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Characterization of Tasks and Skills of Workers, Middle and Top Managers in the Industry 4.0 Context

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Abstract: This study intends to make a characterization of the main tasks and skills needed to face the Industry 4.0. Moreover, it gives special attention to the different company's hierarchical levels. To achieve the goals of this paper, a methodology based on Collaborative Decision Making method was used. Firstly, thirty participants were interviewed to understand their point of views. Next, they were split into Group Works to refine the results. Finally, a Group Concordance took place to create the final list of tasks and skills. The skills were organized into four categories: Technical, Social, Methodological and Personal. The results show different requirements in each level. In the Workers level, due to the presence of more technical tasks, eight of the top ten skills belong to the Technical category. In the Middle Managers level, there are tasks of both leading and analyzing nature and thus the top ten skills needed are split through the four categories. Finally, in the Top Managers level, due to the presence of mainly strategy tasks, the top ten skills are split between the Methodological and Social categories. To the authors' knowledge, this is one of the first studies to use a Collaborative Decision Making methodology to develop a set of tasks and skills that future work environments will demand on the different hierarchical levels of the organization.

Keywords: Industry 4.0; tasks; skills; workers level; middle managers level; top management level; Collaborative Decision Making; consensus; professional's judgment

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1. Introduction

We are currently experiencing the Fourth Industrial Revolution, a revolution which brings with it a huge paradigm change, marked by the digitization of manufacturing and the computerization of industry. The usage of Big Data for constant deep analysis of a very large number of machines, the employment of 3D Technology to support the companies' processes, the use of Internet of Things platforms to collect data, transmit it and communicate with other devices, and the usage of Augmented Reality tools to increase processes' efficiency are some examples of the new features that are becoming more and more prominent in the Industry 4.0 [1].

The evolution of the Industrial Revolutions over the decades have brought about a change in the characteristics of the tasks expected of workers; for instance, in the First and Second Revolutions, the tasks were based on strength with no need for judgement, however, the Third and Fourth Revolutions brought the need for analysis, decision and management tasks [2–4]. Therefore, in order to deal with the changes in the types of tasks, the skills requested of the labor force also had to change.

Furthermore, in the First and Second Industrial Revolutions the tasks (and skills) were practically transversal to the different employees of the companies [5], however, in the Third, and especially in the current or the Fourth Industrial Revolution, there is a

clear distinction in responsibilities (and therefore tasks) of each hierarchical level. Once again, having different types of tasks implies that the skills needed to perform them must necessarily be different [1].

There are several studies analyzing the skills of the future Industry 4.0 world. Some examples are the articles developed by Hecklau et al. [6], Benesova and Tupa [7], Blayone and VanOostveen [8], Alharbi [9] and Baethge-Kinsky [10]. However, none of them analyze the topic of splitting the employees into different hierarchical levels, rather they all consider the employees as a single group. On the other hand, leadership competencies are of crucial importance in every organization as to a large extent they determine its success [11]. Authors probing into leadership within Industry 4.0 [12,13], such as Tetteh (2022) [14], point out that there is a lack of studies on leadership and the Industry 4.0. In general, concerning workers, research from Gajdzik and Wolniak (2022) [15] presents a framework for the profile of an employee employed in an innovative company transforming to Industry 4.0.

In addition, prior to this study, a search was run in the databases ScienceDirect and Scopus using the combination of different keywords—Industry 4.0/Fourth Industrial Revolution together with Skills or Tasks and with Top management or Middle management. However, no relevant outputs appeared, showing that there is a need for research in this area to understand the different tasks and skills expected at each hierarchical level.

Therefore, the following research questions were considered:

Q1. *What are the tasks expected to be executed in each hierarchical level in a company within the Industry 4.0 environment?*

Q2. *What are the skills needed to execute these tasks in each hierarchical level?*

This study intends to propose not only the characterization of the main tasks to be performed in each hierarchical level, but also the characterization of the most important skills needed to run those tasks in an environment of a company with the implementation of the Industry 4.0 pillars. The data obtained through the different phases and the subsequent findings helped to understand the main tasks under the domain of each hierarchical level and the skills expected to evolve in order to properly execute those tasks. Having said that, the main contributions of this paper are a list of the main tasks which will represent the day-to-day work of employees at different hierarchical levels in companies with the implementation of the Industry 4.0 and a list of the main skills necessary for the correct execution of the tasks listed for each level.

The remainder of this paper is organized as follows. In Section 2, a historical overview of tasks and skills throughout the first three Industrial Revolutions is presented as well as a description of the tasks and skills needed in the Fourth Industrial Revolution. In Section 3, the research design is presented and the Collaborative Decision Making method is characterized as a baseline of the research design used. The results achieved in each methodological phase are presented and discussed in Section 4. Finally, Section 5 concludes the paper with some recommendations for further research.

2. Theoretical Background

2.1. Historical Overview: Evolution of Tasks and Skills through the First Three Industrial Revolutions

The First Industrial Revolution had its origins in Great Britain, and is commonly considered to have occurred in the period between 1760 and 1830. Following the country's victory in the Seven Years War (1756–1763), a host of developments and economic achievements would ensue, which would prime the region for the revolution that unfolded. Indeed, such developments were mainly brought about by technical and structural changes which resulted in increased growth in income per capita, as well as in labor productivity [16].

During this period, Great Britain was able to establish an unparalleled naval and commercial hegemony which, combined with the efficiency of its agriculture, moved the country towards an advantageous position with regard to the industrial landscape of the time.

Although the present paper does not intend on providing an exhaustive account of the technological advances which led to each Industrial Revolutions, it is important to determine the key changes brought about by each different era, in order to understand how the type of tasks and skills required for the labor force have changed, leading to the scenario presented in this paper, i.e., the new Industry 4.0 revolution.

Indeed, a series of technological innovations were suddenly introduced, starting in 1760, in England, a fact that can be attested by the catalogue of new patents, as well as by the shifts in prices and exports observed at the time. These innovations were of different kinds, including agriculture, transport, manufacture, trade, and finance [17]. Through iteration and the introduction of incremental improvements into existing technologies, as well as the development of unprecedented ideas, the novel techniques engineered were labor-saving, and thus led to a significant increase in productivity. This would give rise to a new mode of production, namely the factory system, wherein the shift from hand production methods to the use of machinery created a surge in capital, entrepreneurial and manufacturing skills, which would eventually pave the way to the subsequent technological advances in the following Industrial Revolutions [18]. A shift in tasks ultimately led to a shift in skills, with workers performing tasks in a single room. Tasks were mostly focused on machine labor, as hand-made tools were replaced by machinery [16].

Following this great period of growth, the Second Industrial Revolution took place between the years 1870 and 1914, as is generally accepted. This period saw a shift towards the development of technologies with a scientific base, moving from a more empirical view to the development of innovations based on the scientific management method. The refocusing of the scientific thinking due to novel inventions, as well as the technological advances which facilitated the analyses and registering of facts and regularities, was crucial in the proceeding observed growth [19]. Furthermore, the increase in scale and throughput led to a change in production technology, with a focus on building of technological systems to increase coordination [20]. A key development was related to the continuous-flow production, with workers being able to stay stationary and have the tasks moved to them, thereby increasing productivity by reducing the workers' idle time. The key areas of development were agriculture and food production (barbed wire, fertilizers and canned food), steel (Bessemer converter), chemical industry (fertilizers and the development of dyes), electricity (electric generators and the lightbulb), and transportation (the Diesel engine, steam turbine and their subsequent adoption by the naval industry). Similar to the First Industrial Revolution, there was a shift from hand skills, with artisanry decreasing in importance and replaced with mechanical skills important for making and maintaining the novel devices introduced therein [19]. Furthermore, on one hand, the machine operators were mostly regulated by manual labor, but on the other, there was also a demand for engineering and managerial skills, fueling the replacement of unskilled labor (artisanry) with skilled workers [5]. Importantly, there was a furthered gulf between physical tasks performed usually by less skilled workers, and the logistics tasks undertaken by higher levels of hierarchy.

The Third Industrial Revolution, which is still in place according to Janicke and Jacob [21], has seen a significant shift in employment from manufacturing towards services. There is not an academic consensus regarding what exactly the current Industrial Revolution entails, with it being termed a "green industrial revolution", an "efficiency revolution" or a transformation towards "green capitalism". Nevertheless, it is safe to affirm that we are currently in the midst of an Industrial Revolution, with the supply for skilled labor increasing, due to the technical advances over the past decades (namely the move from analogue to digital). The innovations in terms of production methods (cleaner methods), means of transportation (the internet and high-speed railway systems), raw materials (microelectronics and biotechnology), energy base (renewable energies) and societal changes (globalization), and their contrast with the changes seen in the previously mentioned two Industrial Revolutions, further cement the recognition that the current era is one of technological revolutions. Indeed, the shift from the previously discussed mechanical labor

to the more recent Information Age has been accompanied by a change in the types of skills required of a worker. On one hand, the Third Revolution can be seen as a computer revolution, with evidence of this technology changing the structure and economics of work; as such, this seems to indicate that computer use and knowledge is an essential skill in the current labor market [22]. On the other hand, data also seem to indicate that one is required to possess a broader technical and scientific knowledge in order to achieve success in work [23]. There is also evidence that the Third Revolution is one driven by creativity, with creative skills being key to fulfilling the market needs [24]. Indeed, the case may be made that an amalgamation of the aforementioned types of skills is in order, and that there are other skills of great importance as well. These are not only general skills learned in school, but also specialized cognitive, technical, creative, and social skills, cemented in the workplace. As such, the Third Industrial Revolution would be one of critical thinking, problem solving and deductive reasoning, with a focus on analytical and managerial skills [3]. During this period, the separation of tasks based on level of skill widened, with tasks catering to low-, middle- and high-skilled workers. A straightforward example is the definition of routine tasks, which are routinely assigned to middle-skilled cognitive and manual jobs (bookkeeping, clerical work, repetitive production and monitoring). These are mostly well-defined procedures following precise instructions. More abstract tasks, such as ones related to problem solving, intuition, persuasion and creativity are linked to managerial, professional, technical and creative roles, typically performed by highly skilled workers. Contrastingly, non-routine manual tasks are usually assigned to low-skilled workers; examples include driving a truck, preparing a meal, installing a carpet or mowing a lawn. In these cases, although they usually do not require higher education, workers should be physically adept and possess communication skills [25].

2.2. Industry 4.0: Tasks and Skills Needed in the Fourth Industrial Revolution

With the increasing digitization of the entire production pipeline in companies, and the constant connection between people, objects, and systems, stemmed in real-time data exchange, there is a constant push towards the implementation of artificial intelligence and robotics in the manufacturing processes. This cutting-edge endeavor has been considered to be the Fourth Industrial Revolution, or the introduction of Industry 4.0 [6]. Ideally, the implementation of these technologies in the workplace will take place across all participants in the value chain, as well as across all organizational levels. It is fairly evident that, due to the introduction of such recent technological innovations, a reorganization in the manufacturing processes will occur, particularly due to the need to introduce highly specialized staff who can perform technological tasks in a skillful manner, at all levels [26].

In order to further understand the skills required for Industry 4.0, it is useful to cluster them into different clear categories, which will translate into different sets of challenges that need to be addressed in this novel type of industry. Furthermore, since the aim of this paper is to identify the different types of tasks and skills which will be required in Industry 4.0, in the different hierarchical levels, it is important to have clearly defined categories from which the participants in this study will be polled.

Using the approach established by Hecklau et al. [6], one can categorize the distinct competencies into four pools: technical, methodological, social and personal. Starting with the first category, this set of skills deal with the more technical aspects of the work required, including the knowledge of the state of the art, strategic knowledge, the understanding of the underlying processes, the use of smart media (e.g., smart glasses) and the knowledge of IT security, in order to tackle issues related to, for instance, the storage of data in external servers. The methodological set of skills relate to the practical application of skills, such as the ones mentioned above. They are related to the creativity required to develop more innovative products, entrepreneurial thinking at the foundation of the performance of strategic tasks, problem and conflict solving, deal with processes and people, analytical and research skills, through the use of reliable sources and the structuring of data obtained, and efficiency when solving complex problems. In an ever-increasing global economy

and workplace, one needs to possess the right set of social skills in order to perform the demanded tasks. These include intercultural and language skills, communication and networking skills developed through the use of listening and presentation skills, a strong knowledge network, the abilities to work in a team, the ability to be compromising and cooperative as well as skills to transfer knowledge. It further includes all key elements of a normal work situation and leadership skills which are necessary due to the adoption of more flattened hierarchies, which means that all employees become leaders. Lastly, the personal skills relating to oneself, in the sense that the person should be able to act in an autonomous way to develop abilities, and possess strong ethical values. These factors are key in an increasingly automated environment, and include the flexibility with job responsibilities, the tolerance to change, the motivation to learn in an ever-changing work environment, the ability to work under pressure due to shorter product life cycles, the use of a sustainable mindset and a general sense of compliance.

The uniqueness of the Fourth Industrial Revolution, when compared to the previous three, stems from the constant breakthroughs the worker needs to deal with, which broaden the scope of the skills required for the performance of the demanded tasks. The complexity of this new era is further added upon by the fusion of these technologies with the physical, digital and biological domains [1]. Indeed, it is clear, as has been mentioned throughout the current paper, that the chasm between different levels of skills stemming for the different types of tasks necessary during each subsequent era, has led to the progressive introduction of hierarchical levels. If, on one hand, during the First Industrial Revolution, the introduction of separate hierarchical levels was due to the introduction of the factory system, then on the other hand, during the budding Fourth Industrial Revolution, the separate hierarchical levels are somewhat clear. Throughout this paper, this distinction will be made on the basis of worker, middle manager and top manager levels. A Worker level function includes mostly operational production, logistics, quality control and maintenance. These are the functions closest to the product and the production lines/machines. The Workers responsibility is to guarantee that the products are well produced, the material is delivered at the right time and the machines have no quality problems [27]. The Middle Managers level is the intermediate management of a hierarchical organization that is responsible for the lowest levels of the chain. Its duties include creating an effective working environment, administrating the work processes, making sure they are compliant with the organization's requirements, leading people and reporting to the highest level of management [28]. The Top Managers level includes all the steering and administration functions of a factory. Its main functions are to translate company policies into goals, objectives, and strategies, and projects into a shared vision of the future [29]. All these facts help to understand the key factors identified by current workers in Industry 4.0 projects, namely through the survey of crucial tasks and skills, aiding and furthering the common knowledge in the field.

3. Research Design: Collaborative Decision Making

Collaborative Decision Making (CDM) is a method that involves a group of stakeholders working together to reach a consensus on a decision or solution. This method requires active participation from all members, encouraging open communication and constructive feedback. CDM aims to promote a shared understanding of the problem or issue, and to identify and evaluate potential solutions. Through collaboration, stakeholders can leverage their collective knowledge, expertise, and perspectives to arrive at a decision that is mutually agreeable and beneficial for all parties involved [30–33].

The CDM method has been applied in several fields, such as psychology, social sciences, management, healthcare, supply chain, engineering, and others. According to Blunden [34], it is not possible to attribute the origin of CDM to a single person or event, instead the method has evolved over time through the integration of various decision-making processes and practices. Different authors, such as Kameda et al. [30], Cai et al. [31], Heradio et al. [32], Arduin et al. [33] and Zaraté et al. [35] refer several different usages of

the CDM method throughout the 20th Century, showing its increasing usage by companies. That being said, the origins of CDM can be traced to a combination of ideas and practices from several fields, with the method evolving over time through the contributions of many scholars and practitioners [34].

The CDM method offers several advantages, such as (1) Improving decision quality, by involving multiple stakeholders who bring different perspectives and knowledge to the decision-making process; (2) Promoting inclusiveness of all stakeholders, regardless of their social, cultural or economic position, giving the same opportunity to all stakeholders to participate in the decision-making process and contribute to problem solving; (3) Increasing acceptance and commitment, since all stakeholders are involved in the decision-making process, there is a higher likelihood that the solution will be accepted and everyone will be committed to its implementation; (4) Reducing resistance to change, because all stakeholders are involved in the decision-making process and have an opportunity to express their concerns and needs; (5) Promoting transparency, as all stakeholders have access to relevant information and can track the decision-making process; and (6) Helping to achieve more creative and innovative solutions, involving the participation of multiple stakeholders who can bring innovative ideas and solutions to the decision-making process [34,36,37].

Moving on to the procedure itself, which is firmly anchored in the aforementioned concepts, it aimed to define on one hand, the main tasks expected to be performed by each employee at different hierarchical levels, and on the other hand, the set of employee skills for the same hierarchical levels which would be required in the context of Industry 4.0 environments.

The work developed by Morana and Fonzalez-Feliu [38] served as the basis of our study, in regard to the organization of the different phases applied. Their study approach that urged the professionals to find a consensus on an unstudied topic and the investigation goals ending with a list of "content", encouraged us to follow a similar approach. However, there was key difference in the case of skills. In the aforementioned work, the authors do not consider a pre-determined set of indicators; rather, they let the experts openly decide on the set of indicators which are key to them, without any external support. This created an issue, with the individual participants having different ideas on what is a key indicator, which prevented the definition of the categories of indicators. The authors, between the personal knowledge and the sub-group stage, had to define the indicators beforehand, in order to build consensus. Hence, this work provided an impetus for us to define a pre-determined set of skills, rather than letting each individual choose their own [38].

Our study followed three main steps, preceding with a preliminary step represented in Figure 1. In the preliminary step, we started with the collection of the set of skills and the creation of the interview protocol. We chose a set of 74 skills, based on different literature reviews, which include but are not limited to World Economic Forum [39], OECD [40], Hecklau et al. [6], Erol et al. [26] and Benesova and Tupa [7]. Then, we grouped them into different categories, as suggested by Hecklau et al. [6]: Technical, Methodological, Social and Personal. Following the preliminary skill-defining step, we built the interview protocol with several steps, comprising open and closed answer questions. Firstly, we have a topic introduction text, that will be read by the interviewees, sharing the study goals and phases, the different set of skills and their definition. Secondly, we define a list of questions to collect the professional information of the interviewees (including their job level, as well as their perceived level of expertise in Industry 4.0 projects and the level of implementation of such projects in their company) in order to build the profile of each responder. Further, by making use of open questions we tap into their expertise, questioning their view on the types of changes they foresee in the employees' functions at each level due to the implementation of Industry 4.0 projects, as well as the main tasks expected to be performed in the different levels. This interview protocol ends with gathering the interviewees' opinion on the 10 most important skills, from the set of 74 skills, to perform the mentioned tasks for each hierarchical level (Worker, Middle Manager and Top Manager).

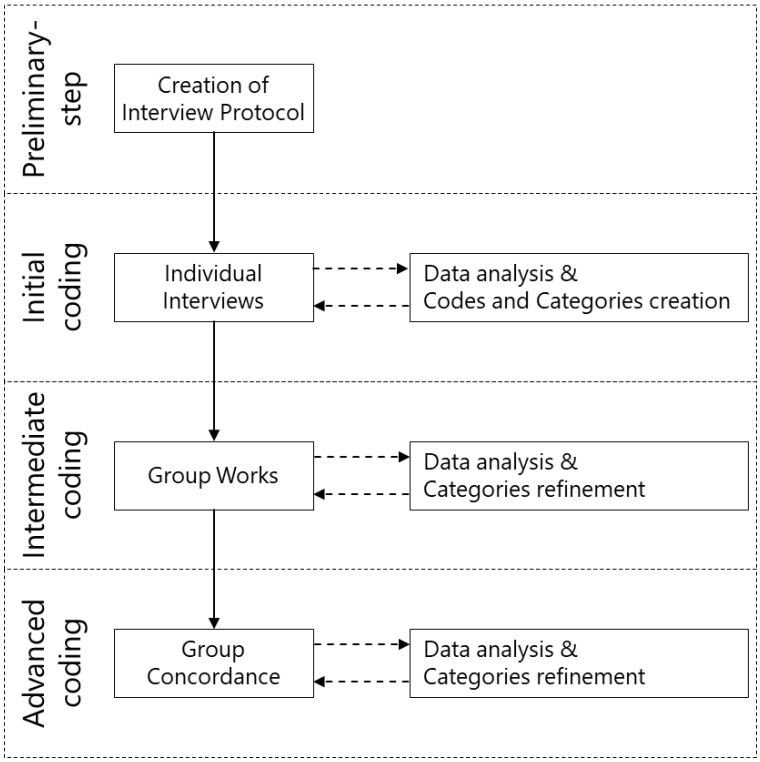

Figure 1. Research process applied.

The first step of the study was Initial coding, wherein a total of 30 interviews were conducted to know the individuals' opinions on both topics, the future tasks in the Industry 4.0 environment and the right skills to successfully perform their jobs. The interviewees were all professionals working in different roles [2 are workers (7%), 20 are part of middle management positions (66%) and 8 are top managers (27%)] in the companies considered for this study. The sampling technique used for this study was purposive or judgmental sampling. As mentioned by Neuman [41], this sampling technique fits when there is a small sample size and when the intention is to select cases that are particularly informative. For this study, it was used as a heterogeneous sampling strategy. The aim was to obtain a diverse set of control parameters for differences in work culture and expertise or business type, as proposed by Patton [42]. As such, the interviewees come from different geographical backgrounds (21 Portuguese, 7 German and 2 Polish); the companies they work for belong to different fields (including but not limited to Automotive Industry, Security Systems Industry and Operational Excellence Consultancy); their level of expertise in Industry 4.0 ranged from beginner (18 interviewees) to intermediate (10) to advanced/expert (2). At this stage, some of the interviews were conducted face-to-face, when the distance was not a restriction. Where distance was an obstacle, the interviews were conducted via web conference tools. Each interview took between 30 and 45 min, and the data were collected by writing down the inputs into the interview protocol and latter transcribing it to word processing.

At the end of the first stage, we consolidated and analyzed the data in order to fully comprehend which different tasks were raised for each different level and the list of the main skills needed to successfully fulfill those tasks. This allowed the differentiated identification of the top 10 skills considered individually by each subject, data which could then be used for the subsequent stages of this study. With regard to the main tasks considered by each interviewee, for each hierarchical level, the questions consisted of an open answer. As such, the data needed to be consolidated into key terms in order to be analyzed using a content analysis. As defined by Strauss [43], this technique aims to code

and structure the data by scrutinizing the interview (in this case) step by step; as such, one can infer concepts from the questions' responses, which will be a fit for the data [43].

The next stage was Intermediate coding, wherein the interviewees were split into different Group Works, each with 5 participants. These were homogeneous, organized by company and the role within the company, with nationality also being considered as a criterion to a lesser extent (in order to control for differences in work culture). All the Group Works' meetings took between two and three hours, and were conducted digitally via web conference, in order to mitigate the distances between the participants. The data obtained in the previous step were given to each sub-group. The data consisted of the most frequently occurring tasks, as chosen by each individual, which were subsequently organized into categories through coding, as previously mentioned, and the summary of the skills selected by all participants organized for each hierarchical level. The discussion occurring within each sub-group surfaced a set of tasks most important for each level, as well as a set of skills sorted by repetition. Specifically, the tasks and skills which were deemed most important individually are now fed to each ensemble, in order for them, as a group, to decide on a new set of tasks and top 10 skills. This allowed us to take advantage of the shared expertise of each small group, in order to first obtain a consensus and refine the data.

Finally, in the third iteration—Advanced coding—the results obtained in the previous stages were presented by each sub-group to all the groups. During an almost 4 hour web meeting, there was a discussion among the participants where each proposal was considered by the groups. Following the debate in this Group Concordance phase, the final set of tasks and 10 skills crucial for the three different hierarchical levels were put forth unanimously, thus answering the initial questions posited by this study.

4. Findings and Discussion

Throughout the results and discussion section, we present the evolution of the tasks and skills defined/chosen for each hierarchical level at each methodological phase. The section is split into three phases: Initial coding, i.e., interview analysis where the results of each interview are presented and analyzed; Intermediate coding, i.e., Group Works analysis where the review and conclusions of each Group Work is shown; and Advanced coding, i.e., Group Concordance analysis where the final discussions and results of the participants are presented. In each methodological step, results are split according to each hierarchical level: Workers level, Middle Managers level and Top Managers level.

4.1. Initial Coding: Interview Analysis

The basis for the Initial coding was the 30 conducted interviews, that revealed the participants' opinion regarding the major tasks that will be performed by the employees at each hierarchical level, and the skills that will be needed to perform them in the future, with the implementation of Industry 4.0 projects and culture.

The interviewees' answers were split into the two main categories, tasks and skills. On one hand, we decomposed their opinion about the tasks, generating as many codes as possible in order to find similarities and differences between them as well as to begin creating groups of tasks, henceforth denominated as Tasks Categories. On the other hand, we aggregated and clustered the 900 answers on the skills (10 skills per hierarchical level per participant) to once again ascertain the similarities and differences between the participants.

The results obtained are presented in the following section, organized according to hierarchical level and category.

4.1.1. Workers Level—Tasks

From the participants' interviews, focusing on the Workers level, it was straightforwardly determined that the majority of them have a common view regarding the regular tasks expected to be performed. After analyzing the data from the 30 interviews, it was

possible to identify 153 codes (you can find examples of those codes in Table A1, under Appendix A) which were divided into eight Tasks Categories, giving rise to Table 1.

Table 1. Interviews analysis—Worker level—Tasks Categories.

Rank	Tasks Categories	Frequency of Answer (No. Participants/30)
1	Production Control	30/30
	Machines Maintainability	30/30
	Problem Solving	30/30
4	Machines Programming	23/30
5	Product Quality Control	20/30
6	Measure and Read KPIs	12/30
7	Process Improvement	5/30
8	Manual Handling Tasks	3/30

Considering the percentage of participants that mentioned each task category, we can conclude that there is a good agreement on the major tasks to be performed by the employees in the Workers level. The categories "Production Control", "Machines Maintainability" and "Problem Solving" were referred by all interviewees (100% of frequency of answer), followed by the categories "Machines Programming" and "Product Quality Control", which were referred by a majority of the participants (23 and 20 participants, respectively).

On the other hand, the categories "Measure and Read KPIs", "Process Improvement" and "Manual Handling Tasks" have a smaller representation, mentioned by 12 or less interviewees.

These results show a high degree of unanimity on the tasks to be performed in the Workers level, setting a good precedent for the skills needed to face the tasks of the future.

4.1.2. Workers Level—Skills

Keeping the analysis in the Workers level, but shifting the focus to the skills needed to face the tasks of the future, we see that the participants have chosen 59 different skills (from a total of 74 skills), with 49% of the skills being identified by one or two individuals. Table 2 consists of the 46 skills that were picked out by at least two participants.

Firstly, we can conclude that there is no unanimity on any skill, considering that none of them was selected by all participants (the skill with the highest frequency of answer has 19 out of 30 responses, representing 63%). Furthermore, four skills are identified by more than half of the group. "Equipment Operation and Control" was chosen by 19 of the 30 participants, 17 selected "Digital Skills" and "Teamwork", and, finally "Equipment Maintenance and Repair" was picked by 16 participants. It can also be concluded that 11 skills were chosen by 10 or more individuals, with the remaining ones being proposed by 9 or less participants.

Taking into account the skill categories but not the individual skills themselves shown in Table 2, we built the graphs presented in Figure 2 to show the distribution and understand which skill categories have a greater influence in the Workers level. The left pie chart of Figure 2 is the representation of all the skill categories and the right chart is the representation of the categories that the top 10 skills fall into.

Analyzing the left chart in Figure 2, it can be concluded that the distribution focuses mostly on the Personal category (33%, 15 skills out of 46), followed by the Technical and Social categories (26% each, 12 skills of 46), and followed by the Methodological category (15%, 7 skills of 46) with least prevalence. Considering the categories of only the ten most frequently chosen skills, the right chart in Figure 2 shows that the high majority (70%, 7 skills of 10) of the skills selected belong to the Technical category.

Table 2. Interviews analysis—Worker level—Skills.

Rank	Skills	Category	Frequency of Answer (No. Participants/30)
1	Equipment Operation and Control	Technical	19/30
2	Digital Skills	Technical	17/30
	Teamwork	Social	17/30
4	Equipment Maintenance and Repair	Technical	16/30
5	Active Learning	Personal	14/30
6	Practical Skills	Technical	12/30
	Process Understanding	Technical	12/30
8	ICT Literacy	Technical	11/30
	Troubleshooting	Technical	11/30
	Problem Sensitivity	Methodological	11/30
11	Analytical Thinking	Methodological	10/30
12	Communication	Social	9/30
13	Media Skills	Technical	8/30
	Adaptability	Personal	8/30
	Flexibility	Personal	8/30
16	Quality Control	Technical	7/30
17	Programming	Technical	5/30
	Virtual Collaboration	Social	5/30
	Ability to Work Under Pressure	Personal	5/30
	Autonomy	Personal	5/30
	Curiosity	Personal	5/30
22	Logical Reasoning	Methodological	4/30
	Active Listening	Personal	4/30
	Initiative	Personal	4/30
25	Complex Problem Solving	Methodological	3/30
	Critical Thinking	Methodological	3/30
	Interpersonal Skills	Social	3/30
	Solidarity	Social	3/30
	Self-organization	Personal	3/30
	Time Management	Personal	3/30
31	State-of-the-art knowledge	Technical	2/30
	Technology and User Experience Design	Technical	2/30
	Computational Thinking	Methodological	2/30
	Visualization	Methodological	2/30
	Assertiveness	Social	2/30
	Coordinating with others	Social	2/30
	Emotional/Social Intelligence	Social	2/30
	Language Skills	Social	2/30
	Respect for others	Social	2/30
	Service Orientation	Social	2/30
	Training and Teaching others	Social	2/30
	Integrity	Personal	2/30
	Resilience	Personal	2/30
	Responsibility	Personal	2/30
	Trust	Personal	2/30
	Written Expression	Personal	2/30

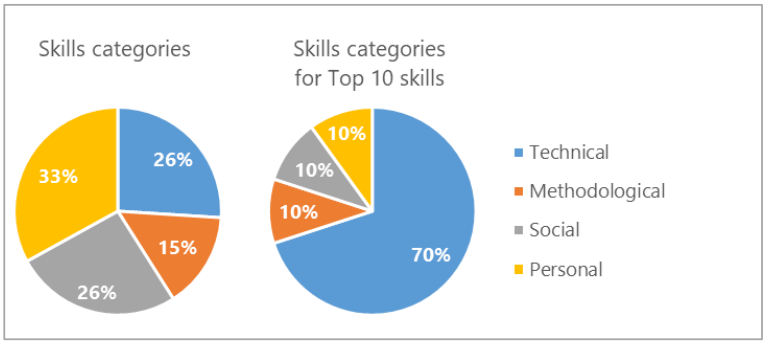

Figure 2. Interviews analysis—Worker level—Skills categories.

Finally, after conducting all the interviews and analyzing their content, and despite the convergence in the Tasks Categories results, it can be concluded that with each participant having their own vision and opinion and running this phase without support or communication, it becomes extremely hard to get a consensus. Another interesting conclusion that is not reflected in the tables or figures is that a higher level of similarity was found between the replies of participants from the same country and also between replies of interviewees from the same company, showing that both company and nations' cultures influence the participants' point of view.

4.1.3. Middle Managers Level—Tasks

From the interview analysis in the Middle Managers level, 111 codes were identified (you can find examples of those codes in Table A2, under Appendix A) which were divided into five Tasks Categories. Table 3 consists of the different identified Tasks Categories.

Table 3. Interviews analysis—Middle Managers level—Tasks Categories.

Rank	Tasks Categories	Frequency of Answer (No. Participants/30)
1	Lead Workers Teams	30/30
	Analyze KPIs and Performance	30/30
3	Drive Problem Solving Projects	23/30
4	Drive Improvement Projects	18/30
5	Provide Trainings	10/30

Similar to the Workers level, a unanimity is found regarding the different tasks that the participants believe the Middle Managers will execute in the future. The first conclusion is related to the number of different Tasks Categories, where the interviewees see no more than five major tasks to perform. Secondly, for four of the five Tasks Categories, there is more than 50% frequency in answers. All participants mentioned both "Lead Workers Teams" and "Analyze KPIs and Performance", followed by "Drive Problem Solving Projects" with 77% replies (23 participants) and "Drive Improvement Projects" with 60% replies (18 participants).

The category, "Provide Training" is at the bottom, mentioned by 10 of the 30 participants, representing a 33% of the answers.

Analogous to the Workers level, there is a high concordance between the participants, denoting a higher degree of confidence for the list of skills needed in the Middle Managers level.

4.1.4. Middle Managers Level—Skills

The participants picked up 64 different skills (from a total of 74 skills) which they believed would be needed in the Middle Managers level to perform their tasks. Of this, 21 were chosen by only one or two participants. Table 4 shows the list of the 54 skills that were selected by at least two participants.

Table 4. Interviews analysis—Middle Managers level—Skills.

Rank	Skills	Category	Frequency of Answer (No. Participants/30)
1	Analytical Thinking	Methodological	16/30
	Leadership Skills	Social	16/30
3	Process Understanding	Technical	15/30
4	Training and Teaching others	Social	13/30
5	Digital Skills	Technical	11/30
	ICT Literacy	Technical	11/30
	Virtual Collaboration	Social	11/30
8	Complex Problem Solving	Methodological	9/30
	Responsibility	Personal	9/30
10	Conflict Solving	Social	8/30
11	Communication	Social	7/30
	State-of-the-art knowledge	Technical	7/30
13	Active Learning	Personal	6/30
	Cognitive Load Management	Methodological	6/30
	Flexibility	Personal	6/30
	Entrepreneurial Thinking	Methodological	6/30
	Critical Thinking	Methodological	6/30
18	Troubleshooting	Technical	5/30
	Understanding IT Security	Technical	5/30
	Time Management	Personal	5/30
21	Teamwork	Social	4/30
	Judgement and Decision Making	Methodological	4/30
	Management of Material Resources	Methodological	4/30
	Monitoring Self and Others	Methodological	4/30
	Systems Analysis	Methodological	4/30
	Active Listening	Personal	4/30
	Persuasion	Social	4/30
	Interpersonal Skills	Social	4/30
	Assertiveness	Social	4/30
	Respect for others	Social	4/30
31	Problem Sensitivity	Methodological	3/30
	Media Skills	Technical	3/30
	Adaptability	Personal	3/30
	Design Mindset	Methodological	3/30
	Programming	Technical	3/30
	Research Skills	Methodological	3/30
	Logical Reasoning	Methodological	3/30
	Intercultural Competencies	Social	3/30
	Networking Skills	Social	3/30
	Technology and User Experience Design	Technical	3/30
	Emotional/Social Intelligence	Social	3/30
	Integrity	Personal	3/30
	Risk-tolerance	Personal	3/30
44	Cognitive Flexibility	Methodological	2/30
	Creativity	Methodological	2/30
	Ability to work Under Pressure	Personal	2/30
	Autonomy	Personal	2/30
	Initiative	Personal	2/30
	Negotiation	Social	2/30
	Computational Thinking	Methodological	2/30
	Visualization	Methodological	2/30
	Coordinating with others	Social	2/30
	Service Orientation	Social	2/30
	Resilience	Personal	2/30

Similar to the Workers level, there is no unanimity on the skills required, with only three skills having the consensus of at least half of the participants. The skills "Analytical Thinking" and "Leadership Skills" are the ones with more occurrences (16 of 30 participants have chosen them), followed by the skill "Process Understanding" chosen by half of the group (15 people). Furthermore, in total, only seven skills have more than 10 participants' votes.

Analyzing the skills categories presented in Table 4, Figure 3 shows which skills categories have a greater influence on the Middle Managers level—the graph on the left side considers all the skills from Table 4, and the right graph analyzes the categories of the top ten most voted skills.

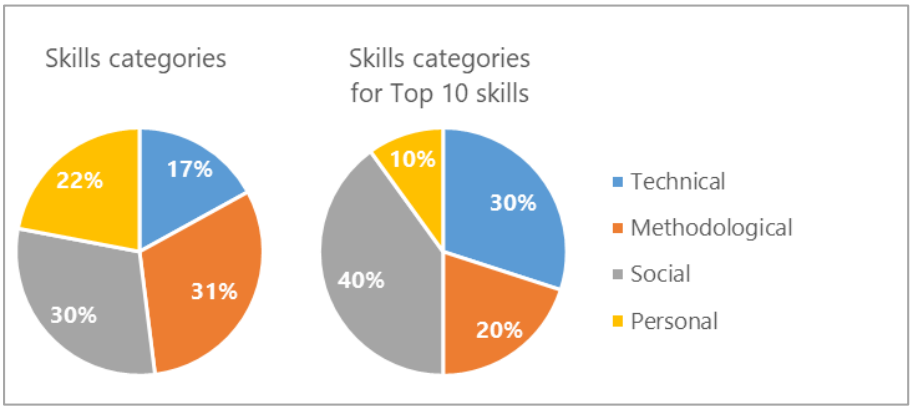

Figure 3. Interviews analysis—Middle Managers level—Skills categories.

From the left graph shown in Figure 3, we understand that the distribution changes when compared to the Workers level (Figure 2). The skills categories focus mainly on two categories—Methodological with 31% (17 skills of 54) and Social with 30% (16 skills of 54). The Technical category has 17% of the responses (9 skills of 54). The right graph in Figure 3, focusing on categories of the top ten most voted skills, shows that the skills categories distribution changes, with the Social category now receiving a higher response rate (40%, 4 skills of 10) followed by the Technical category (30%, 3 skills of 10). Interestingly, the Methodological skill category now dropped from the highest place in Figure 2 (31%) to the third place in Figure 3 (20%).

In conclusion, similar to what was observed in the Workers level, the alignment with regard to the Tasks Categories in the Middle Managers level did not translate into the same results in the skills. The interview results show that we are still far from reaching a consensus.

4.1.5. Top Managers Level—Tasks

Moving on to the Top Managers level, the higher company hierarchical level, the analysis of the interviews generated 127 codes (you can find examples of those codes in Table A3, under Appendix A), divided into eight different Tasks Categories, presented in Table 5.

Once again, we can find a consensus on the major tasks expected to be performed by the Top Managers. Half of the Tasks Categories were mentioned by more than half of the participants. The categories "Define Strategy", "Define Next I4.0 Projects to Run" and "Define Company Targets" were mentioned by all the 30 participants and the category "Analyze KPIs and Performance" was stated by 19 interviewees (63%). Finally, the "Provide Training" category is mentioned by 10 of the 30 participants, representing a 33% of the answers frequency.

Table 5. Interviews analysis—Top Managers level—Tasks Categories.

Rank	Tasks Categories	Frequency of Answer (No. Participants/30)
1	Define Strategy	30/30
	Define Next I4.0 Projects to Run	30/30
	Define Company Targets	30/30
4	Analyze KPIs and Performance	19/30
5	Interact with Customers	8/30
6	Define Investments	7/30
7	Find Talent/Employees	2/30
8	Promote Employees Qualification	1/30

On the other hand, the other half of the categories were mentioned by a smaller number of participants. "Interact with Customer" was mentioned by 27% of the participants (8 of 30), "Define Investments" by 23% of the participants (7 of 30), "Find Talent/Employees" by only 2 participants (7%) and "Promote Employees Qualification" by only a single participant (3%).

Here again, we can see a consensus regarding some of the tasks with a high frequency of answer, and in some Tasks Categories with a small frequency of answer, showing that there is some space for debate and enhancement of the results.

4.1.6. Top Managers Level—Skills

With regard to the future skills for the Top Managers level, the interviewees selected a total of 50 different skills from the original list consisting of 74 skills. A total of 39% of the skills were chosen by one or two participants. Table 6 presents the list of the 50 skills that were picked out by at least two participants.

Following the same tendency found for the previous levels, here too, no unanimous decision was reached regarding any skill. In fact, only one skill was identified by half of the interviewees, "Judgement and Decision Making" which was chosen by 15 of the 30 participants. Furthermore, it is seen that only seven skills were picked out by more than 10 participants, leaving the remaining ones to be proposed by nine or less participants.

By analyzing the data displayed in Table 6, the graphs presented in Figure 4 are obtained; the chart on the left shows the top skills categories in the Top Managers level the most and the right chart shows the categories of the top ten skills most chosen by the participants.

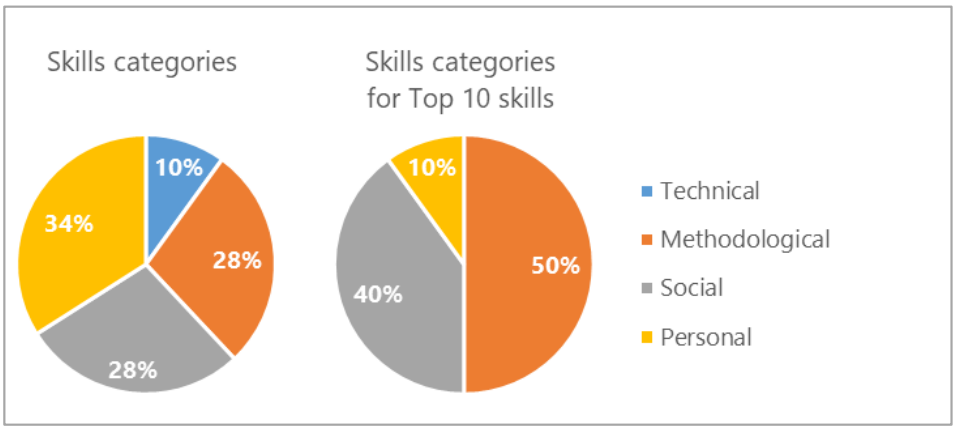

Figure 4. Interviews analysis—Top Managers level—Skills categories.

Table 6. Interviews analysis—Top Managers level—Skills.

Rank	Skills	Category	Frequency of Answer (No. Participants/30)
1	Judgement and Decision Making	Methodological	15/30
2	Leadership Skills	Social	14/30
	Integrity	Personal	14/30
4	Communication	Social	11/30
	Cognitive Load Management	Methodological	11/30
	Entrepreneurial Thinking	Methodological	11/30
	Negotiation	Social	11/30
8	Management of Financial Resources	Methodological	9/30
	Critical Thinking	Methodological	9/30
	Emotional/Social Intelligence	Social	9/30
11	Ability to work Under Pressure	Personal	8/30
	Respect for others	Social	8/30
	Risk-tolerance	Personal	8/30
14	Understanding IT Security	Technical	7/30
	Conflict Solving	Social	7/30
	Intercultural Competencies	Social	7/30
	Networking Skills	Social	7/30
18	Trust	Personal	6/30
19	Digital Skills	Technical	5/30
	Process Understanding	Technical	5/30
	ICT Literacy	Technical	5/30
	Adaptability	Personal	5/30
	Visualization	Methodological	5/30
	Self-confidence	Personal	5/30
	Resilience	Personal	5/30
26	Active Learning	Personal	4/30
	Creativity	Methodological	4/30
	Design Mindset	Methodological	4/30
	Persuasion	Social	4/30
	Time Management	Personal	4/30
	Assertiveness	Social	4/30
	Training and Teaching others	Social	4/30
	Responsibility	Personal	4/30
34	Analytical Thinking	Methodological	3/30
	Flexibility	Personal	3/30
	Virtual Collaboration	Social	3/30
	Active Listening	Personal	3/30
	Interpersonal Skills	Social	3/30
	Language Skills	Social	3/30
40	Mathematical Reasoning	Methodological	2/30
	Monitoring Self and Others	Methodological	2/30
	Sense-making	Methodological	2/30
	Autonomy	Personal	2/30
	Logical Reasoning	Methodological	2/30
	Initiative	Personal	2/30
	Complex Problem Solving	Methodological	2/30
	Self-organization	Personal	2/30
	Technology and User Experience Design	Technical	2/30
	Self-reflection	Personal	2/30
	Written Expression	Personal	2/30

From the left chart in Figure 4, we can conclude that the Personal category is the one with the highest influence (34%, 17 skills of 50), followed very closely by both Methodological and Social categories (28% each, 14 skills of 50). The Technical category is considerably less influential in the Top Managers level (only 10%, 5 skills of 50). Analysis of the right chart, which focuses on the categories of the ten most frequently chosen skills, shows that the Methodological and Social categories exert the most influence, with a total of 90% of the skills (50% and 40%, respectively).

Lastly, and following the trend of the previous levels, it was not possible to find a consensus between the interviewees.

4.2. Intermediate Coding: Group Works Analysis

In order to develop the Intermediate coding, the results obtained in the previous stage were shared with all the 30 participants. After creating the six Group Works, we oversaw a meeting with each one where both topics—tasks and skills for the future—were discussed. In the following section, the consolidated results obtained from the discussion within the Group Works are presented, once again organized according to each hierarchical level.

4.2.1. Workers Level—Tasks

Table 7 shows the results of the six Group Works in the Workers level.

Table 7. Group Works analysis—Workers level—Tasks Categories.

Rank	Tasks Categories	Frequency of Answer (No. Groups/6)	Rankings Comparison Tables 1 and 7
1	Production Control	6/6	1 => 1
	Machines Maintainability	6/6	1 => 1
	Problem Solving	6/6	1 => 1
	Machines Programming	6/6	4 => 1
	Product Quality Control	6/6	5 => 1
	Measure and Read KPIs	6/6	6 => 1
7	Manual Handling Tasks	2/6	8 => 7
8	Process Improvement	1/6	7 => 8

From Table 7, it can be discerned that all the Tasks Categories remain the same as in the first analysis, although some are mentioned only by a small number of Group Works. All Group Works listed the following Tasks Categories: "Production Control", "Machines Maintainability", "Problem Solving", "Machines Programming", "Product Quality Control" and "Measure and Read KPIs".

On the other hand, the category "Manual Handling Tasks" was mentioned only by two Group Works (33%) and the category "Process Improvement" was mentioned by only one (17%). Considering the written memos collected during the Group Works activities, the reason for the Group Works to exclude the "Manual Handling Tasks" as one of the major responsibilities of the Workers level is that it is a part of another Tasks Category—"Production Control"—therefore, they did not see the need to separate them. With regard to the category "Process Improvement", the Group Works that excluded it from the main tasks explained that they believe it is a task to be performed in the Middle Managers level.

From the results presented herein, we can conclude that there is a good level of common agreement between the Group Works, since all of them mentioned the six Tasks Categories.

4.2.2. Workers Level—Skills

The Group Works also evaluated the skills for the future in the Workers level. Table 8 shows the list of skills selected by the Group Works.

Table 8. Group Works analysis—Workers level—Skills.

Rank	Skills	Category	Frequency of Selection (No. Groups/6)	Rankings Comparison Tables 2 and 8
1	Digital Skills	Technical	6/6	2 => 1
	Equipment Operation and Control	Technical	6/6	1 => 1
	Process Understanding	Technical	6/6	6 => 1
	Teamwork	Social	6/6	2 => 1
5	Equipment Maintenance and Repair	Technical	5/6	4 => 5
	Practical Skills	Technical	5/6	6 => 5
7	ICT Literacy	Technical	4/6	8 => 7
	Troubleshooting	Technical	4/6	8 => 7
	Active Learning	Personal	4/6	5 => 7
10	Problem Sensitivity	Methodological	3/6	8 => 10
11	Quality Control	Technical	2/6	16 => 11
	Analytical Thinking	Methodological	2/6	11 => 11
	Communication	Social	2/6	12 => 11
14	Media Skills	Technical	1/6	13 => 14
	Programming	Technical	1/6	17 => 14
	Logical Reasoning	Methodological	1/6	22 => 14
	Autonomy	Personal	1/6	17 => 14
	Flexibility	Personal	1/6	13 => 14

Upon comparing Tables 2 and 8, it is observed that the number of different selected skills reduced drastically from 46 to just 18, which is more than half. It is also discerned that there are variations in the skills' ranking between both tables. The skills "Process Understanding", "Quality Control" and "Logical Reasoning" are the ones with a more significant ranking change (minimum increase of five positions).

Analyzing the frequency of selection, it is possible to determine that four skills were selected by all Group Works; "Digital Skills", "Equipment Operation and Control", "Process Understanding" and "Teamwork". Moreover, ten skills were chosen by at least half of the Group Works.

The analysis of the skills categories, facilitates the creation of the graphs presented in Figure 5, which helps to understand the categories that have a greater influence on the Workers level. The left chart in the graph considered all skills presented in Table 8, while the right chart considered the categories of the top ten skills most chosen by the interviewees.

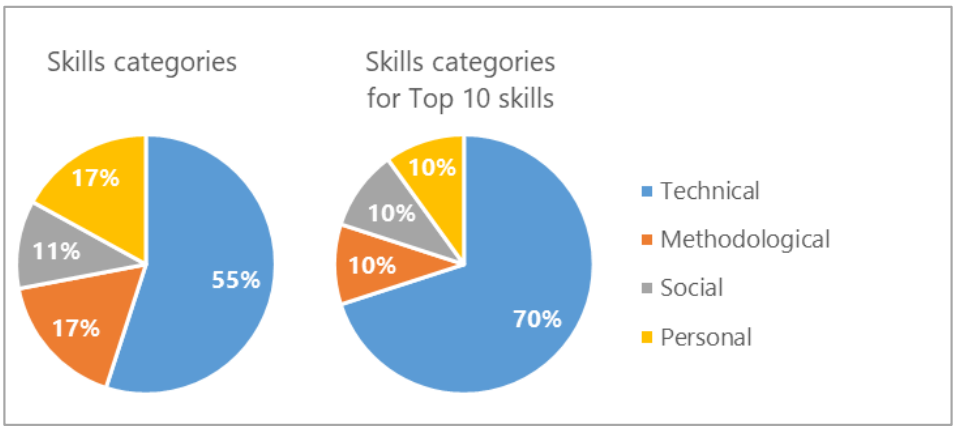

Figure 5. Group Works analysis—Workers level—Skills categories.

Taking into account the data presented in the left chart in Figure 5, we understand that the Technical category has a very high prevalence when compared with the remaining ones

(55%, 10 skills of 18). On the other hand, the right chart, focusing on the categories of the top ten skills most chosen by the interviewees, shows that the Technical category achieves the highest importance with 70% of the skills. To conclude, the Group Works phase have some consensus with regard to the top four skills in the Workers level.

4.2.3. Middle Managers Level—Tasks

Table 9 represents the combined results of the six Group Works in the Middle Managers level.

Table 9. Group Works analysis—Middle Managers level—Tasks Categories.

Rank	Tasks Categories	Frequency of Answer (No. Groups/6)	Rankings Comparison Tables 3 and 9
1	Lead Workers Teams	6/6	1 => 1
	Analyze KPIs and Performance	6/6	1 => 1
	Drive Problem Solving Projects	6/6	3 => 1
	Drive Improvement Projects	6/6	4 => 1
	Provide Trainings	6/6	5 => 1

Analyzing Table 9, we can conclude that all Group Works are in agreement regarding the main tasks that are of most importance in the Middle Managers level. All Tasks Categories—"Lead Workers Teams", "Analyze KPIs and Performance", "Drive Problem Solving Projects", "Drive Improvement Projects" and "Provide Training"—were selected by all Group Works.

At this stage, for the hierarchical level of Middle Managers, we can conclude that there is an agreement on the main tasks that are to be performed.

4.2.4. Middle Managers Level—Skills

Focusing on the skills for the future in the Middle Managers level, Table 10 shows the results obtained from the six Group Works.

Table 10. Group Works analysis—Middle Managers level—Skills.

Rank	Skills	Category	Frequency of Selection (No. Groups/6)	Rankings Comparison Tables 4 and 10
1	Digital Skills	Technical	6/6	5 => 1
	ICT Literacy	Technical	6/6	5 => 1
	Analytical Thinking	Methodological	6/6	1 => 1
	Leadership Skills	Social	6/6	1 => 1
5	Process Understanding	Technical	5/6	3 => 5
	Training and Teaching others	Social	5/6	4 => 5
7	Communication	Social	4/6	11 => 7
	Responsibility	Personal	4/6	8 => 7
9	State-of-the-art knowledge	Technical	3/6	11 => 9
	Complex Problem Solving	Methodological	3/6	8 => 9
	Virtual Collaboration	Social	3/6	5 => 9
12	Troubleshooting	Technical	2/6	18 => 12
	Conflict Solving	Social	2/6	10 => 12
14	Critical Thinking	Methodological	1/6	13 => 14
	Entrepreneurial Thinking	Methodological	1/6	13 => 14
	Judgement and Decision Making	Methodological	1/6	21 => 14
	Monitoring Self and Others	Methodological	1/6	21 => 14
	Teamwork	Social	1/6	21 => 14

Comparing the number of skills chosen between Tables 4 and 10, we can conclude that it has reduced from 54 to only 18, which is almost a decrease of one third. Taking into account the skill rankings between both tables, represented on the last column of Table 10, we can conclude that seven skills had a bigger ranking change. In the first half of Table 10, "Digital Skills", "ICT Literacy" and "Communication" improved by four positions, and in the second half, "Troubleshooting", "Judgement and Decision Making", "Monitoring Self and Others" and "Teamwork" skills improved by a minimum of six positions.

Taking into account the frequency of selection, once more four skills were selected most by all six Group Works—"Digital Skills", "ICT Literacy", "Analytical Thinking" and "Leadership Skills". We can also conclude that 11 skills were chosen by at least half of the Groups.

Reorganizing the data by skills categories, allows us to build the graphs represented in Figure 6, to observe the categories that have a higher predominance in the Middle Managers level.

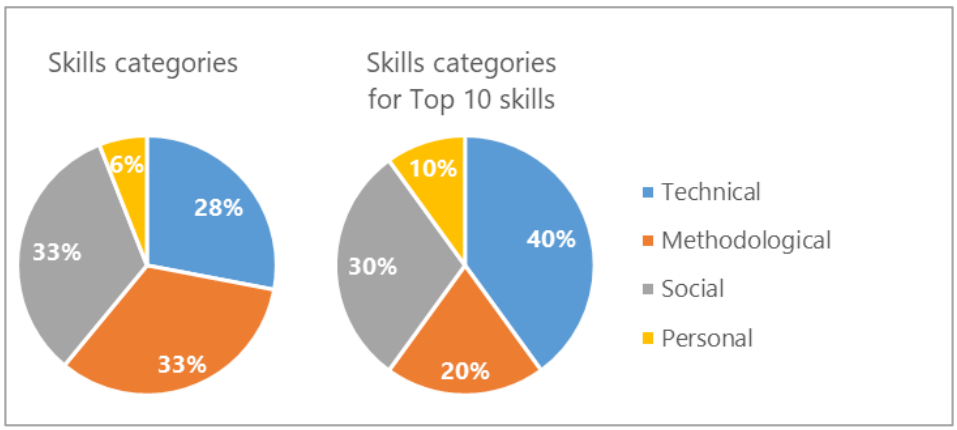

Figure 6. Group Works analysis—Middle Managers level—Skills categories.

Analyzing the chart on the left side in Figure 6, as opposed to the Workers level, it can be seen that the percentages are split mainly across the three categories—Technical (28%, 5 skills of 18), Methodological and Social (each 33%, 6 skills of 18). Focusing only on the ten most chosen skills, the right chart of the Figure 6 graph shows that the Technical category has a higher importance with 40% of the skills, followed by the Social category (with 30% of the skills) and the Methodological category (with 20% of the skills).

Similar to the previously analyzed level, at the end of the Group Works phase we can see a partial consensus on four skills out of the top ten skills required in the Middle Managers level.

4.2.5. Top Managers Level—Tasks

The Top Managers level was the hierarchical level that brought about more discussions within each Group Work. At the end of the Group Works sessions we were able to build Table 11.

Detailed analysis of Table 11 reveals several important conclusions.

Firstly, although the total number of Tasks Categories remains the same (eight categories), two of them were excluded from the previous phase of the Group Works phase, and two new Tasks Categories are listed in their stead.

The task category "Find Talent/Employees" was excluded by the Group Works, based on the argument that it is much more related to the Middle Managers level and should not be part of the main focus in the Top Managers level. In addition, the task category "Promote Employees Qualification" was no longer considered by any Group Work for the same reason (conclusion arrived from the written memos of the Group Works phase).

Table 11. Group Works analysis—Top Managers level—Tasks Categories.

Rank	Tasks Categories	Frequency of Answer (No. Groups/6)	Rankings Comparison Tables 5 and 11
1	Define Strategy	6/6	1 => 1
	Define Next I4.0 Projects to Run	6/6	1 => 1
	Define Company Targets	6/6	1 => 1
4	Interact with External Partners	4/6	New
5	Analyze KPIs and Performance	3/6	4 => 5
	Analyze Company KPIs	3/6	New
7	Interact with Customers	1/6	5 => 7
	Define Investments	1/6	6 => 7

One of the new Tasks Categories mentioned is "Interact with External Partners", which is an evolution brought by some Group Works, based on the Category "Interact with Customers" through the argument that the new category is more complete and covers more responsibilities of the Top Managers. Along the same lines, the task category "Analyze Company KPIs" is a refinement of the category "Analyze KPIs and Performance", based on the argument that the Top Managers level must focus on analyzing the major plant results and KPIs, not the detailed performance of each department (analysis taken from the written memos of the Group Works phase).

Additionally, important to conclude is the fact that six of the eight Tasks Categories were listed by half or more Group Works, while showing a good level of agreement between them.

4.2.6. Top Managers Level—Skills

Finally, the analysis of the results stemming from the six Group Works on the skills needed for the Top Managers level is presented in Table 12.

Table 12. Group Works analysis—Top Managers level—Skills.

Rank	Skills	Category	Frequency of Selection (No. Groups/6)	Rankings Comparison Tables 6 and 12
1	Entrepreneurial Thinking	Methodological	6/6	4 => 1
	Judgement and Decision Making	Methodological	6/6	1 => 1
	Leadership Skills	Social	6/6	2 => 1
4	Critical Thinking	Methodological	5/6	8 => 4
	Management of Financial Resources	Methodological	5/6	8 => 4
	Respect for others	Social	5/6	11 => 4
7	Cognitive Load Management	Methodological	4/6	4 => 7
	Communication	Social	4/6	4 => 7
	Negotiation	Social	4/6	4 => 7
	Integrity	Personal	4/6	2 => 7
11	Ability to Work Under Pressure	Personal	3/6	11 => 11
12	Emotional/Social Intelligence	Social	2/6	8 => 12
	Networking Skills	Social	2/6	14 => 12
14	Understanding IT Security	Technical	1/6	14 => 14
	Visualization	Methodological	1/6	19 => 14
	Conflict Solving	Social	1/6	14 => 14
	Intercultural Competencies	Social	1/6	14 => 14

It can be noticed that there is a decrease in the number of skills selected when comparing Table 6 with Table 12. From a list of 50 skills, the Group Works selected 17 of them, representing 34%. Comparing the skills rankings between both tables, shown in the last column of Table 12, it can be seen that the majority of them changed position, especially six of them, with a minimum change of four positions. Special attention should be given to "Critical Thinking", "Management of Financial Resources" and "Respect for others", from the first half of the table, which had changes of at least four positions.

Analyzing the frequency of selection, it can be discerned that three skills were selected by all six Groups—"Entrepreneurial Thinking", "Judgement and Decision Making" and "Leadership Skills". A total of eleven skills were chosen by at least half of the Groups.

Regrouping the data by skills categories, results in the following graphs presented in Figure 7.

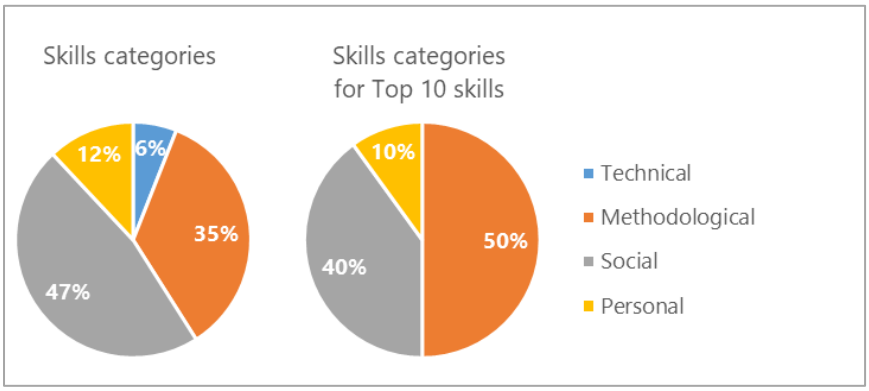

Figure 7. Group Works analysis—Top Managers level—Skills categories.

From the left chart in Figure 7, it can be seen that two of the categories have a higher influence—Methodological (with 35%, 6 skills of 17) and Social (with 47%, 8 skills of 17). Focusing on the categories of the ten most frequently chosen skills, the right chart confirms that the Methodological (with 50% of the skills) and the Social (with 40% of the skills) categories have a very high degree of importance in the Top Managers level.

Lastly, after the Group Works phase, it was possible to reach a partial consensus on three out of the top ten skills in the Top Managers level.

4.3. Advanced Coding: Group Concordance Analysis

The basis for the advanced coding development was the results achieved in the previous stage, shared with all Group Works. In the final meeting, each Group Work presented their arguments for the tasks and skills selection, ending with a discussion and a consensus on the Tasks Categories and the ten most important skills to have in the future, for each hierarchical level.

4.3.1. Workers Level—Tasks

Concerning the Workers level, all participants discussed and streamlined the Tasks Categories for 30 min, the results of which are presented in Table 13.

Table 13. Group Concordance analysis—Workers level—Tasks Categories.

No.	Tasks Categories	Correspondence with Table 7
1	Production Control	Position no. 1
2	Machines Maintainability	Position no. 1
3	Problem Solving	Position no. 1
4	Machines Programming	Position no. 1
5	Product Quality Control	Position no. 1
6	Measure and Read KPIs	Position no. 1

Analyzing Table 13, and comparing it with Table 7, it is observed that the number of Tasks Categories decreased from eight to six. In the previous phase, a consensus was reached in six Tasks Categories, with the remaining two being selected by only one or two Group Works. After a period of discussion, all participants agreed to keep only the six main Tasks Categories, with the reasoning that the task category "Manual Handling Tasks" would be included inside the task category "Production Control", and the task category "Process Improvement" would not be part of the main focus during a working day.

That being said, all participants were able to reach a consensus with regard to the major tasks that will be performed in the future in the Workers level.

4.3.2. Workers Level—Skills

Using the momentum coming from the consensus in the tasks for the Workers level, the participants focused then on the skills needed to perform those tasks. After the Group Works presentation and discussion, the results presented in Table 14 were obtained.

Table 14. Group Concordance analysis—Workers level—Skills.

No.	Skills	Category	Correspondence with Table 8
1	Digital Skills	Technical	Position no. 1
2	Equipment Operation and Control	Technical	Position no. 1
3	Process Understanding	Technical	Position no. 1
4	Teamwork	Social	Position no. 1
5	Equipment Maintenance and Repair	Technical	Position no. 5
6	Practical Skills	Technical	Position no. 5
7	ICT Literacy	Technical	Position no. 7
8	Troubleshooting	Technical	Position no. 7
9	Active Learning	Personal	Position no. 7
10	Quality Control	Technical	Position no. 11

Analyzing Table 14, specifically the final column, it is understood that there were no big surprises when it was time to refine the skills list and define the top ten skills to have in the Workers level. It took roughly 45 min to reach a consensus among all interviewees. The large majority was already well placed in the previously mentioned Table 8, having only one skill coming out of the most voted ones in the previous phases.

Focusing on the skills categories in the graph represented in Figure 8, we can conclude that the category with a higher preponderance is the Technical one, representing 80% of the skills. On the other hand, the Social and Personal categories only represent 10% each, and the skills related to the Methodological category have no presence at all.

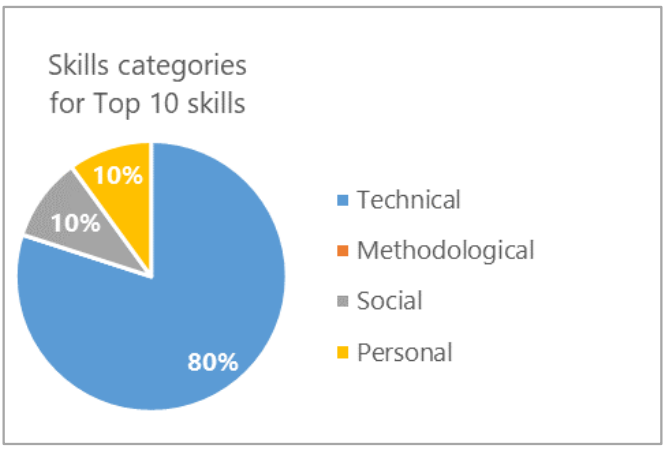

Figure 8. Group Concordance analysis—Workers level—Skills categories.

4.3.3. Middle Managers Level—Tasks

Discerning the Tasks in the Middle Managers level was the most straightforward part of the meeting. In 15 min, all Group Works presented their results and closed the Tasks Categories topic; they selected the same Tasks Categories as in the previous phase. In Table 15, we list the final agreement of all the participants with regard to the main Tasks Categories for the Middle Managers level.

Table 15. Group Concordance analysis—Middle Managers level—Tasks Categories.

No.	Tasks Categories	Correspondence with Table 9
1	Lead Workers Teams	Position no. 1
2	Analyze KPIs and Performance	Position no. 1
3	Drive Problem Solving Projects	Position no. 1
4	Drive Improvement Projects	Position no. 1
5	Provide Trainings	Position no. 1

4.3.4. Middle Managers Level—Skills

Table 16 represents the consensus for the top ten skills needed in the Middle Managers Level to perform the previously defined tasks in the Industry 4.0 world.

Table 16. Group Concordance analysis—Middle Managers level—Skills.

No.	Skills	Category	Correspondence with Table 10
1	Digital Skills	Technical	Position no. 1
2	ICT Literacy	Technical	Position no. 1
3	Analytical Thinking	Methodological	Position no. 1
4	Leadership Skills	Social	Position no. 1
5	Process Understanding	Technical	Position no. 5
6	Training and Teaching others	Social	Position no. 5
7	Communication	Social	Position no. 7
8	Responsibility	Personal	Position no. 7
9	State-of-the-art knowledge	Technical	Position no. 9
10	Complex Problem Solving	Methodological	Position no. 9

Half an hour was the time needed to reach a final consensus for the Middle Managers level. As it is possible to observe in the rightmost column of Table 16, the final list of skills chosen is similar to the ones selected more often in the previous phases, thus there was no surprises in the final results.

Considering the skills categories and the represented data in the graph of Figure 9, we can conclude that the distribution is more balanced throughout the different categories. The Technical category still is the one with higher preponderance; the Social one gains more importance in this level (30% presence), and the Methodological category starts to have some presence, corresponding to 20% of the skills.

4.3.5. Top Managers Level—Tasks

Finally, for the Top Managers level, the results presentation from each Group Work took longer and also had a longer discussion between the participants, due to the new Tasks Categories created by some Group Works (approximately 45 min). Table 17 contains the final list of Tasks Categories that will take the majority of the Top Managers time.

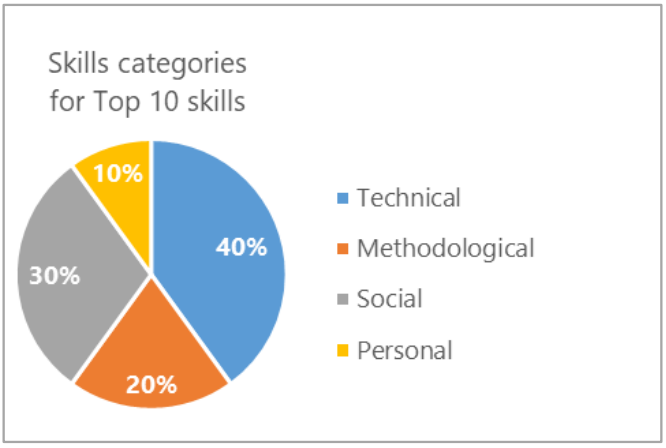

Figure 9. Group Concordance analysis—Middle Managers level—Skills categories.

Table 17. Group Concordance analysis—Top Managers level—Tasks Categories.

No.	Tasks Categories	Correspondence with Table 11
1	Define Strategy	Position no. 1
2	Define Next I4.0 Projects to Run	Position no. 1
3	Define Company Targets	Position no. 1
4	Interact with External Partners	Position no. 4
5	Analyze Company KPIs	Position no. 5

During the Group Works results explanation, it could be seen that some groups were trying to explain the same content using different Tasks Categories. "Interact with External Partners" was a more detailed definition of "Interact with Customers", and "Analyze Company KPIs" was a more detailed version of "Analyze KPIs and Performance".

It took some time to reach an agreement on this detailed evolution of some Tasks Categories between the Group Works; however, at the end, all participants agreed and defined the final list of the main five Tasks Categories.

4.3.6. Top Managers Level—Skills

Table 18 shows the final list of the most important skills needed to manage the future tasks at the Top Managers level.

Table 18. Group Concordance analysis—Top Managers level—Skills.

No.	Skills	Category	Correspondence with Table 12
1	Entrepreneurial Thinking	Methodological	Position no. 1
2	Judgement and Decision Making	Methodological	Position no. 1
3	Leadership Skills	Social	Position no. 1
4	Critical Thinking	Methodological	Position no. 4
5	Management of Financial Resources	Methodological	Position no. 5
6	Respect for others	Social	Position no. 4
7	Cognitive Load Management	Methodological	Position no. 7
8	Communication	Social	Position no. 7
9	Negotiation	Social	Position no. 7
10	Networking Skills	Social	Position no. 12

Once more, it was not hard to reach a final agreement on the ten most important skills in the Top Managers level. After 45 min of discussion, the list was created. As seen in the final column in Table 18, almost all skills were already well placed in the previous phase,

with only one skill that was out of the top ten in the previous phase being considered now—"Networking Skills".

Analyzing the categories of the ten most important skills in the Top Managers level, we see an equal distribution between the Methodological and the Social categories (a total of five skills for each group).

4.4. Theoretical and Managerial Implications

The results obtained in the present paper have several important implications. Firstly, it turned the attention to the split analysis performed on the different hierarchical levels, and the parallel analysis performed on the three main hierarchical categories; Workers level, Middle Managers level and Top Managers level. Considering several studies available in the science medium which only focus on the study of the future skills that will be needed in an environment of Industry 4.0, and are thus not directly comparable, the results of this study are presented in a more generic fashion with regard to the profile of the worker or user. Studies by Hecklau et al. [6], Erol et al. [26], Benesova and Tupa [7], Blayone and VanOostveen [8], Alharbi [9] and Baethge-Kinsky [10] are some examples of that follow this approach. Our study shows results segregated according to each hierarchical level, providing deeper and more accurate results.

Secondly, this study considered the analysis of the main daily tasks expected to happen in the future Industry 4.0 as a starting point to define the skills needed. Again, in the literature, we can find examples of studies (including Hecklau et al. [6] and Benesova and Tupa [7]) that focus on the changes and challenges coming with the Industry 4.0, but not establishing a direct connection with the daily tasks expected to be run in the future by the employees. However, this research uses the experience of the experts in order to define the main tasks expected to emerge in each hierarchical level, based on the future features of the Industry 4.0. In our opinion, this approach gives a proper basis to define the group of skills that will be needed in the future environment of Industry 4.0.

Lastly, for each hierarchical level, this research considers the list of the most important skills required to adequately execute the future Industry 4.0 tasks. It is to be noted that the aforementioned studies focus only on listing the different existing skills that should be present in the future employees, and not on ranking them based on their importance which should be developed as a priority. The present study, on the other hand, focused on finding the ten most important skills for each hierarchical level, whilst also not excluding the importance of each skill, leading to more accurate and precise results.

The findings of this study have implications not only for academia, but also for the professional world. An important insight provided by this study is connected to the way in which companies can prepare to smoothly manage the changes. Considering the obtained results, the companies may study and compare their own employees' skills and understand the current gaps, and focus on providing trainings to improve the needed skills. With regard to the state of the art, our paper contributes to science knowledge since, as far as we are aware, this is one of the first studies to use the Collaborative Decision Making method to develop a set of the most important tasks and skills that future work environment will demand in the different hierarchical levels of the organizations.

5. Conclusions

This study focused firstly on the tasks expected to be executed in the future in the growing Industry 4.0 and, secondly on the main skills required to face those tasks. Moreover, this study did not consider the full group of professionals as one single entity, rather opting to split it into the three main categories in a company: worker, middle management and top management.

With regard to the method applied in this study, i.e., the applied Collaborative Decision Making method, we are satisfied with the relation between effort and benefit. Although the method demands a continuous study and analysis of the results, as it requires a vast amount of time to manage the different iterations, the benefits are very significant. At the

end of the interviews (first phase), it was concluded that a consensus was extremely hard to find. However, through the development of the subsequent phases, it was possible to get a higher consensus, as by the end of the applied method a complete agreement between the interviewees was reached.

In response to the first research question (Q1), regarding the tasks expected to be performed in the future I4.0 environment, the Group Concordance reveals different tasks for each hierarchical level. In regard to the Workers level, the group concluded that their main tasks are related to technical usage of the machinery, control of production and products, measurement and analysis of indicators and problem solving. For the Middle Managers level, the participants established the management of problem solving and improvement projects, the management of teams' tasks and training and the analysis of indicators and performance, as the main responsibilities. Finally, in the Top Managers level, the groups defined that they will be focusing on the definition of company strategy and projects, on deep analysis of company results and targets definition, as well as on the interaction with external partners.

For the second research question (Q2), which probes into the skills needed to execute the tasks mentioned in the previous research question, the results achieved by the interviewees mostly show a different spectrum of skills for each hierarchical level. On one hand, in the Workers level, majority of skills belong to the Technical category whilst the Social and Personal categories has low dominance and the Methodological skills have no presence at all. On the other hand, in the Middle Managers level, the list of skills shows a greater split between categories, with a higher predominance of the Technical and Social categories and a lower dominance of the Methodological and Personal categories. Finally, in the Top Managers level, the skills are split between the Methodological and Social categories, whilst the remaining two categories not present at all.

Some limitations of this research should be noted. Firstly, although there was a participation of 30 people, it would be preferable to have a better balance between the number of workers, middle managers and top managers, in order to have a higher degree of consistency in the results. Secondly, although the participants come from different countries and industries, all 30 of them are from Europe; as such, it could be interesting to extend the method to other continents, in order to infuse the results with a global perspective. Thirdly, the sample does not represent all areas of knowledge. Thus, our results are only representative for the setting in which they were studied.

Future research is needed to further this pilot study. Having identified the required skills for the Workers level, Middle Managers level and Top Managers level in an Industry 4.0 environment, one possible direction for the development of this research in the future is to understand the current gaps existing in the skills needed in the future, applied to both an industry environment and an academic one. Another possible direction is to conduct research related to the steps required to cover the skill gaps, again for both environments, industry and academia. The development of the skills needed in the future Industry 4.0 is, nevertheless, an important subject to increase efficiency and competitiveness in companies. Finally, the validation of the research findings through a questionnaire in different contexts and sectors that differ from the actual research setting could also be another possible contribution.

As a final remark, it should be noted that there is no doubt that the Fourth Industrial Revolution has an important role in improving performance of the industries' sustainability, particularly concerning the environmental aspects; for instance it can help in monitoring the equipment's state and energy consumption, or monitoring the employees' work conditions in real time, and analyzing the collaborative relationship between robots and workers. Moreover, the importance of improving principles, skills and practices in Industry 4.0, either at the bottom level or at the top managers level, is also reported in the bibliography. Hence, this paper can be an important step to promote sustainability in industries, beyond their competitive advantages and economic benefits.

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Appendix A

This appendix intends to show some of the results obtained at the end of the Initial coding phase. Tables A1–A3 show some examples of the codes developed during the analysis of the interview results.

Table A1. Interviews analysis—Worker level—Examples of codes used to generate Tasks Categories.

No.	Tasks Categories	Associated Codes (Examples)
1	Production Control	• Control of daily production. • Check process. • Control productions and machines.
2	Machines Maintainability	• Maintain the machines. • Fix breakdowns. • Perform maintenance activities.
3	Problem Solving	• Focus on problem-solving activities. • Decision-making to answer faster to problems. • React to problems.
4	Machines Programming	• Programming tasks. • Programming machines. • Use IT knowledge to program machines.
5	Product Quality Control	• Quality control. • Product quality. • Adjust machines parameters.
6	Measure and Read KPIs	• Measure indicators. • Interpretation of deviations. • Analyze outputs.
7	Process Improvement	• Improve programming and flows. • Improve processes. • Constant training in new technologies.
8	Manual Handling Tasks	• Supply machines. • Exchange of containers. • Manual loading and unloading.

Table A2. Interviews analysis—Middle Managers level—Examples of codes use to generate Tasks Categories.

No.	Tasks Categories	Associated Codes (Examples)
1	Lead Workers Teams	• Empower workers. • Lead workers team. • Conflict Management.
2	Analyze KPIs and Performance	• Analyze KPIs. • Analyze data. • Control performance.
3	Drive Problem-Solving Projects	• Problem solving focus. • Complex problem solving. • Responsible for problem solving.
4	Drive Improvement Projects	• Search for potential to improve. • Run improvement activities. • Improvements driven by results.
5	Provide Trainings	• Ensure adequate trainings. • Coach new workers. • Support and provide trainings to workers.

Table A3. Interviews analysis—Top Managers level—Examples of codes used to generate Tasks Categories.

No.	Tasks Categories	Associated Codes (Examples)
1	Define Strategy	• Define strategy to achieve goals. • Strategy definition. • Focus on company vision.
2	Define Next I4.0 Projects to Run	• Find the next transformation steps. • Next steps in digital transformation. • Find opportunities to create value with new projects.
3	Define Company Targets	• Define targets for the company. • Clear targets definition. • Goals definition to increase or keep competitiveness.
4	Analyze KPIs and Performance	• Analyze big KPIs. • Analyze plant performance. • Monitor and analyze data output.
5	Interact with Customers	• Evaluate and rethink customer experience. • Customer centricity. • Interaction between customer and company.
6	Define Investments	• Decide investments. • Search for new machinery solutions for the company. • Continuous investment planning.

Table A3. *Cont.*

No.	Tasks Categories	Associated Codes (Examples)
7	Find Talent/Employees	• Focus on hiring people that covers the company gaps regarding I4.0 capabilities. • Fight for talent. • Give opportunities to internal employees to grow.
8	Promote Employees Qualification	• Promote employee qualification. • Development of human excellency. • Promote teams' interaction towards a constant learning process.

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