D5.4

Final impact assessment & policy recommendations

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Lead partner:	Politecnico di Milano (Polimi)
Author(s):	Federica Acerbi – Mahdi Mohammadian (POLIMI)
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Disclaimer

Executive Summary

The implementation of Industry 4.0, Data Management, digital platforms, and the use of modern technology in the production and manufacturing process, as well as the occurrence of unexpected events and crises, necessitates an optimal and proportionate review of company performance by measuring key performance indicators in various dimensions such as operational/technical, economic, environmental, and others, as well as the need for new skills within a company's workforce. Aspects such as lifelong learning and new educational paradigms are becoming increasingly important in improving company resilience. This deliverable (D5.4) [Due to Month:27] “Final impact assessment & policy recommendations” is related to WP5, presents the following aspects:

Research background, related reports, and result of first iteration of 6Ps methodology (Performance, and People dimension): This section contains a brief reference to previous studies on the topics of performance and people (skills), the results of the first iteration (started in M9) of the methodology, which were collected through surveys from project partners and fully reported in the D5.3, were then briefly recalled. The main parts of these surveys were focused on the performance and people dimensions of the 6Ps tool, which in the first round we examined the partners' current (AS-IS) situation. The results of the second iteration (M20), the comparison of both rounds, and suggested activates to bridge their gaps are fully stated in the continuation of this deliverable.

Performance Dimension: after the second iteration of the survey, it emerged that some of the respondents decided to better focus their attention on specific performances to improve their resilience against future disruptive changes. The choice of the specific performance was aligned with their core strategy to provide a unique guideline towards future improvement. Indeed, the selection of the performances to start to be monitored is not equal for all the respondents having them different strategies for the future. Nevertheless, both the economic and the supply chain-related performances are considered fundamental to be monitored to improve the resilience of companies.

People Dimension: Following the implementation of the first round of the methodology, which included the introduction of jobs and the design of surveys, as well as an analysis of the partners' AS-IS conditions in relation to the introduced skills and jobs (D5.3), we implemented the second phase of the surveys in this deliverable. The extent of the improvement in the partners' conditions was checked using the complete analysis of the responses received, and the gaps that have not yet been resolved were also identified, and solutions to fill these gaps were introduced.

Training courses were identified as one of the most important solutions by investigating the websites that provide these training courses. The analysis of each course at three levels (Awareness, Foundation, and Extended know-how) have been conducted. In addition to training courses, the use of virtual training tools is also introduced as another significant tool for filling gaps that were investigated in this project in collaboration with project partners (Intellimech, VIS).

Keywords: 6Ps migration model, Performance dimension, People dimension, Surveys, Gap analysis.

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Definitions and acronyms

AAS	Asset Administration Shell
AI	Artificial Intelligence
AM	Additive Manufacturing
AMN	Additive Manufacturing Network
AOs	Application Ontologies
API	Application Programming Interface
BCF	Business Continuity Framework
BFO	Basic Formal Ontology
BPM	Breaths Per Minute
CA	Consortium Agreement
CAD	Computer Aided Design
CCE	Clinical Care Equipment
CNC	Computer Numerical Control
CPPS	Cyber Physical Production Systems
CSV	Comma Separated Values
DDOs	Domain Dependent Ontologies
DIH	Digital Innovation Hub
DMP	Data Management Plan
GD&T	Geometries and Dimensional and geometric Tolerances
GMP	Good Manufacturing Practices
DE	Digital Enabler
DFA	Digital Factory Alliance
DIROs	Domain Independent Reference Ontologies
DoA	Description of Action
DSROs	Domain Specific Reference Ontologies
EC	European Commission
EDI	Electronic Data Interchange
EU	European Union
Euratex	European textile and clothing industry
FF	Full Face
FO	Foundation Ontology
FTP	File Transfer Protocol
GA	Grant Agreement
I4.0	Industry 4.0
IDS	International Data Spaces
IDSA	International Data Space Association
IIC	Industrial Internet Consortium
IOF	Industry Ontology Foundry
IPP	Intermediate Product Properties
IRR	Internal Rate of Return
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
LCA	Lifecycle Assessment
LCC	Life Cycle Costing
MAL	Manufacturing Autonomy Level

MaaS	Manufacturing as a Service
MES	Manufacturing Execution System
MILP	Mixed-Integer Linear Programming
MRT	Manufacturing Repurposing Transformations
NPV	Net Present Value
OEM	Original Equipment Manufacturer
PBT	Pay Back Time
PC	Personal Computer
PDF	Portable Document Format
PLM	Product Lifecycle Management
PoC	Proof of Concept
PP	Polypropylene
PPE	Personal Protection Equipment
PPS	Production Planning and Scheduling
P&R	Plug & Respond
QIF	Quality Information Framework
RA	Reference Architecture
REST	Representational State Transfer
RFQ	Request For Quote
ROI	Return on Investment
SCMP	Supply Chain Management Platforms
SCSN	Smart Connected Supplier Network
SFW	Smart Factory Web
SFWC	Smart Factory Web Connector
S-LCC	Social Life Cycle Costing
SMMA	Smart Matching/Mediation App
SROI	Social Return of Investments (SROI)
TC	Technical Coordinator
W3C	World Wide Web Consortium
WHO	World Health Organization
WP	Work Package
XSDL	XML Schema Definition Language
ZDM	Zero Defect Manufacturing

1 Introduction

1.1 Scope and Purpose

For over one year and half, the Eur3ka project has been actively working towards the specification, implementation, and validation of a novel manufacturing response framework, which demonstrates the critical importance of paying attention to the evolving technological trends, novel performance, and new skills needed in the manufacturing environment together with the rising of unexpected events and crises. Within this evolutionary context, Industry 4.0 technologies are spreading worldwide. The development of these new digital tools had a significant impact on the two primary dimensions of manufacturing activities, performance, and people, and could represent the driver towards the creation of more resilient companies. The performance dimension is related to the monitoring of indicators such as Overall equipment effectiveness, Yield, cost, throughput, and others that can be used to measure the efficiency of factory production activities. On the other hand, the people dimension is related to the creation of new jobs and skills that include people at all levels "management, professional, and worker."

In these regards, during Eur3ka project, two main assessment tools have been developed: one on performances (i.e. looking at the KPIs that manufacturing companies might keep under control in terms of Operational/Technical, Economic, Environmental, Social, Product-Service Lifecycle, and Supply Chain dimensions) and one on people (i.e. looking at the emerging new skills and job requirements aligned with Data Science Management, as well as new skills about Professions due to the COVID-19 to improve employees' abilities at three different organizational levels (Manager, Professional, and Worker levels). Therefore, this deliverable proposes the updated results from the application of the two assessment tools focused respectively on performances, and skills whose structure has been widely described in D3.1 and D3.2 and its first deployment has been reported in D5.3. In particular, this deliverable reports the results obtained from the second iteration of the survey, of both the assessment models, which have been deployed among the Eur3ka partners. Moreover, it also elucidates the results coming from the adoption of the model by external stakeholders.

1.2 Linking to/and differences from Deliverables D3.1, D3.2, and D5.3

The present deliverable titled " Final impact assessment & policy recommendations" can be considered as a continuation of the D3.1, D3.2, and D5.3 in the workforce training, and performance/Financial Impact Assessment sections. However, with respect to the D3.1, D3.2, and D5.3 deliverables, the D5.4. has the following differences:

- **In the performance section**: Following the financial review performed in D3.1 and updated with its extension in D3.2, this Deliverable extends the results obtained and reported in D5.3 after the first survey iteration, by conducting a second iteration of the survey to evaluate the resilience maturity level of manufacturing companies belonging to the Eur3ka project looking at the six performance dimensions. Indeed, the results of this second survey are discussed looking at all the six dimensions: operational/technical, economic, environmental, social, product-service lifecycle,

and supply chain. They are compared and discussed in relation with the first iteration to observe whether improvements have been registered and update set of indicators have been employed. Moreover, in this deliverable, the results obtained through the application of the model to external stakeholders with respectoth the Eur3ka project are reported and discussed to evaluate whether additional KPIs have been employed.

- **On the people, dimension**: the introduction of jobs in the field of data science management and Professions due to the COVID-19 was done in the D3.1 by investigating WMF[1][2] and WEF[3] annual reports and Osservatorio Industria 4.0[4] of Politecnico di Milano. These jobs and their skills were updated in D3.2, and two main surveys "voting survey" and "Possessed and Needed survey" were designed and implemented to understand the current level (AS-IS) of project partners in relation to these roles. Based on that, D5.3 proposed the analysis of the responses received from project partners, through a first survey iteration, in relation to the introduced jobs and skills in order to identify gaps and propose a suitable solution to bridge these gaps. This deliverable extends the results from D5.4. by presenting and discussing the results obtained through a second iteration of the survey. Moreover, it presents the results obtained from the application of the model on stakeholders external to the project.

1.3 Structure of the Document

The present document is structured as follows:

- Chapter 2: reports an analysis of the background explaining the key concepts of the two assessment models.
- Chapter 3: reports the summary results from the first iteration of the surveys.
- Chapter 4: reports the results from the second iteration of the survey on Performance.
- Chapter 5: reports the results from the second iteration of the survey on skills and job profiles.
- Chapter 6,7, and 8: elucidates the ethical issues, future steps, and conclusion.

[1] World Manufacturing Forum's ten skills for the future of manufacturing World Manufacturing Forum - https://worldmanufacturing.org/

[2] https://worldmanufacturing.org/wp-content/uploads/WorldManufacturingForum2020_Report.pdf

[3] World Economic Forum, 2020, The Future of Jobs Report, October 2020.

[4] Osservatorio Industria 4.0 - Politecnico di Milano

2 Research Background and related reports

2.1 Background on Performance / Financial Impact Assessment

The global market has been recently highly affected by great events (e.g., COVID-19 pandemic) creating several issues on the entire society and touching the manufacturing world too. For this reason, it has been set down a number of countermeasures to react and to be ready in the next future.

More in detail, looking at this project, among the different goals the willingness is also to understand how to keep under control the resilience of manufacturing companies and to do that, it has been initially thought to ensure the monitoring of financial performances of a company once it has undertaken and conducted certain investments to face these challenging events.

Although it was evident the need for companies to monitor their financial prosperity in this context, it was immediately evident that the number of issues to be kept under control that characterize the resilience of a company are many more such as the production or operational resilience, the product or material resilience, the social of people resilience, and the supply chain resilience (Romero et al. 2021). For this reason, it was considered necessary to extend this limited view on the financial part towards other elements, thus integrating the 6Ps methodology already developed and validated in a previous EU project (additional information are reported in Chapter 1) with the results from previous studies on resilience in manufacturing. The modification and update of the framework has been reported extensively also in D3.2, and D5.3.

This updated version of the assessment framework enabled to provide manufacturing companies with an extended view of the key aspects to be monitored to be resilient. Therefore, as widely described in Chapter 4 of this deliverable, the model facilitates companies in understanding where they are currently positioned and where the areas of improvement are. These results emerged especially from the survey conducted with participants of the project.

2.2 Background on workforce training

Global labour markets are undergoing major transformations, with changes to business needs and unexpected crises (such as Covid-19), workforce profiles picking up an even more incredible pace in recent years. The human-centered paradigm shift will only be successful if work processes are reshaped, and new training approaches are introduced to support the continuous development of skills taking into account personal capabilities, skills, and situational preferences of individual operators[5]. The Future of Jobs Report 2020[6] from World Economic Forum (WEF) maps the jobs and skills of the future and explains that the COVID-19 pandemic-induced lockdowns and related global recession of 2020 have created

[5] Ace factories, White paper on Human-centred factories from theory to industrial practice. Lessons learned and recommendations, 2019.
[6] https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

a highly uncertain outlook for the labour market and accelerated the arrival of the future of work. In this regard, below are some of the achievements of this report[6]:

“**Although the number of jobs lost will be outnumbered by the number of 'jobs of tomorrow' created, job creation is slowing while job destruction accelerates in comparison to previous years**": Employers anticipate that by 2025, increasingly redundant roles will fall from 15.4% to 9% of the workforce (6.4% decline) while emerging professions will increase from 7.8% to 13.5% (5.7% growth).

"Skills gaps persist as in-demand skills across jobs change over the next five years": Employers see critical thinking and analysis, as well as problem-solving, as rising in importance in the lead-up to 2025, as well as self-management skills such as active learning, resilience, stress tolerance, and flexibility. Companies estimate that 40% of workers will require reskilling in six months or less, and 94% of business leaders expect employees to learn new skills on the job, a significant increase from 65% in 2018.

"Online learning and training are on the rise, but the picture differs for those in and out of work.”: Personal development courses are becoming more popular among working people, with an 88% increase in enrollment. Unemployed people have prioritized learning digital skills such as data analysis, computer science, and information technology.

"In the newly constrained labor market, the window of opportunity to reskill and upskill workers has shrunk": This applies to both workers who are likely to stay in their positions and those who are at risk of losing their positions due to rising recession-related unemployment and cannot expect to retrain at work. The share of core skills that will change in the next five years for those workers expected to stay in their roles is 40%, and 50% of all employees will require reskilling (up 4%).

All in All, as mentioned in D3.2 and D5.3, we identified new roles and professions in the field of data science management and resilience based on the content of the Eur3Ka project. In section 5, we will determine the continuation of the 6Ps methodology process (People dimension) for analysing introduced profiles in project partners, reviewing and comparing their As-Is and desired situation (To-Be) by implementing the second Iteration of surveys.

3 Performance and People pathways – 6Ps Methodology

3.1 6Ps Methodology Overview

As already mentioned in previous deliverables (D3.1, D3.2, and D5.3), the 6Ps methodology applied in Eur3ka partners has been developed by Politecnico di Milano university, within the H2020's MIDIH Project. This structured methodology is aimed at supporting manufacturing companies in defining their current level of digital maturity, identifying the desired level of digital maturity to reach in a given time horizon, and consequently structuring a digital transformation roadmap to achieve the goals set (Spaltini et al. 2022).

As visible in Figure 1, this methodology is organised according to 6 dimensions (the Ps), 3 belonging to the technical area (Product, Process, Platform) and 3 belonging the socio-business area (People, Partnership, Performance). Through the analysis of these dimensions, it is meant at identifying the most suitable strategy to ensure the successful digital improvement together with the identification of the right tools and services propaedeutic to concretely reach the results.

Figure 1 6Ps Digital transformation tool

3.1.1 Performance Dimension

6Ps' **Performance dimension** aims at investigating what the role that Industry 4.0 technologies have in the definition, monitoring, and interpretation of KPIs of manufacturing enterprises. As anticipated before, this part of the 6Ps model has been updated and used to cover the Financial Performance analysis (see also for additional details D3.2) and here a brief summary has been reported (further details are available in D5.3).

The dimension is divided into six areas, namely: Operational/Technical, Economic, Environmental, Social, Product-Service Lifecycle, and Supply Chain and they are analysed across five levels of maturity as reported in Table 1.

Table 1 Performance dimension table

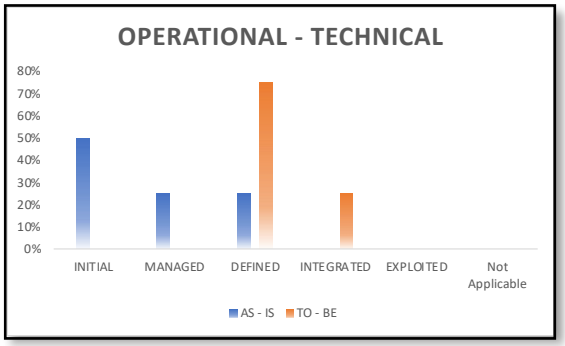
OPERATIONAL/ TECHNICAL	Performance is often not measured or understood	Descriptive Measurement and analysis are largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
ECONOMIC	Performance is often not measured or understood	Descriptive Measurement is largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
ENVIRONMENTAL	Performance is often not measured or understood	Descriptive Measurement is largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
SOCIAL	Performance is often not measured or understood	Descriptive Measurement is largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
P-S LIFECYCLE	No product life cycle assessment	A few aspects are included	Life Cycle Costing (LCC)	Life Cycle Costing + Environmental LCA	Life Cycle Costing + Environmental LCA + Social LCA
SUPPLY CHAIN	Performance is often not measured or understood	Only the most important physical performance of suppliers (e.g., punctuality, quality, operational flexibility)	Physical and Economical performance (purchase price, non-quality costs, delivery delays, lack of flexibility, etc.).	Physical, economical, and sustainability performance for almost all the suppliers.	Physical, economical, sustainability and integration with other external sources (e.g., social media, weather)

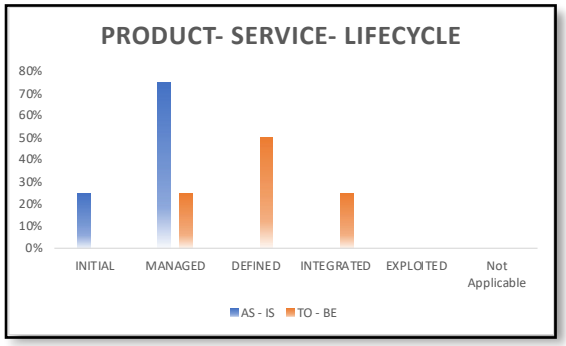
The first iteration of the survey about the performance dimension of the 6Ps methodology has already been completed among project partners (see deliverable D5.3) asking them

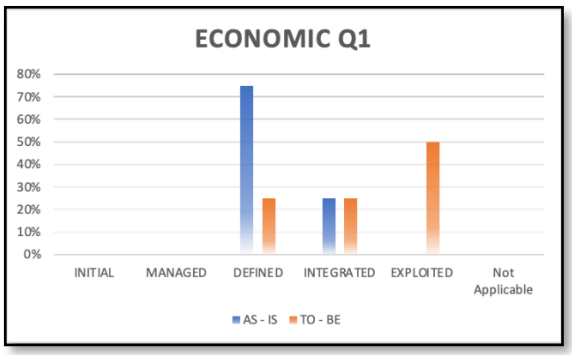
their AS-IS and desire TO-BE situation. Here, in this document, the results of the second iteration of the survey are reported (see Chapter 4) to compare the current AS-IS situation in comparison to the past AS-IS situation and the desired TO-BE.

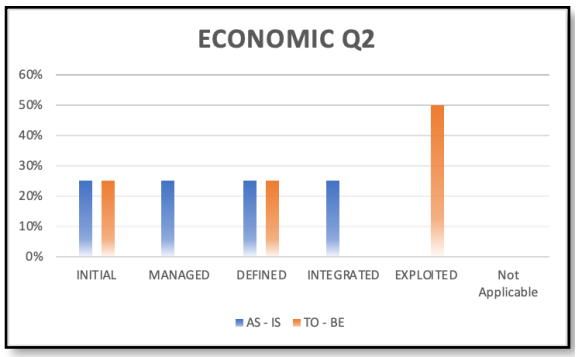
3.1.1.1 Performance Dimension first iteration results

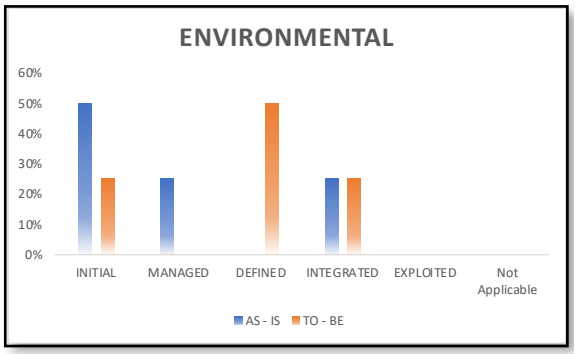
This chapter summarizes the results out of the first iteration of the survey that has been detailed in D5.4. Below, the key graphics representing the results from the previous iteration are reported highlighting the AS-IS situation during the first iteration in comparison with the TO-BE situation during the first iteration, which should be aligned with the current AS-IS situation of the second iteration.

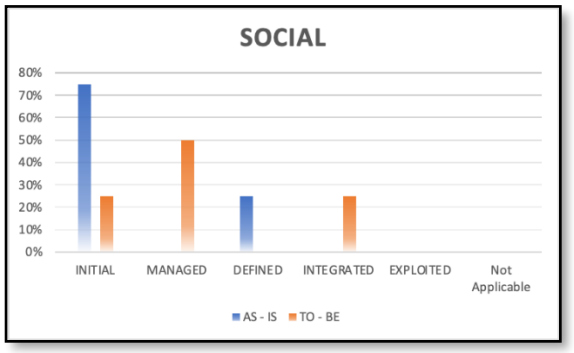












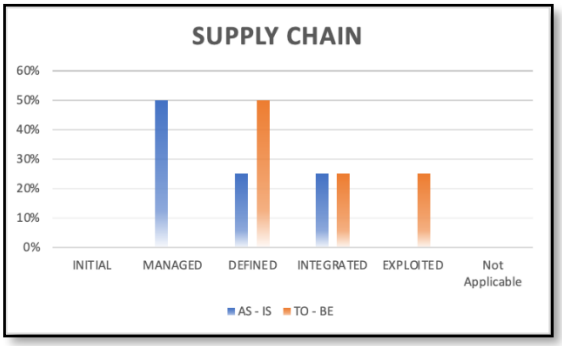


Figure 2 Performance dimension first iteration results

More in detail, starting from the first left picture, the “operational-technical” dimension was assessed positioning the desired level at least at the “defined” one starting from the lowest levels in the AS-IS situation. Then, the “product-service system” dimension results are more heterogeneous aiming at reaching improved levels of maturity reaching the integrated one. Regarding the economic performances, both for past (“economic 1”) and future (“economic 2”) investments, the desired TO-BE level is the exploited one even though the AS-IS situation resulted to be at higher levels as far as economic 1 is concerned (thus considering the performance monitoring on previous investments) in respect with the economic 2 ones. As far as environmental is concerned, the respondents were positioned at low levels of maturity in an heterogenous way (from initial to integrate) while desiring higher levels of maturity, at least to reach an “integrated” level. In contrary, the “social” performances were located at low levels, hence most of respondents were positioned at an “initial” level and were willing to reach an “integrated” level as well as for the environmental performance. Last, the supply chain level emerged to be the most advanced one among the performances kept under control.

3.1.1.2 Gap identification and Suggested actions

Based on the results observed in the survey, it emerged the need to improve from their AS-IS situation with the idea, in most of the cases, to keep under control specific KPIs to not be limited to a diagnostic purpose only, but also to predictive and prescriptive ones. This future orientation is the key element fostering companies’ resilience performances and facilitates them in facing rapidly or even better anticipating, problems and challenges.

It is worth to mention that the expected improvements should be linked to the strategy of the company. Indeed, they must be fully integrated with the vision, mission, and strategy of the company itself. Therefore, structured improvement paths need to be designed and put in practice. The improvement process should be supported by a structured and objective roadmap aligned with their strategic goals enabling to improve in a coherent manner.

Additionally, according to the context, a certain company might require keeping a specific performance under control since highly relevant for its resilience and thus, efforts in that direction should be conducted.

3.1.2 People Dimension

The Ace factories 2019, and the 2020 WEF (Mentioned in Chapter 2) suggest that the digitalization process and upgrading skills based on new crises in the world and new technologies do not refer to technologies and processes but must encompass also a proportionate empowering of skills at every level (from shop floor to top management) and eventually the creation of roles aligned to the digital advancement that industry is facing. In light of this, metrics aimed at measuring which skills are needed and how much developed must be at every level of an organization seems to be a fundamental element to transform the suggestions articulated into practice.

The main scope in this chapter is to consider People dimension of the 6Ps model affected by digitalization within industrial environments. In this regard, the objective is to design and develop a structured methodology (6Ps) able to assess the current level of digital and resilience maturity of manufacturing companies (AS-IS), quantify the desired level of digital and resilience maturity that these latter aim at achieving (TO-BE), and design a specific action plan to allow the transition needed to fill the gaps identified. The main focus will be on the People dimension since a thorough analysis of current jobs and professions involved in this project context will be conducted in order to identify possible skills gaps digital and resilience adoption. In addition, this process will dedicate some of the efforts to organizing workshops and surveys to collect the needed feedback from the partners in the development stage of the project to ensure providing simple and easy-to-use tools. A structured approach – Survey-based (Industry 4.0) will be followed and skills needed/possessed analysed and discussed as well as identification of the most suitable training programs to bridge such gaps. The first step of this methodology is primarily concerned with identifying new roles, professions, and relevant skills based on the project's content. In addition, related to these new roles and skills, two main questionnaires were asked of project partners and the first iteration of surveys implementation among project partners have already been completed. (The Summary result of this step is reported in 5.3). Here, in this document, the results of the second iteration of the survey are reported (see Chapter 4) to compare the current AS-IS situation in comparison to the past AS-IS situation and the desired TO-BE.

It should be noted that the jobs listed below are appropriate for the organisational environment from the perspective of the project partners, and because many of them can be implemented remotely, they can also be performed and controlled remotely in the event of a crisis such as Covid 19. On the other hand, as businesses move towards digitalization, skills in data analysis and data management will become increasingly important in the near future.

3.1.2.1 People Dimension first iteration results.

This chapter summarizes the results out of the first iteration of the surveys that have been detailed in D5.4. Below, the key results from the previous iteration are reported.

I. Voting survey

The main purpose of this survey was to prioritize the skills assigned to each job title according to the opinions of the project partners. Below you can find the results of this survey in brief:

- **Data Science Manager**
  - Develop and execute the data strategy according to business objectives - **28.95%**
  - Manage the data science team and resources - **21.05%**
  - Communication with domain experts - **18.42%**
  - Knowledge about domain-specific processes - **13.16%**
  - Knowledge of business processes - **10.53%**
  - Knowledge about performance indicators - **7.89%**
- **DATA Science Architect**
  - Ability to select software platforms for big data (Hadoop, Data Lake) - **35.48%**
  - Knowledge about big data architectural standards - **22.58%**
  - Ability to integrate data universe - **22.58%**
  - Ability to select hardware platforms for big data (performances, costs, etc.) - **19.35%**
- **DATA Scientist**
  - Use of machine learning, Bayes classifier, Deep Learning techniques, and OR methods - **20%**
  - Identify and interpret relevant data sources - **17.78%**
  - Ability to use a programming language (R, Python) - **15.56%**
  - Mathematical and statistical models Knowledge - **13.33%**
  - Communicate with domain experts - **13.33%**
  - Use of optimization algorithms - **13.33%**
  - Knowledge about domain-specific processes - **6.67%**
- **Data Engineer**
  - Knowledge of data storage and query languages - **25.71%**
  - Ability to maintain security, quality, integrity, safety, and availability of data - **22.86%**
  - Ability to integrate new data technologies into existing systems - **22.86%**
  - Develop data models and workflows - **20%**
  - Ability to use cloud computing - **8.57%**
- **Visual Data Designer**
  - Create infographics (maps, charts, diagrams) - **22.86%**
  - Develop interface and interaction to increase user experience - **17.14%**

- Develop vector graphics, scientific illustrations, and icons (maps, charts, diagrams) - **14.29%**
- Ability to understand complex information - **14.29%**
- Develop insightful and engaging data analytics view - **11.43%**
- Visualize the huge and complex volume of data - **11.43%**
- user experience analysis, design, and evaluation - **8.57%**

- **Remote Worker**
  - Interpret quantitative data, graphs (KPIs), and 3D digital models - **33.33%**
  - Use applications to increase sensory, remote, and cognitive abilities - **27.78%**
  - Perform scenario analysis to evaluate and prepare for possible interventions - **27.78%**
  - Understand and use additive manufacturing technologies and mathematical models - **11.11%**
- **Resilience Manager**
  - Foresee elements of flexibility, when necessary, in redesigning production processes - **22.22%**
  - Engage and dialogue with stakeholders, and trade unions first and foremost, to better manage change related to the introduction of new technologies - **19.44%**
  - Understand the impact of emerging technologies on business (e.g., distributed systems, …) - **16.67%**
  - Anticipate business requirements and end-user needs - **13.89%**
  - Redesign the production process end-to-end, improving it with the introduction of new technologies 4.0 - **11.11%**
  - Rapidly adapt technological innovations to business and Supply Networks - **8.33%**
  - Collaborate with other players (including those from outside the company) and integrate them into the value chains - **8.33%**
- **Repurposing Supervisor**
  - Identify opportunities for new/alternative applications of existing components, products, machines, etc. - **21.88%**
  - Ability to define the business model around the product-service - **21.88%**
  - Knowledge and ability to use and Re-use (new) materials - **18.75%**
  - Ability to design around new materials/processes or used materials/processes (e.g., light polymerization, …) - **15.63%**
  - Knowledge about Reduce, Reuse, and Recycle Waste - **15.63%**

- Ability to innovate and engineer the product from a 3D printing perspective and to use 3D printers - **6.25%**

- **Operator 4.0**
  - Analytical skills to Interpret data from operations - **40.74%**
  - Use sensors/actuators/ ports/ antennas/HMI standards - **25.93%**
  - interact with smart warehouses equipped with automated picking systems and autonomous vehicles - **14.81%**
  - Ability to use 3D printers - **11.11%**
  - Ability to use discrete event simulation - **7.41%**
- **Soft skills (**most important skills in management, professional, and worker levels**)**
  - Management level: Ethical – Legal mindset **(9.09%)**, Interpersonal skills, Professional ethics, and communication **(7.79%)**
  - Professional level: Interpersonal skills, and Teamwork **(9.86%)**
  - Worker level: Teamwork **(15.05%)**

II. Possessed and Needed survey

The main purpose of this survey is to investigate the As-Is and To-Be conditions of the project experimenters “Tech providers and Users” and identify relevant gaps by analysing the answers received. Below you can find the results of the first iteration.

- **Data Science Manager**

Based on the answer received for this role, project partners are needed this role and relevant skills at the intermediate to expert level or they already possessed them in these levels. According to the supplementary answer we received from these partners, it can be understood that they achieved the desired level so far by relying on the capabilities of the company itself, and they will improve their levels by holding training courses, and re-reskilling the current situation.

- **Data Scientist**

For this role and relevant skills, project partners have needed them at the intermediate to expert level or they already possessed them in these levels. According to the supplementary answer we received from these partners, it can be understood that they achieved the desired level so far by relying on the capabilities of the company itself, or collaboration with partners. They also considered making collaboration with other project partners as a suitable way to bridge these gaps.

- **Data Science Architect**

In Data science Architect role and relevant skills, project partners have needed them at the upper intermediate and expert levels, or they already possessed them in these levels. Based on the supplementary comments we received from these partners, it can be understood that

they have achieved the desired level so far by relying on the capabilities of the company itself or collaboration with internal and external partners. Also, one of these partners stated that there is no need to create a permanent job position like this and they can hire that person for a short period of time when needed.

- **Data Engineer**

Regarding this profile and relevant skills, project partners needed them at intermediate to expert levels or they already possessed them in these levels. Based on the supplementary comments we received from these partners, it can be understood that some of partners have been achieved the desired level so far by relying on the capabilities of the company itself or up-re skilling activities, but they still need to improve.

- **Visual Data Designer**

In this role and relevant skills, four partners out of eight stated that they possessed its skills now or will need it in the near future. According to the votes received can be concluded that the level which partners are currently at or need to reach is in the intermediate to expert levels. On the other hand, according to the additional comments received by partners, it can be understood that some of partners have achieved the desired level so far by relying on the capabilities of the company itself or up-re skilling activities, but they still need to improve. In addition, some other partners stated that they feel the need for this job title and related skills soon, so they considered holding training courses and hiring new personnel as a suitable way to bridge these gaps.

- **Remote Workers**

In this part partners mostly need this role and relevant skills at intermediate and expert levels, or they already possessed them in this level. Based on the supplementary comments we received from these partners, it can be understood that some of them have achieved the desired level so far by relying on the capabilities of the company itself. Of course, they still need to improve and believe training courses could be the most important method. Also, few partners stated that they feel the need for this job title and related skills soon especially to avoid being caught unawares in unexpected crises like Covid-19.

- **Resilience Manager**

Regarding this job profile and relevant skills, Partners have needed them at the intermediate to expert levels or they already possessed them in these levels. According to the supplementary comments we received from these partners, it can be understood that a few partners have achieved the desired level so far by relying on the capabilities of the company itself. And some others stated that they feel the need for this job title and related skills soon, so they considered holding training courses, hiring new personnel, and up-re skilling activities as suitable ways to bridge this need.

- **Repurposing supervisor**

Regarding this job profile and relevant skills, according to the answer and supplementary comments received, it can be understood that partners need them at the intermediate to expert levels. In addition, they pointed out that based on company conditions the most appropriate way to bridge these gaps will be up-re skilling activities.

- **Operator 4.0**

In this role and relevant skills, some partners stated that they need them at the intermediate to expert levels or they already possessed them in these levels. Based on the supplementary comments we received from these partners, it can be understood these partners have achieved the desired level so far by relying on the capabilities of the company itself. In addition, a few partners stated that they feel the need for this job title and related skills soon, so they considered holding training courses as a suitable way to bridge this need. Also, one of these partners stated that there is no need to create a permanent job position like this and they can hire that person for a short period of time when needed.

3.1.2.2 Gap identification and Suggested actions

Based on the results observed in the surveys, it emerged the need to improve from their AS-IS situation with the idea, in most cases, it can be seen that the project partners have a great desire to cooperate with each other to share experiences and improve skills.

On the other hand, another effective approach to bridge the gaps and improve skills is to hold training courses. In this regard, a list of training activities has been prepared from different sources such as: “I4MS Catalogue of Trainings” (https://i4ms.eu/trainings/), “POLIMI open knowledge” (www.pok.polimi.it/), Coursera (https://www.coursera.org/), Udemy (https://www.udemy.com/), and others.

In addition, the use of virtual training tools is also introduced as another significant tool for filling gaps that were investigated in this project in collaboration with project partners (Intellimech, VIS).

4 Performance (financial) Survey – Second Iteration

The “performance” survey covered the financial part of the assessment tool extending the limited view over economic performance only, by adding other relevant performances as anticipated in the “Background” chapter of this deliverable. In detail, in this section, the results coming from the second iteration of the survey covering the performances reflecting those of the 6Ps (i.e., technological, organizational, environmental, social, product-service system, and supply chain) are discussed across five levels of maturity.

4.1 Introduction to survey structure - goal - audience

This sub-chapter aims to clarify the key elements characterising the performance-related survey thus, the goal of the survey, the audience addressed in this survey, and the structure of the survey itself.

4.1.1 Goal

The goal of this second iteration of the survey is to investigate the resilience of companies by looking at their current maturity (the AS-IS maturity) of 6 relevant dimensions (i.e., economical, operational and technical, environmental, social, product-service system, and supply chain) from the resilience perspective and compare these results with the previous iteration. Indeed, the main objective of this survey is describing a company’s current resilience level and comparing it with the desired future level (i.e., TO-BE they declared during the previous iteration identified by the company itself). The gaps between their current AS-IS (in this deliverable is defined as TO-BE) and the previous AS-IS and the desired TO-BE maturity levels declared during the first iteration are discussed to investigate the potential corrective actions towards a resilience strategy.

4.1.2 Audience

The target audience is companies, especially manufacturing companies (internal project partners), which dealt with the rising of exogenous changes and issues (e.g., COVID-19) which can be considered the causes affecting the entire organization and, especially their core business activities, asking them for greater levels of resilience. Indeed, the representatives of different companies were asked to participate to the survey (i.e., one person for each company) to answer in the name of the company itself. In this way, the company can understand the current state and imagine the potential improvements towards a TO-BE scenario to be more resilient in the future. The anonymity was ensured to avoid sharing confidential information.

4.1.3 Structure

The survey is based on seven questions (one for each dimension except for the economic performance which has two corresponding questions). For each question, it was asked to specify the company’s current level (AS-IS) and the expected and desired level (TO-BE) to be achieved at the completion of the Eur3Ka project. The questions will be focused on

different performances to ensure to keep under control several aspects characterising resilience which are: operational and technical, economic, environmental, social, product/service lifecycle, and supply chain.

OPERATIONAL / TECHNICAL: What approach does your company adopt for measuring operational performances (e.g., OEE) to monitor the flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Operational performance is often not measured or understood
- MANAGED: Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective
- DEFINED: Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affect events and behaviours
- INTEGRATED: Predictive Performance - Measurement of KPIs is prospective. AI, statistical models, and forecasts techniques to understand the future KPIs
- EXPLOITED: Prescriptive Performance – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and operational KPIs measurement

ECONOMIC - Q1: What approach does your company adopt for monitoring economic performances on the already established investments (e.g., ROI)?

- INITIAL: Operational performance is often not measured or understood
- MANAGED: Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective
- DEFINED: Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affect events and behaviours
- INTEGRATED: Predictive Performance - Measurement of KPIs is prospective. AI and statistical models and forecasts techniques to understand the future KPIs
- EXPLOITED: Prescriptive Performance – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and operational KPIs measurement

ECONOMIC - Q2: What approach does your company adopt to compare the economic performances of different investment opportunities (e.g. NPV, PBT, IRR) required to ensure flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Operational performance is often not measured or understood
- MANAGED: Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective
- DEFINED: Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affect events and behaviours

- INTEGRATED: Predictive Performance - Measurement of KPIs is prospective. AI and statistical models and forecasts techniques to understand the future KPIs
- EXPLOITED: Prescriptive Performance – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and operational KPIs measurement

ENVIRONMENTAL: What approach does your company adopt for measuring environmental performances (e.g., CO2 emissions, water consumption per product, LCA) about investments performed to ensure sustainable flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Environmental performance is often not measured or understood
- MANAGED: Descriptive – Measurement of environmental KPIs is largely retrospective
- DEFINED: Diagnostic - Measurement of environmental KPIs is clear. Attempt to understand the causes of events and behaviours
- INTEGRATED: Predictive - Measurement of environmental KPIs is prospective. AI and statistical models and forecasts techniques to understand the future
- EXPLOITED: Prescriptive – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and environmental KPIs measurement

SOCIAL: What approach does your company adopt for measuring social performances (e.g., social return on investments S-ROI, Social lifecycle assessment S-LCA) about investments performed to ensure flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Social performance is often not measured or understood
- MANAGED: Descriptive - Measurement of social KPIs is largely retrospective
- DEFINED: Diagnostic - Measurement of social KPIs is clear. Attempt to understand the causes of events and behaviours
- INTEGRATED: Predictive - Measurement of social KPIs is prospective. AI and statistical models and forecasts techniques to understand the future
- EXPLOITED: Prescriptive – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and social KPIs measurement

PRODUCT-SERVICE LIFECYCLE: Which dimensions of analysis are taken into account in the assessment of the lifecycle of the products/services offered to the customers in a disruptive situation (like a Covid Pandemic)?

- INITIAL: No product life cycle assessment

- MANAGED: A few life-cycle aspects are included in some KPIs but occasionally
- DEFINED: Life Cycle Costing (LCC) towards recycling, de- re-manufacturing KPIs
- INTEGRATED: Life Cycle Costing + Environmental LCA towards Circular Economy
- EXPLOITED: Life Cycle Costing + Environmental LCA + Social LCA towards Sustainability and Green Deal

SUPPLY CHAIN: Which dimensions of analysis are taken into account for the overall evaluation of your company's supply chain resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Performance is often not measured or understood
- MANAGED: Only the most important physical performance of suppliers (e.g., punctuality, quality, operational flexibility)
- DEFINED: Physical and Economical performance (purchase price, non-quality costs, delivery delays, lack of flexibility, etc.).
- INTEGRATED: Physical, economical, sustainable performance for almost all the suppliers. In addition, the recovery time of the entire supply chain is monitored to evaluate resilience.
- EXPLOITED: Physical, economic, sustainability, and integration with other external sources (e.g., social media, weather). In addition, both disruption severity and recovery time of the entire supply chain are monitored to evaluate resilience.

Moreover, for each performance, it is asked the AS-IS and TO-BE levels, whether they achieved an improved level, and which types of performances have started to be monitored.

4.2 Result of second Iteration

This sub-chapter aims to clarify and interpret the results observed from the performance survey. Indeed, in each sub-section of this sub-chapter is going to be reported an analysis of the different performances. An anticipation of the results can be reported here, hence, in accordance with what was studied in the extant literature and what emerged from the preliminary interactions with practitioners, none of the performance was considered not applicable, highlighting the key role covered by all of these performances in the resilience of all the manufacturing companies.

4.2.1 Operational and Technical

The respondents of the second iteration of the survey about performances, when asked about the improvement in terms of "Operational and Technical" performances monitoring provided different answers. More in detail, the 33% highlighted their interest in improving their current level stressing the fact that they already improved respect with the first iteration by without reaching the desired level TO-BE. Indeed, they reached a "Managed" level while trying to improve to reach the "defined" level in the future. Indeed, they introduced the following performance indicators:

- Customer satisfaction
- Internal Process Quality
- Employees Satisfaction

The remaining 67% replied that they are not currently interested in focusing their attention on such performances and thus, they did not provide any information about their current state and whether it was different respect with the first iteration.

4.2.2 Economic

Regarding the “Economic” performances considering the already performed investments, the 75% of the respondents to the second iteration highlighted their capacity in having achieved the desired level TO-BE which was expressed during the first iteration of the survey. Indeed, in accordance with their previous AS-IS and desired TO-BE levels, they reached either the “defined” or the “integrated” level. The remaining 25% answered that they improved their level, even though they have not yet achieved the desired TO-BE positioning still either at the “initial” or at the “managed” levels.

Among the new introduced indicators, there are:

- Financial Performance (e.g., revenues, investments)
- Turnover

4.2.3 Economic

The “Economic” performance is also related to the decision-making support for future investments which might be based on economic considerations. In this regard, 50% of respondents replied that, although they are interested in improving their current state, they have not yet reached to desired TO-BE level. The remaining 50% are not interested in improving this aspect.

In general, all the participants have improved their level positioning themselves in either “managed” or “defined” ones.

The indicators that they have introduced are the following:

- Net Present Value
- Internal Rate of Return
- Other specific indicators are under investigation

4.2.4 Environmental

The “Environmental” performances were considered important to be addressed in the future during the first iteration, and the 25% of respondents replied that they have already achieved the desired level TO-BE. The same percentage, the 25%, replied that they are interested in improving but they have not yet achieved the desired TO-BE level. Last, the remaining 50% are not interested in taking into account this type of performance to be resilient in the future.

The respondents are currently positioned at both “managed” and “integrated” levels, and they have introduced methodologies like the “Life Cycle Assessment” and the “environmental footprint assessment.

Moreover, they have installed solar panels and monitoring systems to monitor the energy consumption of their machineries.

4.2.5 Social

The social performances were considered the least important to be resilient in the future. More in detail, the 75% of the respondents did not consider improving themselves in this term since they do not consider this aspect as a priority. The remaining 25% instead aim at improving their current level, although without reaching the desired TO-BE level. Indeed, they are currently at the “initial” level, but they aim to reach the “managed” one.

Among all, they have introduced indicators to monitor the work life balance (especially for the smart working) and gender equality. In the future, they aim to introduce ad hoc surveys for their employees to monitor the advancements and the opinion of their employees.

The other respondents considered important the possibility to keep under control their employee’s well-being, but they have not yet introduced performance indicators to monitor this issue.

4.2.6 Product – service life cycle

Regarding the last performance, “the product-service life cycle”, no one considered it as an opportunity to be more resilient in the future. They are currently understanding how to start monitoring this aspect although it not they highest priority. All the respondents remained at their initial maturity level.

4.2.7 Supply chain

Last, regarding the “supply chain” related performances, although the 50% declared to not be interested in improving this issue, the 25% underlined their capacity in having reached the desired level TO BE and the remaining 25% answered to be interested in improving their current level although they have not yet reached the desired level TO BE. Being at either “initial” or “defined” levels they aim to reach the “managed” or “integrated” levels.

4.3 Gap identification and Suggested actions

The actual results of the survey highlighted the need for companies to better understand the reasons why it would be suggested to keep under control all the above-mentioned performances to be more resilient. Indeed, until now, they are not aware about the possibility to exploit environmental-related indicators to take decisions that could direct towards more resilient solutions, and the same for the social aspect. For instance, having flexible and open- minded employees would benefit the company in addressing disruptive events.

Additionally, the product-service system together with the lifecycle perspective are both important issues to be considered when looking at resiliency. Indeed, the possibility to deliver services rather than producing only products might be good to enhance flexibility and

the lifecycle perspective is even more important in this context to take decisions on the long term and not only on the short term.

It is hence suggested to enhance awareness in companies to start investigating on how to start monitoring these performances to improve their current level and keep under control the relevant performances.

Regarding the suggested KPIs to be monitored in the future, below a list is reported divided by the specific performance to be taken into account:

- OPERATIONAL/TECHNICAL:
  - Percentage of projects completed on time and within budget
  - Number of reworked items and related time and resources loss
- ECONOMIC:
  - Return on investment (ROI)
  - Payback time
  - Net Profit Value (NPV)
- ENVIRONMENTAL:
  - Environmental impact assessments for new projects
  - Compliance with environmental regulations and standards
- SOCIAL:
  - Employee satisfaction and engagement surveys
  - Health and safety incidents and lost time due to injury or illness
- SUPPLY CHAIN:
  - Supplier performance metrics such as on-time delivery and quality
  - Supply chain risk assessments and mitigation plans

5 Workforce training surveys

5.1 Introduction to survey structure - goal - audience

This sub-chapter aims to clarify the key elements characterising the skills-related surveys: the goal of these surveys, the audience addressed in these surveys, and the structure of the surveys.

5.1.1 Goal

III. Voting survey

This survey has the main objective of Introducing new skills, roles, and professions about DATA, Resilience, and Emerged roles or skills during Covid-19 and voting to relevant Skills. The main goal of second iteration of this survey is to examine the views of the project partners, according to the experiences gained during the months of project, whether they have maintained the prioritization of their skills or whether they need to change the priority of skills, in addition, there is a possibility to add or remove skills.

IV. Possessed and Needed survey.

This survey has the main objective of analysing the Possessed and Needed of (AS-IS) and partners' expectation (TO-BE) situation about new skills, roles, and professions. Since the AS-IS situation of partners have been analysed in the first iteration of the survey, the main purpose of second Iteration of this surveys is to investigate the (TO-BE) conditions, expectations, and the extent of their improvement compared to the start of the project. In this survey, the partners can also express the level of improvement (from basic to expert) and the method of improvement and share it with other project partners.

5.1.2 Audience

The target audience is companies, especially manufacturing companies (internal project partners), which dealt with the rising exogenous changes and issues (e.g., COVID-19) that can be considered the causes affecting the entire organization and, especially their core business activities, asking them for greater levels of resilience. Indeed, for **voting** survey all individual internal to the project team can participate, while for **possessed and needed** survey representatives of different companies were asked to participate in the survey (i.e., one person for each company) to answer in the name of the company itself. In addition, the anonymity was ensured to avoid sharing confidential information.

5.2 Result of second Iteration

5.2.1 Voting survey

In the second iteration of the voting survey, the main goal is to collect the opinions of the project partners regarding the skills assigned to each job title after months of gaining experience from the project. The preliminary focus in this stage is to compare the results of the second iteration with the first one (which is reported in the section 3.1.2.1 and D5.3),

record the main skills, and remove the skills not related to each job title. (13 votes have been received)

Data Science Manager

Based on the responses received for “Data Science Manager” – Figure 3; Skills can be divided into three categories; The most important skills are “Develop and execute the data strategies – 23.33%”.

Then “Communication with domain experts – 20%”, “Knowledge about domain-specific processes- 20%”, and “Manage the data science team and resources – 20%” are in the second place.

Finally, “Knowledge about business processes – 6.67%” and “Knowledge about performance indicators – 10%” are less important than others.

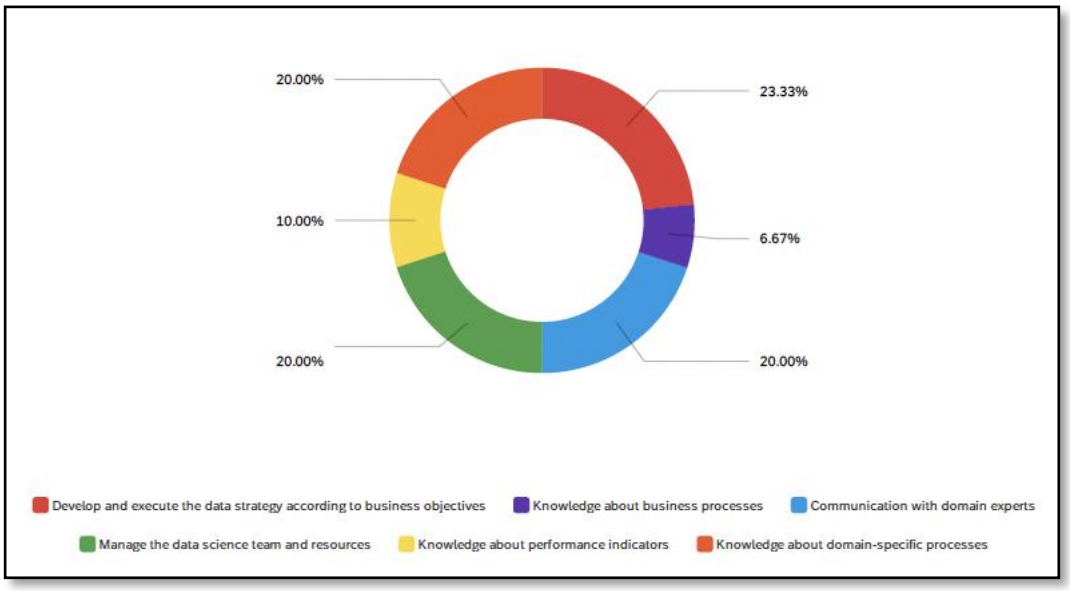


Figure 3 Data science manager - result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; according to the project partners' opinion, based on their experiences and organizations’ conditions the skills mentioned below are more important than other ones:

a) Develop and execute the data strategies.

b) Communication with domain experts.

c) Knowledge about domain-specific processes.

d) Manage the data science team and resources.

but the skills of the third category which are “Knowledge about business processes “and “Knowledge about performance indicators” have lower importance, as a result, these two skills are ignored in this job title.

In order to improve the main skills, courses in the section 5.3 have been suggested that each of the partners can strengthen their knowledge and expertise in these skills by participating in these courses. (This part is also applicable to other roles and skills).

Data Scientist

Skills related to this job title – Figure 4, in terms of importance can be divided into high priority " Use of machine learning, Bays classifier, Deep learning, and OR methods – 18.92 %", "Identify and Interpret relevant data sources – 18.92%", and "Ability to use a programming language – 18.92 %", medium priority "Use of optimization algorithm – 16.22%", "mathematical and statistical models knowledge – 13.51%", then "communicate with domain expert – 8.11%", as well as "Knowledge about domain-specific process – 5.41%" have low priorities.

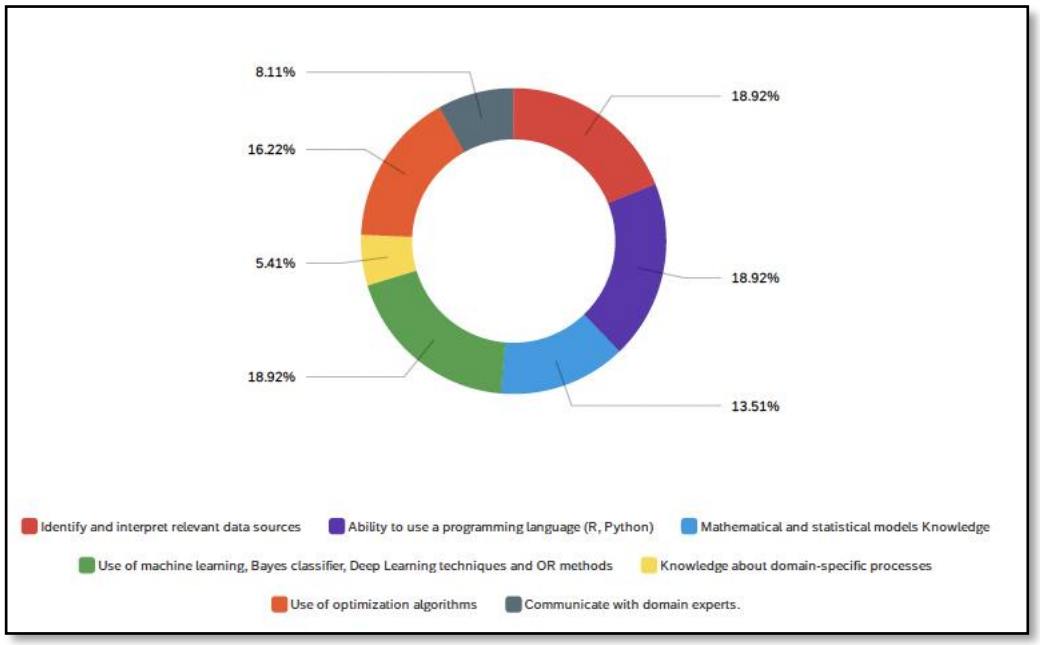


Figure 4 Data scientist – result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; the skills mentioned below are more important than the other ones:

a) Use of machine learning, Bays classifier, Deep learning and OR methods.

b) Identify and interpret relevant data sources.

c) Ability to use a programming language.

d) Use of optimization algorithm.

e) mathematical and statistical models' knowledge.

But the skills of the third category which are "communicate with domain expert "and "Knowledge about domain-specific process" have lower importance, as a result, these two skills are ignored in this job title.

One of the significant results in the second iteration for this job title is related to the skill of "communicate with domain expert" which was mentioned as one of the main skills of this job in the first iteration, but after the months of the project and since the partners become more familiar with the content of the activities of this job title, based on their opinion this skill and skills of "Knowledge about domain-specific process" received fewer votes than other skills.

Data Science Architect

In this job profile – Figure 5, all the identified skills are nearly equal in importance, but it should be noted that according to the project partners' point of view "Ability to select software platforms for big data (Hadoop, Data Lake, …) – 30.43%" and "knowledge about big data architectural standards – 30.43%" are more significant than the other skills.

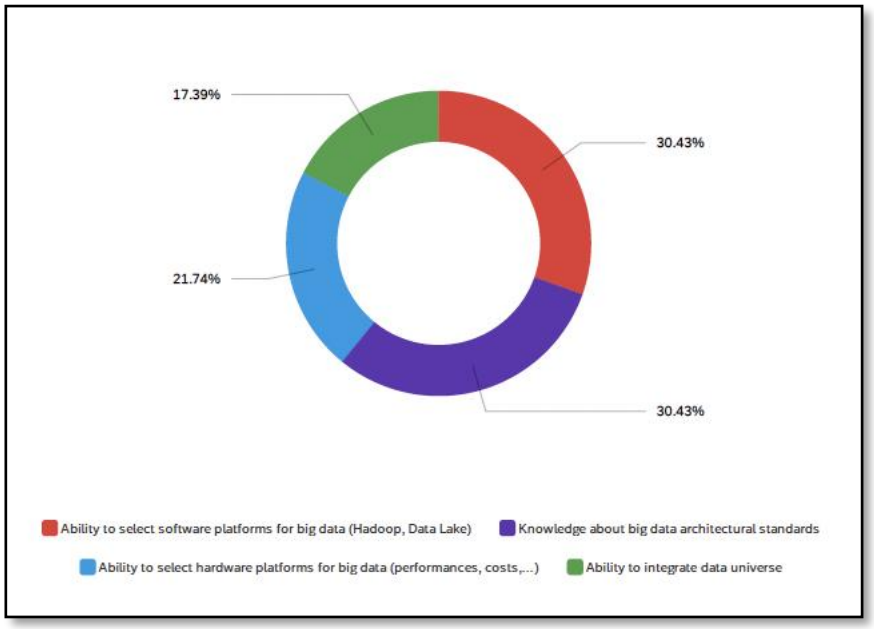


Figure 5 Data science architect – result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; all the skills assigned to this job title have been correctly introduced and they can all be considered among the main skills of this job.

a) Ability to select software platforms for big data (Hadoop, Data Lake).
b) Knowledge about big data architectural standards.
c) Ability to select hardware platforms for big data (performances, costs, etc.).
d) Ability to integrate data universe.

Data Engineer

In this role – Figure 6, four main skills are "knowledge about data storage and query languages – 26.92%", "Develop data models and workflows – 23.08%", "Ability to maintain security, quality, integrity, safety, and availability of data – 19.23%", and "Ability to integrate new data technologies into existing systems – 19.23%", which are related to information about new technologies and how to use them in existing systems and organizations.

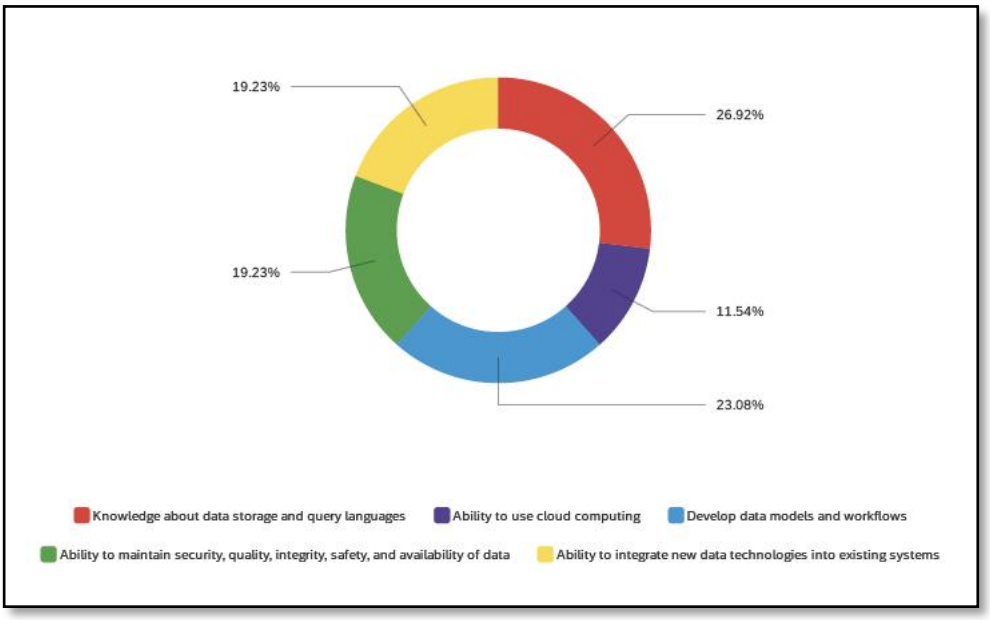


Figure 6 Data engineer – result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; the skills mentioned below are more important than other ones:

a) Knowledge about data storage and query languages.

b) Develop data models and workflows.

c) Ability to maintain security, quality, integrity, safety, and availability of data.

d) Ability to integrate new data technologies into existing systems.

but the skill about “Ability to use cloud computing” has lower importance, as a result, this skill ignored in this job title.

Visual Data Designer

As can be seen in the Figure 7, the most important skills of this job are “Create infographics (maps, charts, diagrams) – 24 %”, and “Develop interface and interaction to increase user experience – 20 %” which are related to better display data and create better communication with users.

Then “Visualize the huge and complex volume of data – 16%”, “Develop insightful and engaging data analytics view”, and “Develop vector graphics, scientific illustrations, and icons – 12%” are in the second place.

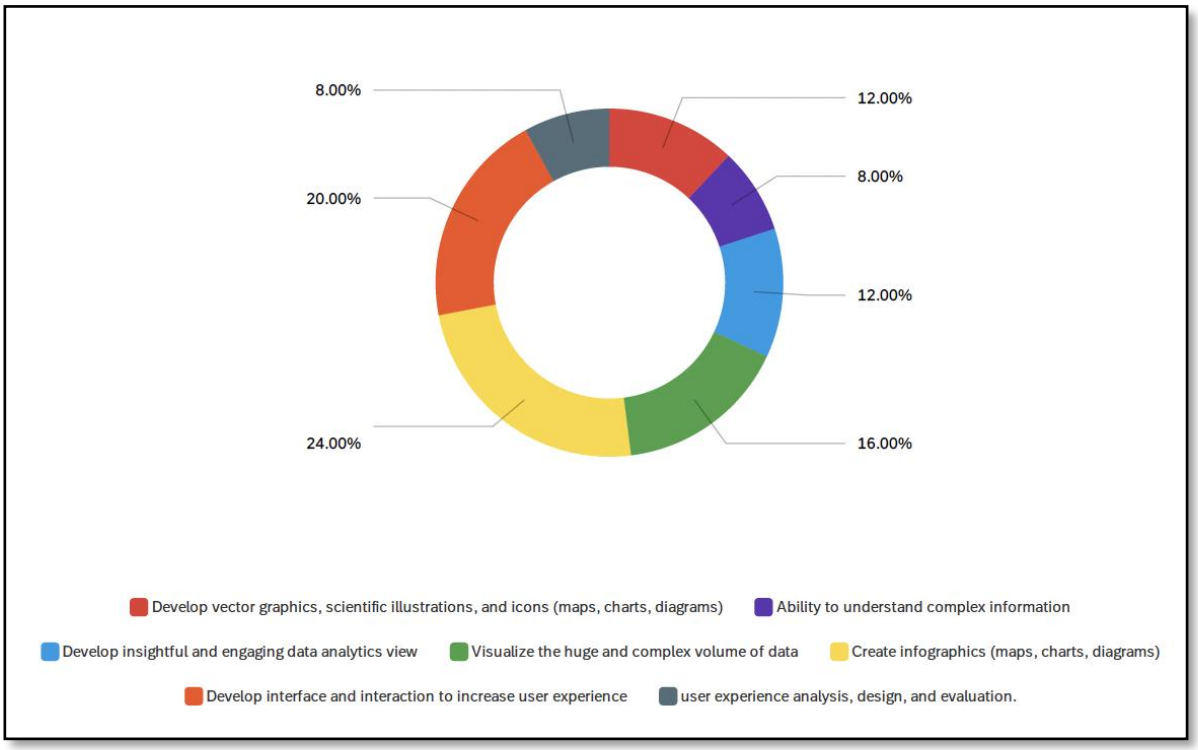


Figure 7 Visual data designer- result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; the skills mentioned below are more important than other ones:

a) Create infographics (maps, charts, diagrams).

b) Develop interface and interaction to increase user experience.

c) Visualize the huge and complex volume of data.

d) Develop insightful and engaging data analytics views.

e) Develop vector graphics, scientific illustrations, and icons.

but the skills about “Ability to understand complex information”, and “user experience analysis, design, and evaluation” have lower importance, as a result, these skills are ignored in this job title.

Remote Workers

Since people in this role work from outside the company environment, skills such as “Use applications to increase sensory, physical, and cognitive abilities – 36.36%”, and “Interpret quantitative data, graphs (KPIs), and 3D digital models – 27.27%” are crucial and according to the responses received from project partners “Understand and use additive manufacturing / AI technologies and mathematical models- 18.18%”, and “Perform scenario analysis to evaluate and prepare for possible interventions – 18.18%”, are the skills with less importance compared to others (Figure 8).

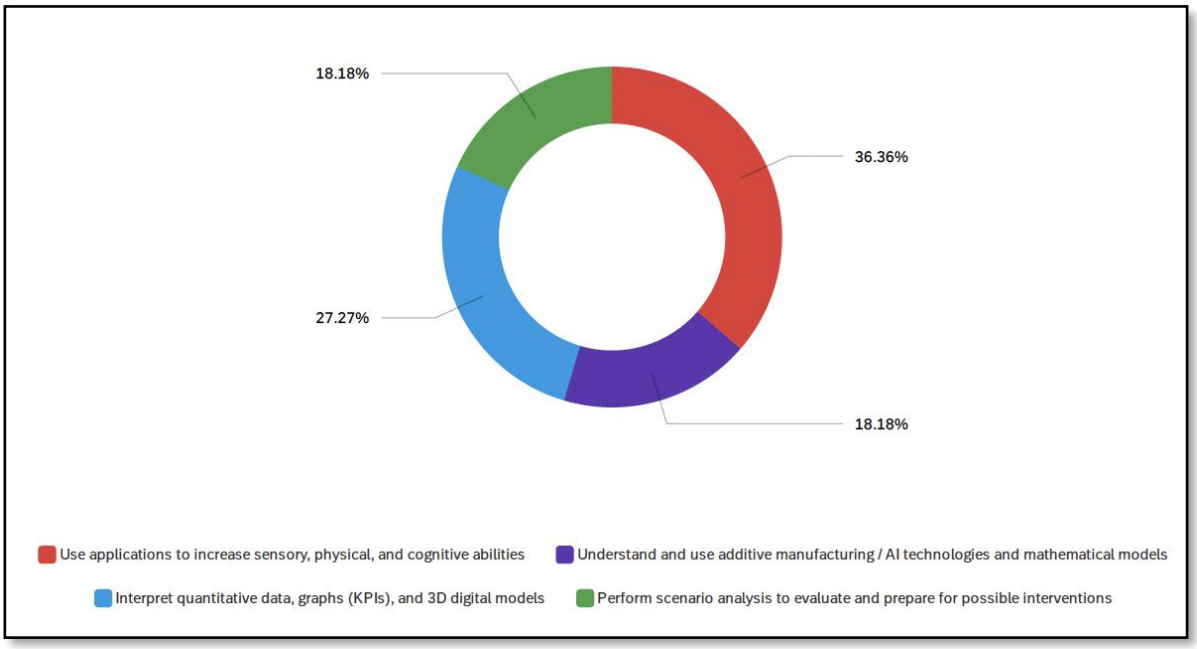


Figure 8 Remote worker - result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; all the skills assigned to this job title have been correctly introduced and they can all be considered among the main skills of this job.

a) Interpret quantitative data, graphs (KPIs), and 3D digital models.

b) Use applications to increase sensory, remote, and cognitive abilities.

c) Perform scenario analysis to evaluate and prepare for possible interventions.

d) Understand and use additive manufacturing technologies and mathematical models.

Resilience Manager

This job, which has been analyzed at the management level, needs to improve some skills due to the growing trend of technology and rising new crises. The most important of which (Figure 9) are related to “Foresee elements of flexibility, when necessary, in redesigning production process – 25.93%”, and “Engage and dialogue with stakeholders and trade unions to better manage change related to the introduction of new technologies – 18.52%”.

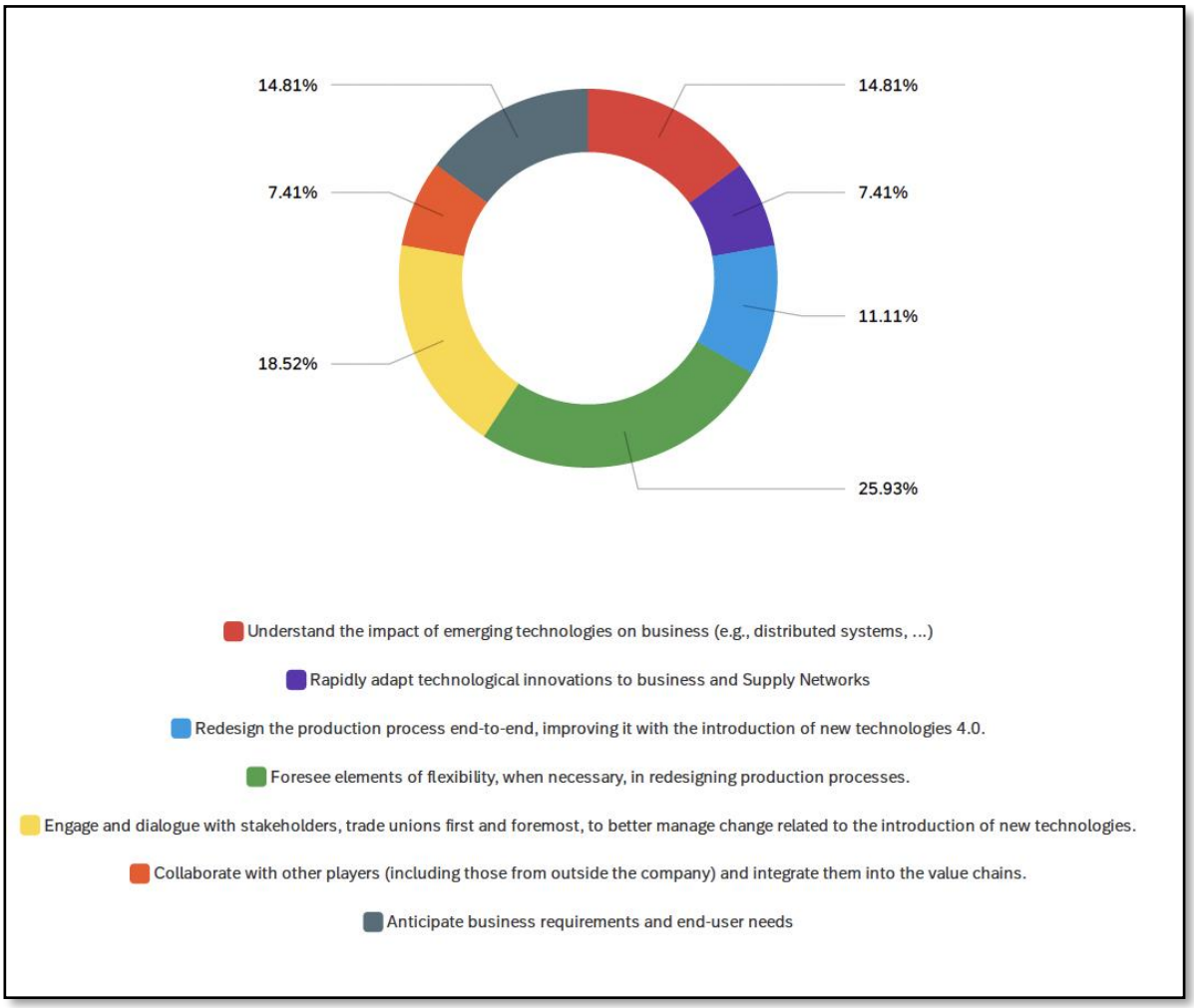


Figure 9 Resilience manager - result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; the skills mentioned below are more important than other ones:

a) Foresee elements of flexibility, when necessary, in redesigning the production process.

b) Engage and dialogue with stakeholders and trade unions to better manage change related to the introduction of new technologies.

c) Understand the impact of emerging technologies on business.

d) Anticipate business requirements and end-user needs.

e) Redesign the production process end to end, improving it with the introduction of new technologies 4.0.

but the skills about “Collaborate with other players (including those from outside the company) and integrate them into the value chains”, and “Rapidly adapt technological innovations to business and supply networks” have lower importance, as a result, these skills are ignored in this job title.

Repurposing supervisor

This job profile (Figure 10) has been analyzed in professional level. Its skills need to be improved in line with trend of new technologies. Therefore, the most important skills which have been considered by project partners are “Identify opportunities for new/alternative applications of existing components, products, machines, etc. – 20.83%”, and “Knowledge about reduce, reuse, and recycle wastes – 20.83%”.

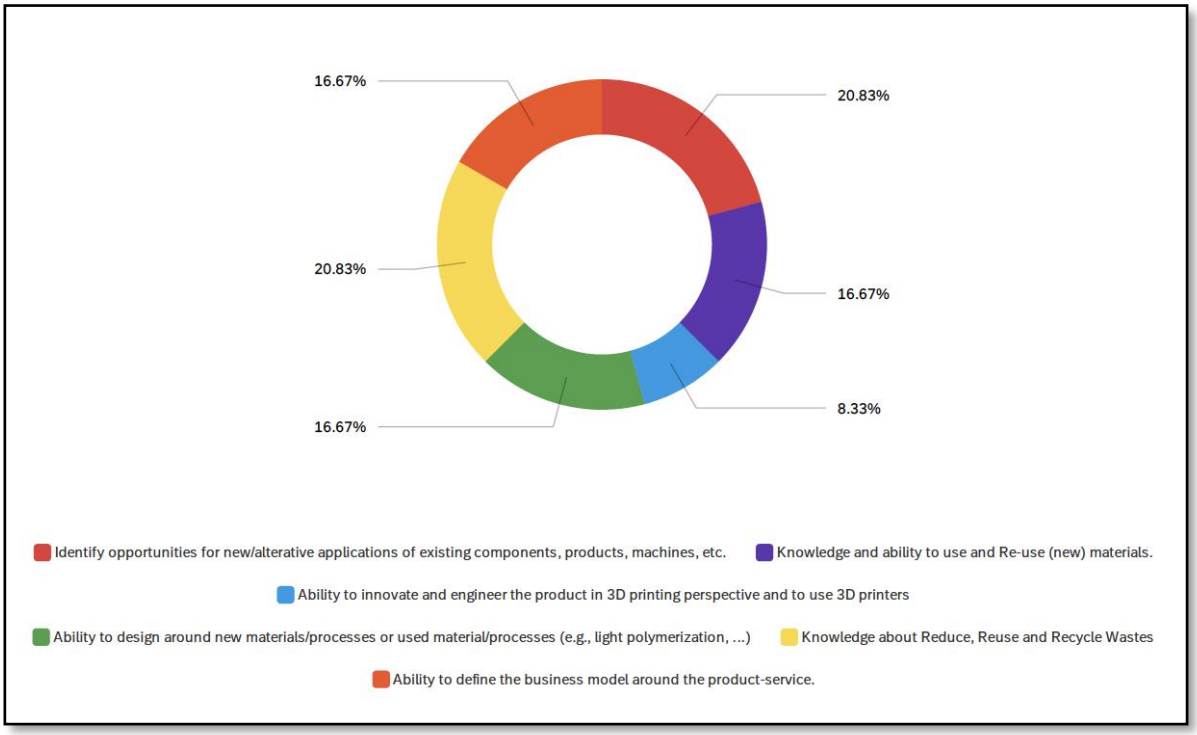


Figure 10 Repurposing supervisor - result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; the skills mentioned below are more important than other ones:

a) Identify opportunities for new/alternative applications of existing components, products, machines, etc.

b) Knowledge about reduce, reuse, and recycle wastes.

c) Ability to design around new materials / processes or used material/processes.

d) Ability to define the business model around the product service.

e) Knowledge and ability to use and re-use materials.

but the skill about “Ability to innovate and engineer the product in 3D printing perspective and to use 3D printers” has lower importance, as a result, this skill ignored in this job title.

Operator 4.0

This job title (Figure 11) is a role that is analyzed at the worker level. Crucial skills in this profile are about “Analytical skills to interpret data from operation – 28.57%” and “Use sensors, actuators, ports, antennas, HMI standards – 28.57%” which are mostly related to using new technologies and interpreting production data by workers.

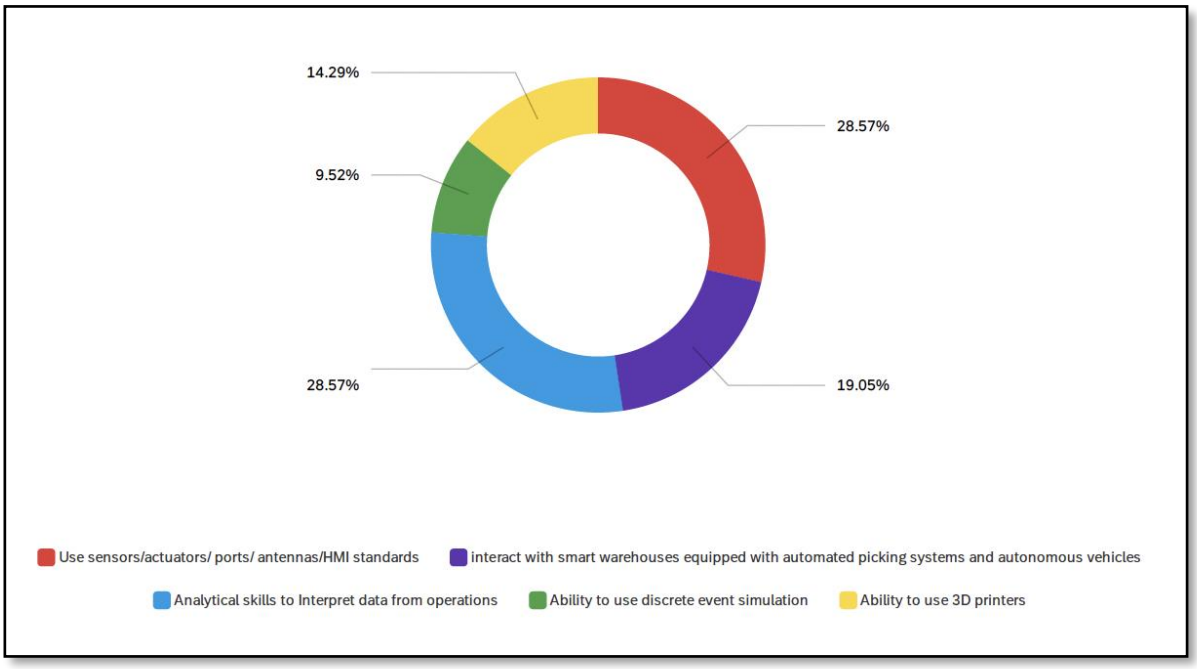


Figure 11 Operator 4.0 - result of voting survey – 2nd Iteration

By comparing the results of first iteration and the second one, it can be concluded that; the skills mentioned below are more important than other ones:

a) Analytical skills to interpret data from the operation.

b) Use sensors, actuators, ports, antennas, and HMI standards.

c) Interact with smart warehouses equipped with automated picking systems and autonomous vehicles.

d) Ability to use 3D printers.

but the skill about “Ability to use discrete event simulation” has lower importance, as a result, this skill ignored in this job title.

5.2.2 Soft Skills

In addition to technical skills (which are mentioned In Section 5.2.1), Soft skills have been also analyzed at three different levels: Management, Professional, and Worker levels, which in the Table 2 you can see the results of the 2nd iteration of the survey.

Table 2 Soft skills in three different levels

#	Field	Managers	Professionals	Workers
1	Teamwork	6.32%	10.81%	17.39%
2	communication	6.32%	8.11%	6.52%
3	Professional ethics	6.32%	4.05%	6.52%
4	Problem solving	7.37%	6.76%	10.87%
5	Critical thinking	7.37%	5.41%	6.52%
6	Innovation	7.37%	8.11%	2.17%
7	Emotional Judgment	5.26%	1.35%	0.00%
8	Speak second language	5.26%	5.41%	0.00%
9	Time managemnt	5.26%	9.46%	4.35%
10	Interpersonal skills	7.37%	10.81%	10.87%
11	Critical problem solving	6.32%	2.70%	6.52%
12	Digital literacy problem solving	4.21%	4.05%	4.35%
13	Self-managemnt	5.26%	9.46%	13.04%
14	Digital skills	4.21%	8.11%	8.70%
15	Ethical - Legal mindset	8.42%	2.70%	2.17%
16	Global Perspective	7.37%	2.70%	0.00%
		95	74	46

According to the answers received from the project partners, it can be concluded that skills related to “Ethical and legal mindset, International perspective, innovation, critical thinking in critical situations, problem solving, and Interpersonal Skills” are the most important soft skills at the management level.

Skills about “Teamwork, internal and external organizational Communication, innovation, time management, Interpersonal Skills, digital skills, and Self-management in different situations” are crucial skills at the professional level.

In addition, “Teamwork, interpersonal skills, Problem-solving mindset especially during crises, and self-management” at the labor level are more important than others.

Furthermore, as can be seen, Interpersonal skills are a common skill for all three levels, as well as Teamwork and self-management at professional and worker levels, which indicates the importance of these skills in the workplace.

5.2.3 Possessed and Needed survey

In order to assess the AS-IS situation of the project partners and also their future expectations in relation to the jobs introduced in D5.3 and Section 5 of this deliverable, the second survey entitled “Possessed and Needed” was asked of partners, in this survey partners specify whether they need these skills in their company or were currently improve and using them. To display this information, a numerical range between 1 and 5 has been used, in which 1 depicts "basic level required" and 5 shows "expert level required".

The most important purpose of this chapter is to compare the AS-IS situation and TO-BE condition (end of the project), finding the gap between them and the possible activities of the partners to bridge these gaps.

This survey was published in online mode[7] and in the following sections, the results of its second iteration and a comparison between the first and second iteration are depicted (based on the eight votes received).

Data Science Manager

Regarding this job profile, in the first iteration, four out of eight industrial partners stated that they possessed it now or will need it in the near future. According to Table 3, the skills introduced for this job are needed in these four partners at the intermediate to expert level or they already possessed them in these levels.

Table 3 Data science manager - possessed and needed survey – 1st iteration

#	Field	N/A	1	2	3	4	5	Total
1	A: Develop and execute the data strategy according to business objectives	0.00%	0.00%	0.00%	25.00%	25.00%	50.00%	4
2	B: Knowledge about business processes	0.00%	0.00%	0.00%	0.00%	50.00%	50.00%	4
3	C: Communication with domain experts	0.00%	0.00%	0.00%	0.00%	25.00%	75.00%	4
4	D: Manage the data science team and resources	0.00%	25.00%	0.00%	0.00%	25.00%	50.00%	4
5	E: Knowledge about performance indicators	0.00%	0.00%	0.00%	50.00%	25.00%	25.00%	4
6	F: Knowledge about domain-specific processes	0.00%	0.00%	0.00%	50.00%	25.00%	25.00%	4

According to the second iteration (Table 4) of this survey, three out of four partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners correctly predicted the future status of their organization in the first stage, and they were able to reach the intermediate and professional level in some of the skills of this job profile through training courses, hiring new personnel, up-re-skilling and making new collaborations.

[7] https://polimi.eu.qualtrics.com/jfe/form/SV_bqJ3lzFpVb7fbUy

Table 4 Data science manager - possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3- Intermediate	4- Upper Intermediate	5- Expert
1	As - Is (M1 of project)	33.33%	0.00%	33.33%	33.33%	0.00%
2	To - Be (Now till End of project)	0.00%	33.33%	0.00%	33.33%	33.33%

Data Scientist

Regarding “Data Scientist” role, in the first iteration, as it is shown in Table 5, five out of eight partners stated that they possessed its skills now or will need it in the near future. According to the Table 4 the skills introduced for this job are needed in these five partners at the intermediate to expert level or they already possessed them in this level.

Table 5 Data scientist - possessed and needed survey – 1st iteration.

#	Field	N/A	1	2	3	4	5	Total
1	A: Identify and interpret relevant data sources	0.00%	0.00%	20.00%	0.00%	60.00%	20.00%	5
2	B: Ability to use a programming language (R, Python)	0.00%	0.00%	0.00%	0.00%	20.00%	80.00%	5
3	C: Mathematical and statistical models Knowledge	0.00%	0.00%	0.00%	20.00%	0.00%	80.00%	5
4	D: Use of machine learning, Bayes classifier, Deep Learning techniques, and OR methods	0.00%	0.00%	0.00%	0.00%	40.00%	60.00%	5
5	E: Knowledge about domain-specific processes	0.00%	0.00%	20.00%	20.00%	20.00%	40.00%	5
6	F: Communicate with domain experts	0.00%	0.00%	0.00%	20.00%	40.00%	40.00%	5
7	G: Use of optimization algorithms	0.00%	0.00%	0.00%	20.00%	20.00%	60.00%	5

According to the second iteration (Table 6) of this survey, two out of five partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners correctly predicted the future status of their organization in the first stage, and they were able to reach the intermediate and professional level in some of the skills of this job profile through developing new experiments, training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 6 Data scientist - possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5- Expert
1	As - Is (M1 of project)	0.00%	0.00%	50.00%	50.00%	0.00%
2	To - Be (Now till End of project)	0.00%	0.00%	50.00%	0.00%	50.00%

Data Science Architect

In this role, in the first iteration, six out of eight partners stated that they possessed its skills now or will need it in the near future. According to the Table 7, the skills introduced for this job are needed in these six partners at the upper intermediate and expert levels or they already possessed them in these levels.

Table 7 Data science architect - possessed and needed survey – 1st Iteration

#	Field	N/A	1	2	3	4	5
1	A: Ability to select software platforms for big data (Hadoop, Data Lake)	0.00%	0.00%	0.00%	0.00%	20.00%	36.36%
2	B: Knowledge about big data architectural standards	0.00%	0.00%	0.00%	0.00%	40.00%	18.18%
3	C: Ability to select hardware platforms for big data (performances, costs,...)	0.00%	0.00%	0.00%	66.67%	20.00%	18.18%
4	D: Ability to integrate data universe	0.00%	0.00%	0.00%	33.33%	20.00%	27.27%

According to the second iteration (Table 8) of this survey, four out of six partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners could not approach the expert level in this job position as much as they specified in the first month of the project, but they were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 8 Data science architect - possessed and needed survey – 2nd Iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5 - Expert
1	As - Is (M1 of project)	0.00%	100.00%	0.00%	50.00%	0.00%
2	To - Be (Now till End of project)	0.00%	0.00%	100.00%	50.00%	0.00%

Data Engineer

Regarding this profile, in the first iteration, as it is shown in Table 9, five out of eight partners stated that they possessed its skills now or will need it in the near future. The skills introduced for this job are needed in these five partners at intermediate to expert levels or they already possessed them in these levels.

Table 9 Data engineer - possessed and needed survey – 1st iteration.

#	Field	N/A	1	2	3	4	5	Total
1	A: Knowledge about data storage and query languages	0.00%	0.00%	0.00%	0.00%	40.00%	60.00%	5
2	B: Ability to use cloud computing	0.00%	0.00%	0.00%	20.00%	40.00%	40.00%	5
3	C: Develop data models and workflows	0.00%	0.00%	0.00%	20.00%	40.00%	40.00%	5
4	D: Ability to maintain security, quality, integrity, safety, and availability of data	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	5
5	E: Ability to integrate new data technologies into existing systems	0.00%	0.00%	0.00%	0.00%	20.00%	80.00%	5

According to the second iteration (Table 10) of this survey, three out of five partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners could not approach the expert level in this job position as much as they specified in the first month of the project, but they were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 10 Data engineer - possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5 - Expert
1	As - Is (M1 of project)	33.33%	33.33%	33.33%	0.00%	0.00%
2	To - Be (Now till End of project)	0.00%	33.33%	33.33%	33.33%	0.00%

Visual Data Designer

In this Job profile, in the first iteration, as it is shown in Table 11, four partners out of eight stated that they possessed its skills now or will need it in the near future. According to the votes received can be concluded that the level which partners are currently at or need to reach is in the intermediate to expert levels.

Table 11 Visual data designer- possessed and needed survey – 1st iteration.

#	Field	N/A	1	2	3	4	5	Total
1	A: Develop vector graphics, scientific illustrations, and icons (maps, charts, diagrams)	0.00%	0.00%	0.00%	0.00%	25.00%	75.00%	4
2	B: Ability to understand complex information	0.00%	0.00%	50.00%	25.00%	0.00%	25.00%	4
3	C: Develop insightful and engaging data analytics view	0.00%	0.00%	0.00%	0.00%	50.00%	50.00%	4
4	D: Visualize the huge and complex volume of data	0.00%	0.00%	25.00%	25.00%	25.00%	25.00%	4
5	E: Create infographics (maps, charts, diagrams)	0.00%	0.00%	0.00%	0.00%	25.00%	75.00%	4
6	F: Develop interface and interaction to increase user experience	0.00%	0.00%	0.00%	0.00%	50.00%	50.00%	4
7	G: User experience analysis, design, and evaluation	0.00%	0.00%	0.00%	25.00%	50.00%	25.00%	4

According to the second iteration (Table 12) of this survey, two out of four partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners could not approach the expert level in this job position as much as they specified in the first month of the project, but they were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 12 Visual data designer- possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5 - Expert
1	As - Is (M1 of project)	0.00%	50.00%	50.00%	0.00%	0.00%
2	To - Be (Now till End of project)	0.00%	0.00%	0.00%	100.00%	0.00%

Remote Workers

For this role, in the first iteration, three out of eight partners stated that they possessed its skills now or will need it in the near future. According to the Table 13, the skills introduced for this job are needed in these three partners mostly at intermediate and expert levels or they already possessed them in this level.

Table 13 Remote worker - possessed and needed survey – 1st iteration.

#	Field	N/A	1	2	3	4	5	Total
1	A: Use applications to increase sensory, remote, and cognitive abilities	33.33%	0.00%	0.00%	0.00%	33.33%	33.33%	3
2	B: Interpret quantitative data, graphs (KPIs), and 3D digital models	0.00%	33.33%	0.00%	33.33%	0.00%	33.33%	3
3	C: Understand and use additive manufacturing technologies and mathematical models	33.33%	33.33%	0.00%	0.00%	0.00%	33.33%	3
4	D: Perform scenario analysis to evaluate and prepare for possible interventions	0.00%	0.00%	0.00%	33.33%	33.33%	33.33%	3

According to the second iteration (Table 14) of this survey, two out of three partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners could not approach the expert level in this job position as much as they specified in the first month of the project, but they were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through demonstrator and prototype development and testing, training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 14 Remote worker - possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5 - Expert
1	As - Is (M1 of project)	0.00%	0.00%	100.00%	0.00%	0.00%
2	To - Be (Now till End of project)	0.00%	0.00%	50.00%	50.00%	0.00%

Resilience Manager

Regarding this job profile, in the first iteration, three out of eight industrial partners stated that they possessed it now or will need it in the near future. According to the Table 15, the skills introduced for this job are needed in these three partners at the intermediate to expert levels or they already possessed them in these levels.

Table 15 Resilience manager - possessed and needed survey – 1st iteration.

#	Field	N/A	1	2	3	4	5	Total
1	A: Understand the impact of emerging technologies on business (e.g., distributed systems, ...)	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	3
2	B: Rapidly adapt technological innovations to business and Supply Networks	0.00%	0.00%	0.00%	0.00%	33.33%	66.67%	3
3	C: Redesign the production process end-to-end, improving it with the introduction of new technologies 4.0.	0.00%	33.33%	0.00%	0.00%	0.00%	66.67%	3
4	D: Foresee elements of flexibility, when necessary, in redesigning production processes	0.00%	0.00%	33.33%	33.33%	33.33%	0.00%	3
5	E: Engage and dialogue with stakeholders, trade unions first and foremost, to better manage change related to the introduction of new technologies	0.00%	0.00%	0.00%	0.00%	66.67%	33.33%	3
6	F: Collaborate with other players (including those from outside the company) and integrate them into the value chains	0.00%	0.00%	0.00%	33.33%	0.00%	66.67%	3
7	G: Anticipate business requirements and end-user needs	0.00%	0.00%	0.00%	33.33%	0.00%	66.67%	3

According to the second iteration (Table 16) of this survey, two out of three partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners could not approach the expert level in this job position as much as they specified in the first month of the project, but they were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through interaction with stakeholders, training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 16 Resilience manager - possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5 - Expert
1	As - Is (M1 of project)	0.00%	50.00%	0.00%	50.00%	0.00%
2	To - Be (Now till End of project)	0.00%	0.00%	50.00%	50.00%	0.00%

Repurposing supervisor

Regarding this job profile, in the first iteration, "Table 17" only one answer was received, and according to the supplementary comments, it can be understood that it needs the skills related to this job at the intermediate to expert levels.

Table 17 Repurposing supervisor - possessed and needed survey – 1st iteration

#	Field	N/A	1	2	3	4	5	Total
1	A: Identify opportunities for new/alternative applications of existing components, products, machines, etc.	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	1
2	B: Knowledge and ability to use and Re-use (new) materials	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	1
3	C: Ability to innovate and engineer the product in 3D printing perspective and to use 3D printers	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	1
4	D: Ability to design around new materials/processes or used material/processes (e.g., light polymerization, ...)	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	1
5	E: Knowledge about Reduce, Reuse and Recycle Wastes	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	1
6	F: Ability to define the business model around the product-service	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	1

According to the second iteration of this survey, the partner stated that has already improved its skills related to this job title. By comparing the first and second iterations, it is possible to conclude that this partner could not approach the expert level in this job position as much as specified in the first month of the project but were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through interaction with stakeholders, training courses, hiring new personnel, up-re-skilling and making new collaborations.

Operator 4.0

In this role, in the first iteration, four out of eight partners stated that they possessed it now or will need it in the near future. According to the Table 18, the skills introduced for this job are needed in these four partners at the intermediate to expert levels or they already possessed them in these levels.

Table 18 Operator 4.0 - possessed and needed survey – 1st iteration.

#	Field	N/A	1	2	3	4	5	Total
1	A: Interact with smart warehouses equipped with automated picking systems and autonomous vehicles	25.00%	0.00%	0.00%	50.00%	25.00%	0.00%	4
2	B: Ability to use discrete event simulation	50.00%	25.00%	0.00%	25.00%	0.00%	0.00%	4
3	C: Analytical skills to Interpret data from operations	0.00%	0.00%	0.00%	75.00%	0.00%	25.00%	4
4	D: Use sensors/actuators/ ports/ antennas/HMI standards	25.00%	0.00%	0.00%	25.00%	25.00%	25.00%	4
5	E: Ability to use 3D printers	50.00%	0.00%	0.00%	25.00%	0.00%	25.00%	4

According to the second iteration (Table 19) of this survey, two out of four partners stated that they have already improved their skills related to this job title.

By comparing the first and second iterations, it is possible to conclude that the partners could not approach the expert level in this job position as much as they specified in the first month of the project, but they were able to reach the intermediate and upper intermediate level in some of the skills of this job profile through developing new experiments, training courses, hiring new personnel, up-re-skilling and making new collaborations.

Table 19 Operator 4.0 - possessed and needed survey – 2nd iteration.

#	Field	1- Basic	2- Lower Intermediate	3 - Intermediate	4 - Upper Intermediate	5 - Expert
1	As - Is (M1 of project)	0.00%	0.00%	50.00%	50.00%	0.00%
2	To - Be (Now till End of project)	0.00%	0.00%	0.00%	100.00%	0.00%

5.3 Gap identification and Suggested actions

Since one of the main solutions to improve skills and bridge gaps was to participate in training courses, in this section, according to the skills and jobs introduced in the previous a number of training courses from reputable sources such as the I4MS training catalogue[8], Polimi Open Knowledge[9], Coursera[10], Udemy[11], are listed.

In this step, first of all, three levels “Awareness”, “Foundations”, and “Extended Know-How” were considered which Awareness refers to general knowledge and information to get familiar to the subject. Foundation refers to basic useful information with more detail compared to awareness level, and Extended Know-How refers to a range of information that can help audience to increase their level of knowledge and understanding of how to use the

[8] https://i4ms.eu/trainings/
[9] www.pok.polimi.it
[10] https://www.coursera.org/
[11] https://www.udemy.com/

technology. Then, each of the training courses that were introduced in “I4MS Catalogue of Trainings”, “POLIMI open knowledge”, Coursera, and Udemy were analyzed and the correlation between jobs and related skills and these courses at three levels were defined (Table 21).

Table guide:

Table 20 Table guide

Numbers and letters in the Table 21	meaning
1	Awareness level
2	Foundations level
3	Extended Know-How level
a- b - c -… -z	Approved skills for each job title (shown in the section 5.2.1)

Table 21 Database of training activities

Job Profiles and important skills																																				
Courses	Data Science Manager				Data Science Architect				Data Scientist					Visual Data Designer					Data Enginner				Remote Worker				Resilience Manager					Repurposing supervisor					Operator 4.0			
	a	b	c	d	a	b	c	d	a	b	c	d	e	a	b	c	d	e	a	b	c	d	a	b	c	d	a	b	c	d	e	a	b	c	d	e	a	b	c	d
AI Opportunities for SMEs	1		1						3			1							3			2																
Artificial Intelligence and legal issues	1					1									2						3	1			1														
Data science, visualization and interactive narratives for CCIs	1		2	2	2	2		1	2	1					2		1	2	2		1	1																	
I4.0 Workshop			1	1	1				2	1		1										1				1											1			
Blockchain Technology in Manufacturing Industry		1			1	2			2			1			2		2				1	2				2														
Increasing Work Efficiency through Innovative Digital Tools and Technologies			1	1		1			2	1		1							2			2																	
Industrial Internet of Things – An Introduction to IIoT	1		2	1				1						1		1				2	1	2															1			
Industry 4.0 Fundamentals & Certification									1										1					1														1		
Industry 4.0 Technologies & IIoT Data Platform			1			2								1	1					1																			
Integrate Human Factors, Cognitive and Behavioral Analysis, to improve the acceptability of Innovations and New Digital Tools		1	1						1													1		2													1		
Internet of Things and Big Data	1		2	1	1		2			1										2		2				1													
Introduction to INDUSTRY 4.0			1	1	1		1															1																	
Management of Large-Scale Projects in Manufacturing Companies through ICT		1												1			1						1		1												1			

Process Mining and Predictive Process Monitoring														3		1			
Value Stream Analysis 4.0																				
Artificial Intelligence - An Overview	1		1	1	1		3	1		1		1	3						2	
Assessing HPC readiness for SMEs																				
Ethics of Artificial Intelligence			1							1										
Technologies and platforms for Artificial Intelligence	1		2						3			2								
IBM AI Engineering Professional Certificate	1				1		1	1	3	1	1	2	2							2
Data Science: Statistics and Machine Learning Specialization					1		1	1	2	2		3	3		1				2	2
Software Architecture for Big Data Specialization					2	3	2	2	1	1	1	1	1	1	1	1	1	1	1	
Information Visualization: Foundations					1		1			1				2	2	1	1	2		
Organize yourself as a remote worker or self-employed				2	1		1				1									1
Positive Psychology: Resilience Skills																				
Supply chain management: Be global																				
Managing Supply Chain Disruption During COVID-19																				
Circular Economy - Sustainable Materials Management																				
Big Data Modeling and Management Systems	1		1	2	1		1	2	1				1							1
3D CAD Fundamental																				1

Process Mining and Predictive Process Monitoring																	1			
Value Stream Analysis 4.0	3			1	1	1														
Artificial Intelligence - An Overview		1				2														
Assessing HPC readiness for SMEs	1			1																
Ethics of Artificial Intelligence	3	1																		
Technologies and platforms for Artificial Intelligence		2				2														
IBM AI Engineering Professional Certificate	2	1	1			1														
Data Science: Statistics and Machine Learning Specialization	1		1																	
Software Architecture for Big Data Specialization	2																			
Information Visualization: Foundations	1																			
Organize yourself as a remote worker or self-employed	1	1	1	2	2	1														
Positive Psychology: Resilience Skills							1		1		2	1	2	1		1				
Supply chain management: Be global							1		1	1	2	1		1	1					
Managing Supply Chain Disruption During COVID-19							1	2	3	2	2	1	1		2	1				
Circular Economy - Sustainable Materials Management							2	2	1	1	3	1	2		1	2				
Big Data Modeling and Management Systems	2	1	1			1														
3D CAD Fundamental			2			1												1		3

3D Printing Applications																			1			2			1												1		3
Supply Chain Operations																										1	2	1	1	2	1	2	2	1	1				
Digital Manufacturing & Design Technology Specialization											1	1									2					1	2	2		3			1	1	2				
Supply Chain Logistics																											2	1		2		1		1				2	
Sensor Manufacturing and Process Control																						1	3		1											1	3		
The Fundamentals of Resilience																										2				2		1		1					
Warehouse Management in Logistics & Supply Chain Management																										1	2	1	1	2	1	1	2	1	2	1		1	
Data Management Masterclass - The Complete Course		1		2	1	1	1	2	1										2	2		1														1			
Logistics and Supply Chains - Fundamentals,Design,Operations																										1	2		1	2	1	1		1	2			1	
Sensors: Everything You Need To Know																						1	2		1												3	1	
Sensors and Sensor Fundamentals																						1	2		1												3	1	
Manufacturing 4.0 - Impact of Industry 4.0 on Manufacturing																										1	2	3	1	3	1		1	1		1	1	1	2
Virtual Teams: Remote Team Management & Leadership				1																				1	1											1	1	1	
Remote Team Management & Leadership - Manage A Remote Team																								1	1											1	1	1	
How To Adapt to the Remote Work Lifestyle				1																				1	1											1	1	1	

In this database, all nine jobs that were introduced in the previous sections and their most important skills are covered.

Table guide: (how to interpret)

For example, in the first column of the courses, we have the “AI Opportunities for SMEs” which is presented by the “I4MS Catalogue of Trainings”. This course is held in the context of new technology, especially “Artificial intelligence” and in connection with the “Data science management Roles and Professions” provides explanations in awareness level for “Knowledge about domain specific process” and “Develop and execute the data strategy according to business objectives” skills, Knowledge in Foundation level for “Knowledge about business processes” skill. Also, its main focus is on “Use of AI, machine learning, and Deep learning techniques” skill which provides in information Extended Know-How Level.

It should be noted that this database was open source during months of the project, which means that if the partners were able to improve their required skills using other training activities, they could add to this file so that other partners could get acquainted with it.

5.4 VR tool and survey

In addition to the training courses that were mentioned in the previous section, providing virtual tools is another pathway to improve the skills of employees.

Digitalization and particularly the digital twin provides a fast and reliable technology to support the 6P (People dimension) methodology (As described in Section 3.1.2), using agile training adapted to each actor. The digital twin combines the digital models of the production facility equipment, with the simulation models and the existing data sets from the production to train the personnel in the 3D virtual environment. The virtual environment can be combined with VR technologies to extend the visualization capabilities and provide the employee with an immersive experience that provides a realistic feeling of being in the real production environment, even if the system is still in the concept phase (Figure 12). In addition to the vision sensors to control the VR devices can introduce actions so the operator is getting to interact with equipment, tools, and resources in the virtual space, obtaining a real operation sensation and acquiring the working skills while training in the digital domain.

The research developed and validated in the EU Project Factory2Fit[12] demonstrated that the virtual factory was an excellent environment to train the employees to acquire new skills, in addition, the digital environment not only allowed them to get new knowledge but also to share and get tacit knowledge that the skilled employees have, in a digital and shareable way with other workers including design colleagues.

[12] https://cordis.europa.eu/project/id/723277

Figure 12 Virtual tool example – Training

In this project, VIS and Intellimech, developed virtual training tools, as it is shown in the Figure 12, Figure 13, and Figure 14 (as an example of the designed environments). In addition, these tools have unique features, among which the following can be mentioned:

- Capability to support changing needs between different departments.
- Creation of virtual experiences without the need for programming skills.
- AI automatic feedback through AI of assembly operations which helps improve engineering and design.
- Instructions built from what the operator really does rather than from a design standpoint.

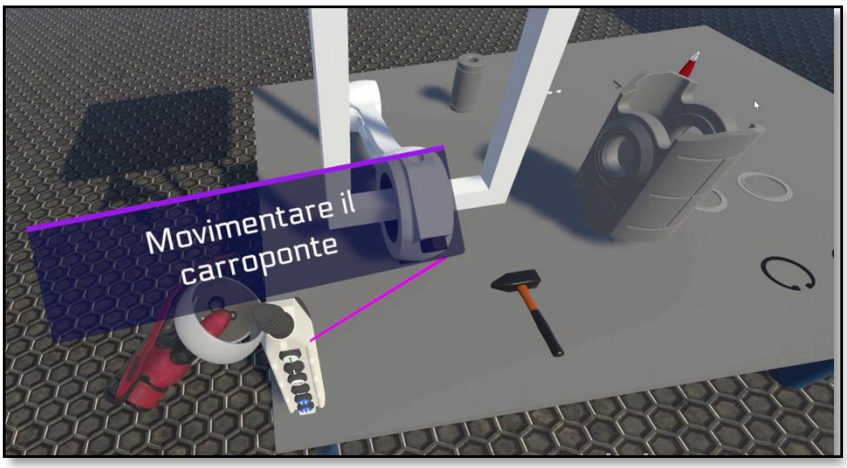


Figure 13 Virtual tool example – Training

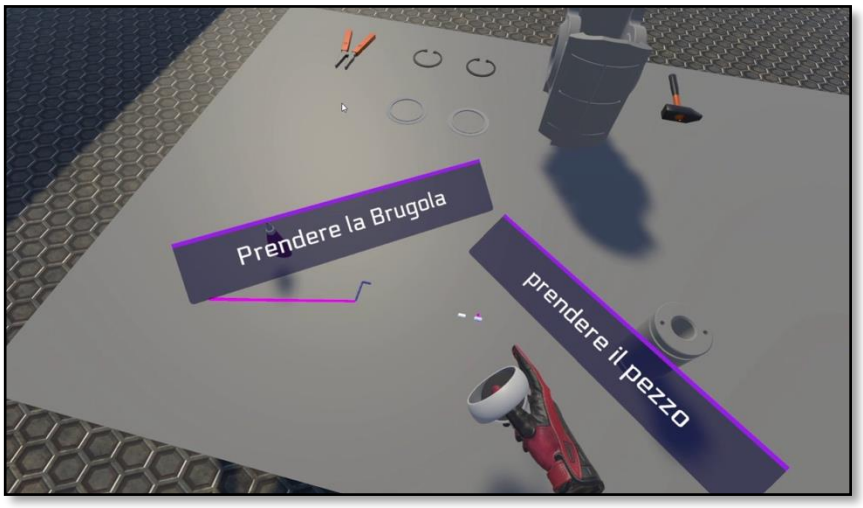


Figure 14 Virtual tool example – Training

Following the implementation of the second iteration of the people dimension methodology, the developers and users of these virtual tools were asked questions via a questionnaire; below are some of these questions, and analyses of the responses are provided:

Q1: After using the virtual tool, in which section do you find the use of this tool more effective?

According to the responses received from the project partners and as can be seen in Table 22, these virtual tools mostly at the professional level (maintenance department, design of products, remote assistant) and worker level (Industrial training), have high or extremely high effects.

The least amount of effect is in administrative and financial activities since in these departments, employees generally work with special software, and the simulation of industrial environments is not effective in these departments.

Table 22 Virtual tool survey – Q1

#	Field	Ineffective	Low effect	Medium effetc	High effect	Extremely high effect
1	Management Level (Strategy Decision makers)	25.00%	25.00%	25.00%	0.00%	25.00%
2	Commercial department (e.g., virtual commissioning, virtual marketplaces)	0.00%	0.00%	0.00%	50.00%	50.00%
3	Administrative activities (HR, Finance ,...)	50.00%	25.00%	25.00%	0.00%	0.00%
4	Professional level (Technical department)	0.00%	0.00%	0.00%	50.00%	50.00%
5	Professional level (Standardisation activities)	0.00%	0.00%	50.00%	25.00%	25.00%
6	Professional level (Quality Control department)	0.00%	0.00%	25.00%	75.00%	0.00%
7	Professional level (Maintenance department)	0.00%	0.00%	0.00%	25.00%	75.00%
8	Professional level (Design of products)	0.00%	0.00%	25.00%	0.00%	75.00%
9	Professional level (Remote assistance)	0.00%	0.00%	0.00%	0.00%	100.00%
10	Operational level and operational activities (Assembly, Quality inspection)	0.00%	25.00%	0.00%	50.00%	25.00%
11	Laboratory and R&D activities	25.00%	0.00%	25.00%	50.00%	0.00%
12	Student Training (Academic environment)	25.00%	0.00%	0.00%	25.00%	50.00%
13	Industrial Training	0.00%	0.00%	0.00%	25.00%	75.00%

Q2: Which of the jobs introduced in section 3.1.2.1 requires information about the VR, and AR technologies?

In this section, as in the Q1, most of the votes were related to the jobs available at the professional and worker levels.

- **Remote Workers**: He or She is a worker of a company but works outside of a traditional plant environment – **26.67%**
- **Operator 4.0**: works in a field of technology who is proficient in the relevant skill and technique, with a relatively practical understanding of the theoretical principles - **26.67%**
- **Repurposing supervisor**: transforms products or their components to suit a second purpose after their first has expired – **20%**
- **Visual Data Designer**: creates custom visualizations from complex data sets in a compelling way – **20%**

Q3- How do virtual educational technologies and tools can help in crisis management (in a crisis situation such as Covid-19)?

According to the responses received, virtual tools help to create flexibility, and remotization and speed up the integration of new technologies into the current system. Many problems with communication between organisational levels can also be solved in this manner. Furthermore, VR allows us to visualise the entire process in greater detail than static CAD drawings on a PC. As a result, we will be better at identifying problems early on and delivering operational equipment more quickly.

In addition to the aforementioned results and suggested remedial actions, several Key Performance Indicators (KPIs) were internally reviewed and improved. The indicators that were prioritized during the analysis included:

Number of data science management and resilience-oriented profiles: As stated in section 3.1.2.1, nine roles were identified, out of which six were related to data science management and three were resilience-oriented roles at various organizational levels (management, professional, and worker).

Number of skill development pathways: As mentioned in sections 5.3 and 5.4, 45 training courses were identified, and each course was analyzed at three levels (awareness, foundation, and extended know-how) per skill. Additionally, two virtual training tools developed by Intellimech and VIS were introduced.

Virtual reality adoption: According to the questionnaire implemented in section 5.4, the level of adoption of virtual reality tools among partners at executive levels requires more practice and training, and this should be implemented bilaterally. On one hand, training tools should be improved, and on the other hand, training courses should be implemented for employees.

Employee engagement: As mentioned above, the expectation of participation at the worker and professional levels is much higher than at the management level, which is related to the nature of executive activities by these levels.

Time to recovery (or required time to develop new tools): This KPI is related to the level of activity of the partners and their relationship with virtual training tools. Based on the experience gained during this project, it takes approximately one and a half year to develop training tools at the laboratory level.

6 Policy developments and recommendations

Based on the analysis of the Key Performance Indicators and the identified gaps, it is recommended that the organization implement certain policies and strategies to address the challenges faced. The following recommendations are provided to improve the performance, skills, and resilience of the organization:

Short-term recommendations: (People dimension)

Provide targeted training: Companies can provide targeted training programs (such as courses mentioned in section 5.3) to help employees improve their data science and resilience skills. This could include workshops, online courses, or mentoring programs.

Offer flexible working arrangements: Companies can provide flexible working arrangements, such as remote work (such as roles mentioned in section 3.1.2.1), to help employees manage their workload and maintain their work-life balance.

Encourage cross-functional collaboration: Encouraging cross-functional collaboration can help employees develop a more holistic understanding of the business and build resilience by leveraging the expertise of their colleagues. This recommendation extracted from comments received in Possessed, and Needed survey, which show the high interest of partners to make partnership and collaboration.

Long-term recommendations: (People dimension)

Invest in technology and infrastructure: Investing in technology and infrastructure can help companies build a more resilient and adaptable business model. This could include implementing data analytics tools or virtual reality platforms to enable remote work.

Foster a culture of learning and innovation: Fostering a culture of learning and innovation can help companies build a workforce that is adaptable, resilient, and always seeking to improve. This could include encouraging employees to attend industry conferences, workshop, and training courses or providing opportunities for innovation through hackathons or other events.

Rapid actions: (People dimension)

Implement rapid upskilling programs: To ensure that employees are equipped with the necessary skills to respond to the crisis, companies can implement rapid upskilling programs. These programs can include virtual training sessions, online courses, or mentoring programs to provide employees with the skills they need to adapt to new roles and responsibilities.

Provide ongoing training and development opportunities: In addition to rapid upskilling programs, companies should also provide ongoing training and development opportunities for their employees. This can help to ensure that employees are continually developing new skills and staying up to date with the latest industry trends and best practices.

Leverage data analytics and AI: Data analytics and AI can be powerful tools in managing a crisis such as COVID-19. Companies can leverage these tools and relevant roles (as mentioned in section 3.1.2.1) to analyze data and identify trends that can inform decision-

making, such as predicting the spread of the virus or identifying areas where resources are needed most.

Foster collaboration and communication: Collaboration and communication are key during a crisis. Companies should establish regular communication channels and forums for employees to share information and ideas. This can include virtual town hall meetings, online chat platforms, or regular email updates.

Below is the list of policies and strategies for performance dimension.

Short-term recommendations: (Performance dimension)

Identify and assess risks and vulnerabilities in the supply chain. In this regard, it will be fundamental to understand and map who are the stakeholders which may impact on the resilience of the entire Supply Chain. (Supply chain)

Develop contingency plans and alternative sources of supply to mitigate supply chain disruptions. (Supply chain)

Support employee mental health and well-being through resources and programs. These programs can facilitate the mental resilience of people, thus indirectly improving their performances during their working activities (Social)

Implement policies to reduce energy and resource consumption. On one hand, reduce waste and implement recycling programs to start using more secondary resources and less primary resources. On the other hand, start using renewable sources of energy and optimize internal processes to reduce the need of energy consumption. (Environmental)

Evaluate and adjust budgets and forecasts to reflect changes in demand and revenue during and post eventual crises (Economic)

Improve internal processes to optimize internal flows of resources and exchange of information. Strengthen IT infrastructure to support remote working activities while ensuring cybersecurity to the whole infrastructure. In addition, develop and implement a crisis management plan to respond efficiently to future emergencies. (Operational and Technical)

Long-term recommendations: (Performance dimension)

Diversify the supply chain to reduce dependence on a single supplier or region and e stablish long-term partnerships with key suppliers to improve reliability and flexibility. (Supply chain)

Foster a culture of community involvement and corporate social responsibility. Invest in employee training and development plans to support career growth and personal fulfillment. (Social)

Develop and implement a sustainability plan that considers environmental impacts throughout the organization's operations on the long term by also acting on the review of product and process design. (Environmental)

Conduct regular assessments of financial risks and opportunities and adjust strategies accordingly monitoring the trend to anticipate actions also on the long run. Invest in research and development to identify new opportunities for growth and innovation. (Economic)

Monitor and evaluate the effectiveness of operational and technical policies and make adjustments as necessary with a long-term view. Promote a culture of continuous improvement to increase agility and adaptability to changing circumstances. (Operational and Technical)

Rapid Actions: (Performance dimension)

Identify and assess risks and vulnerabilities in the supply chain. Identify new potential collaborations to make the supply chain more robust. (Supply chain)

Implement health support plans for employees. (Social)

Strengthen the IT infrastructure to ensure remote working activities. (Operational and Technical)

Map and study internal processes to exploit inefficiencies as opportunities to improve resource management. (Environmental)

Keep under control return on investments (economic)

7 Ethical Issues

In order to coordinate the surveys implemented in this deliverable with the ethical issues mentioned in D7.1, the confirmation form on behalf of the POLIMI team has been placed in the annex section, and here are some of its crucial points.

Goals of the Task/Activity Involving Humans: The activity's goal is to collect data from Eur3ka partners using two assessment models developed in WP3 for skills and performance, respectively. The ultimate goal of these assessment models is to assist partners in becoming aware of their current state and embarking on structured improvement paths. The assessment models will be applied internally to the consortium in WP5, while the community will be expanded in WP6.

It should be noted that the goal of these surveys is the entire organization, rather than a single person (individual). In this manner, a representative from each organization fills out surveys regarding the overall performance and skills of the organization.

Methods of research: The research methods will include pre-existing surveys to investigate partners'' responses gleaned from the survey.

Number of subjects will be recruited to the study: The subjects involved in the two iterations of the models are the industrial partners who are actively participating in WP5. The surveys will be centered on the industrial entity rather than the individual.

It should be mentioned that the recruitment took place during the Eur3Ka project's bi-weekly meetings, asking people if they were willing to participate in the surveys, and the people involved were asked to provide their answers while agreeing not to share the results externally. Nonetheless, no questions about privacy or security were asked of participants.

8 Future Steps

Regarding the future plans that should be considered to complete the process related to “Performance and People” it is worth to mention the involvement in the European funded project. Indeed, the involvement of some of the partners of Eur3ka project in new European funded Projects leads towards the integration of resilience-related topics with circularity and sustainability research streams. This integration may strengthen the results of the Eur3ka project delineating the creation of new and tailored Key Performance Indicators, new assessment methodologies, and new training paths.

Therefore, in the future, the proposed survey enabling the assessment might be extended and integrated with other research streams (i.e. circular economy) to explore whether circularity may empower companies making them become more resilient.

9 Conclusions

The result of this deliverable can be divided to two main categories: Performance dimension and People dimension results. On one hand, the performance part was structured to investigate both the current maturity of companies (AS-IS situation) and the TO-BE desired scenario in keeping under control a set of indicators looking at the 6 dimensions which were considered fundamental not only in I4.0 projects but also for resilience-monitoring purposes.

On the other hand, people dimension “skills and workforce training” presents the list of emerging new skills and job requirements and, eventually, a prioritization for critical ones, as well as their need and availability in project experiments, regarding the digital transformation and technology growth.

In this regard, after reviewing previous studies conducted in both dimensions and introducing the 6Ps, Performance, and People dimensions model (aimed at supporting manufacturing companies in defining its current and future level of digital maturity), were defined. In addition, 2 iterations of surveys and each iteration includes one survey in performance dimension and two surveys related to prioritizing skills dedicated to each profile according to experiments' conditions and analyzing experiments' AS-IS and TO-BE situations regarding identified job profiles and skills were implemented.

The performance survey presented quite heterogeneous results among the participants but also among the different performances. The first iteration results according to which the main aspect that emerged was the higher maturity in keeping under control supply chain performances in respect with the others, was confirmed also in this second turn. This result might be influenced by the common knowledge about the need to monitor the stakeholders along the value chain to anticipate possible detrimental effects on the core business. The other performances have been taken into account for future plans by the several companies differently and in accordance with their core strategy.

The voting survey, which was conducted online to examine the opinions of project partners regarding the skills assigned to each job profile and their prioritization, received 13 votes; based on these votes, the skills for each profile were prioritized in order of importance for project partners. Furthermore, by comparing the first and second rounds, it is possible to conclude that the results of both iterations were very close to each other and that the skills required by the project partners were correctly identified. In addition, as it is also mentioned in section 5.2.1 that some skills received fewer votes, indicating the less importance of these skills; as a result, the less important skills were removed from the package of that job and related analysis about training courses was conducted on critical skills.

The needed and possessed survey, which was asked of the experiments to examine their AS-IS and TO-BE situations in relation to the jobs and skills introduced, received eight votes. (It should be noted that the target group of this survey was manufacturing companies (internal project partners). After reviewing, analyzing, and comparing the received responses from two iterations, the partner’s improvement during the project time and their existing gaps related to the skills became apparent. The important result obtained from the analysis of the responses is this; most of the partners believed that the crucial solutions to

cover the existing gaps in relation to the jobs and skills are creation of cooperation with project partners for up-re skilling as well as the use of training courses to get acquainted with new jobs and skills and improving the level of skills. Furthermore, since the use of training courses was one of the important strategies to cover the job and skill gaps in experiments, the list of training activities (from I4MS catalogue of training, and POLIMI open knowledge website, Coursera, and Udemy), field of training, level of information they provide to the audience (awareness, foundation, and extended know/how) were also offered to partners so that they have the possibility to use these training courses to improve their skills in the field of introduced jobs. In addition, the use of virtual training tools is also introduced as another significant tool for filling gaps that were investigated in this project in collaboration with project partners (Intellimech, VIS).

As a general conclusion, we can affirm that the purpose of this deliverable “Final impact assessment & policy recommendations” is well covered in this report.

10 Annex

EUR3KA SURVEY – Requirement No. 1 from WP7

Partner: POLIMI

Involvement of human participants

Table 23 Requirement No. 1

Aims of the Task /activity that involve humans. *Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application* The activity aims to collect data from Eur3ka partners based on the application of two assessment models, **respectively on skills and performances**, that have been developed in WP3. These assessment models have the final goal to support partners in becoming aware about their current state and to undertake structured improvement paths. In WP5 the assessment models are applied internally to the consortium, while in WP6 the community is going to be expanded. It should be noted that, in these surveys, the goal is the whole organisation and the focus is not on one person (individual). In this way, a representative from each organization fills in the surveys in relation to the performance and skills of the whole organization.
Which methods of research involving or affecting humans will be executed (e.g. interviews, experiments, observations, workshops, trainings)? The methods of research are going to be both surveys, already developed, and interviews with the same participants of the survey to investigate their responses gathered from the survey.
How many subjects will be recruited to the study (by group if appropriate)? Regarding the first application of the models, the subjects involved are the industrial partners who are actively participating in WP5. The survey and the subsequent interviews are going to be focused on the industrial entity and not on the person.

Will any of the subjects be from the following vulnerable groups -	**YES/ NO**
Children under 18	No
Adults with learning or other disabilities	No
Very elderly people (+80)	No

Healthy volunteers who have a dependent or subordinate relationship to investigators (e.g., **employee – employer relationship**)	Yes
Other vulnerable groups	No

If YES to any of the above, please specify and justify their inclusion

The assessment was aimed at investigating the current state of **performance monitoring and skills development** in the companies and was performed through the survey to collect their responses. A representative who employed in internally to the consortium companies and has enough information about skills and performance of whole organization can fill out the surveys.

Inclusion and exclusion criteria

Please indicate, with reasons, the inclusion and or exclusion criteria for the research activity.

The other typologies were not needed for this study

Please describe how and where recruitment will take place

The recruitment took place during the bi-weekly meeting of the Eur3Ka project asking people whether they were willing to take part to the survey.

Please indicate the informed consent procedures that will be implemented for the participation of humans

The people involved were asked to provide their answers ensuring them to not share externally the results. Nevertheless, no privacy and security related data were asked to participants

Do the proposed methods of research generate potential safety risks for the participating persons or researchers? If yes, which measures are planned to ensure safety and reduce potential risks?

No risks arise from the application of the model

Can the safety of persons at any time be guaranteed? If not, why?

Yes

Based on your national legal framework or internal policy, are you required to obtain an Ethics Approval for the above-mentioned activities?

No

References

1. Romero, David, Johan Stahre, Lisa Larsson, and Anna Ohrwall Ronnback. 2021. “Building Manufacturing Resilience through Production Innovation.” In 2021 IEEE International Conference on Engineering, Technology, and Innovation, ICE/ITMC 2021 - Proceedings. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICE/ITMC52061.2021.9570204.
2. Spaltini, Marco, Federica Acerbi, Marta Pinzone, Sergio Gusmeroli, and Marco Taisch. 2022. “Defining the Roadmap towards Industry 4.0: The 6Ps Maturity Model for Manufacturing SMEs.” Procedia CIRP 105: 631–36. https://doi.org/10.1016/j.procir.2022.02.105.
3. World Manufacturing Forum's ten skills for the future of manufacturing World
4. Manufacturing Forum - https://worldmanufacturing.org/
5. https://worldmanufacturing.org/wpcontent/uploads/WorldManufacturingForum2020_Report.pdf
6. World Economic Forum, 2020, The Future of Jobs Report, October 2020.
7. Osservatorio Industria 4.0 - Politecnico di Milano
8. Ace factories, White paper on Human-centred factories from theory to industrial practice. Lessons learned and recommendations, 2019.
9. World Economic Forum, 2020, The Future of Jobs Report, October 2020.
10. https://i4ms.eu/trainings/
11. https://www.pok.polimi.it/
12. https://www.coursera.org/
13. https://www.udemy.com/

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