitating the exchange of goods in global supply chain networks*"[26]. Through the usage of IP systems, more and more devices

[24] V.L. Da Silva, J.L. Kovalesky and R.N. Pagani, "*Technology Transfer and Human Capital in the Industrial 4.0 Scenario: A Theoretical Study*", Future Studies Research Journal Trends and Strategies, 2019, pp.106.
[25] K. Zhou, T. Liu and L. Zhou, "*Industry 4.0: towards future industrial opportunities and challenges*", International Conference on Fuzzy Systems and Knowledge Discovery, 2015, pp. 2149.
[26] R. Weber, "*Internet of things – Need for a new legal environment?*", Computer law & security review 25, 2009, pp. 522.

will become part of a unique network: undoubtedly, this tool is extremely powerful in a 4.0 context.

3) **Big Data**: they are "*information assets characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value*"[27]. In the environment of Industry 4.0, they can give useful information thanks to real-time sensor data and can be used for the analysis and the optimization of the supply chain, as long as the product quality control.[28]

4) **Autonomous Robots**: this term refers to machines developed to perform autonomously a specific task. Whether they are programmed to perform repetitive tasks or not, their usage in industry 4.0 is steadily increasing: an increased productivity and higher work safety are just a few of the reasons of this aptitude.[29]

5) **Simulation**: it can be defined as "*the method of using models* – physical or mathematical mainly - *of a real or imagined system or a process to better understand or predict the behavior of the modelled system or process*."[30] The usage of simulation in Industry 4.0, in combination with all the other tools, can be extremely powerful since it grants the possibility to simultaneously design production processes and products. Moreover, it allows cost reduction along with process quality enhancement[31].

[27] A. De Mauro, M. Greco, M. Grimaldi, "*A formal definition of Big Data based on its essential features*", Libr. Rev. 65, 2016, pp. 122–135.
[28] B. Chen et al., "*Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges*", IEEE Access, volume 6, pp. 6531.
[29,31] V.L. da Silva, J.L. Kovalesky and R.N. Pagani, "*Technology Transfer and Human Capital in the Industrial 4.0 Scenario: A Theoretical Study*", Future Studies Research Journal Trends and Strategies, February 2019, pp.106.
[30] B. Rodič, "*Industry 4.0 and the New Simulation Modelling Paradigm*", Oganizacija, 50(3), 193-207.

6) **Cyber Security**: The usage of connected devices and standard communication protocols, instead of the traditional production system, expose the organization to several risks (data, information and knowledge stealing). Thus, investing in systems to protect all these assets is incredibly important nowadays.[32]

7) **Cloud Computing**: Increasing the number of connected devices, also increases the necessity to invest in high performance cloud technologies, to grant the appropriate processing, storage, and connectivity.

8) **Augmented Reality**: The industrial augmented reality can be defined as a new technology that provides "*powerful tools that support the operators that undertake tasks, helping them in assembly tasks, context-aware assistance, data visualization and interaction, indoor localization, maintenance applications, quality control or material management*."[33]

9) **Additive Manufacturing**: in the industry 4.0 context, the additive manufacturing systems, such as 3D printing, are used to produce highly customizable products, offering "*construction advantages, such as complex, lightweight designs*."[34]

10) **Horizontal and Vertical System Integration**: thanks to the integration of global data, the new value chains will involve industries and other internal and external elements, such as departments, suppliers and also customers.

[32] M. Rüßmann et al., "*Industry 4.0 The Future of Productivity and Growth in Manufacturing Industries*", Boston Consulting Group, 2015.
[33] P.L. Fraga-Lamas et al., "*A review on industrial augmented reality systems for the industry 4.0 shipyard*", IEEE Acess, Volume 6, 2018, pp. 13358
[34] source: https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries

Now that the key technologies have been identified, it is worthwhile making a further analysis regarding the concepts of digitization, digitalization, and digital transformation, in order to fully understand its deeper and, for the purpose of this study, appropriate meaning:

a) **Digitization**: it refers to the transition process from the analog to the digital form.[35]
b) **Digitalization**: this term is not only about the usage of digital technologies, because it describes "*the use of digital technologies to innovate a business model and provide new revenue streams and value-producing opportunities in industrial ecosystems"*[36].

The concept of "Digital Transformation" somehow intersects with the one of Digitalization. Indeed, it is true that a Digital Transformation is based on digitalization, since it involves the introduction of digitalization projects to bring new digital technologies inside the organization, but it also has a deeper and stronger impact: from the elements analyzed in this section, it seems clear that it also brings a complete renewal of the organization's core competencies, and thus its business and strategy. To better explain this concept, it will be now described how some enterprise, like IKEA and Disney, have introduce the digital transformation within their businesses.

[35] S.D. Lee, "*Digitization: is it worth it*?", Computers in libraries, 2001.
[36] V. Parida, D. Sjödin and W. Reim, "*Reviewing Literature on Digitalization, Business Model Innovation, and Sustainable Industry: Past Achievements and Future Promises*", Sustainability 11, 2019, pp. 6.

"*Thanks to new technologies, IKEA is changing the shopping experience of its customers for the better and optimizing its costs in the process. In 2017, the company acquired TaskRabbit. This is a website that lets you search for people to help with the assembly or delivering furniture purchased at IKEA to your apartment. Thanks to this, customers who can't manage these tasks on their own are more likely to use the services of the company. In addition, IKEA has decided to implement a smart home project. For the furniture industry tycoon this includes intelligent kitchen equipment and lighting. The company also uses Augmented Reality in the IKEA Place application to make it easier for customers to choose furniture and virtually "furnish" the apartment before making purchases in the store*" … "*It would seem that Disney World parks are the most "analogue" entertainment. Unexpectedly, however, the brand has become one of the excellent digital transformation examples and greatly improved visitor experience. The MagicBand has been implemented in the parks, which lets parkgoers make payments, manage reservations and access their hotel rooms. In turn, each guest is identified with MyMagic+ straps, which provides them with individual experiences. The system works by displaying personalized interactive screens in the park. Another example of digital transformation at Disney is the Disney+ streaming platform, which has also proved to be a great success as of late. Previously, the brand licensed its content, including Netflix, but finally decided to sell its content itself"*[37].

[37] source: https://brainhub.eu/library/digital-transformation-examples/

Overall, it is possible to state that "*we digitize information, we digitalize processes and roles that make up the operations of a business, and we digitally transform the business and its strategy"*[38].

1.2.2: Relevant Implications from the Theoretical Background

As it was stated in the previous sections, adopting the 4.0 paradigm involves radical changes in the structure and functioning of the organizations. Therefore, it seems relevant to analyze the most important aspects of this paradigm, trying to understand what are the potential *benefits* and *challenges* that an organization may incur into.

Among the benefits, it seems[39] that the new technologies – described in the previous section, such as the CPSs – offer several opportunities, such as new business models that aim at meeting individual customers' requirements, thanks to the direct involvement of the customer himself in the production process, from the design to the manufacture, and higher flexibility, granted by a more dynamic configuration of some business processes' aspects such as time, quality, and price. Furthermore, Kagermann believes that real-time data will give the possibility to have an early verification of the decisions taken, optimizing therefore the decision-taking processes. Another research[40] states that since Industry 4.0 enables simultaneous planning and production processes, it reduces the time-to-market and favors the

[38] J. Bloomberg, "*Digitization, Digitalization, And Digital Transformation: Confuse Them at Your Peril*", Forbes, 2018, pp. 5.
[39] H. Kagermann, W. Wahlster and J. Helbig, "*Recommendations for Implementing the Strategic Initiative Industrie 4.0*", 2013, pp. 14-17.
[40] T.D. Oesterreich and F. Teuteberg, "*Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry*", Computers in Industry, 83, 2016, pp. 121-139.

quality's enhancement; moreover, real-time data allows predictive maintenance and in turn, by repairing machines before their break, a considerable cost reduction.

The research made by Kiel[41] highlighted various other possible benefits related to the adoption of the 4.0 paradigm: by interviewing 46 managers, it turned out that, first of all, the majority of the respondents believes that the firms' competitiveness can increase thanks to higher market shares and penetration, along with a strategic differentiation, and new competitive advantages. Secondly, cost reduction potentials and higher sales can induce financial benefits. Thirdly, it seems that the overall equipment effectiveness will increase: indeed, 4.0's technologies enhance the production processes' quality and, thanks to lower scraps and failure tests, also delays and downtimes are drastically reduced.

Overall, considering the previous literature overview, it seems that Industry 4.0 offers various benefits and opportunities, such as new business models, higher productivity, logistic optimization, production process quality enhancements, efficient resource management, higher customer satisfaction and higher potential revenues. On the other side though, as it was stated before, it also brings several challenges that have to be addressed by firms. Kiel, for instance, underlined that the most relevant one is represented by the technical integration. Indeed, "*the companies face the task of implementing intra-firm and inter-firm connection based on modern IT infrastructure. Intra-firm connection requires the technical transformation and modernization of production facilities as well as the*

[41] D. Kiel, J.M. Muller, C. Arnold and K.Voigt, "*Sustainable Industrial Value Creation: Benefits and Challenges of Industry 4.0*", International Journal of Innovation Management, 2017, pp. 11- 34.

harmonization of mechanical, electrical, digital, and connected components…In addition, inter-firm connection throughout entire supply and value chains necessitates an industry-spanning standardization of IIoT (4.0) technologies and interfaces in order to ensure cross-company interactions"[42]. Another challenge is represented by the organizational transformation that firms have to face: this paradigm requires an adaptable and flexible corporate culture and hierarchical structure, along with the involvement of the top management and the company stakeholders, as it will be described in the next section. There are also some other challenges that SMEs in particular have to face[43], such as the lack of expertise, the risk of obsolescence (since by the time an SME introduces and masters a new technology, another one - more efficient – could be introduced into the market) and the employees' possible perception of industry 4.0 as a surveillance tool.

Other possible challenges[44] might be represented by the protection of the data stored in the organization and by the necessity of an intelligent decision-making and negotiation mechanism. Lastly, it seems that the enormous quantity of resources that has to be invested in the new technologies represents one of the highest barriers to the 4.0 paradigm adoption.

[42] D. Kiel, J.M. Muller, C. Arnold and K.Voigt, "*Sustainable Industrial Value Creation: Benefits and Challenges of Industry 4.0*", International Journal of Innovation Management, 2017, pp. 11- 34.

[43] A. Moeuf, S. Lamouri, R. Pellerin, S. Tamayo-Giraldo, E. Tobon-Valencia and R. Eburdy, "*Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs*", International Journal of Production Research, vol. 58, n. 5, 2019, pp. 1384-1400.

[44] S. Vaidya, P. Ambad and S. Bhosle, "*Industry 4.0 – A Glimpse*", Procedia Manufacturing 20, 2018, pp. 233-238.

1.3: A NEW ORGANIZATION

Looking at the historical context that has brought to the Fourth industrial revolution, it is clear that organizations are gradually shifting from a human-centric to a techno-centric philosophy, by increasing day by day the usage of machines and digital technologies, while the human capital still being at their center.

This trend, as it was underlined in the previous paragraph, has been steeply enhanced by the adoption of the industry 4.0 paradigm and it is supposed to radically change the structuring and the functioning of organizations, both at macro and micro levels, as well as the role of the human worker. Because of that, it seems appropriate to focus the first part of this section on the changes that the organization's setup has incurred into to adapt properly to the industry 4.0's paradigm, and its possible future trends.

Once this analysis is concluded, since the thesis hinges on the skills (especially the soft ones or, as the reader will have the chance to discover lately, behavioral competencies) that the 4.0's employee has to master, the role of the human worker in the 4.0 environment will be studied to conclude this first chapter: more specifically, the focus will be on the relation between employees and technological tools or, as Dregger [45] pointed out, the HTO (the human-technology-organization) relation.

[45] J. Dregger et al., "*Challenges for the future of industrial labor in manufacturing and logistics using the example of order picking systems*", Procedia CIRP, 2018, pp. 140 – 143.

1.3.1: The 4.0 organizational setup: from the "3.0" to the "smart factory" paradigm

The adoption of Industry 4.0 implies some radical changes to the traditional organizational paradigm: all those changes contribute to the creation of the typical manufacturing solution related to industry 4.0, the "Smart Factory". The term "smart" refers to the key technologies that have been analyzed before: thanks to them, there are "*smarter, more efficient, safer and more environmentally sustainable*"[46] factories, that host "*smart manufacturing processes*"[47]. A study from Wang[48] has deeply analyzed the differences between such new factories and the traditional ones. More specifically, he identified 6 main technical features that differentiate them:

- The typical 3.0 paradigm of mass production is based upon a set of limited and predetermined resources that are used to produce a specific kind of product, whereas in the 4.0 context there will be multiple kind of resources that enable the firm to produce multiple types of products.
- Instead of a fixed production line characterized by a fixed routing, the 4.0 context grounds on a dynamic routing that allows the processing of the different kinds of resources.
- In the 4.0 factory, assets and workers are connected by a high-speed network infrastructure, whereas in the traditional line this aspect is much more limited.

[46] F. Strozzi, C. Colicchia, A. Creazza and N. Noè, "*Literature review on the "Smart Factory" concept using bibliometric tools*", International Journal of Product Research, 2017, pp. 2.
[47] Alasdair Gilchrist, "*Industry 4.0*", Apress, 2016, pp. 218.
[48] S. Wang, J. Wan, D. L and C. Zhang, "*Implementing Smart Factory of Industrie 4.0: An outlook*", International Journal of Distributed Sensor Networks, 2016, pp 3.

- In the smart factory there is a deep convergence between the physical and the digital assets, whereas in the 3.0 paradigm there is a distinct separation between them.
- The level of control is completely different: in the traditional manufacturing line, each machine is independent from the others, whereas in the smart factory "*the control function distributes to multiple entities*" and "*these smart entities negotiate with each other to organize themselves to cope with system dynamics"*[49].
- The information system that characterizes Industry 4.0 is based on "big data", a high quantity of data that are then processed and analyzed to give useful and real-time information to the decision-makers, whereas in the traditional factory the information is isolated.

To make all those radical changes possible, it is necessary to have a flexible structure, whereby the decisions are decentralized, and the length of the command chain is limited. Therefore, it seems[50] that the ideal structure is based on fewer hierarchical levels and a wider span of control with respect to the 3.0 paradigm, thus forming a flat[51] organization.

The exploitation of all these improvements is strictly related to the capability of the firm to handle five[52] main challenges:

[49] S. Wang, J. Wan, D. L and C. Zhang, "*Implementing Smart Factory of Industrie 4.0: An outlook*", International Journal of Distributed Sensor Networks, 2016, pp 3.
[50] C. Cimini, A. Boffelli, A. Lagorio, M. Kalchschmidt and R. Pinto, "*How do industry 4.0 technologies influence organisational change? An empirical analysis of Italian SMEs*", Journal of Manufacturing Technology Management, 2019, pp. 12.
[51] Henry Mintzberg, "*The structuring of Organizations*", 1979.
[52] Z. Shi, Y. Xie, W. Xue, Y. Chen, L. Fu and X. Xu, "*Smart factory in Industry 4.0*", "Systems Research and Behavioral ScienceVolume 37, 2020 p. 607-617.

1) **Cost challenge**: as it has been previously highlighted, Smart Factories are made of several new technologies that require high investments. Thus, one of the main challenges for an organization is represented by the possibility to afford those investments.
2) **People challenge**: making the personnel feeling at ease with the new paradigm is not easy. People tend to feel more comfortable with the prior technologies[53], and the bitterness over the new ones is enhanced by the perception of them as a threat to the established competencies and as surveillance tools[54] (especially in SMEs). Facing the people challenge is particularly difficult because it does not apply exclusively to the 4.0 paradigm, but it is something much more complicated which is inherent to the human being's nature, as Sara Fine stated in 1986[55]. The author's research shows that "*human beings tend to resist change, even when change represents growth and development. ... [and will lead to] greater efficiency and productivity*"[56]. The main reason of such behavior is that people fear the unknown, that is, "*they feel anxiety about how the change will affect them, their job performance, their relationship with other employees, and other job-related factors. In fact, psychologists say that fear of the unknown is a rational, rather than an irrational, response to change*"[57].

[53] D.R. Sjödin, V. Parida, M. Leksell & A. Petrovic, "*Smart Factory Implementation and Process Innovation*", Research-Technology Management, 2018, pp. 22-31
[54] A. Moeuf, S. Lamouri, R. Pellerin, S. Tamayo-Giraldo, E. Tobon-Valencia and R. Eburdy, "*Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs*", International Journal of Production Research, vol. 58, n. 5, 2019, pp. 1384-1400.
[55,57] Sharon L. Baker, "*Managing Resistance to Change*", 1987, pp. 53.
[56] Sara Fine, "*Technological innovation, diffusion and resistance: A historical perspective*". Journal of Library Administration, 1986, pp 56.

3) **Technology challenge**: as it has been stated before, smart factories are made of several elements that are connected by a high-speed network infrastructure and the data generated requires a considerable storage space, along with the capability to analyze it. It is therefore necessary to have the capability to handle this technological challenge in order to exploit all the potential benefits offered.
4) **Structural challenge**: implementing efficiently a smart factory requires an improvement of the organizational structure as a whole: production, marketing, control systems, routines, everything has to evolve.
5) **Security challenge**: as it was stated in the previous section, security and privacy are two fundamental elements that have to be controlled by the organization.

Overall, it seems now clear that the organization is about to change radically due to the introduction of the 4.0 paradigm: the new technologies will enhance the levels of flexibility, productivity, and all the other aspects that have been analyzed in the previous sections, but at the same time they will require the firm to handle several challenges, since there is a significant difference between the traditional 3.0 paradigm and the new one. One of the aspects that has not been covered yet, is the relation between industry 4.0 and the human worker. In the next part, there will be just an introduction of such topic since it will be deeply analyzed over the second and the third chapters.

1.3.2: The role of employees in Industry 4.0

Human beings represent an incredibly important factor that must be considered when talking about a technological transition. Not only because of its impact over workers' careers and lifestyle, but also because the effectiveness of the transition itself mainly depends on the human element. An example of that might be represented by what happened in the 1960s, when AMTs, the main technological pillar at the basis of the 3.0 paradigm, was introduced. It seems that "*approximately 50% to 75% of the advanced manufacturing technology implementations executed in the United States are believed to be failures in terms of flexibility, responsiveness, reliability, and quality" and that the primary cause of these failures was represented by an "improper attention to the human aspects*"[58]. Thus, although it is true that in industry 4.0 "*most of the work traditionally done by the workers will now be done by the CPS in the smart factory*"[59], it seems crucial to understand how CPS and human activities intersect, in order to understand the human's role in this new environment and effectively implement the 4.0 paradigm. Gorecki et al.[60] identify the mobile devices, such as smartphones tablets and smart glasses, as the main tools for the human worker to cope with CPS: indeed, thanks to touch screens, voice recognition and gesture recognition the worker will be able to interact with its digital counterpart, in a dynamic and efficient way.

[58] C.A. Chung, "*Human issues influencing the successful implementation of advanced manufacturing technology*", Journal of Engineering and Technology Management, 1996, pp- 283-299.
[59] M. Sony and S. Naik, "*Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review*", Benchmarking International Journal, 2020, pp. 2224.
[60] D. Gorecky, M. Schmitt, M. Loskyll and D. Zühlke, "*Human-Machine-Interaction in the Industry 4.0 Era*", IEEE Xplore, 2014, pp. 289.

This interaction is assisted by user interfaces that give useful and clear insights about the functioning of the CPS. As the system's complexity grows, those tools have to be flanked by adaptive, learning assistance systems which have the task of supporting him in difficult situations.

Overall, it seems that the workers' primary function will be "*to dictate a production strategy and supervise the implementation thereof by the self-organizing production processes*"[61] and therefore the individual worker will assume more responsibility, a larger operating area, and the role of the problem solver. This means that the physical, heavy, and repetitive activities will shift to machines, and so that the human worker will focus on constructive planning activities, i.e., intellectual work. If the top management is not up to face this challenge, those radical changes will cause a deep and negative impact over the employees, promoting an uncertainty climate[62]. Indeed, "*not knowing how the change will affect their advancement opportunities, training requirements, or even if they will have a job in the restructured or merged organization can be highly stressful*"[63]. Moreover, as Charalambous et al.[64] noticed, also the turnover intentions and the job satisfaction levels would be negatively affected. From this research, it emerges that two main strategies could be adopted to reduce the uncertainty climate during this

[61] D. Gorecky, M. Schmitt, M. Loskyll and D. Zühlke, "*Human-Machine-Interaction in the Industry 4.0 Era*", IEEE Xplore, 2014, pp. 289.
[62] N. Di Fonzo and P. Bordia, "*A tale of two corporations: Managing uncertainty during organizational change*", Human Resource Management, 37, 1998, pp. 295 – 303.
[63] P. Bordia, E. Hunt, N. Paulsent, D. Tourish and N. DiFonzo, "*Uncertainty during organizational change: Is it all about control?*", European Journal of Work and Organizational Psychology, 2004, pp. 345–365.
[64] G. Charalambous, S. Fletcher and P. Webb, "*Identifying the key organizational human factors for introducing human-robot collaboration in industry: an exploratory study*", International Journal of Advanced Manufacturing Technology, 2015, pp. 2143-2155

period of changes: an effective communication and the employee participation in implementation. The first one could be used to inform the employees on how their tasks, the policy and the other organizational issues are about to change, as well as creating a community within the organization. In this way, thanks to a formal and effective communication system, the level of commitment should be enhanced and the one of uncertainty should be lowered. The second one, instead, is about sharing decisions between superiors and subordinates, and it seems to be equally important to the first one. The participation in implementation and decision-making should favor a supportive and positive behavior from employees, as long as increasing the sense of ownership, control, and readiness to the upcoming change.

The author, then, identifies five possible success factors that may arise from the correct involvement of the workforce, stressing therefore again the importance of human beings in technological transitions:

1) **Training and Development of the workforce**: the implementation of the previous manufacturing technologies and processes such as AMTs, just-in-time, cellular manufacture or lean production was driven also thanks to the training and the development of the workers.
2) **The process champion**: Having a "champion" in the roster, a top-quality worker who understands the technology, might help the transition.
3) **Employee empowerment**: As it was stated before, the new structure of a 4.0 organization should be as flexible as possible, flat, whereby the decision

making is decentralized. Therefore, empowering employees over their job might help them to understand better the ongoing changes and to handle them more efficiently.

4) **Senior management involvement**: usually, changes are driven by the senior management and, therefore, higher is the level of commitment and support of this category, higher will be the chances of success.
5) **Union involvement's impact**: it seems that heavily unionized organizations will struggle with the implementation, although the unions' impact over this transition has not been clearly identified yet.

Once the importance of employees has been underlined, it is finally possible to make the last step before concluding this first chapter, by outlining how their role is changing in the context of Industry 4.0.

1.4: NEW ORGANIZATION, NEW EMPLOYEE?

In the previous paragraph, the reader had the chance to understand how deeply the organization has changed due to the technological transition brought by the Digital Transformation wave. As it was stated previously, in such critical event the employees become a key factor that must be taken into consideration when talking about the 4.0 paradigm. Therefore, it will now be briefly introduced who the new employee in Industry 4.0 is – a topic that will be deeply discussed in the next Chapter – by answering the following question: how can the human factor foster a smoother and more successful Digital Transformation?

Over the years, several research have been made about the success rate of the technological transitions brought by the Industrial Revolutions, and the result can be summarized with the following statement: transformations are hard, but digital ones are harder. [65]

First, a measurement metric shall be introduced: when is it possible to declare "successful" a transformation? McKinsey proposes to award a technological transition as "successful" when it is capable at both improving performance and equipping the organization to sustain improvements over time.

As it was stated before, transformations are hard since usually less than 30 percent succeeds. Digital Transformations, though, tend to have a way lower percentage of success: only the 16% of respondents "*say their organizations' digital transformations have successfully improved performance and equipped them to*

[65] McKinsey&Company, "*Unlocking Success in digital transformation*", 2018, source: https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations

sustain changes in the long term. An additional 7 percent say that performance improved but that those improvements were not sustained"[66]. This trend has been confirmed also in digitally savvy industries, such as high tech, media, and telecom, whereby the rate does not exceed the 26%.

Of course, firms have the chance to enhance these percentages by working on several key factors. Among them, having the right technology in the right place seems to be a fundamental starting point: correctly deploying the traditional web technologies, cloud-based services, mobile internet technologies, Big Data, IoT, Artificial intelligence tool or Robotics is crucial in the 4.0 environment. That is not enough, though. McKinsey indeed points out 21 keys to success that are attributable to five main categories: having the right, digital savvy leaders in place, empowering people to work in new ways, building capabilities for the workforce of the future, giving day-to-day tools a digital upgrade, and communicating frequently via traditional and digital methods. It seems clear, therefore, that the human factor is crucial to successfully complete a digital transformation and so that the capability to leverage the business potential due to innovative digital technologies is in the hands of the employees.

This capability, as it was stated in a recent Report from Hoberg[67], is predominantly determined by the digital skills of the employees a company has access to and the reason of that lies within the complexity of a phenomenon, the digital transformation one, that to be triggered needs several specialized skills. Among

[66] McKinsey&Company, "*Unlocking Success in digital transformation*", 2018, source: https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations

[67] Patrick Hoberg, Helmut Krcmar and Bernd Welz, "*Skills for Digital Transformation*", IDT, 2017 pp. 1-10.

them, the digital security domain is one of the most important ones: in a heavy digitalized business world, haunted also frequently by ransomware and other informatic attacks, having extensive networking, sensory and computing capabilities is incredibly important. Along with the digital security ones, there are several other important skills, such as mobile technologies, big data analytics, IoT, AI, cloud computing or business network. Hard skills' characteristics and importance in Industry 4.0 will not here be deepened since the focus of the thesis is on the soft skills domain, but highlighting their importance was crucial to start drawing the shape of the 4.0 employee, a worker with also high and extensive technological skills.

Talking about soft skills, a topic that will be deeply discussed and analyzed in the next section, it is possible to state that the new employee must be characterized by the possession of several traits: self-awareness, empathy, flexibility, teamwork, problem solving, creativity, initiative, leadership, interdisciplinary thinking, organizational awareness, and efficiency orientation seem to be some of the most important ones. Overall, what here has been briefly stated and that in the next part will be analytically discussed, is that employees are crucial factors for a firm that wants to successfully complete its digital transformation process: the 4.0 employee is an individual with deep technological skills and attitudes that thanks to his/her transversal/soft traits is capable of leveraging the business potential and help the organization to achieve its goals.

CHAPTER 2: HUMAN CAPITAL 4.0

The aim of the first Chapter was to introduce and explain the concept of Industry 4.0, what its main technologies and characteristics were and how the working environment had to change accordingly to this new paradigm.

Once this purpose has been achieved, it is finally possible to move further, into a deeper analysis of this complex phenomenon that will lead the reader to discover how much the human capital is being influenced by the 4.0 paradigm: so much, indeed, that is even possible to talk about a 4.0 human capital, whereby an individual must have certain characteristics to deal properly with its new work environment. More specifically, the 4.0 employee must have some specific skills that distinguish its behavior: those traits are typically transversal and intangible, and throughout the thesis they will be addressed as "behavioral competencies".

The term "skills" is particularly complicated and soaked of meanings, and that is why this chapter will start with a focus on that concept, to catch what those traits are and why are they so important in the 4.0 context. Starting from its etymological definition and proceeding into a more philosophical and sociological point of view, the reader is going to discover the meaning of the skill's concept; or, at least, the most appropriate one for the purpose of this research. Once this concept has been clarified, it is possible to move into a deeper analysis that will lead to explore the definitions and meanings of hard and soft skills, and why for the purpose of this thesis the terms soft skills and behavioral/transversal competencies will be

considered as synonyms. Then, it will be briefly described why behavioral competencies are so important for employers and employees and why they are considered crucial in Industry 4.0. Once their importance has been explained, a literature review will follow to identify and list the main behavioral competencies in the 4.0 context. After having presented and analyzed what behavioural competencies are, two main questions will be answered at the end of the chapter: Is it possible to develop them and, if so, how?

The reader will discover that despite some difficulties, mainly linked with the necessity to grant high levels of interaction and constant practice, it is possible to develop those kinds of competencies and that, moreover, the modern tools offered by digital technologies might represent a key factor for this purpose.

2.1: SKILL: DEFINITION AND EVOLUTION

Among the scholars, the concept of "skill" has always been a critical topic of discussion and analysis, especially in the field of labor economics and sociology. However, the debate around its definition should not be seen just as an academic whim: nowadays, especially with the spread of Industry 4.0, the concept of "skill" has come to assume even more importance than before. Therefore, before stepping into the analysis of its evolution in the context shaped by the Fourth Industrial Revolution, it seems appropriate to examine its definition and its evolution.

What is "skill"? To answer this question, a common observer would check the dictionary. From an etymological point of view, skill is "*the ability to do an activity or job well, especially because you have done it many times*"[68], "*the ability to do something well, usually as a result of experience and training*"[69], "*the ability to do something well*"[70] or "*the ability to use one's knowledge effectively and readily in execution or performance*"[71]. Attewell[72] observed that the dictionaries, despite identifying slightly different definitions from each other, tend to link the concept of "skill" with the one of proficiency, or competence: to basically do something well and effectively. The main problem of this definition, as the author himself stated, is that "*like so many commonsense concepts, skill proves on reflection to be a complex and ambiguous idea*"[73], and this ambiguity is enhanced by the school of thought that is analyzing it.

[68] https://dictionary.cambridge.org/dictionary/english-italian/skill
[69] https://www.macmillandictionary.com/dictionary/british/skill
[70] https://www.oxfordlearnersdictionaries.com/definition/english/skill?q=skill
[71] https://www.merriam-webster.com/dictionary/skill
[72,73] P. Attewell, "*What Is Skill?*", Work and Occupations, 1990, pp. 422-448.

As stated by Esposto, "*In the social sciences, and in particular in the fields of industrial sociology and labour economics, most of the controversy and confusion in defining and measuring skill arises out of a number of theories of skill that hold different notions and are blind to their preconceptions regarding skill*"[74]. For instance, the Taylorism's[1] outbreak in the early 1900s brought to the skill definitions of Pear "*the integration of well-adjusted muscular performances*"[75] and Renold "*any combination, useful to industry, of mental and physical qualities which require considerable training to acquire"*[76].

To schematize and identify all the possible definitions, in the 1990 Attewell[77] decided to trace and categorize the notions of skill into four schools of thought: Positivist, Ethnomethodological, Weberian and Marxist.

1) **Positivist**: skill is seen as a measurable, a characteristic which is objective and easy to measure. The drawback of this school of thought is that the definition of skill is too reductive: the scholars who follow the positivist approach tend to "*treat skill as an attribute of jobs rather than persons and, in particular, are unable to deal adequately with the subjective dimensions that affect assumptions, definitions and measures of skill*"[78].

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[1] A management theory introduced by Federick Taylor in 1911, based on the usage of scientific methods to identify the most efficient production process in order to increase productivity.

[74,78] A. Esposto, "*Skill: An Elusive and Ambiguous Concept in Labour Market Studies*", ABL Vol 34, No 1, 2008, pp. 101.
[75] T.H. Pear, "*Skill*", Journal of Personnel Research, Vol. 5, 1927, p. 478-489.
[76] C. More, "*Skill and the English working class"* in "*Typology of knowledge, skills and competences: clarification of the concept and prototype*", by J. Winterton, F. Delamare and E. Stringfellow, Cedefop Reference series (64), 2006, pp. 26.
[77] P. Attewell, "*What Is Skill?*", Work and Occupations, 17 (4), 1990, pp. 422-448.

2) **Ethnomethodological**: skill is seen as a larger and more dynamic concept than in the previous approach. All the human activity is believed to be complex, and so whatever action is the result of a multiples choices, movements, decisions, and skills. The drawback of this approach is the opposite of the one seen in the positivist thought: skills are too complex and multifaced to be catalogued and studied.
3) **Weberian**: The Weberian school of thought aims at understanding the conditions under which occupations are socially defined as skilled, and the system by which some skills lie in a higher standing than the others. The doubts on this approach are related to the role of the society in determining the importance of skills. As Attewell says, "*the important question that emerges is whether the elevated status and claims to skill of some occupations are purely a matter of social construction and supply and demand or whether they rest on a real technical skills or task complexity*"[79].
4) **Marxist**: the author believes that the concept of skill breaks into the Marxist theory in the "Labour theory of value", the labour aristocracy and the theory of alienation and technological change. In this approach, the concept of skill is believed to be a common-sense category that does not require a definition or explanation.

[79] P. Attewell, "*What Is Skill?*", Work and Occupations, 17 (4), 1990, pp. 430.

Despite its importance in Sociology and Labour Economics studies, the framework defined by Attewell did not give a precise answer to the question raised before: what is skill?

Although yet there is no consensus over the meaning of the skill concept[80], which is often given as obvious and left unstated[81], for the purpose of this research three main suitable definitions have been identified:

a) **Proctor**: skill is "*a goal-directed, well-organized behavior that is acquired through practice and performed with economy of effort"*[82].
b) **Welford**: skill is a mix of factors that "*make up a competent, expert, rapid and accurate performance"*[83].
c) **A.S. Reber and E. Reber:** skill is "*the capacity for carrying out complex, well-organized patterns of behavior smoothly and adaptively so as to achieve some end or goal*"[84].

The terms used ("capacity", "patterns of behavior" instead of "behavior", "adaptively"), the exhaustive but at the same time concise language, made me opt for the third definition. Therefore, over the thesis the term "skill" will be linked to the meaning given by Reber.

In the later sections the analysis of the various kinds of skills will be deepened, but before stepping further, to avoid misunderstandings, it seems appropriate to highlight its difference from the concepts of competence and competency, since

[80] F. Green, "*What is skill? An Inter-Disciplinary Synthesis*", LLAKES Research paper 20, pp.4.
[81] K.I. Spenner, "*Skill: meanings, methods and measures*", SAGE, 1990, pp. 402.
[82] R.W. Proctor and A. Dutta, "*Skill acquisition and human performance*", Advanced psychology texts (Vol. 1), 1995, pp. 18.
[83] A.T. Welford, "Fundamentals of skill", Methuen and Co Ltd, 1968, pp.12.
[84] A.S. Reber and E. Reber, "*The Penguin Dictionary of Psychology*", Penguin Books 3rd edition.

they are commonly used as synonyms. The concept of competence (or competency, since "*competence generally refers to functional areas and 'competency' to behavioural areas, but usage is inconsistent*"[85]) was introduced in 1973 by David McClelland[86], when he found out that "competence" was the characteristic that really differentiated top from average performers at work. More precisely, by collecting data from more than thirty companies and interviewing executives, the American psychologist discovered that the real performance differentiator between workers was represented by a wide range of emotional competencies and so that competence was more important for success in work and life than intelligence. The results achieved by McClelland influenced all the scholars from the mid 70s up to nowadays: among them, the studies of Boyatzis seem to be particularly interesting to deepen and clarify the concept of competence. In "The Competent Manager"[87] Boyatzis defines competency as "*an underlying characteristic of a person"*. For instance, it could be a "*motive, trait*, *skill, aspect of one's self-image or social role, or a body of knowledge which he or she uses*"[88]. Therefore[89], in the Boyatzis' competency approach, competencies are capabilities that bring to a superior performance, and that are made of how an individual reacts in a specific situation (action) and how much effort he spends in something (intent). There are four main domains in which the competencies are identified: self-awareness, self-management, social awareness, and relationship management. Self-awareness, obtained through a self-assessment that should highlight everyone's strengths and

[85] F. Le Deist and J. Winterton, "*What is competence*?", Human Resource Development International, Vol. 8, No. 1, 2005, pp. 27-46.
[86,89] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 43.
[87,88] R.E. Boyatzis, "*The competent manager: a model for effective performance*", Wiley & Sons, 1982, pp.1-328.

weaknesses, is a critical component since it represents the "*ability to identify our own emotions and the effect they have on us and the others*"[90]. Self-management, instead, is the ability to manage the inner emotions, states, and impulses, allowing so the individual to regulate its behaviors accordingly to it. Social awareness consists of taking the perspective of and empathizing with others, whereas Relationship management regards all the competencies that "*involve the relationships with others and the capacity to induce desirable responses in others*"[91]. The research of the Greek theorist has been followed by the ones of several other important scholars, such as Quinn, Faerman, Thompson and McGrath[92], who in the early 1990s stated that competencies "*were associated with knowledge and skills for implementing certain assignments or projects effectively*"[93]. Further, Spencer and Spencer contributed in the mid 1990s to clarify the definition of this term, and distinguish it from the one of skill, by affirming - similarly to Boyatzis- that it is "*an underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation*"[94]. In this definition there are two terms worth an in-depth analysis: "underlying characteristic", used also by Boyatzis, which refers to the fact that a competency is a deep and enduring part of a person's personality, and "criterion-referenced", which means that "the competency actually predicts who

[90,91] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 43.
[92] Quinn, E. R. et ali.," Becoming *a master manager: A competency framework*" New York: John Wiley & Sons, 1990
[93] Su-Chin Hsieh et ali, "*Analysis on Literature Review of Competency*", International Review of Business and Economics Vol.2 pp.25-50, October 2012
[94] Spencer, L., & Spencer, M., "*Competence at work: Models for superior performance*", N.Y.: John Wiley & Sons, 1990.

does something well or poorly, as measured on a specific criterion or standard"[95]. Although many other scholars have faced the competency issue in the attempt to identify its most appropriate meaning, such as Cardy and Selvarajan[96], Hoffmann[97] or Burgoyue[98], it seems[99] that one of the most accepted definitions is the one given by Parry: "*A competency is a cluster of related knowledge, skills, and attitudes that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measure against well-accepted standards, and that can be improved via training and development*"[100]. To summarize, from this section it is possible to identify two main outputs: the definition of skill, as "*the capacity for carrying out complex, well-organized patterns of behavior smoothly and adaptively so as to achieve some end or goal*[101], and the one of competency, "*a cluster of related knowledge, skills, and attitudes that affect a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measure against well-accepted standards, and that can be improved via training and development"*[102]. Once the difference between skill and competency has been underlined, it is possible to step into another crucial topic, the difference between hard and soft skills.

[95] L. Spencer and M. Spencer, "*Competence at work: Models for superior performance*", N.Y.: John Wiley & Sons, 1993.
[96] R.L. Cardy and T.T. Selvarajan, "*Competencies: Alternative frameworks for competitive advantage*", Business Horizon, 49, 2006, pp. 235-245.
[97] T. Hoffmann, "*The meanings of competency*", Journal of European Industrial Training, 23(6), 1999, pp. 275-285.
[98] J. Burgoyue "*The competence movement: Issues, stakeholders and prospects*" Personnel Review, 22(6), 1993, pp. 6-13.
[99] Su-Chin Hsieh, Jui-Shin Lin and Hung-Chun Lee, "*Analysis on Literature Review of Competency*", International Review of Business and Economics Vol.2 pp.25-50, October 2012.
[100,102] A.D. Lucia and R. Lepsinger, "*The art and science of competency models: Pinpointing critical success factors in organizations*", 1999, pp.9.
[101] A.S. Reber and E. Reber, "*The Penguin Dictionary of Psychology*", Penguin Books 3rd edition.

2.1.1: Soft vs Hard Skills

The distinction between hard and soft skills is crucial. Not only because this thesis is going to focus mainly on soft skills, but also because nowadays, especially in the context of Industry 4.0 - as it was stated over the first chapter, and as it will be confirmed and reinforced over the second and third ones – the latter ones seem to represent a key factor of success for both employee and employers.

Therefore, it seems appropriate to make a sound literature overview of the two terms, in order to catch their meaning and difference.

Hard skills are skills "*related to technical aspects to do some tasks in the job"*[103] which are cognitive and influenced by intellectual quotient (Hendarman et al.[104]; Muhammad et al.[105]; Kenayathulla, Ahmad & Idris[106]; Tsotsotso et al.[107]; Fan, Wei & Zhang[108]). Moreover[109], they have some unique characteristics. For instance, they represent a kind of knowledge that can be easily documented, formed, and articulated. They are tangible, since not only they describe specific and explicit behaviors and skills but also produce something that is visible and direct. They can be assessed from technical or practical tests, and they are easy to measure.

[103,104,109] A.F. Hendarman and U. Cantner, "*Soft skills, hard skills, and individual innovativeness*", Eurasian Business Review, 2018, pp. 141

[105] A. Muhammad et ali, "*Factor Analysis of the Companies Demands to the Polytechnic Graduates in Indonesia*", Advanced Science Letters, Volume 25, Number 1, 2019, pp. 5.

[106] H. Kenayathulla, N. Ahmad and A. Idris, "*Gaps between competence and importance of employability skills: evidence from Malaysia*", Higher Education Evaluation and Development, Vol. 13 No. 2, 2019, pp. 97-112.

[107] K. Tsotsotso et ali, "*Determinants of skills demand in a state- intervening labour market: The case of South African transport sector*", Higher Education, Skills and Work-Based Learning, Vol. 7 No. 4, 2017, pp. 408-422.

[108] C.S. Fan, X. Wei and J. Zhang, "*Soft Skills, Hard Skills, and The Black/White Wage Gap*", Wiley Online Library, 55(2), 2017, pp. 1032-1052.

A list of possible hard skills might be represented by define, calculate, explain, describe, classify, identify, predict, analyze, compare, differentiate. To conclude, hard skills can be defined as "*technical abilities or solid factual knowledge required to do a job*"[110].

The characteristics of soft skills make their definition much more complex than the one of hard skills. Indeed, over the years scholars have given many definitions to this vague term, such as "*learned behavior based on individual's predispositions"*[111], *"the interpersonal, human, people, or behavioral skills needed to apply technical skills and knowledge in the workplace*"[112], "*intrapersonal skills such as one's ability to manage oneself as well as interpersonal skills such as how one handles one's interactions with others"*[113], *"intra- and inter- personal (socio-emotional) skills, essential for personal development, social participation and workplace success"*[114], or as "*Skills, abilities, and traits that pertain to personality, attitude and behavior rather than to formal or technical knowledge"*[115].

[110] Verica Babić and Marko Slavković, "*Soft and Hard Skills Development: A Current Situation in Serbian Companies*", Management, Knowledge and Learning. International Conference, 2011, pp. 409.
[111] J. Balcar, "*Is it better to invest in hard or soft skills?*", The Economic and Labour Review Volume 27(4), 2017, pp. 2
[112] M.R. Weber, A. Crawford, D. Rivera and D.A. Finley, "*Using Delphi panels to assess soft skill competencies in entry level managers*", Journal of Tourism Insights, 1(1), 2011, pp. 98
[113] D.R. Laker and J.L. Powell, "*The differences between hard and soft skills and their relative impact on training transfer*", Human Resource Development Quarterly, 22(1), 2011, pp.112.
[114] K. Kechagias, "*Introduction to Soft Skills and Generic Competencies*", 2011, pp. 33, in "*Teaching and Assessing Soft Skills*" by K. Kechagias, MASS Project, 2011.
[115] P. Moss and C. Tilly, "*Soft Skills and Race: An Investigation of Black Men's Employment Problems*", Work and Occupations, 1996, pp. 156.

For the purpose of this thesis, the most appropriate definition has been given by Verica Babić and Marko Slavković: soft skills are "*interpersonal, human, people or behavioural skills necessary for applying technical skills and knowledge in the workplace*"[116]. Those skills are knowledge in the human mind, very personal and difficult to formulate[117]. Intangible, in one word.

Before moving forward, a clarification has to be done among the concepts of "skill", "competency", "behavioral skill" and "soft skill". Despite the difference that has been underlined before, for the purpose of this thesis the terms skill and competency have to be intended as synonyms, as long as the terms behavioral skills (or, behavioral competencies) and soft skills, as Rao[118] suggests.

[116] Verica Babić and Marko Slavković, "*Soft and Hard Skills Development: A Current Situation in Serbian Companies*", Management, Knowledge and Learning. International Conference, 2011, pp. 410.
[117] A.F. Hendarman and U. Cantner, "*Soft skills, hard skills, and individual innovativeness*", Eurasian Business Review, 2018, pp. 141.
[118] M.S. Rao, "*Soft skills: toward a sanctimonious discipline*", Emerald Publishing Limited, Vol. 26 No. 3 2018, pp. 218.

2.1.2: The importance of Behavioral Competencies for the organization

The aim of this thesis, the creation of a 4.0 competency model that focuses on behavioral competencies (or, soft skills), requires an in-depth analysis of those kinds of traits. Indeed, after the statement of their meaning, two more issues should be considered: why are they so important and when do they come into play. The answer to these questions, has been partially given by the studies of McClelland and the other researchers previously quoted. First and foremost, behavioral competencies represent a performance differentiator. It is not by chance that from an interview of five hundred famous innovators it turned out that most of them went to Montessori schools[119], whereby a particular and novel educational model was applied. Dr Montessori modified the educational environment, "*giving great importance to the free movement of the child, emphasizing rigorous preparation of teachers and mixing students of different ages in three communities of learning (3-6, 6-9, 9-12), providing education a family-like natural social approach*"[120]. Moreover, she transformed classrooms into environments whereby all the proper objects are available and positioned at children's height, favoring therefore the interaction with them and so the learning process. This method, if properly applied, allows children to learn and practice their behavioral competencies continuously, preempting therefore the ones who did not attend such kinds of school. This is not the only example that explains the importance of behavioral competencies.

[119] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 43.
[120] Maria-Teresa Lepeley, Nicholas J. Beutell, Nureya Abarca and Nicolas Majluf, "*Soft Skills for Human Centered Management and Global Sustainability*", Routledge, March 2021, pp. 1-184.

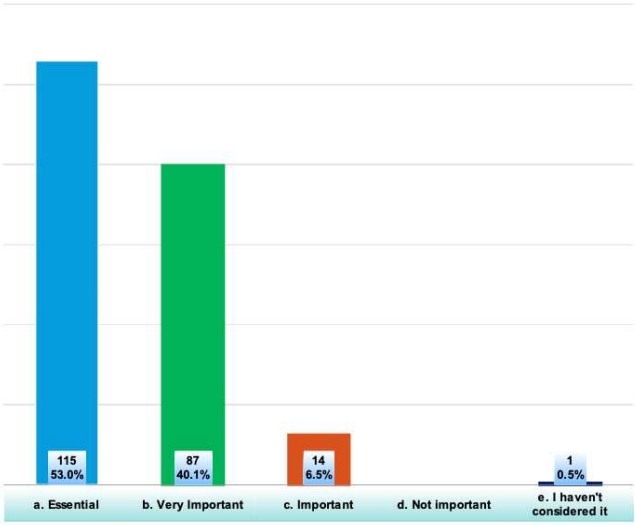
Recent research in Indian banks revealed that there is a positive and linear relationship between soft skills development and employee's knowledge, skill, behavior, teamwork and, in turn, performances[121]. Other studies[122] have shown the crucial role of behavioral competencies in people's success. Indeed, the Harvard University highlighted the importance of soft skills in people's life, concluding that 80% of job success comes from having well-developed soft and people skills, and only 20% is due to technical, hard skills. Also, the National Association of Collage and Employee (NACE), with a survey to 457 business leaders, has shown that among 20 important quality of success people, 18 are related to soft skills. Therefore, it is possible to state that from an employee point of view, the importance of behavioral competencies lies within the possibility to increase their on-the-job performances' and so, success.

If this is true, another straightforward consideration should come up about the managers of the organization: soft skills should be considered as a crucial resource to help them in the selection and development of employees. Indeed, as it is possible to see from a recent survey of Wonderlic (represented in Figure 2) [123], a company specialized in the creation of pre-hiring assessment platforms, it turned out that soft skills are "essential" when making hiring decisions:

[121] Sanjay Deshpande and M. Munshi, "*A study on soft skill training as an intervention to reinforce employee performance in the contemporary banking sector"*, SIMSARC, 2019, pp. 1-19.
[122] Wagiran, "*The Importance Of Developing Soft Skills In Preparing Vocational High School Graduates*", Soft Skills Training and Certification, 2008, pp 5.
[123] Figure 2. Source: The Wonderlic Company, "*Hard Facts About Soft Skills: An actionable review of employer perspectives, expectations and recommendations*", 2016.

Figure 2

		Median	Favorable % (a. + b.)	a. Essential	b. Very Important	c. Important	d. Not important	e. I haven't considered it
Q2. Importance of soft skills when making hiring decisions	217 100.0%	a. Essential	93.1%	115 53.0%	87 40.1%	14 6.5%	- -	1 0.5%



As it is possible to see from the above table [124], among the 257 managers from a wide range of different sized companies (SMEs to MNEs), 99% of them believes that soft skills are at least "important" in the selection process. This is not the only research that faced the soft skills importance in hiring: the studies of Glenn[125], Mitchell et. al.[126], Perreault[127], Sutton[128] and Wilhelm[129] have shown that in the 21st

[124] Figure 2. Source: The Wonderlic Company, "*Hard Facts About Soft Skills: An actionable review of employer perspectives, expectations and recommendations*".
[125] J.L. Glenn, "*The "new" customer service model: Customer advocate, company ambassador*", Business Education Forum, 62(4), 2008, pp. 7-13.
[126] G.W. Mitchell, L.B. Skinner and B.J. White, "*Essential soft skills for success in the twenty-first century workforce as perceived by business educators*", Delta Pi Epsilon Journal, 52, 2010, pp. 43-53.
[127] H. Perreault, "*Business educators can take a leadership role in character education*", Business Education Forum, 59, 2004, pp. 23-24.
[128] N. Sutton, "*Why can't we all just get along?*", Computing Canada, 2002, pp. 20.
[129] W.J. Wilhelm, "*Determinants of moral reasoning: Academic factors, gender, richness of life experiences, and religious preferences*", Delta Pi Epsilon Journal, 46, 2004, pp. 105-121

century employers want to hire people with high interpersonal skills [130].

The consensus around this belief can be easily explained: especially nowadays, working in a company means to interact with other people. Negotiating to win a contract, presenting an idea to the other colleagues or the board, networking for a new job, asking for help to the back office, solving a conflict, and so on, are all actions that require interaction with other human beings. Therefore, the higher the level of behavioral competencies, the higher the chances to be successful at work, as it has already been remarked over this paragraph.

According to a study[131] by Boston College, Harvard University and The University of Michigan, training behavioral competencies such as problem solving or communication can boost the levels of productivity and retention by 12%, and delivers a 250% return on investment based on these increases. A report[132] from Hay Group has shown that managers who incorporate soft skills into their leadership approach can increase their team's performance by up to 30%.

What has been stated up to now can be further reinforced by focusing on the relation between behavioral competencies and Industry 4.0: the spread of the new technologies is leading to a business world whereby having sound behavioral competencies is crucial for the success of the worker and the organization itself. In the digital transformation era, the new working environment is characterized by machines that can do numerous activities better than human beings. Examples

[130] Marcel M. Robles, *"Executive Perceptions of the Top 10 Soft Skills Needed in Today's Workplace*", Business Communication Quarterly, 75(4), 2012, pp. 453–465.

[131] https://michiganross.umich.edu/rtia-articles/soft-skills-training-boosts-productivity

[132] https://www.shrm.org/hr-today/news/hr-magazine/0416/pages/hrs-hard-challenge-when-employees-lack-soft-skills.aspx

might be represented by: data gathering, analysis, interpretation, and actions' implementation: those, as it was stated in "*The Rise of AI Makes Emotional Intelligence More Important*" [133], are actions that machines can do much more efficiently and effectively than humans. A question might come up straightforward: if machines are becoming better than humans, why are behavioral competencies so important for the success of the employee and the employer?

Because they represent one of the few capabilities that machines, and AI, have trouble replicating. Therefore, developing behavioral competencies is a key step for the worker to have success in his/her career, and for the organization to better exploit the potential of machines.

Once the importance of behavioral competencies for organizations has been highlighted, it is possible to move forward, and explore in-depth the relation between these traits and the world of Industry 4.0.

[133] Megan Beck and Barry Libert, "*The Raise of AI Makes Emotional Intelligence More Important*", Harvard Business Review, 2017, pp.1-5.

2.2: THE IMPORTANCE OF BEHAVIORAL COMPETENCIES IN INDUSTRY 4.0

The Fourth Industrial Revolution is changing the shape of organizations, forcing them to manage both the opportunities and challenges brought by the Digital Transformation, a phenomenon that affects the entire "*supply chain, comprising product design and development, operations management and logistics*"[134].

Therefore, firms that want to remain competitive must adapt themselves to this new environment, relying on their capabilities: among them, "agility" seems to be the most important one[135]. This term characterizes a company that can obtain valuable information due to the correct usage of big data, to exploit market opportunities, to adapt to changes, to decentralize its decision-making process or to adopt swift responses to changes. However, the agility of a company has also to be seen as a function of the flexibility and adaptability of its employees, whose work is about to change radically in Industry 4.0 due to its higher complexity and the spread of the new technologies. Although it is not possible to identify a precise set of 4.0 skills yet, it seems that in addition to hard skills there will be a sharp increase of the behavioral competencies demand, especially the ability to team play, to foresee new possible threats or to adjust quickly to unexpected situations. The aim of this section is precisely to show, thanks to a literature overview of the industry 4.0 competencies, how much their importance is increasing inside the organizations.

[134] G. Prause, "*Sustainable business models and structures for industry 4.0*", Journal of Security and Sustainability, vol. 5, no 2, 2015, pp. 160.
[135] M. Götz, "*The Industry 4.0 Induced Agility and New Skills in Clusters*", Foresight and STI Governance, vol. 13, no 2, pp. 72–83.

The Boston Consulting Group's "Man and Machines"[136] has deeply analyzed the impact of Industry 4.0 in Germany: it seems that performing efficiently in 4.0 requires the mastery of a variety of hard skills, especially the ones related to IT. Indeed, the demand of IT and software development competencies is growing, contributing to a 96% increase of jobs in IT and data integration. More specifically, employees will have to combine the know-how required by a specific job or process with IT competencies, "*that range from basic (using spreadsheets and accessing interfaces) to advanced (applying advanced programming and analytical skills)*."[137] However, the control of the multiple hard skills required is also highlighting the importance of behavioral competencies, since employees "*have to be even more open to change, possess greater flexibility to adapt to new roles and work environments, and get accustomed to continual interdisciplinary learning*"[138]. Fitsilis et al.[139], in their training framework for Industry 4.0, identify "Transversal Skills" as a key dimension that characterizes the new era introduced by the Fourth Industrial Revolution. They can be defined as skills not related to a specific job, task, or area of knowledge, but that can rather be used in a wide variety of situations and work settings. Among them, it is possible to find:

a) **Personal Competencies**: they can be described as the ability to act autonomously.
b) **Social and interpersonal competencies**: the capability to communicate and work with other individuals and teams.

[136, 137, 138] M. Lorenz, M. Rüßmann, R. Stranck, K.L. Lueth and M. Bolle, "*Man and Machine in Industry 4.0*", The Boston Consulting Group, 2015, pp. 1-22.
[139] P. Fitsilis, P. Tsoutsa and V. Gerogiannis, "*Industry 4.0: Required Personnel Competences*", International Scientific Journal "Industry 4.0", 2018, pp. 130-133.

c) **Action-Related Competencies**: the capacity to take individual or socially constructed ideas into action.

d) **Methodological Competencies**: creativity, problem solving, entrepreneurial thinking, efficiency orientation and decision making are a few of the skills that belong to this category.

Piwowar-Sulej[140], too, by considering several studies have identified the competencies of the future: first of all, from the "Foresight of modern economy human resources", a project commissioned by the Polish Agency for Enterprise Development, it turned out that spatial mobility, information technology skills, command of foreign languages and team working in international teams will be more and more required to workers. Secondly, the "Employers' perception of graduate employability" report by Gallup indicated six main skills that should be mastered by university graduates to successfully face the new working environment: teamwork skills, technical skills, interpersonal communication skills, computer literacy, adaptability and functioning in a new situation and reading/writing skills. Thirdly, the "Future work skills 2020" report identified other key competencies, such as sense-making, transdisciplinarity, cross-cultural competencies, social intelligence, internet, and computer skills (or, digital competencies), the assessment of sources' credibility, the ability to use them in a smart way, flexibility, openness to change and social intelligence.

[140] Katarzyna Piwowar-Sulej, "*Employee 4.0 from the competitive perspective*", Studia I Prace WNEiZ, 2018, pp. 122-129.

"The Future of Jobs"[141], by the World Economic Forum, is another important source to understand the impact of Industry 4.0 over the workforce. From the study of the Report, it is possible to infer that the skills requirements are rapidly changing: the new technologies brought by the Digital Transformation are highlighting the importance of working with data and making data-based decisions, in a new environment characterized by a high complexity.

Thus, problem solving, social skills (persuasion, teaching others, emotional intelligence), content skills and cognitive skills (such as creativity) are expected to become new core competencies in the 4.0 era, even in occupations that until nowadays were considered purely technical. For example, the automation of diagnosis and personalization of treatments will redefine the role of healthcare practitioners, who will shift their focus on translating and communicating the data obtained to patients. Similarly, in any sales job creativity will be a new fundamental core skill, due to the outbreak of e-commerce and online competition. Overall, the conclusions found in the research previously analyzed are confirmed also in the Report, which highlights too the importance of behavioral competencies for the 4.0 worker: in a heavily digitalized and complex working environment, creativity, team working and problem solving are just a few of the capabilities that he must develop to successfully work in Industry 4.0.

The concept of soft, behavioral skills and their importance in the Digital Transformation context has also been studied by other scholars, such as Sabine

[141] World Economic Forum, "*The Future of Jobs*", 2015, pp. 1-167.

Pfeiffer.[142] Although hard skills and qualification requirements are certainly important, the author believes that transversal competencies requirements are playing an even more important role into an increasingly digitalized world of work. Specifically, Pfeiffer believes that the 4.0 employee should have the capacity to work in a team, link the material and the abstract, think systematically, act confidently in conditions of uncertainty and be creative. The research of Kipper[143] has also pointed out similar results to the ones already discussed: the introduction of new technologies has completely changed the working environment, along with the required skills. The high complexity of knowledge, both tacit and explicit, underlines the need of interdisciplinary thinking among the employees, whereas the collaboration between workers and robots requires a high degree of flexibility, adaptability, and creativity. Benešová and Tupa[144] have tried to identify the skills demanded for some new job profiles in Industry 4.0, such as the Robot Programmer, the PLC Programmer, the Data Analyst, or the Cyber Security expert. It seems worth noticing that apart from qualifications and hard skills, each job also requires the mastery of transversal skills. For example, the Informatic Specialist is required not only to have a postgraduate education in IT and an advanced knowledge of large domain and network management, but also to have the ability to communicate effectively, plan and lead small teams, and to be flexible. The PLC programmer should have advanced programming and knowledge of PLC, but he should also be

[142] S. Pfeiffer, "*Effects of Industry 4.0 on vocational education and training*", Institute of Technology Assessment Manuscripts, 2015, pp. 1-51.
[143] L.M. Kipper, S. Iepsen, A.J. Dal Forno, R. Frozza, L. Furstenau, J. Agnes and D. Cossul, "*Scientific mapping to identify competencies required by industry 4.0*", Technology in Society, Vol 64, 2021, pp 5.
[144] A. Benešová and J. Tupa, "*Requirements for Education and Qualification of People in Industry 4.0*", Procedia Manufacturing, Vol 11, 2017, pp. 2195-2202.

flexible, reliable, and able to communicate effectively. Those skills, and others such as creativity, problem solving and autonomy, are required for the other job profiles too. So far, likewise it was noticed in the Report of the World Economic Forum, it seems that also purely technical job profiles nowadays have to consider behavioral, soft skills as part and parcel of their work. To conclude the previous paragraph the research of Beck and Libert was highlighted in order to demonstrate that even in this new, digital, and highly technological world, the presence of human beings is still crucial. Indeed, "*skills like persuasion, social understanding, and empathy are going to become differentiators as artificial intelligence and machine learning take over our other tasks*"[145], and therefore – again - it seems that employees' soft skills are fundamental in the 4.0 environment. To conclude, from the proposed literature overview, and the ones made by other scholars such as Chaka[146], it comes to light the necessity for the "new" employee to master at the same time both hard and soft skills. So far, the outbreak of the new technologies requires high technical skills to handle properly the new technologies, but also soft ones, due to the high complexity of a new working environment where being flexible, able to work in teams or open to changes is becoming a primary concern. Finding an employee with this right mix of skills is not easy though, as Nesta pointed out[147]. Anyway, before stepping into the development of these kind of traits, which will be the main topic of the next section, it should be clearly defined what are the most important behavioral competencies in Industry 4.0.

[145] Megan Beck and Barry Libert, "*The Raise of AI Makes Emotional Intelligence More Important*", Harvard Business Review, 2017, pp.1-5.
[146] C. Chaka, "*Skills, competencies and literacies attributed to 4IR/Industry 4.0: Scoping review*", International Federation of Library Associations and Institutions, 2020, pp. 338.
[147] K. Baker, "*The Digital Revolution*", Edge Foundation, 2016, pp. 7.

2.2.1: The 4.0 Behavioral Competencies

At this point, it seems appropriate to give substance to what has been shown up to now. Defining the most important behavioral competencies in Industry 4.0 is a key step that must be addressed to analyze this phenomenon deeply and meticulously.

For the purpose of this thesis, 10 main behavioral competencies, or soft skills, for Industry 4.0 will be presented and discussed.

The first one, is **Self-Awareness**: it can be described as the capability to "*understand one's own emotions and their effects but also to know one's inner values, strengths and limits*"[148]. It is one of the most important and fundamental components of emotional intelligence, because being self-aware means "*really knowing who you are*"[149]. This is not its only meaning. An article from the Harvard Business Review[150] explains that the term "self-awareness" encompasses two broad dimensions: the internal and the external self-awareness. The definition given before represents the first one, and it is extremely important since it is usually associated with a large spectrum of feelings, such as happiness, anxiety, stress, and depression. The second one, instead, means "*understanding how other people view us*"[151], which affects other important characteristics, especially in Industry 4.0, such as empathy and teamworking.

Given their meanings, it is finally possible to state that this trait is particularly important, since it allows to better interpret (and so, avoid misinterpreting) the

[148] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 1-105.
[149] Ronald Wheeler, "*Soft Skills: The Importance of Cultivating Emotional Intelligence*", Boston University School of Law, 2016, pp. 29.
[150,151] Tasha Eurich, "*What Self-Awareness Really Is (and how to cultivate it)*", Harvard Business Review, January 2018.

surroundings, the colleagues, and the overall working environment. In the context of Industry 4.0, this might mean not to have bias over machines/technologies and their outcomes and to better fit into a complex and non-linear environment.

Besides its meaning and importance, it seems appropriate to do some other considerations over this kind of competency. First, there is no direct relationship between internal and external self-awareness: being high on one type does not mean being high also on the other. Second, people tend to be overconfident over their level: the article revealed that only 10-15% of the people studied correctly guessed their self-awareness level. Third, being introspective – i.e. "*examining the causes of our own thoughts, feelings, and behaviors"*[152] – does not always improve self-awareness: yet, "*one of the most surprising findings of our research is that people who introspect are less self-aware and report worse job satisfaction and well-being*"[153]. Overall, this brief section highlighted the importance and the complexity of the Self-Awareness trait, and that is why literature, such as "*Behavioral competencies of digital professionals"*[154], "*Competencies for Industry 4.0*"[155] or "*Scientific mapping to identify competencies required by industry 4.0*"[156] agrees on identifying Self-Awareness as one of the key soft skills in Industry 4.0. The second behavioral competency that is going to be discussed, is **Empathy.** It is the ability to "*understand and share the feelings of the others*"[157], to sense others' emotions.

[152,153] Tasha Eurich, "*What Self-Awareness Really Is (and how to cultivate it)*", Harvard Business Review, January 2018.

[154] Sara Bonesso, Elena Bruni, and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 1-105.

[155] Marcela Hernandez-de-Menendez, Ruben Morales-Menendez, Carlos A. Escobar and Megan McGovern, "Competencies for Industry 4.0", International Journal on Interactive Design and Manufacturing, 2020, pp. 1115-1124.

[156] L.M. Kipper et ali, "*Scientific mapping to identify competencies required by industry 4.0*", Technology in Society, 2021, pp. 1-9.

[157] Ronald Wheeler, "*Soft Skills: The Importance of Cultivating Emotional Intelligence*", Boston University School of Law, 2016, pp. 31.

Empathy allows to be a good team player, since it helps to better understand the effects of one's actions over the others, the way colleagues see things and therefore anticipate the wants and needs of others in the workplace. This competency might help to catch the team's uncertainties and fix them in the fastest possible way: "*The company decided to adopt a new software, SAS. Most of the employees were not familiar with this software, and they looked scared; they were resistant to the change. How did I understand that they were skeptical? Well, it was from their attitudes, their behaviors, how they talked to give you some information, how they said uhm*"[158]. Another important soft skill is **Flexibility**. In the 2.2 Section it was remarked that the agility of a company is also a function of the flexibility of its employees, considering their work is about to change radically. In a few words, Flexibility can be described as someone's *"capacity to adapt*"[159] and, even if at this point it might sound redundant, it is important to stress again that such capability is fundamental for the employees' and firms' survival and growth. Indeed, the 4.0 paradigm "*will require a shift from more manual labour to a more knowledge-based work, as a significant part of the future workers' tasks will entail activities that involve applying, searching, creating and sharing complex knowledge. However, this might be a difficult adaptation, especially for an aging labour force that might not have the appropriate training and required skills. Hence, it is important that workers are motivated, flexible and open to change so that they can collaborate more effectively.*"[160]

[158] S. Bonesso et ali, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 78.
[159] William Golden and Philip Powell, "Towards a definition of Flexibility: in search of the Holy Grail?", Omega, 2000, pp. 373.
[160] S. Bragança et ali., "*A Brief Overview of the Use of Collaborative Robots in Industry 4.0: Human Role and Safety*", Springer Nature Switzerland, 2019, pp. 648.

Furthermore, as it was stated in the previous chapter, the working environment introduced in Industry 4.0 is made of multidisciplinary tasks, whereby workers are required to cooperate across different functions, and thus to face issues not related to their competencies: therefore, in such environment, being flexible and open-minded represents a key element to identify and solve issues. Overall, being able to adapt in such situations, being flexible, is a key behavioral competency that will help both the employer and the employee to survive in the 4.0 context.

The fourth competency is **Teamwork,** that is the capability to work in concert with other people.[161] This competency is particularly important, for several reasons[162]. First of all, it brings efficiency: it lets difficult tasks to be split into simpler ones, making each worker to focus on a specific task, develop specialized skills, and complete them in a faster and more efficient way. Secondly, there are higher levels of goal-monitoring: in teamwork many people have indeed responsibility for the same goal, and therefore teammates observe and depend on the quality of each other's work. Thirdly, tackling a problem as a team means having multiple points of view, experiences, and skills on the same issue, favoring therefore a faster and deeper innovation Finally, another reason that might explain its importance is the performance improvement lead by teamworking: by "*working together, they* - the employees - *will soon learn each other's strengths and correct each other's mistakes. And everyone's performance will improve*" [163].

[161] Andreas Xyrichis and Emma Ream, "*Teamwork: a concept analysis*", Journal of Advanced Nursing, 2008, pp. 235.
[162,163] https://www.brighthr.com/articles/culture-and-performance/teamwork/the-importance-of-teamwork-in-the-workplace/

Further, a research[164] has shown that teamworking is also linked with employees' well-being and intention to remain in the organization: from a social and psychological point of view, poor employee well-being might trigger two kinds of withdrawal behavior: the psychological one, characterized by a detachment from people that one works with, and the behavioral one, associated with the intention to resign from the organization. As it was stated just before, those two behaviors can be avoided, or at least lessen, thanks to teamworking: if the organization is capable of building teams whereby each member can have positive and healthy interactions with the others, then their level of commitment at work will be higher along with their identification with the working environment, thus leading to a greater desire to remain employed in the organization. Before stepping into the next behavioral competency, there is another reason to consider teamworking as a crucial soft skill that it is worth discussing: its impact over Industry 4.0. The activities done in the industry 4.0 work environment are so complicated, fast-paced and interconnected that it is only by working in synergy with the other members that is possible to solve issues and achieve high performances. An example of the importance of this synergy has been given in Behavioral Competencies of Digital Professionals[165], when a data scientist who work for a company that develops video games explained that it was only by combining the members' individual expertise that it was possible to solve a computational issue. The high complexity introduced by the Digital Transformation paradigm underlines also the necessity to have a workforce that is

[164] C. Ogbonnaya, C.J. Tillman, K. Gonzalez, "*Perceived Organizational Support in Health Care: The Importance of Teamwork and Training for Employee Well-Being and Patient Satisfaction*", SAGE Journals, Group & Organization Management, April 2018.

[165] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 76.

capable to solve complicated problems. **Problem solving** is therefore a key capability that might be described as "*a goal-directed sequence of cognitive and affective operations as well as behavioral responses for the purpose of adapting to internal or external demands or challenges*".[166] More specifically, this sequence is elaborated by the individual to successfully address the following phases, or questions[167]: what is the problem? What are the causes of the problem? What are the possible alternatives to the problem and which alternative should be applied?

Therefore, first the individual must conduct an analysis of the problem and become aware of what kind of issue is facing. Then, it is necessary to identify its causes, also by exploiting colleagues' and supervisors' different skills, point of views and experiences. Once the causes have been identified, the individual should determine all the possible alternatives that could be applied to solve it: among them, someone that masters this behavioral competency can identify the one that most effectively and efficiently could solve the issue. Of course, the capability to identify and solve the problem depends on the individual but also on the complexity of the situation that is being addressed, and that is why such behavioral competency is so important in Industry 4.0: in this particular working environment, leaders and employees have to make "*thousands of choices, often under pressure, between alternatives with different overall value outcomes, and thereby exercise their ability to make adequate decisions. This ultimately determines their individual and organizational success*"[168].

[166] Peter A. Frensch and Joachim Funke, "Complex Problem Solving", Psychology Press, 2014.
[167] Radhika Kapur, "*Problem Solving Skills: Essential Skills in Providing Solutions to Personal and Professional Problems*", University of Delhi, 2020.
[168] J.V.Diez et ali, "*Characterization of Industry 4.0 Lean Management Problem-Solving Behavioral Patterns Using EEG Sensors and Deep Learning*", 2019.

Those kinds of problems require innovative and non-linear responses and therefore the capability to link apparently non-linked phenomena with each other. This requirement of industry 4.0 can be met throughout the fifth behavioral competency of this list, the **Creativity**. Such soft skill can be described as "*the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena, and to generate solutions*".[169] In order to be effectively exploited, the creative individual must be recognized by the management of the organization that has to find the most appropriate tools to capitalize such amazing trait. It is indeed the "*central role of management to release creativity, facilitate its birth and fruition and to access the impact of creativity on quality, productivity, and profits. This is effective management, and it is consistent with the goals of both employees and the firm*"[170]. The author of the article, based on the cases analyzed, suggests managers to follow several steps to effectively exploit the creativity of human capital: first of all, a clear goal should be settled. Then, the management should maximize the contacts and flow of communication within the firm, by favoring knowledge and ideas sharing among employees. Once those actions have been settled, and the creative individuals identified, the management shall give creative professionals the chance to set up their workplace in a way they are comfortable with, some time to spend alone, help them to feel secure, self-confident, and showing tolerance for their possible failure. Lastly, creative ideas should be evaluated quickly, and if considered useful, properly

[169] Katarzyna Grzybowska, Anjali Awasthi and Rapinder Sawhney, "*Sustainable Logistics and Production in Industry 4.0: New opportunities and challenges*", Springer Nature Switzerland, 2020, pp. 25.
[170] Mohammed Abdulrahman Alomar, "Creativity in Architecture and Management", 6th Asian design international conference, 2003, pp. 7.

rewarded. Following those guidelines will help the management to set up an environment that will allow to identify and exploit the creativeness amongst employees, and therefore to have higher chances to survive and succeed in Industry 4.0. Yet, it is possible to state that creativity is one of the most important[171] skills in the working environment introduced by the fourth industrial revolution: according to the research of Schwab[172], it is considered the most important soft skill to develop along with "complex problem solving" and "critical thinking".

Once the importance of Creativity has been highlighted, it is finally possible to focus on another critical competency, **Initiative**, a skill that refers to "*the ability to independently assess issues and initiate solutions*"[173]. This skill is particularly important in the world of Industry 4.0, whereby there are numerous phenomena that must be analyzed, and multiple problems that must be addressed by both employers and employees. For instance, the software currently used might not represent the best solution for a company, and therefore having employees with the Initiative capability might bring to new and more effective solutions. This is perfectly explained in the example offered by Bonesso[174], when a young business analyst realized the inaccuracy of the system currently used in the Company and decided to develop a new, better solution. Of course, as for the Creativity, it is necessary to have a healthy workplace, whereby employees are encouraged to take risks, propose

[171] https://www.ediweekly.com/creative-work-skills-helping-drive-4th-industrial-revolution-fusion-biological-digital-physical/ source based on the article of E. Mott, "Creatorbase," 29 April 2016. Available at: http://www.creatorbase.com/blog/2016/04/creativity-becomes-a-top-job-skill-in-the-4th-industrial-revolution.html.

[172] K. Schwab, "Fourth Industrial Revolution," in World Economic Forum, 2016.

[173] source: https://www.indeed.com/career-advice/career-development/tips-for-taking-initiative-at-work

[174] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 76.

solutions and new ideas to the management. As it was stated just before, the management shall adopt the necessary actions to promote such behavior: among them, it seems that shaping the structure of the organization accordingly to the 4.0 needs might be extremely important. Indeed, "*industry 4.0 needs an organic organization design which is not very formal; prefers flexible rules and policies; decentralization; empowerment of employees; collaborative teamwork; and horizontal communications*"[175]. In such context, "*the responsibility and authority for decision making is usually transferred to the lower staff levels*"[176], which is therefore encouraged to directly face the issues and propose solutions.

The description of such workplace leads to introduce the 7th behavioral competency of this list, the **Leadership**: an ability that represents the "*process of social influence, which maximizes the efforts of others, towards the achievement of a goal*"[177]. As it was stated before, the new paradigm is characterized by the necessity to make numerous decisions, even difficult ones, and therefore having someone that assumes the responsibility to take them is incredibly important. The decision itself, though, is not enough: the leader must make everyone committed to what has been decided to achieve high performances, and that is why having Leaders is crucial for the success of the company in the 4.0 paradigm. A question might arise at this point: what kind of leader and leadership are required in Industry 4.0? he answer to such question might be given by a research[178] that has shown that has shown that each industrial revolution is usually characterized by a specific leadership style:

[175, 176] Saqib Shamim, Shuang Cang, Hongnian Yu and Yun Li, "*Examining the Feasibilities of Industry 4.0 for the Hospitality Sector with the Lens of Management Practice*", Energies, 2017, pp. 5.
[177] Kevin Kruse, "*What is Leadership*?", Forbes, 2013, pp. 3.
[178] R. Kelly, "*Constructing leadership 4.0. Swarm Leadership and the Fourth Industrial Revolution*", Palgrave Macmillan, (2018).

"*For the first IR, charismatic leadership is related to how leader act and mobilize an organization through actions and personal characteristics. The second IR was strongly shaped by scientific management, in which leaders assume a top- down style, while they could be characterized as a directive leadership. For the third IR, leadership is characterized by relational leadership, considering the theories of transformational leadership to stimulate the autonomy of followers for new ideas, collaboration among them. The third IR is also characterized by transactional leadership more conducted and recognized by the achievements of followers' goals*"[179]. The fourth industrial revolution, instead, is characterized by a particular style, referred by Kelly himself as Leadership 4.0[180], or **digital leadership** [181]. To conclude, it is possible to state that Leadership in this context is fast, cross-hierarchical, team-oriented, and cooperative. The eight behavioral competency is **Interdisciplinary Thinking**. This skill refers to "*the ability to consider multiple disciplinary perspectives concerning the phenomenon under study, analyze the strengths and weaknesses of those perspectives, and integrate their insights to produce a new, more comprehensive understanding of the phenomenon*"[182]. In industry 4.0, interdisciplinary thinking has become a need that is direct consequence of the high complexity of knowledge (both tacit and explicit) at companies.[183] The high complexity of knowledge and activities held in the 4.0 environment reflects also in the organizational structure: yet, the typical top-bottom, pyramidal

[179] Valeria E. Guzman, Bernd Muschard, Mateus Gerolamo, Holger Kohl and Henrique Rozenfeld, "*Characteristics and Skills of Leadership in the Context of Industry 4.0*", Procedia Manufacturing, 2020.

[180,181] R. Kelly, "*Constructing leadership 4.0. Swarm Leadership and the Fourth Industrial Revolution*", Palgrave Macmillan, (2018).

[182] source: https://psufys.pressbooks.com/chapter/interdisciplinary-thinking/

[183] Liane Kipper, Sandra Iepsen, Ana Dal Fornod, Rejane Frozza, Leonardo Furstenau, Jessica Agnes and Danielli Cossul, "*Scientific mapping to identify competencies required by industry 4.0*", Technology in Society, 2021, pp. 5.

organization of the 20th century has been replaced by a "flat" one, whereby communications have a multidirectional flow.

In this kind of workplace, having an **Organizational Awareness** seems to be crucial and it can be described as the capacity to "*recognize the values and the culture of an organization but also to understand its informal processes and structure, the unspoken rules and the key power relationships*"[184]. That is, the employee that wants to survive and successfully face the 4.0 environment necessitates to understand how the decision-making process works within the organization, who are the key subjects to talk to when encountering a problem, to whom propose a new idea or a solution, what kind of style adopt while communicating (digitally and physically). To conclude, an environment's high complexity reflects also to the organization's structure, and therefore the employee has to understand how to interact with such new and complex context. The tenth competency is the **Efficiency Orientation**. Identified by Fitsilis[185] as one of the key transversal competencies for Industry 4.0, this skill is extremely important to achieve the Firm's goals. Previously, it was highlighted the issue of facing multiple problems, decisions, and possibilities in the Digital Transformation Era. Which way should the Company follow? Why should the team adopt a solution rather than another one? Being able to identify the cost-benefit ratio in every situation is therefore crucial nowadays. This was remarked in another example by Bonesso[186], when an expert data scientist decided to adopt a certain solution not only because

[184,186] Sara Bonesso, Elena Bruni and Fabrizio Gerli, "*Behavioral competencies of digital professionals*", Palgrave MacMillan, 2020, pp. 74.
[185] P. Fitsilis, P. Tsoutsa and V. Gerogiannis, "*Industry 4.0: Required Personnel Competences*", International Scientific Journal "Industry 4.0", 2018, pp. 130-133.

he felt – by experience - that it was the best for its company, but also because he had carefully considered the cost-benefit ratio, ending up that its idea would have been the most advantageous for the Firm. As the reader had the chance to notice while analyzing this section, the ten behavioral competencies that have been described represent key traits for the survival and the success of both employees and employers in the context of Industry 4.0. Despite their importance, over the last years several other soft skills have been identified by literature as potential key traits in the workplace settled in the fourth industrial revolution: therefore, before stepping into the next part of the Chapter, it seems appropriate to introduce some of them, in order to give the reader a complete overview of such important topic. A research from Cotet[187] identifies three main behavioral competencies that an individual shall master in Industry 4.0: creativity, emotional intelligence, and proactive thinking. The first one has been deeply described just before, therefore the focus will now be on the other two, **emotional intelligence** and **proactive thinking**. The first one "*is a type of social intelligence that involves the ability to monitor one's own and others' emotions, to discriminate among them, and to use the information to guide one's thinking and actions*"[188]. Such behavioral competency is strictly related to empathy but differs from it because if the latter consists of understanding *"the feelings of the others*"[189], the former consists of managing each owns emotions and feelings, along with the others' ones.

[187] Cotet, G.B., Balgiu, B.A. and Zaleschi, V.C, "*Assessment procedure for the soft skills requested by Industry 4.0*", MATEC Web of Conferences, 2017, pp. 121.
[188] John D. Mayer, "*The Intelligence of Emotional Intelligence*", Intelligence, 1993.
[189] Ronald Wheeler, "*Soft Skills: The Importance of Cultivating Emotional Intelligence*", Boston University School of Law, 2016, pp. 31.

In the previous pages several times has been remarked the complexity of the 4.0 workplace, an environment characterized – among the others – by strict relations between people with extremely different professional backgrounds, and therefore mastering the capability to understand and manage others' emotions is a crucial factor for the success of an organization. Proactive thinking, instead, is directly linked with the initiative capability, as it represents the ability to "*anticipate events so that*" it is possible to "t*ake control of a situation and prepare for the situation ahead of time*"[190]. Another study which is particularly useful for the purpose of this section is the one of Adolph, Tisch and Metternich[191], that have highlighted a few other important behavioral competencies, such as **self-learning** and **process reshaping**. The first one represents a process by which "*individuals take initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals… and evaluating learning outcomes*"[192]. This soft skill is crucial in Industry 4.0 since, as it was discussed in the previous sections, the 4.0 work environment is constantly changing and therefore it is fundamental that employees keep on studying and updating their knowledge: in such context, having the capability to understand each owns knowledge gaps and how to fill them, is crucial. The second one, instead, consists of having the capability to re-imagine a process, which is extremely important in a context like the 4.0 one: especially in manufacturing, where new technologies are continuously introduced and there is a high level of uncertainty, "*employees need to have the competence to reshape*

[190] source: https://aventislearning.com/proactive-thinking/
[191] Adolph, S., Tisch, M. and Metternich, J., "*Challenges and approaches to competency development for future production*", Journal of International Scientific Publications–Educational Alternatives, 2014, pp. 1001-1010.
[192] Malcom Shepherd Knowles, "*Self-Directed Learning: A Guide for Learners and Teachers*", 1975.

processes so that quality is ensured to produce stable high-quality products, even under variable aspects of processes"[193].

Once the literature overview has been concluded, it is finally possible to step forward and try to understand how it might be possible to develop those kinds of behavioral competencies: this is going to be the main topic addressed in the next section.

[193] Adolph, S., Tisch, M. and Metternich, J., "*Challenges and approaches to competency development for future production*", Journal of International Scientific Publications–Educational Alternatives, 2014, pp. 1001-1010.

2.2: HOW TO DEVELOP BEHAVIORAL COMPETENCIES

Is it possible to develop behavioral competencies? What are the best ways to do it? Those are the questions that will be addressed in this section. To answer the first one, it is necessary to understand the way human beings learn things and develop. Over the years, several studies have tried to identify the way humans develop, but for the purpose of this research the one of Lewin[194] might represent a good starting point.

In 1951, Lewin proposed a simple but powerful scheme to represent the way humans learn: he believed that behaviors are a given by the interaction between a person (P) and his or her environment (E): Behavior = f (P, E).

In turn, this means that in order to acquire a skill having a sound desire (P) is necessary but not sufficient, since favorable environmental factors are fundamental too. Over his explanation, Levasseur enriches the arguments brought by Lewin with a powerful example: "*a person may want to learn to play the violin, but without the money to pay for lessons will not be able to develop that skill. Similarly, a person may not want to learn mathematics, but if acquiring that skill is necessary for earning a college degree, he or she will have to develop that ability*"[195]. In both cases, one key factor is missing to successfully develop as human beings: in the first one, the environment (E), in the second one the willingness to learn (P).

In 1979, the studies of Lewin have been further developed by Bronfenbrenner, who identified in the "environment" the key factor for the human development.

[194,195] Robert E. Levasseur, "*People Skills: Developing Soft Skills – A Change Management Perspective*", Interfaces, 2013, pp. 566-571.

Therefore, he decided to deepen this topic: the environment (which he calls "ecological environment") is made of several superstructures that like a set of Russian dolls are each inside the next. There are four structures:

a) **Microsystem**: the inner-most level, that contains the individual and the people in the immediate surroundings.
b) **Mesosystem**: the systems with whom the individual has continuous interactions.
c) **Exosystem**: the people and system that influence the individual, but not vice versa.
d) **Macrosystem**: the culture or broader society that surrounds the individual.

Bronfenbrenner thinks that each time the ecological environment is altered because of a change in the role of the individual, the system, or both, there is an "ecological transition": this concept is crucial, since each time a transition occurs there is the chance to develop as human beings. Again, Levasseur brings an example to explain this concept: "*attending or graduating from school, accepting or quitting a job, and marrying or divorcing are ecological transitions that have significant development opportunities associated with them*"[196]. Therefore, a change (for better) of the systems in the environment, along with personal motivation to change, will bring to the individual's growth and development. For example, "*if you want a child to learn to read better and faster, read with that child and make it fun. This favorable change in the child's mesosystem, which constitutes a change in the role of the child*

[196] Robert E. Levasseur, "*People Skills: Developing Soft Skills – A Change Management Perspective*", Interfaces, 2013, pp. 568.

from individual learner to active participant in an enjoyable and collaborative learning process, will encourage an ecological transition; in all likelihood, the child will become motivated to learn to read on his or her own. The result will be human development"[197].

Thinking now about the definitions of hard skills and behavioral competencies (or soft skills) given in section 2.1, and inserting them in this topic might bring the reader to arise such question: what does those theories tell us about the development of behavioral competencies? The author says that essentially developing hard skills requires personal motivation (P), a proper environment (E), and a minimum level of interpersonal interactions. The development of behavioral competencies, instead, "*requires the personal motivation to learn and a much more complex ecological environment to support the personal interaction with others, which is necessary to foster the individual's development*"[198]. Therefore, the development of soft skills is much more difficult than the one of hard skills, because along with the motivation and the environment, there must be a high level of interaction with other people.

It is then possible to state that:

a) Hard skills= P+E
b) Behavioral Competencies= P+E+I, whereby I stands for interactions.

Despite the apparent difficulty, the development of those kind of skills is not only possible but also crucial for the survival of employers and employees in the age of Industry 4.0. Indeed, the wave of Digital Transformation that is taking over the

[197, 198] Robert E. Levasseur, "*People Skills: Developing Soft Skills – A Change Management Perspective*", Interfaces, 2013, pp. 568, 569 and 560.

organizations has to be effectively handled by the management: to face the 4.0 revolution hiring and firing are costly and complex[2] processes that cannot be used to replace the entire workforce with a new, more suitable one. Moreover, organizations should trust their employees and capabilities, since it seems[199] that the majority of them, at least in developed countries, should be able to conform to the new changes: in Germany, for example, it is estimated that more than 65% of the employee can adapt to the 4.0 technological transition. Therefore, the development of the actual work force is an essential achievement that should be sought by offering appropriate tools. At this point, the first question has been answered: is it possible to develop behavioral competencies? Yes, the studies above have shown that it is possible to do it. Once the first answer has been finally given, it is possible to step into the second question: what are the best ways to do it? How can the human capital develop those kinds of traits? Several studies have been elaborated for this purpose, such as the ones of the University of Ca' Foscari. In 2012, the University created the Competency Centre, a hub that does research, training and consulting activities in the area concerning the development and assessment of behavioral competencies.

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[2] Those two processes may encounter several difficulties. On one hand, recurring to the external labor market to hire may lead the firm to face the problem of asymmetric information, as long as the loss of the specificity of the human capital. On the other, instead, firing could lead to a negative impact over the firm's reputation, especially if there has been a collective firing process, as long as to strikes and high costs to manage the turnover.

[199] M. Lorenz, M. Rüßmann, R. Stranck, K.L. Lueth and M. Bolle, "*Man and Machine in Industry 4.0*", The Boston Consulting Group, 2015, pp. 1-22.

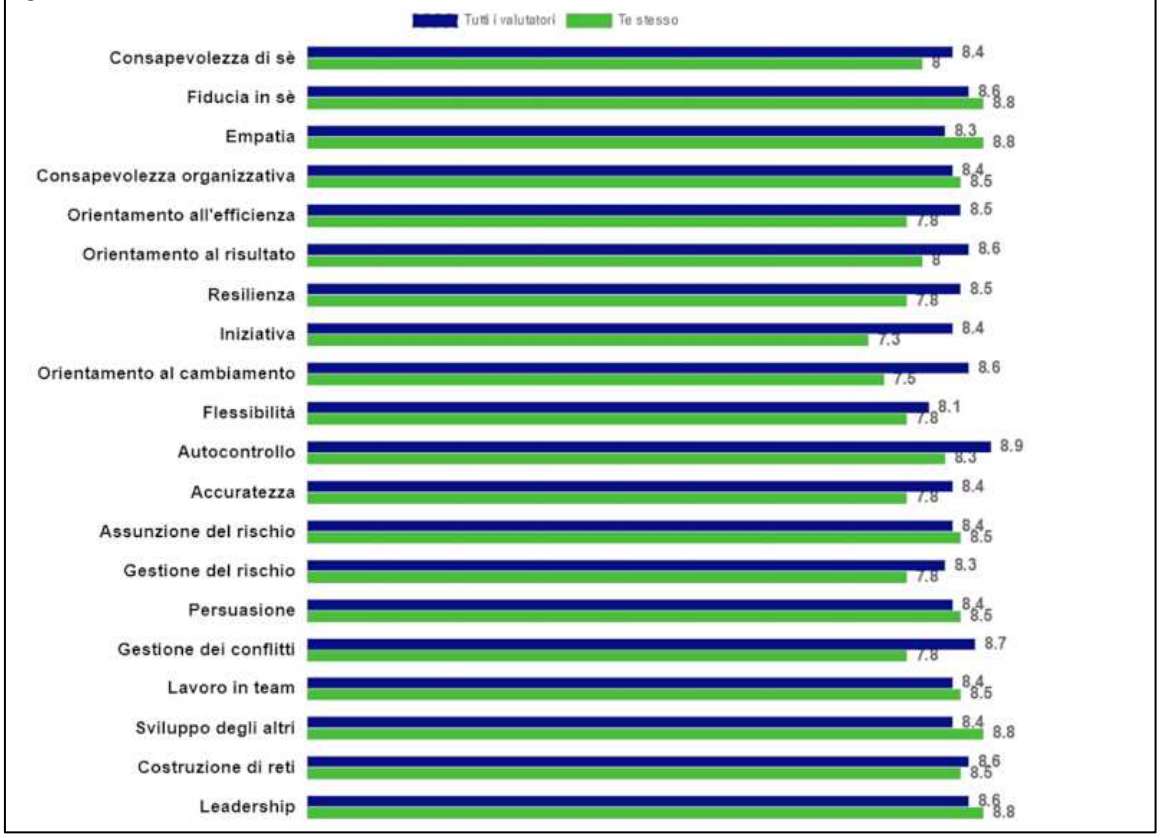
As the CFCC website reports, "*the main aim of the Ca' Foscari Competency Centre is to improve the performance and the employability of people through the development of their competency portfolio*"[200] and the way to achieve this development is "*through different techniques which vary according to the type of competency and the initial level of possession by the individual. The fundamental elements which enable individuals to develop their own behavioral competencies are:* ***awareness*** *of the current level of possession;* ***definition*** *of a desired level of possession;* ***actual intent*** *to undertake change*"[201].

Therefore, the CFCC method first of all lets the individual understand what his/her strengths and weaknesses in terms of behavioral competencies are: thanks to the Behavioral Competencies Multi-Rater Evaluation 360° (BECOME360), 31 behavioral competencies are evaluated by auto-assessments and an external analysis of the individual's behaviors. Then, the individual is given a report whereby the external evaluation is compared with the auto-assessment.

An example is reported in Figure 3[202], displayed in the following page.

[200, 201,202] source: University of Ca' Foscari's CFCC Website: https://www.unive.it/pag/31164/

Figure 3

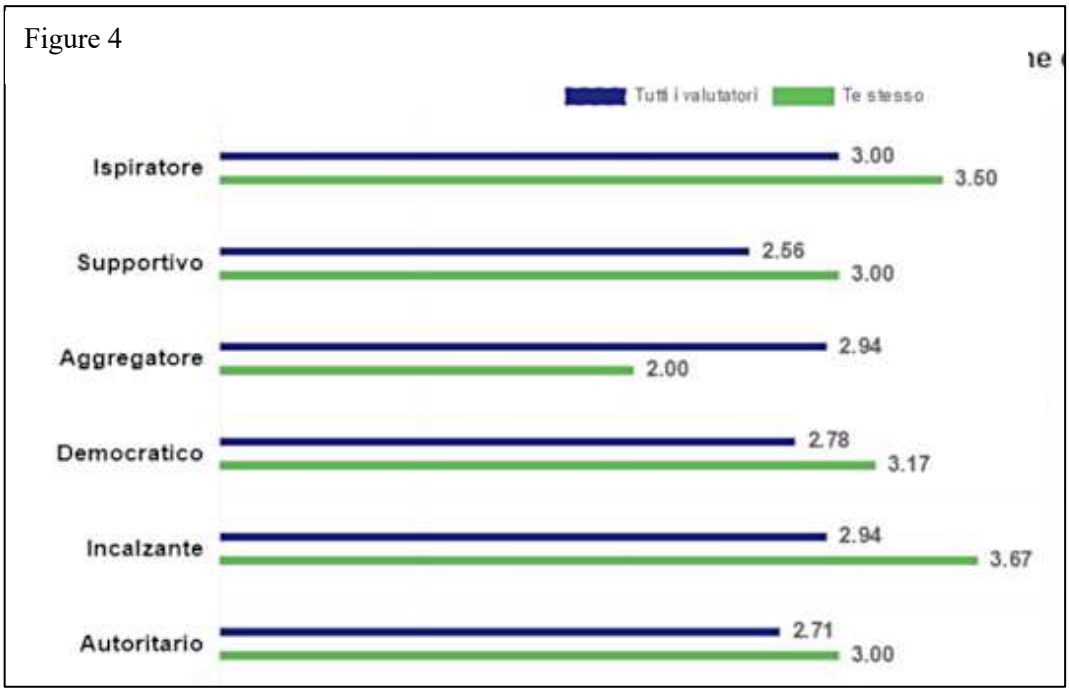


The green bar (Figure 3[203]) represents the self-assessment, whereas the blue bar the external evaluation. This way of assessing behavioral competencies starting level is particularly interesting because usually their intangibility does not let the individual understand what his current level is: yet, this solution should grant a higher level of accuracy. The BECOME360 is not the only solution offered to assess competencies, since the CFCC offers two more tools: the BELEADER360 and the COBRA. The former is a tool to evaluate the leadership styles adopted by the individual and it is based on a survey that participants and their evaluators have to fill. Then, the BELEADER360, based on the replies given in the survey, elaborates

[203] Figure 3, source: University of Ca' Foscary's CFCC Website: https://www.unive.it/pag/31164/

a personalized report that shows what is the level of the individual on each of the six leadership styles identified by the CGCC (Figure 4[204]):

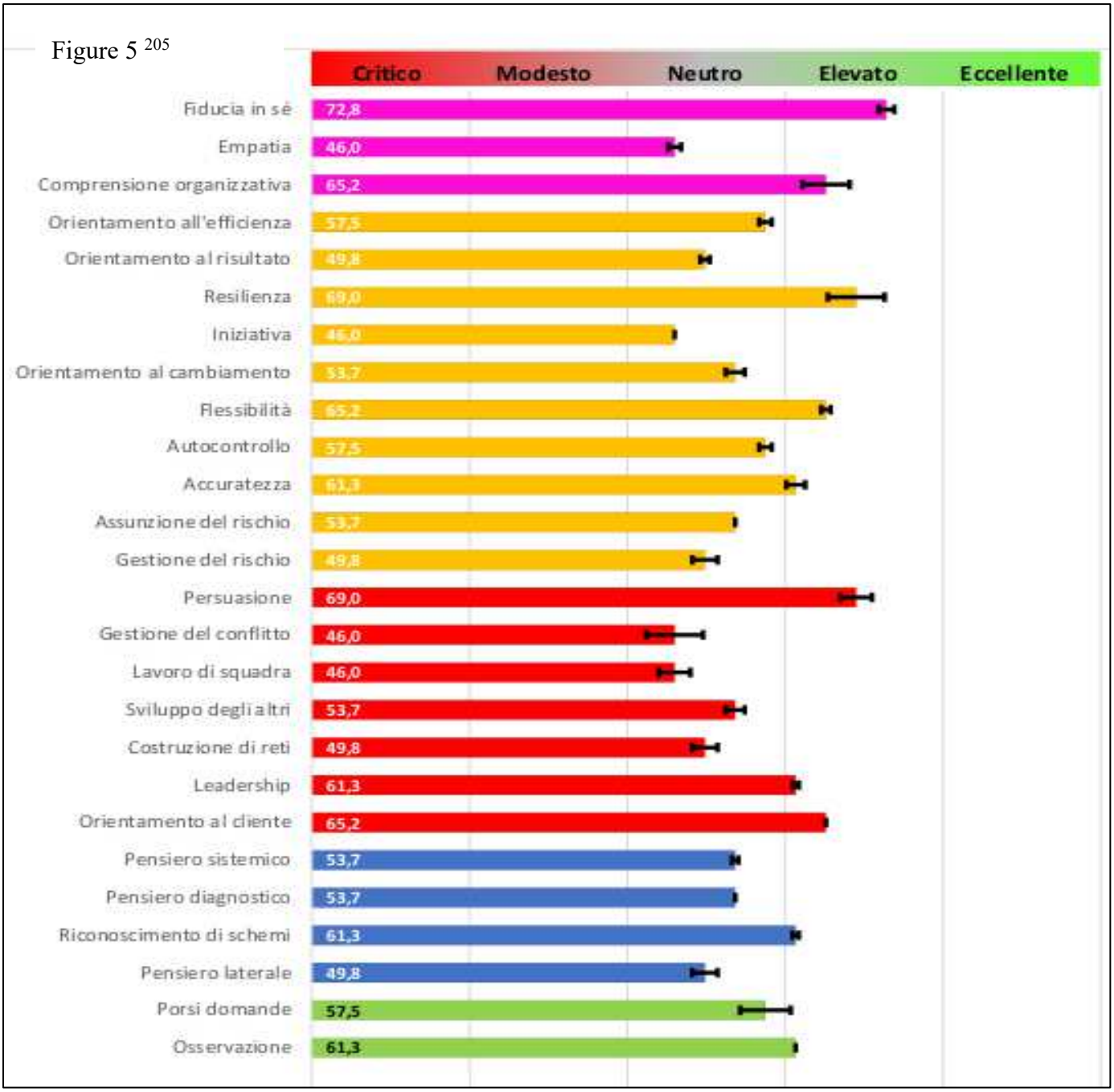
Figure 4



Again, the average between the self-assessment and external one should give an accurate representation of what the actual level is. The latter, instead, is a survey that through the choice of the behaviors that would be activated by the individual in different hypothetical situations, elaborates a detailed graph that exhibits the participants' behavioral competencies, displaying a frequency level on a scale that goes from 0 to 100 and showing if his/her overall level on that skill is "critical", "moderate", "neutral", "high" or "excellent". A graphical representation of the overall skills' level is given by Figure 5, displayed in the following page:

[204] Figure 4, source: University of Ca' Foscary's CFCC Website: https://www.unive.it/pag/31164/

Figure 5 [205]



[205] Figure 5, source: University of Ca' Foscary's CFCC Website: https://www.unive.it/pag/31164/

Overall, these three tools let the participant understand what his/her actual level is in matters of behavioral competencies and guide the hub in defining the best root to improve the individual's professional performances. Once this phase, named "Check", has been completed, it is possible to move to the "Discover" phase, whereby the participant discovers his/her strengths and weaknesses to his/her professional goals. To achieve this goal, the main tool used by the CFCC is the "Career Lab": it consists of 4 meetings, each lasting 3 hours, where the individuals become aware of what behavioral competencies are and what is their impact on work performances (1st), define their Personal Vision (2nd), evaluate their competencies and therefore strengths and weaknesses (3rd) and define their individual apprentice plan (4th). Those meetings are based on high levels of interactions between participants, constant support by the teachers and finalized to stimulate a pro-active behavior. Once the individual has finished this phase of exploring and discovering, it is possible to start learning. The "Learn" phase indeed consists of several meetings that focus on specific behavioral competencies and the best way to develop them: "adaptability", "empathy", "creative thinking", "conflict management" and "teamwork" are just a few of the workshops offered by the hub. The strong theoretical background built during the "Learn" phase is then required to be tested, in order to understand if the candidate has effectively developed the behavioral competencies addressed by the workshops: the "Practice" phase begins. The CFCC proposes several indoor and outdoor activities to stimulate the

participants to use the competencies learnt during the courses: among them, the hub offers "Coaching", "Orienteering", "Outdoor", "Serious Games" and "Team Building" activities.

1) **Coaching**: Even though nowadays is quite common in the business world, the coaching practice exists since decades in the school and sports fields.[206] In general, this term refers to the practice of entrusting an experienced person to enhance the growth of the participant through an active and constant support. In this particular case, the tool consists of individual coaching sessions that aim at practicing behaviors functional to the development of the behavioral competencies learnt in the previous phase.
2) **Orienteering**: it consists of "*a competitive or noncompetitive recreational activity in which participants use a map and compass to navigate between checkpoints along an unfamiliar course (as in the woods)*"[207]. This activity is particularly useful to develop decisional and relational strategies that could be used by the participants to face uncertain situations in their workplace.
3) **Outdoor activities**: The activities held outside the work environment might help the candidates to integrate the behavioral competencies in their daily life, enhancing therefore their development
4) **Serious Games**: this term, coined by Clark in the 1970, refer to the proposal of games that "*have an explicit and carefully thought-out educational*

[206] source: https://www.etymonline.com/word/coach
[207] source: https://www.merriam-webster.com/dictionary/orienteering

purpose and are not intended to be played primarily for amusement."[208]

5) **Team Building**: as the CFCC hub reports[209], this tool aims at developing a stronger relationship with the colleagues, in order to increase trust and collaboration within the team, through the proposal of activities that require a cooperative approach.

Once the behavioral competencies have finally been developed, they have to be certificated. With the "Certificate" phase, the CFCC has identified a method to by-pass the soft skills' typical intangibility and, therefore, assessment. Indeed, the hub assigns to the participants an Open Badge, which is "*an online representation of a skill you've earned*"[210]. More specifically, they are open standards represented by images that contain data related to the competency that has been developed by the user: who the earner is, the method used and the institution that has delivered it are just a few of the information that can be found inside them. The six phases of the CFCC method have been particularly useful for the purpose of the thesis because they represent a concrete answer to both the questions addressed in this section: indeed, not only the University of Ca' Foscari has shown that is possible to develop behavioral competencies, but it has also developed a way to do it in a really efficient and effective way.

Overall, the CFCC proposes a method that answers also the second question proposed at the start of this section: how is it possible to develop behavioral competencies?

[208] Damien Djaouti, Julian Alavrez, Jean-Pierre Jessel and Oliver Ramonoux, "*Origins of Serious Games*", Serious Games and Edutainment Applications", 2011, pp. 26.

[209] source: https://www.unive.it/pag/fileadmin/user_upload/centri/CFCC/documenti/Brochure_CFCC_2020.pdf

[210] source: https://support.mozilla.org/en-US/kb/why-open-badges

The hub has shown that Coaching, Orienteering, Outdoor, Team Building and Serious Games represent a concrete way to achieve this end. The solution brought by the Ca' Foscari University is, though, not the only solution to develop those kinds of competencies: especially in the last years, several research have tried to analyze the importance of behavioral competencies and their development. For instance, the one of Barbara Cimatti[211]. The author, at some point of her studies, comes out with the question: how is it possible to teach behavioral competencies in a company? Since the target is represented by adult people who have already developed their personal traits, it is not an easy task. Two things should be kept in mind by the HR manager: the same skill should be taught in a different way depending on the role and the assignments of the receiver, and that the training should differ accordingly to the phase of the career of the trainee. Anyway, since in this section the focus is on understanding how to develop behavioral competencies, it seems appropriate to go straight to the point: despite the difficulties, and the distinctions that must be done to effectively pursue this goal, it seems that Case Studies might represent a useful tool. Indeed, presenting a simulation connected to the processes and tasks of the receiver, with the guidance of some senior employees, might represent a powerful tool to replicate stressful situations whereby the trainee has the chance to enhance several soft skills, such as decision-making, problem-solving, critical thinking, adaptability, communication, and teamwork. To conclude this part and summarize what has been stated up to now, one thing should be clearly

[211] Barbara Cimatti, "*Definition, Development, Assessment Of Soft Skills And Their Role For The Quality Of Organizations And Enterprises*", International Journal for Quality Research, 2016, pp. 97–130.

kept in mind: whatever is the method referred and used, the training session is only a starting point[212]. Each one of these tools can impart knowledge, but because of their short duration, they can at best only initiate the process of development: "*the real development comes from continually practicing the skills and processing performance feedback, based on self-reflection or constructive inputs received from others, which fosters ongoing development of those skills*"[213].

In the next and final Chapter, thanks to the study that has been done up to now, the reader will be introduced to a competency model whose aim is to define the readiness of firms to the 4.0 environment in terms of behavioral competencies.

[212,213] Robert E. Levasseur, "*People Skills: Developing Soft Skills— A Change Management Perspective*", Interfaces, 2013, pp. 571.

CHAPTER 3: A BEHAVIORAL COMPETENCY MODEL

In chapter 3, the reader will have the chance to discover a new competency model for Industry 4.0 that was developed based on the theories presented in the previous chapters and on the results of a research that I have conducted in the preceding six months. The aim of this study was to define and evaluate the digital maturity of firms operating in the 4.0 context, with the aim to obtain one specific outcome: a model that by focusing exclusively on behavioral competencies could identify the profile of the 4.0 employee. Such individual is characterized by specific traits that let him/her survive the high complexity of the 4.0 working context, and develop successful strategies for the success of his/her organization: those traits, as it was specified in the previous chapter, are named behavioral competencies, and can be defined as "*interpersonal, human, people or behavioural skills necessary for applying technical skills and knowledge in the workplace*"[214]. At this point, before concluding this brief introduction and stepping into the chapter itself, it seems worth specifying the reason behind the decision to focus exclusively on those kinds of competencies.

In recent years, various models have been introduced in literature with the aim to describe the main skills that characterize industry 4.0. The vast majority of them, though, tend to focus mainly on hard skills, especially the ones related to the engineering field, and are therefore applicable only to a restricted number of

[214] Verica Babić and Marko Slavković, "*Soft and Hard Skills Development: A Current Situation in Serbian Companies*", Management, Knowledge and Learning. International Conference, 2011, pp. 410.

businesses and organizational functions. The model that is going to be presented, instead, was designed to be applied across sectors and businesses within the 4.0 environment, and give therefore to all the organizations a useful tool that might help them – as the reader will have the chance to acknowledge during this third chapter – to conduct a more appropriate recruiting process, develop better employees' development paths and manage the whole structure more properly.

To conclude, chapter 3 has been entirely dedicated to the model's development and presentation: in the first part, the methodology is going to be discussed. More accurately, the reader will be introduced to the main outcomes of the first two chapters and to the explanation of the approach used to gather the data for the model's construction. The second part, instead, focuses on defining the profile of the 4.0 ideal employee, by introducing and describing the main behavioral competencies that such individual should have to survive the 4.0 environment. The third and final part will further analyze the traits that have been previously discussed, by identifying three different mastery level: low, mid, and high. Thanks to concrete examples of how each of these traits will impact the life of employees within the organization, the reader will finally have the chance to fully understand who the 4.0 ideal employee is, and what are the main characteristics that make such professional so important for the organizations' survival and success.

3.1: METHODOLOGY

The competency model has been designed based on 3 main phases:

a) Phase 1

During the first phase, two main concepts were addressed and studied: the one of Industry 4.0, and the one of Skill. The analysis of the first one ended up with a concise yet powerful definition of Industry 4.0 as "*utilizing the power of communications technology and innovative inventions to boost the development of the manufacturing industry*"[215], along with the identification of its main technological pillars, namely:

- **Cyber-Physical Systems**, or "*digital integrations with physical processes, where integrated computers and networks monitor and control physical processes*"[216].
- **Internet of Things**, which represents an "*emerging global, Internet-based information service architecture facilitating the exchange of goods in global supply chain networks*"[217].
- **Big Data**, "*information assets characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value*"[218].

[215] Shu Ing Tay, Lee Te Chuan, A.H. Nor Aziati and Ahmad Nur Aizat Ahmad, "*An Overview of Industry 4.0: Definition, Components, and Government Initiatives*", Journal of Advanced Research in Dynamical and Control Systems, 2018, pp. 1381.
[216] V.L. Da Silva, J.L. Kovalesky and R.N. Pagani, "*Technology Transfer and Human Capital in the Industrial 4.0 Scenario: A Theoretical Study*", Future Studies Research Journal Trends and Strategies, February 2019, pp.106.
[217] R. Weber, "Internet of things – Need for a new legal environment?", Computer law & security review 25, 2009, pp. 522.
[218] A. De Mauro, M. Greco, M. Grimaldi, "*A formal definition of Big Data based on its essential features*", Libr. Rev. 65, 2016, pp. 122–135.

- **Autonomous Robots**, and therefore machines developed to autonomously perform a specific task.
- **Simulation**, a method consisting of "*using models* – physical or mathematical mainly - *of a real or imagined system or a process to better understand or predict the behaviour of the modelled system or process*."[219]
- **Cyber Security**, intended as systems introduced to protect crucial assets from data, information and knowledge stealing.
- **Cloud Computing**, defined as high performance technologies (cloud technologies) that grant the appropriate data "*processing, storage and connectivity*"[220].
- **Augmented Reality**, a new technology that provides "*powerful tools that support the operators that undertake tasks, helping them in assembly tasks, context-aware assistance, data visualization and interaction, indoor localization, maintenance applications, quality control or material management*."[221]
- **Additive Manufacturing**, that consists of systems used to produce highly customizable products, offering "*construction advantages, such as complex, lightweight designs*"[222].

[219, 220] V.L. da Silva, J.L. Kovalesky and R.N. Pagani, "*Technology Transfer and Human Capital in the Industrial 4.0 Scenario: A Theoretical Study*", Future Studies Research Journal Trends and Strategies, February 2019, pp.106.
[221] P.L. Fraga-Lamas et al., "*A review on industrial augmented reality systems for the industry 4.0 shipyard*", IEEE Acess, Volume 6, 2018, pp. 13358
[222] source: https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries

- **Horizontal and Vertical System Integration**, which "*consists of integrating independent production chains and the value-added subsystems of a single company*"[223]. Such integration is particularly important in Industry 4.0, whereby all the assets inside and outside the firm have to be perfectly interconnected, and that is why usually this system is usually referred as the industry 4.0's backbone.

The word "skill", instead, refers to "*the capacity for carrying out complex, well-organized patterns of behavior smoothly and adaptively so as to achieve some end or goal*"[224] and it divides into two categories: hard and soft skills. The first ones are skills "*related to technical aspects to do some tasks in the job"*[225], whereas the second ones (named soft skills or behavioral competencies) are "*interpersonal, human, people or behavioural skills necessary for applying technical skills and knowledge in the workplace"*[226]. Once the meaning of such concept was identified, and the importance of behavioral competencies in Industry 4.0 discovered, a literature overview held to a list of 10 main competencies: the list will be used in phase 3, in comparison with the outcome of the research.

[223] M. Hernandez, R.M. Menendez, C.A. Escobar, and M. McGovern, "*Competencies for Industry 4.0*", International Journal on Interactive Design and Manufacturing, 2020, pp. 1511.
[224] A.S. Reber and E. Reber, "*The Penguin Dictionary of Psychology*", Penguin Books 3rd edition.
[225] A.F. Hendarman and U. Cantner, "*Soft skills, hard skills, and individual innovativeness*", Eurasian Business Review, 2018, pp. 141.
[226] Verica Babić and Marko Slavković, "*Soft and Hard Skills Development: A Current Situation in Serbian Companies*", Management, Knowledge and Learning. International Conference, 2011, pp. 410.

b) Phase 2

The second phase represents the research's core part. In order to better understand the impact of behavioral competencies in Industry 4.0, and therefore build a new competency model, it was necessary to start collecting data. Among the numerous ways to collect data, a qualitative method was chosen: more specifically, interviews. They represent a popular way of gathering qualitative research data since they are perceived as "*talking, and talking is natural*"[227]. Moreover, "*interviews do not presuppose any statistical knowledge, and persons to interview, called respondents, might be close at hand and willing*"[228]. On the other hand, though, such method might be characterized by some issues: for instance, the respondents might not have an opinion, or may not be able to state it in a clear way, and therefore the interviewer has to be flexible and adapt the conversation accordingly to the respondent he/she is talking to. Or, the people interviewed might not be able to say what they think[229], and that is why they were granted the anonymity in this study. To initialize the research, it was necessary to determine the type of interview to collect data: among the numerous kinds[230], it was opted for the semi structured one, whereby questions are predetermined but the interviewer is free to ask for clarification. Then, it was necessary to decide whom to interview: because of the industry 4.0's complexity, it was established not to consider only HR leaders but also business ones, in order to take into consideration a wider range of professionals, experiences and opinions. Deciding whom to interview means also

[227,228,229] Dale T. Griffee, "*Research Tips: Interview Data Collection*", Journal of Development Education, 2005, pp. 36
[230] G. Hitchcock and D. Hughes, "*Research and the teacher: A qualitative introduction to school-based research*" (2nd ed.), New York: Routledge, 1995.

determining the businesses that will be considered in the model's development, but since the aim of this thesis is to break the barriers across businesses and consider Industry 4.0 as a whole, the respondents were chosen among different backgrounds: university professors and managers from Startups, SMEs and MNEs. More specifically, 7 professionals were chosen, as it is possible to notice from the table below:

Table 1 Data collection overview

N.	Role	Business	Records	Length (minutes)
1	Co-founder	Consulting	Notes	66
2	Executive VP	Thermal comfort	Notes	50
3	HRM	Energy	Notes	40
4	PhD	University	Notes	38
5	HRM	Oil & Gas	Notes	30
6	CEO	VR & AR	Notes	15
7	HRM	Eyewear	Notes	45

Once the method was appointed, and the respondents identified, it was necessary to start thinking over which questions to ask: since behavioral competencies represent the model's focus, 5 non-biased questions were developed to understand the respondents' thoughts. More specifically, the professionals were asked:

1) In your opinion, what is the impact of new technologies on the organization and on employees?
2) In your opinion, what are the main factors that hinder or facilitate the firms' transition to the adoption of new technologies?
3) Who are the actors in supporting the innovation process?
4) What are the soft skills that you would consider mandatory in this new context?
5) How do you develop these skills?

As it was specified in the introduction of this chapter, since one of the barriers to obtain a high-quality output might be represented by the impossibility for the respondent to answer sincerely, it was opted to grant each of them the anonymity before starting the interviews.

Lasting between 30 and 40 minutes, those one-to-one virtual conversations gave useful insights that were studied and used in phase 3 to develop the model.

c) Phase 3

In phase 3, the respondents' answers were finally analyzed, and the model developed. Yet, one of the most critical activities when using the interview's method is to analyze the answers: indeed, "*the interview data are not only the literal words from a respondent but include evaluator assumptions, biases, and questions*"[231] and therefore the interviews' outcome constitutes "*raw data, somewhat like the numbers resulting from a test. Raw data does not reveal its meaning: rather, it must be interpreted*"[232]. Among the strategies suggested by Hitchcock and Hughes to succeed in such target, the one of becoming "familiar" with the data was chosen: that means, "*going over notes many times, listening to tapes repeatedly, or constantly reading and rereading the interview transcripts. The idea is that, as the evaluator becomes familiar with the data, slowly but surely categories "emerge" or become apparent. The data are reviewed, and the evaluator begins to see that the respondent has been talking about theme A, theme B, and so on. Pondering on these themes, the evaluator finally comes to understand (interpret) that the respondent is talking about X*"[233]. Once the data were analyzed, it was opted to use a tool to organize and display the significant amount of data that were previously collected, with the aim to present graphically the model before discussing it, and also to make it easier and more pleasant to read. Among all the possible tools, I have decided to opt for CmapTool. It can be described as a concept mapping software developed by the Florida Institute for Human and Machine

[231, 232, 233] Dale T. Griffee, "*Research Tips: Interview Data Collection*", Journal of Development Education, 2005, pp. 37.

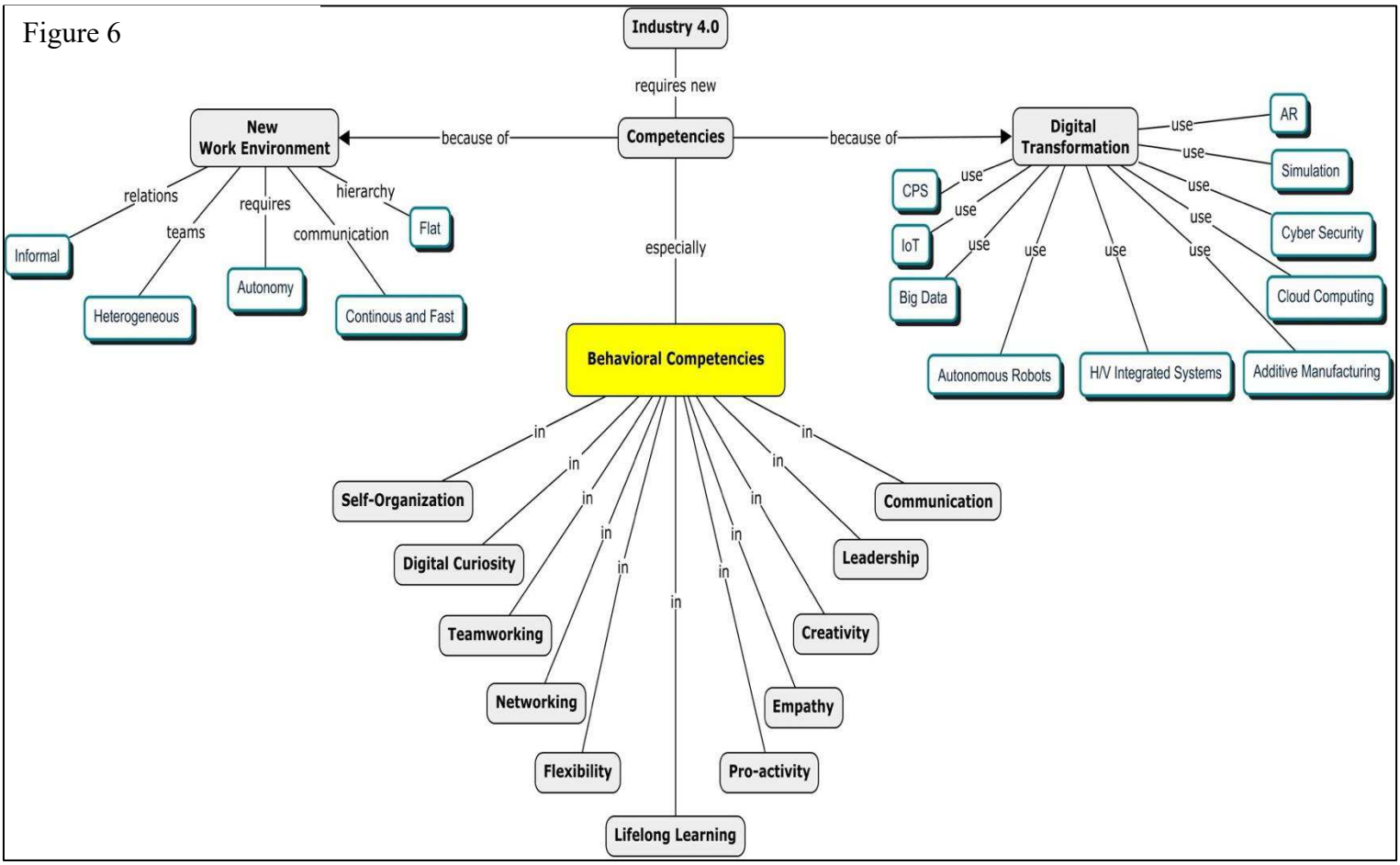
Cognition (IHMC) which "*empowers users to construct, navigate, share and criticize knowledge models represented as concept maps*"[234]. The reason behind such decision is that this software allows to easily create graphical nodes representing concepts, connect them with lines and linking words, and therefore present even extremely complicated topics in a more understandable and clear way. The presentation of the model was then followed by a section that focused on the identification of the ideal 4.0 employee profile: more specifically, the definition of 11 main behavioral competencies that characterize such individual. Each of those competencies have been further categorized into three levels according to the mastery grade achieved by the employee: Low-Level, Mid-Level and High-Level. Before stepping into the model, it seems worth clarifying that despite the first two levels being extremely important, the 4.0 employee is characterized by the third one (High-Level), since the aim of the model is to identify the *ideal* 4.0 professional.

[234] CMAP official website: https://cmap.ihmc.us

3.2: HUMAN CAPITAL 4.0: A NEW COMPETENCY MODEL

Section 3.2 represents the core part of the Thesis, since here the model is going to be presented and discussed. As it was stated in the previous part, the CMAP software has been used to better organize and display the model: the figure below[235] represents therefore a summary that will be used as a starting point to discuss and explain it:

Figure 6



[235] Figure 6, Author's elaboration

The term “Industry 4.0” describes a complex manufacturing system that bases its functioning and performances on a set of digital technologies that have deeply changed the way organizations operate and people work.

This new system, that brings the necessity for employees to develop and master a new set of skills, bases its foundations on two highly interconnected elements: the work environment, and the digital transformation’s technologies. Since the second ones have been deeply analyzed during the course of the Thesis, and the respondents’ answers have confirmed what was already underlined during the theoretical background of the first two chapters, the focus will now be on the first element. Understanding how the work environment has changed after the Fourth Industrial Revolution is particularly important because the skills that characterize the 4.0 ideal employee, and that are about to be shown and explained in this model, do not derive only from the necessity to adapt to the new digital technologies, but also to this new environment. More specifically, the progresses achieved in the contemporary age and the introduction of the previously mentioned technologies have shaped a new setting whereby four main characteristics shall be identified and analyzed. First of all, the fall of social classes’ differentiations among individuals along with higher levels of education have favored the birth of more informal contexts, in which all the professionals across the hierarchy – from the trainee to the top manager – tend to communicate and exchange ideas way too frequently than it used to happen 20 or even 10 years ago.

In turn, this means that everyone in the workplace - even a new graduate student who is about to enter the labor market – must develop high and effective communication skills. Furthermore, the usage of digital tools (such as Microsoft Teams, Skype, Outlook, or WhatsApp) has enhanced the communication flow, which now is continuous and fast. Secondly, the increased complexity of the production process, along with the necessity to assume decisions faster and more easily, has reduced the chain of hierarchy, which now is flatter than before: this means that employees are required to be pro-active and willing to take initiative in order to solve business issues, even without the managers' direct support. Thirdly, to better address issues teams tend to be heterogeneous and made of individuals with different academic backgrounds: empathy and teamworking are therefore crucial traits that should be developed to successfully cooperate with the team members.

It is commonly acknowledged that another main characteristic of Industry 4.0 is the digitalization of a large number of processes, achieved thanks to all the technological innovations occurred in recent years. A direct consequence of this characteristic is that numerous operations and tasks that until a few years ago were done almost exclusively offline can now be executed remotely, reducing the necessity for organizations to own a physical structure that could house all its workers: digitalization has indeed changed «*not only the way business is conducted, especially in countries whereby the digital revolution is proceeding at a slow pace,*

like Italy», one of the respondents said, «*but also the way organizations are structured and therefore their workspaces*». More specifically, the firms' acknowledgement of the possibility to perform remotely part of their activities – for instance, customer service, recruiting, and training ones -, combined with the situation generated by the COVID-19 pandemic, has led them to a progressive renovation of the working structure, which is getting smaller and more efficient than before (and impacting positively on fixed costs). The physical space reduction does not affect only structures populated by white collars, though. Indeed, there are two factors that are granting the possibility to also modify the size of factories in which manual activities are held:

1) **Introduction of new technologies and reduction of human presence**: numerous manual labor activities are being progressively done by autonomous robots instead of humans, and this is leading firms to optimize and therefore reduce the size of some of their factories. This is especially true for logistics and warehouse factories, in which robots can easily substitute almost all the activities once done entirely by humans and can move within extremely small spaces without any issue.
2) **Smart working and new work necessities**: what has been stated in the previous point shall not evoke dystopic thoughts on the reader. Indeed, if it is true that manual labor activities are being replaced by new technologies, it is also true that «*tons of new activities that require the human contribute*

are emerging», said the HR manager of an eyewear MNE, «*such as process reshaping or software management activities*», and that is why her company is experimenting smart working not only for white collars (which has exponentially increased due to the pandemic, as it was stated before), but also for blue ones. More precisely, one day per week workers are required to work remotely and complete various tasks, such as: digital tools' courses, meetings, training, and e-learning activities. All these efforts give workers the chance to reskill and upskill themselves, and therefore to carry out a wider range of activities, not only manual ones, which can be performed also remotely.

Overall, it is possible to state that the 4.0 technologies and characteristics are offering firms the possibility to reduce the size of their structures, making Smart Workspaces more efficient that the traditional ones, and that the emergency situation created by the COVID-19 pandemic has accelerated this process. Despite that being true, before stepping further it must be underlined that not all the businesses can be favored by such factor: indeed, «*only the firms that operate in high-tech businesses*» can exploit it properly, stated an interviewee who works in the AR and VR business. From a behavioral competencies' point of view, what has been previously discussed has various implications: first of all, the overall digitalization process along with the necessity to have a re/up-skill is requiring employees to be curious and willing to update their "digital" knowledge. Secondly,

the progressive departure from the physical workspace, and the substitution of a constant, direct, and physical interaction with a digital one, is demanding them to boost their communication skills. Lastly, the eye-wear HR manager suggested that such a deep and revolutionary change in the work environment is inevitably generating uncertainties and chaotic situations in the every-day life, and that employees are therefore required to learn how to manage their priorities and organize the work schedule. To conclude, the factors previously discussed, along with the firms' size reduction and the COVID-19 pandemic, have completely changed the work environment of firms, especially the ones operating in the 4.0 context, and so characterized by heavy-digitalized production processes. The Smart Workspace is therefore requiring employees to master a new set of soft skills that since a few years ago were not considered so important, especially for factory workers and employees who did not fulfil a managerial position within the organization. Among them, as it was underlined previously in this section, and as the reader will have the chance to discover in the next section, there are: lifelong learning, digital curiosity, communication, and self-organization. Once the link between the 4.0 work environment and behavioral competencies has been highlighted and deepened, it is finally possible to step into the core of the model, and therefore describe what are the competencies that the ideal 4.0 employee should have. It is important to remind, as it was stated in the introduction, that this model

does not consider hard skills, despite them being crucial also in Industry 4.0, but only soft skills, or behavioral competencies.

3.2.1: The 4.0 Employee Profile

From the literature reviews made in chapter 2 and the analysis of the interviews done, it is possible to state that the ideal 4.0 employee is characterized by 11 main behavioral competencies. In this section I am going to define each one of them and, following the respondents' insights, try to explain why they are considered so important in Industry 4.0.

1) **Self-Organization**: to manage and organize the work schedule in a correct and organized way, based on the daily work priorities. According to the interviewees, there are mainly two reasons to consider such competency extremely important in the 4.0 context. First of all, the complexity of the system: nowadays, as respondent 7 has noticed, the work environment has become extremely complicated, and the majority of the tasks are both time and energy consuming. This means that employees have to understand which task has the priority over the others and in which way they have to be completed. Secondly, the smart and remote working methods: working from home can generate a sense of confusion and disorientation which has to be faced by the employee with a rigorous and precise working method. In this process of self-organization, that manager has to support his/her employees,

help them if necessary, and trust in their capabilities and work ethic: as respondent 2 has suggested, the more employees feel the manager's trust, the better they will perform.

2) **Communication**: to communicate effectively and clearly with colleagues, by using properly both nonverbal and verbal cues. In the previous section, among the factors that characterize the 4.0 work environment, it was highlighted the importance of having heterogeneous teams, made of professionals with even extremely different academic and cultural backgrounds. In such context, it is therefore fundamental for the employee to learn how to communicate properly, in order to avoid misunderstandings and share information and ideas in an effective and efficient way. Furthermore, the hierarchy's flattening has increased the communication flow not only horizontally, between the different functions of the organization, but also vertically: this means that employees are required to interact way more frequently than before with their managers or even the firm's top managers. This, in turn, as respondent 7 underlined, requires everyone to learn how to shape their language (digital, verbal, and non-verbal) accordingly to the interlocutor's position within the organization. It must be specified, though, that this continuous communication "modelling" refers almost exclusively to the *content* of the message that has to be shared, not its *style*: the interviewees, especially numbers 1, 2 and 7, confirmed what

was described in theory before, that is the informality of relations in Industry 4.0.

3) **Digital Curiosity**: to be distinguished by an intrinsic drive to learn as much of the digital world as possible. The powerful and profound bond between Industry 4.0 and the digital world has been stressed all over the thesis: therefore, it does not seem unexpected that one of the key behavioral competencies that the ideal 4.0 employee shall master is digital curiosity. The importance of such trait has been widely discussed and underlined by respondent 1, partner and co-founder of a Startup whose aim is to help firms achieving the ability to compete in the digital world by adopting lean and agile business solutions, who during the interview has stressed the importance of employees to be characterized by this kind of curiosity. Despite that being true, another extremely interesting insight came out from the conversation: digital curiosity shall not characterize only employees, but also and especially managers and employers. Indeed, if employers are not ready and willing to accept this digital shift, then it will not be possible for the organization to enter and survive the digital transformation that outlines Industry 4.0. Of course, as respondent 6 suggested, the importance of such characteristic gets higher the higher is the technology level required by the sector in which the activity is held: organizations that operate in high-tech

businesses require tech-savvy professionals (from the bottom to the top of the organizational pyramid), who are extremely curious and willing to adopt new technological solutions.

4) **Leadership**: to influence and guide the members of a team, or the entire organization, towards a well-defined goal. During the interviews, almost all the respondents have not only confirmed what was previously stated in the theory reviews held in chapter 2, and so that such capability should be considered as one of the most important ones in Industry 4.0, but also deepened this topic by analyzing the style that should characterize the 4.0 ideal leader. Coherently with the chapter's 2 literature review and the digital curiosity capability's analysis, it is possible to state that the 4.0 leader is actually a digital leader. That is, the main duty of a leader in Industry 4.0 is to foster the development of new ideas and the successful implementation of new technologies in order to increase the firm's competitiveness. In order to do so, various characteristics of the ideal 4.0 leader were identified: first of all, he/she must have the ability to assess correctly and equally employees' performances and set up feedback routines to support the team's professional growth. Secondly, he/she has to adopt a cooperative and delegative approach, by supporting the team members when needed and delegating them initiative. Thirdly, he/she must be extremely good at coordinating the team's goals with the organization's one. Fourthly, as it

was previously stated, he/she must be an innovator himself and a digital savvy individual. Lastly, he/she should have the ability to deal with change and exploit it to boost the team's and organization's performances.

5) **Teamworking**: to work efficiently and effectively together with the other team members to complete a task or a large goal. There are numerous reasons to consider teamworking as a crucial skill in Industry 4.0: first of all, as theory suggests and as respondent 2 highlighted, the 4.0 production system is so complicated that most of the tasks requires – to be executed efficiently and effectively – a team. Secondly, a complex and fast-paced environment such as the 4.0 one is usually characterized by high levels of stress among employees, and teamworking can be a viable way to reduce it by splitting tasks among multiple individuals rather than gathering them upon only one. Thirdly, considering the teams' heterogeneity, teamworking offers an incredible opportunity for employees to learn from their colleagues' different background and capabilities. Fourthly, it enhances communication skills. Indeed, if in Industry 4.0 employees are somehow forced to cooperate with other people to complete a task, they will be also forced to communicate and in turn this will increase their communicative capabilities. Fifthly, working in a team increases the output's quality: since each team member has the same goal (e.g. a project delivery), they have to observe their teammates work, and in turn this enhances the overall output's

quality. Lastly, and this characteristic is particularly important in the 4.0 context, team working fosters innovation: working on the same object means having multiple perspectives on it, and therefore multiple ideas.

6) **Creativity**: to look at the organizations' processes critically, and think out of the box to find innovative solutions. There are three main reasons to insert such capability in the list of the main behavioral competencies that the ideal 4.0 employee should have: the first one, is that the previously mentioned complexity of the system and – consequently – of the issues that employees have to face daily at work requires people that can think out of the box and find innovative and efficient ways to solve them. The second one, is that the new technologies do not represent only problems, but also and especially opportunities. The role of a creative person in such system is to identify such opportunity and then exploit it to boost the firm's competitiveness and performances. The third and most important one has been partially discussed in chapter 1 and in the description of the new work environment in chapter 3: the new technologies introduced by the digital transformation are progressively reducing the necessity for humans to perform manual and mechanical tasks. Autonomous robots, for instance, can execute those kinds of tasks way faster and more efficiently than humans, obtaining therefore higher quality outputs and giving firms the opportunity to reduce costs. What technology cannot express yet, is a creative output: what really

differentiate humans from robots today is therefore the possibility to elaborate something creative, which does not follow a specific algorithm, and that is why it is so important to have a creative workforce.

7) **Networking**: to initiate, maintain and boost professional relationships and social contacts. In an environment where employees are required to work constantly together, the hierarchical chain is flat, a constant cooperation is needed not only between team members but also colleagues within the organization, it seems obvious that the capability to initiate, maintain and boost relationships is crucial. An interesting insight that came from the interviews is that actually this capability shall not refer only to the relations between employees within the organization, but also between them and professionals that work in other organizations. Indeed, having a solid and wide social and professional network means also being able to compare and discuss ideas with people that come from different backgrounds, cultures, and experiences: in turn, this might help employees in elaborating new ideas and proposals that benefit the firm's competitiveness. There is another element that points out this capability's importance: it is known that the 4.0 context is characterized by high levels of competition between firms, whereby even a detail might help the organization in outperforming competitors, and that is where networking might come into play. For instance, as respondent 7 suggested, in Industry 4.0 it is sometimes difficult

to find a professional with a specific competency and therefore having an enduring and positive relation with someone in a temping agency, might give the organization a fast track in this profile's research.

8) **Empathy**: to understand each owns' and others' feelings and thoughts, and consequently interact with them in the most appropriate way. In the previous pages, it was highlighted several times the importance of cooperation, coordination, and leadership in Industry 4.0. Those objectives cannot be achieved without empathy, though: indeed, being able to understand others' feelings means also being able to create a solid and positive link between them and the empath. This capability is particularly important, because if employees believe to be understood, they tend to feel safe and are therefore more likely to share ideas, thoughts, and proposals. The reader shall not forget, though, that as it was stated in the definition, being empathic means also being able to deal with ours' emotions, and this is crucial in an environment like the 4.0 one. Indeed, if it is true that Industry 4.0 demands people to be creative, to take initiative, and to foster innovation, it is also true that those claims tend to charge employees from an emotional point of view. Being able to control their own emotions is therefore important, because it allows employees to face stressful and complicated situations with optimism and awareness.

9) **Flexibility**: to efficiently adapt to different situations, tasks, and events. At the start of this section, it was stated that nowadays employees have to develop and master a new set of behavioral competencies mainly because of two elements: a new work environment, and the digital transformation. Both of them have introduced numerous changes to the way people have to perform their job, and therefore being flexible first of all means to adapt successfully to those changes. Flexibility is not only about that, though, since it represents an extremely useful trait also in several other situations. For instance, it represents a key tool in team working. Projects, especially long-term ones, in industry 4.0 tend to be addressed by constant and sudden changes which might in turn slow down the team's work or generate high levels of stress: in such situation, being flexible helps out the team members to reduce the stress level and keep on the schedule's track.

During the interviews, respondents have highlighted another benefit for employees characterized by flexibility and, in turn, for the organization itself. Being flexible, as it was stressed before, grants the capability to face issues in an appropriate and positive way, which helps out the employee in reducing his stress level and achieving a healthy work-life balance. This, of

course, has an extremely positive impact also for the organization mainly for two reasons: first of all, a pleasant employee tends to perform better. Secondly, and consequently, the firm's turnover rate tends to get lower.

10) **Pro-activity**: to self-initiate a behavior that aims at solving a problem or an issue before its occurrence. In Industry 4.0, being proactive is crucial. The innovations that are constantly introduced and the fast-pacing environment that was previously described can offer numerous opportunities that require proactive people to be properly managed. First of all, indeed, being proactive means not to allow circumstances to control you, but rather control and exploit them. Secondly, it allows to better use resources, especially time and energy: a person characterized by such traits does not waste time and energies on non-value-added activities for the organization. On the contrary, he/she is able to identify in advance the problem or the issue that the organization will face and to focus his time and energies on that, neglecting secondary and less important activities. Thirdly, by acting preventively on the problem, the proactive prevents the problem from occurring or, at least, reduce its negative impact on the organization. Similarly to what was stated before for Flexibility, pro-activity means to have higher control of the situation, and therefore allows the employee not to feel overwhelmed, but rather a greater sense of control: this, in turn, makes him/her less stressed. Lastly, in the previous pages it was underlined

the importance of having leaders in Industry 4.0, and to be a proper 4.0 leader it is fundamental to be pro-active.

11) **Lifelong Learning**: to be willing to keep on improving knowledge, skills, and competencies throughout the entire work life. This capability was considered probably the most important by the majority of the respondents, and it was deeply discussed and analyzed especially by respondent 3. Industry 4.0 makes organizations facing continuous and sometimes even radical changes: the introduction of new technologies is frequent, the products' life cycle is getting lower year by year, the competitiveness of firms is constantly increasing, and this requires a workforce that is willing to keep on updating its knowledge and skills. The main problem related to such capability is that firms tend often to think that this is only an employees' matter, without realizing their importance in favoring such behavior by creating an environment that enables employees to have the time and the incentive to learn. Fulfilling employees' daily work schedule with meetings and activities that will keep them busy for the entire day will never grant the possibility, even for the Lifelong learning individual, to update their knowledge. Organizations shall instead introduce specific time frames that are entirely dedicated to learning activities. For instance, respondent 7 established that every week, on Tuesday, her subordinates have to spend time in updating their knowledge and then, before starting

working again on their daily tasks, they have to send an email to the colleagues that summarize what they had learned in that hour.

Once they have been defined and described each of those competencies can be further categorized according to the mastery level achieved by the individual: Low-Level, Mid-Level and High-Level. Initially, the years of experience were added to the model, but since transversal competencies are highly subjective and depends on the worker talent, experience, and traits, they have been removed, lending the model also a higher flexibility and applicability.

It seems also worth saying that the model does not consider the generational gap between professionals: for instance, Generation Z (people who were born from 1995 onwards) – which is now entering the workforce – has innate characteristics that suit the industry 4.0's technologies and work environment. Their digital tools' consumption and usage completely differs from previous generations, they are tech-savvy, entrepreneurial, willing to co-create the organizational culture, and usually characterized by interdisciplinary thinking, problem solving and flexibility skills. Because of such characteristics, it is not possible to develop a model that contemporaneously considers all the different generations' characteristics, strengths, and weaknesses, and that is why the competencies' levels will remain generic and therefore applicable to everyone within the organization.

Future works might deepen such issue, in order to identify a completer and more realistic model, that highlights the generational differences and their impact.

Competency	Low-Level	Mid-Level	High-Level
Self-Organization	He does not know how to organize properly his work and therefore tends to observe and talk with his colleagues to better understand their habits and draw inspiration from them. Not able to recognize the priority levels, he tends to complete tasks in a chronological order unless he is told to do differently.	He understands how priority works, and is able to organize the work schedule accordingly to it. He does not need any assistance, and the interaction with his colleagues is aimed at coordinating on solving issues rather than drawing inspiration from their habits.	Thanks to his experience and knowledge of the organization, he is able to change priorities accordingly to the occurring events. He provides support and share his habits with the new entries and colleagues.

Competency	Low-Level	Mid-Level	High-Level
Communication	He is not able to use properly both nonverbal and verbal cues in the work environment. Moreover, he is flanked by his supervisor in the communication process with other colleagues or managers. He does not know how the communication patterns works within the organization.	By properly using the cues, he is able to communicate effectively with his colleagues and managers. The communication patterns across the hierarchy are well-known and exploited properly.	He masters nonverbal and verbal cues, is able to effectively communicate the information that has to be shared and knows exactly how to shape his communication pattern accordingly to the interlocutor.

Competency	Low-Level	Mid-Level	High-Level
Digital Curiosity	He is curios and acknowledges the importance of digital tools. Despite not being a digital enthusiast, he tries his best to develop at least the minimum knowledge that is required to successfully complete the assigned task.	He is keen on technology and digital tools, and tries to use the most appropriate ones accordingly to the issue or the problem faced. He asks colleagues for help or surfs frequently the internet to improve his digital knowledge.	A tech-savvy individual, who is constantly up to date with the digital innovations and helps his colleagues over the digital tools' usage. He pushes the firm to experiment and adopt new technologies to improve the organization's systems and production processes.

Competency	Low-Level	Mid-Level	High-Level
Leadership	He does not have the capability to influence the colleagues, or to lead a team. Rather, he prefers to follow others' instructions and ideas and does not try to take initiative to solve problems or issues at work.	He is able to influence the others' opinions, and convince them to follow his plan or ideas. Despite that, his mid-level leadership capability does not let him to become a landmark for the organization.	He has outstanding leadership capabilities, and is able to convince not only his colleagues but also the top management to follow his ideas. He represents a leader for the organization, someone to follow in order to achieve the organization's goals.

Competency	Low-Level	Mid-Level	High-Level
Teamworking	He does not have the capability to work in team, and usually prefers to work solely to complete the assigned tasks. If asked to work in team, he tends to show one main behavior: a complete disengagement from the team's goal, leading him to follow other's instruction without endeavoring any particular effort.	He is keen on teamworking, loves to discuss and share his ideas with the other team members and the team leader. Moreover, he is willing to act as team leader if asked so.	He believes that teamworking is the best way to solve problems and achieve the organization's goals. He prefers to be the team leader, and tends to take care of his team members to achieve the predetermined goal in the most efficient and effective way.

Competency	Low-Level	Mid-Level	High-Level
Creativity	He prefers to follow the methods that have always been used to solve issues, without addressing them in a critical and curious way. He tends to ask colleagues for help, to understand how they are used to solve problems and does not propose innovative and creative solutions.	He follows the organization's methods to face issues, but he also tries to develop new paths and solutions that might help the firm to perform better. If possible, he tries to exchange ideas with colleagues, to drive inspiration from their methodology and improve his own one.	He thinks out of the box and finds innovative methods that might replace old and institutional ones. He believes that being creative is important for the firm's survival and success, and suggests frequently the management to adopt new and innovative schemes of working.

Competency	Low-Level	Mid-Level	High-Level
Networking	He is able to initiate professional and social relationships with his colleagues, but not to maintain nor boost them. Communications and interactions with the colleagues do not happen frequently, but only to solve problems or other issues at work.	He has the capability to initiate and maintain relationships, but is not willing or able to boost and take advantage of them. The interactions with colleagues are frequent, not only to address issues that have arisen at work, but also to socialize and get in touch with them.	He is capable of initiating, maintaining, and boosting the relations with all the colleagues within the organization. Therefore, is able to build a wide and heterogeneous network of relations which might be exploited to increase performances at work.

Competency	Low-Level	Mid-Level	High-Level
Empathy	He cannot understand others' feelings, tends to behave insensitively or at least not considering the consequences of his actions over the colleagues, to blame others for his problems, to be unable to cope with emotionally charged situations, and to struggle with relationships.	He is interested in colleagues' emotions and thoughts, behaves in accordance with them, or at least trying not to hurt them. Furthermore, he can manage a wide range of emotionally charged situations.	He understands and takes care of colleagues' feelings, is capable of inspiring them, driving their actions, and gaining their trust. Thanks to such outstanding competency, the empath can maximize employees' performances, especially if working in team.

Competency	Low-Level	Mid-Level	High-Level
Flexibility	He is not willing or able to embrace new tasks and challenges calmly, nor to adapt to new situations or changes within the organization. If his daily working routine changes, he tends to be confused, nervous, and his performances tend to drastically drop, along with his motivation.	Despite preferring to remain within the status quo, and preserve his working habits and routines, the mid-level flexible individual is also willing to accept some changes, since he recognizes in them the opportunity to have both a personal and professional growth.	The High-Level Flexible professional gets frustrated and annoyed if asked to perform the same activities, and therefore embraces new tasks with enthusiasm. Moreover, his mindset grants the capability to face those changes and challenges calmly and positively, boosting therefore his performances.

Competency	Low-Level	Mid-Level	High-Level
Pro-activity	An individual with a low pro-activity level focuses only on his daily routine, without even trying to understand how the organization works in its entirety, or to imagine the potential issues, problems, bottlenecks within the system that might be solved thanks to his intervention.	He is interested in understanding how the system works, and why he is asked to perform certain tasks. He tries to find solutions to enhance the organization's performances, and tries therefore to activate a behavior that aims at solving an issue or a problem before its occurrence.	The High-Level pro-active professional looks beyond the assigned tasks, and tries to imagine what could be done to enhance the system or solve a problem that has not already arisen. Once the solution is found, he acts immediately by proposing it to the manager or by directly applying it.

Competency	Low-Level	Mid-Level	High-Level
Lifelong Learning	He believes that the learning process has concluded during his academic career, and therefore he is not willing anymore to study or keep up to date with the fast-paced environment of Industry 4.0. Moreover, he does not take part gladly to training courses and team building activities.	He thinks that increasing his knowledge and keeping up to date is crucial to properly complete the assigned tasks and/or boost his performances. Despite not enjoying them particularly, he willingly participates to all the development courses offered by the organization.	This individual is convinced that in the 4.0 era it is not possible to work properly without keeping on studying and updating each owns knowledges. Therefore, not only he is willing to join the courses offered, but keeps on studying also on his own.

The model that was introduced in the previous pages has described all the characteristics that an individual who operates in the context of Industry 4.0 should have. Of course, since the aim of the model is to describe the *ideal* 4.0 employee, it should be assumed that such professional masters (or, has a High-Level of) each of those characteristics.

To conclude, it is possible to state that the ideal 4.0 employee is a tech-savvy individual, that throughout his outstanding capability to understand others' emotions and feelings, along with his communication style, is capable of working and leading a team, organizing and changing the daily routine accordingly to priorities, building and maintaining solid relationships, anticipating and solving issues thanks to his flexible, creative and pro-active mentality, and willing to keep on studying and improving his skills and knowledge over the years.

Before stepping into the conclusions of the chapter, and the thesis itself, it seems worth deepening briefly how this model could be used by firms: the next section is therefore focused on answering the question "How could the model be used?".

3.2.2: Insights on how to use the model

The model can be used by firms operating in Industry 4.0 as a tool to achieve 3 main goals: to carry out a better and more appropriate recruitment process, to define suitable employees' development paths and to build a culture that is in harmony with the 4.0 environment.

The first goal, that is to carry out a better and more appropriate recruitment process, can be easily achieved by following the model was presented in the previous pages. That means, trying to evaluate during the selection if the candidate has some of the behavioral competencies that were described and, if so, what his mastery level over them is. Despite those two tasks being difficult to execute since behavioral competencies are usually evaluated on the job, and are much more difficult to assess during a recruitment process, the interviewer's experience along with the appropriate questions might offer useful insights to make a preliminary evaluation of such capabilities. Questions about volunteering activities or sports could represent convenient markers about the candidate's pro-activity, flexibility and team working capabilities, for instance. A senior recruiting specialist once appointed that one of the key questions to understand a candidate's proactivity, especially a junior one, is: "did you (or do you) practice any sport at a competitive level?". «*Accordingly to my experience* – she said – *I have learned that statistically people that have practiced sports at competitive level at least until university have way higher chances to be characterized by pro-activity at work*». Making "creative"

questions might instead offer insights on the candidate's flexibility and problem-solving capabilities: during interviews, a plant controller used to alternate traditional HR questions (about the academic and professional career, hobbies, sports, culture) with more complicated and inventive ones. More specifically, he used to ask how many liters of water could fill the San Siro stadium of Milan. «*With such question, I do not aim at obtaining the correct mathematical answer. - he said - Rather, I want to understand if he can switch from easy to challenging questions or tasks without losing patience and calm. Furthermore, in this way I can understand what kind of mindset he has: for instance, to be a controller you need to have a mathematical and scientific mindset. This means that if the candidate starts thinking about the shape of the stadium to understand how to compute its area, for me it is a good indicator of his mindset*». Those ones are just a few examples of how questions during an interview could help the HR specialist to understand and assess the candidate's behavioral competencies.

The second goal of my research was to help firms identify the most appropriate development paths for their employees. Literature reviews and interviews have highlighted that it is not only possible, but also extremely important to focus on employees' development, also from a soft skills' point of view. Thanks to this model, and therefore the identification of the most important behavioral competencies in Industry 4.0, organizations now acknowledge *where* to intervene. Despite that being important, it is also crucial at this point to determine *how* to do

it. First of all, similarly to what the Ca' Foscari institute does, it is important to assess the mastery level of each competency: self-assessment surveys, interviews, feedback routines and games might represent useful tools for such purpose. Once the level has been assessed, the organization shall categorize the employees according to the soft skill that has to be enhanced, and start preparing specific activities to achieve this goal. When asked about which kinds of activities had to be prepared for this purpose, the respondents' answers have somehow confirmed what it had been previously described in the literature reviews of chapter 2: games, training, coaching, and e-learning represent the main methodologies to be followed. The last goal that this model pursues, is to help organizations in building a culture harmonized with the industry's 4.0 characteristics. From this point of view, the description of the 11 behavioral competencies gave useful insights: first of all, extremely complex systems like the 4.0 ones require firms to adopt decisions and react to events quickly. This, in turn, as it was underlined in the previous sections, means that firms have to empower their employees in taking decisions: to achieve such purpose, it is fundamental that the employee does not feel stressed and anxious about the possibility of taking a risk and failing. Therefore, throughout their managers, organizations shall reassure them and encourage them to be pro-active, make decisions and propose ideas to solve actual or potential issues. For instance, firms could activate an e-mail box or a specific web page whereby employees can propose their ideas and reward them throughout money or welfare initiatives.

Secondly, it is known that in industry 4.0 employees have to keep on updating themselves and therefore the organizations shall favor and spread a culture that facilitates such goal. To do so, firms could grant their employees the possibility to access daily and freely to newspaper and specialized magazines. Or, they could subscribe to digital platforms that give their employees the possibility to update themselves by discussing a certain topic with specialists from other firms, such as MyHRGoal by the HRC group. This platform offers subscribers the possibility to join daily meetings about various kinds of topics (HR and marketing ones especially) and a forum to discuss ideas and opinions. Thirdly, since flexibility and teamworking represent key behavioral competencies in industry 4.0, firms should periodically organize events, such as business cases, games, and sport competitions, to challenge their employees and make them work in teams.

Overall, this model should be seen by organizations as a *starting point*, which grants them the chance to understand what the main behavioral competencies in industry 4.0 are and why they should be developed: then, it is up to the organization to understand which one of them prioritize and in which way accordingly to its business sector.

3.3: FINAL CONSIDERATIONS

Before stepping into the conclusions of the thesis, it might be worth reminding that, as it was underlined all over the thesis, it has been voluntarily omitted to include hard skills in the model: the reason is that the aim of such research was to prepare a tool that could be used by all the organizations that operate in the context of industry 4.0, independently from the business in which they operate, to make the best out of their workforce and, consequently, to boost their performances. Therefore, this thesis has focused only on behavioral competencies, or soft skills. By combining the knowledge developed through deeply studying the 4.0 literature with the interviews to HR and business leaders, the profile of the ideal 4.0 employee has been finally identified: an individual, as it was stated during this chapter, that is characterized by 11 main competencies. More specifically: self-organization, communication, creativity, teamworking, empathy, leadership, lifelong learning, flexibility, pro-activity, networking, and digital curiosity.

To conclude, as it was stated at the end of this chapter, the model should be defined as a *starting point* for firms whose willingness is to increase their competitiveness in Industry 4.0 by creating powerful and proper paths that will grant the evolution of their workforce into a 4.0 human capital.

CONCLUSIONS

The aim of this research was to find a way to assess the digital quotient of organizations operating in Industry 4.0 independently from their business or sector. To achieve such purpose, it was necessary to start by making a preliminary research over the whole 4.0 revolution, and identify its main characteristics. More specifically, those that follow represent the main results that were obtained through such analyses in chapter 1: first of all, the definition of "Industry 4.0" as "*utilizing the power of communications technology and innovative inventions to boost the development of the manufacturing industry*"[236]. Secondly, its main technological pillars, namely: IoT, Big Data, Autonomous Robots, Horizontal and Vertical System Integration, Cyber Security, Additive Manufacturing, Virtual Reality, Simulation, Cloud Computing and Cyber Physical Systems. Thirdly, its impact over the organizations, which can be summarized with the following characteristics: flat hierarchy, continuous and multidirectional communication flows, heterogeneous teams, informal relations, and high interconnection between physical and digital assets. Lastly, its impact over employees, which are now required to be flexible, tech-savvy, creative, pro-active, and able to work in teams. Once the main characteristics of Industry 4.0 were identified, in chapter 2 another key concept for the purpose of the thesis was analyzed: the one of "skill". Such term defines "*the capacity for carrying out complex, well-organized patterns of behavior smoothly*

[236] Shu Ing Tay, Lee Te Chuan, A.H. Nor Aziati and Ahmad Nur Aizat Ahmad, "*An Overview of Industry 4.0: Definition, Components, and Government Initiatives*", Journal of Advanced Research in Dynamical and Control Systems, 2018, pp. 1381.

and adaptively so as to achieve some end or goal"[237]. To be properly studied, this concept had to be further deepened into 2 categories: hard and soft skills (or, behavioral competencies). The first ones are "*related to technical aspects to do some tasks in the job*"[238], whereas the second ones are "*interpersonal, human, people or behavioural skills necessary for applying technical skills and knowledge in the workplace*"[239].

Once the preliminary and groundwork studies were completed, it was finally possible to step into the third and final chapter, whereby it has been achieved the goal of assessing the digital quotient of firms in Industry 4.0 by developing a new competency model that could be used by firms to identify the 4.0 ideal employee: since the aim was to create a tool that could be used across businesses, sectors and organizational functions within Industry 4.0, the model has focused exclusively on behavioral competencies, or soft skills, which by nature are transversal. More specifically, by combining the preliminary studies held in the first two chapters with some interviews made to HR and Business leaders among Startups, SMEs and MNEs, it came out that the ideal 4.0 employee is «*a tech-savvy individual, that throughout his outstanding capability to understand others' emotions and feelings, along with his communication style, is capable of working and leading a team, organizing and changing the daily routine accordingly to priorities, building and maintaining solid relationships, anticipating and solving issues thanks to his*

[237] A.S. Reber and E. Reber, "*The Penguin Dictionary of Psychology*", Penguin Books 3rd edition, 2001.
[238] A.F. Hendarman and U. Cantner, "*Soft skills, hard skills, and individual innovativeness*", Eurasian Business Review, 2018, pp. 141.
[239] Verica Babić and Marko Slavković, "*Soft and Hard Skills Development: A Current Situation in Serbian Companies*", Management, Knowledge and Learning. International Conference, 2011, pp. 410.

flexible, creative and pro-active mentality, and willing to keep on studying and improving his skills and knowledge over the years». This ideal profile has been created to help organizations in 3 main ways: improve their recruitment processes, define appropriate development paths for their employees and adapt their structure accordingly to the characteristics of the 4.0 environment.

As it was highlighted in the thesis, this model is *generic*, and therefore it should be seen as a *starting point* by firms that want to boost their performances in such complex environment.

Further studies could deepen various aspects of the model, such as the different categories of employees within firms (e.g. organizational function, type of worker), or the kind of business in which it is applied in order to enhance it accordingly to the sector's characteristics.

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