Skills Data Collection for Connectivity Devices and Services/CDS (IOT in Smart Manufacturing)

Talentjourney 2.1 Report

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Date: 06/04/20

List of Abbreviations

AI – Artificial Intelligence

AR – Augmented Reality

CDS – Connectivity Devices and Services

CEDEFOP – European Centre for the Development of Vocational Training

CoVE – Centres of Vocational Excellence

ECVET – European Quality Assurance in Vocational Education and Training

EQAVET – European Credit System for Vocational and Education Training

EQF – European Qualifications Framework

ESF – European Structural Fund

EU – European Union

ICT – Information and Communication Technology

IOT – Internet of Things

IIOT - Industrial Internet of Things

NGO – Non-Governmental Organisation

OECD – Organization for Economic Co-operation and Development

OREF – Observatoire Régional Emploi Formation

SDG – Sustainable Development Goal

SMEs – Small Medium Enterprises

SSCs – Sector Skills Councils

STEM – Science, Technology, Engineering, Mathematics

VET – Vocational Education Training

VR – Virtual Reality

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1.0 Introduction

The manufacturing sector has an optimistic future and can provide major opportunities for people to develop rewarding careers in an industry that is an essential part of the European Union (EU)'s economic infrastructure. Manufacturing is an essential service that is used in almost every activity that we undertake individually and as a community. Without manufacturing, our standard of life would change beyond conception and would have an unfathomable economic impact. In 2018, the EU manufacturing sector accounted for 16% of the total EU GDP, for around 2 million enterprises and 33 million jobs[1]. Of these 33 million individuals, 2.4 million were employed in what is considered high-tech manufacturing. One out of three employed in the high-tech sector was a woman[2].

Figure 1. Employment in Technology and Knowledge-intensive Sectors in 2018[1]

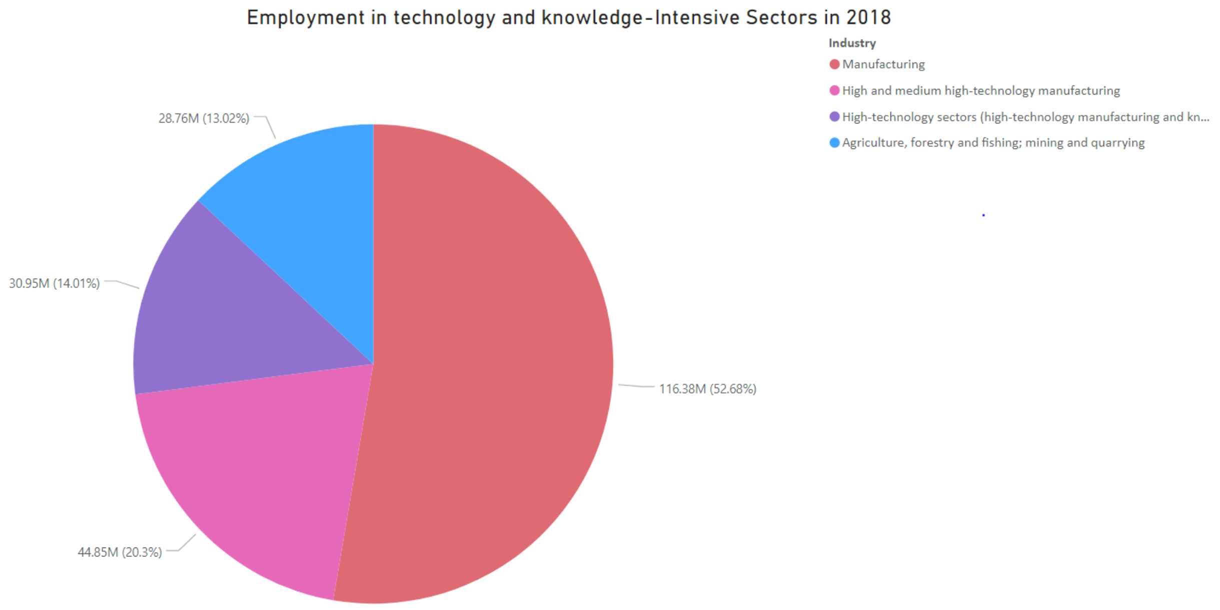
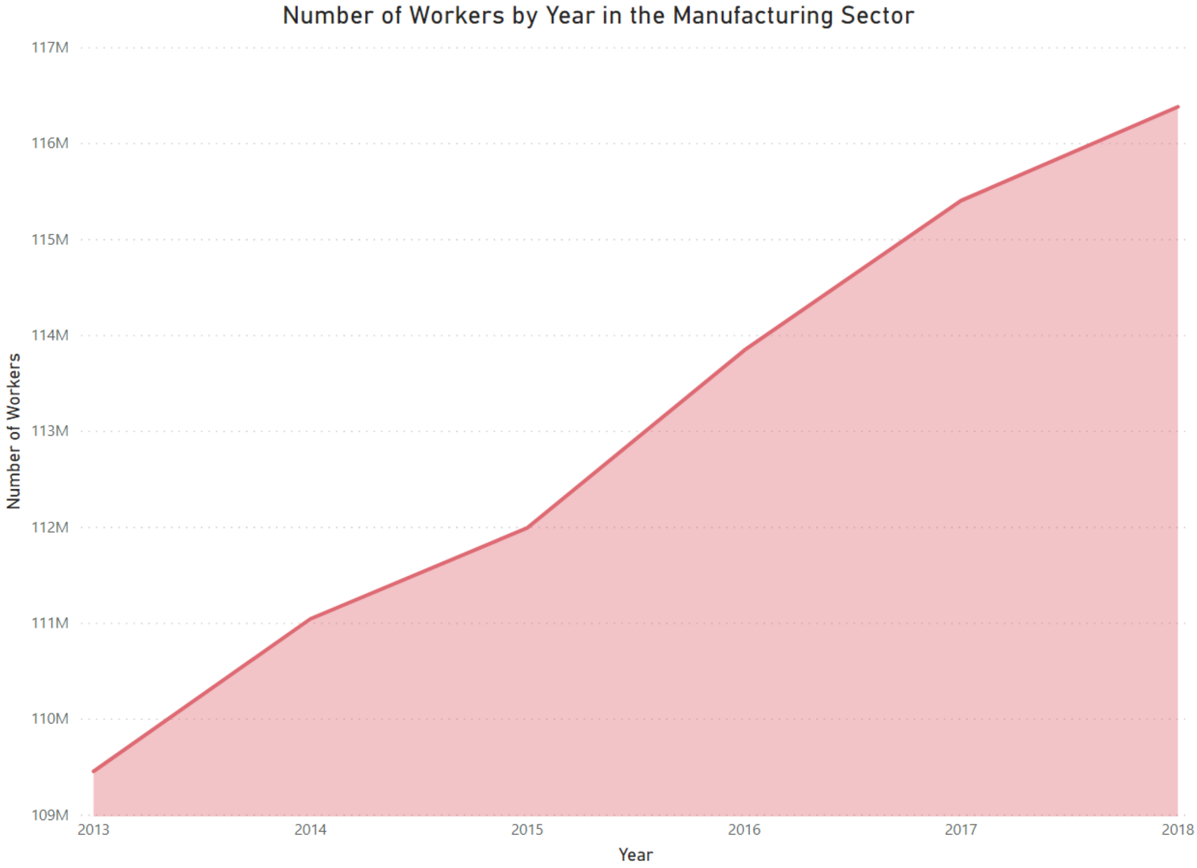


Figure 2. Number of Worker (in Millions) in the Manufacturing Sector Over Time[1]



As apparent in Figures 1 and 2, employment in production and manufacturing is of high economic importance in the European Union – and the demand for manufacturing jobs is only growing. Between 2018-2013, there was an approximate 5.6% increase in the number of manufacturing jobs in the EU (see Figure 2), and a combination of desk research and in-depth interview responses within the Talentjourney project suggests this increasing trend will continue in the future. The manufacturing sector is a skills-intensive business, reliant on a varied range of occupations and a maintainable supply of professional, technical and operational skills to service product production in its various forms. This report will outline the challenges and key actions required in developing a coherent, complementary/collaborative skills system to ensure the EU's manufacturing sector workforce is competent enough to capitalise on these opportunities, especially in the transition to IOT, smart manufacturing and Industry 4.0.

1.1 Industry 4.0

Industry 4.0, often referred to as the fourth industrial revolution, encompasses a wide variety of technological advances across the entire value-chain. Industry 4.0 technologies and processes include the following, automation through digitisation and robotics, internet of things (IOT), artificial Intelligence (AI), additive manufacturing, etc. All these innovative technologies and processes are revolutionising traditional manufacturing processes. As a result of increased use of digital technologies, the boundary between the real and the virtual world is increasingly narrowing, commencing in what is sometimes referred to as cyber-physical production systems.

Industry 4.0 is transforming production value chains and business models into digital supply networks. Digital supply networks are dynamic and integrated, allowing faster and real time decision making, for example in the area of predictive maintenance, quality management and demand forecasting. A "smart factory" is then a flexible system capable to self-optimise performance, to self-adapt to and learn from new conditions, and to autonomously run entire production processes[3].

1.2 What is Talentjourney?

Employer research points to a perceived skill set that sits beyond traditional education models. In some spheres these are called meta skills or universal skills. Employers lack in many of these skill sets when looking at workforce planning. Simultaneously, digital technology will transform our future. Data driven innovation through intelligent use of data is already exploding, tied into the growth of AI and automation. VETs need to address the oncoming 'Fourth Industrial Revolution' through education and skills to equip future employees whilst re-equipping the current workforce. In reality, employers report that their futures are very much fixed on the present, with shortages due to a lack of staff with sufficient technical knowledge in the emerging smart manufacturing sector. In order to face these challenges and look to the future, it is necessary to make the most of the current workforce and bring them through this transition period. Understanding and responding to the evolving skills needs of business is critical to increasing economic growth and productivity in the EU.

Talentjourney is an EU-funded Erasmus+ project that brings thirteen project partners from across Europe (Slovenia, Italy, Finland, Estonia, Germany) with the same idea and goal to bring VET provision to the excellence in manufacturing sector. Specifically, the international Talentjourney consortium is focused on Connectivity Devices and Services/CDS (IOT in smart manufacturing), which lays its focus on solutions that are user oriented, user friendly and eco-friendly and become as such a world example for the excellence in that field. The name of our platform for CDS VET excellence is Talentjourney, as our vision is to design a collaborating and engaging ecosystem where everyone can grow into a satisfied person and successful professional. The CDS field deals with the ability to connect services and devices to central controlling applications or a remote operator and is important to run a cost-effective business operation, is transferable to other sectors and in many cases connected to artificial intelligence. The platform will build on excellence by providing top skills in CDS field and innovative approaches that will foster developing talents.

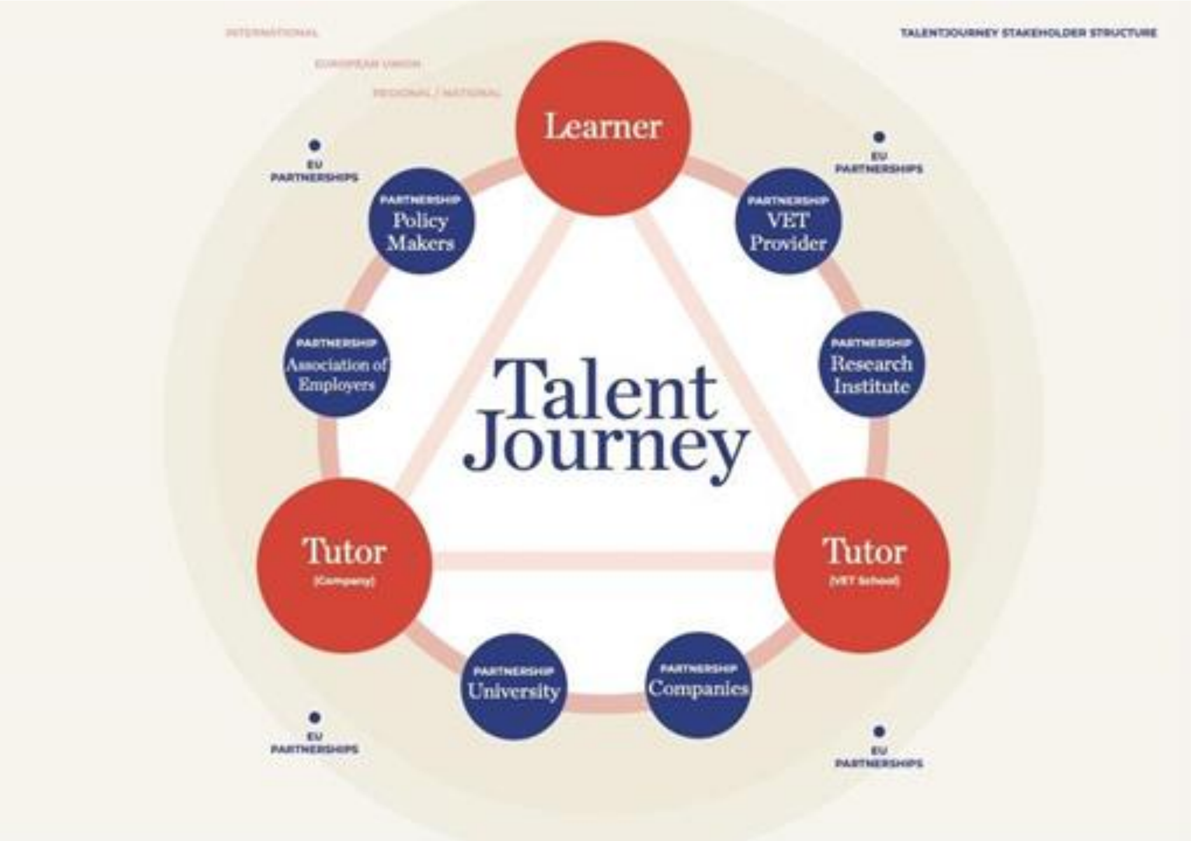
Talentjourney will represent a network of inter-connected regional and EU stakeholder ecosystems with emphasis on sharing, networking, working in teams and providing information. The centre of Talentjourney will be the learner supported by tutors and other stakeholders to help him/her discover and develop their talents. Talentjourney will provide the manufacturing sector with an international talent pool of future employees and CDS fluid experts to foster innovation and capacity building to master the future of the manufacturing sector.

Talentjourney will:

- Place a strong emphasis on digital, international, user-centred, personalised and flexible in content and relationship for the user, easy to use
- Utilise digital tools to allow flexibility in learning (''I as a student/teacher/employee can choose subjects/modules and projects that I'm interested in and the ones that are going to help me grow professionally'')
- Receive tutorship from tutor in any countries using digital tools
- Transform knowledge stocks into knowledge flows

Talentjourney will lead on innovative approaches to developing the smart manufacturing workforce of the future and develop flexible ways to address these challenges effectively. Talentjourney aims to future-proof industry in order to meet their needs to recruit staff, to upskill staff, to reskill staff and to help organisations in the EU to become globally competitive in the smart manufacturing sector.

Figure 3. What is Talentjourney?[4]



1.3 Research Methodology

Desk-based research was used to identify skill gaps and opportunities for the development of smart manufacturing skillsets on which to focus the research as well as to map existing European competency frameworks to design surveys and prepare for in-depth interviews. Desk-based research also provided industry data and data from existing projects/research to assess current and future (in 5-10 years' time) skill gaps, ultimately providing a basis for designing a methodology for VET programmes related to smart manufacturing. The report will also include the data about the existing and the potential occupations and about the existing educational and training programmes in that specific sectoral field in European Union and worldwide.

1.4 Surveys and In-Depth Interviews

In-depth interviews were conducted with a sample of employers, manufacturers, training providers and relevant stakeholders in each partner country:

- Slovenia
- Italy
- Finland
- Estonia
- Germany

2.0 The Market for IOT/Smart Manufacturing Skills in the European Union

The European Commission has defined six priority Key Enabling Technologies (KETs) for Europe[5]. The Commission has reported that mastering these technologies is regarded as crucial for ensuring the competitiveness of European industries in the knowledge economy. KETs enable the development of new goods and services and the restructuring of industrial processes needed to modernise EU industry and make the transition to a knowledge-based and low carbon resource-efficient economy[6].

IOT and connected devices are the single most important drivers of innovation and growth for national and regional economies across all sectors. More than 75% of the value added created by the Internet is in traditional industries. Fifty-five percent of ICT practitioners work outside the ICT sector itself. Given the aforementioned evidence, the purchase of ICT equipment, software and broadband is not enough. Attaining the objective of enhanced use of IOT and the associated connected devices in manufacturing requires a combination that includes measures to improve digital skills.

In the World Economic Forum's Global Competitiveness Report[7], Klaus Schwab, the World Economic Forum's Chair, said: "Embracing the Fourth Industrial Revolution has become a defining factor for competitiveness. I foresee a new global divide between countries who understand innovative transformations and those that don't. Only those economies that recognise [its] importance will be able to expand opportunities for their people."

The manufacturing industry is a strong asset of the European economy, accounting for 2 million enterprises and 33 million jobs. Europe's competitiveness is highly dependent on the ability of this sector to deliver high-quality innovative products using the latest advances in ICT. Manufacturing accounts for 16% of Europe's GDP. The sector is responsible for 64% of private sector Research & Development expenditure and for 49% of innovation expenditure in Europe[8].

Industry 4.0 based solutions applied across the manufacturing value chain will help to make processes more efficient, but companies will require support in doing this. It is very apparent that the internet will enable the creation of more personalised, diversified and mass-produced products as well as flexible reaction to market changes, these changes will require a new set of skills in the transition phase. Smart Manufacturing uses comprehensive digital innovations such as artificial intelligence, Internet of Things, modelling and simulation & big data analysis, to name but a few, many of these skills are emerging ones and are not plentiful in number, hence Centres of Vocational Excellence will need to equip themselves appropriately in people and physical resources accordingly, in an effort to meet the demands of consumers and industry.

The flagship initiative of the Europe 2020 Strategic Policy[9] sets out a strategy that aims to boost growth and jobs by maintaining and supporting a strong, diversified and competitive industrial base offering well-paid jobs while becoming less carbon intensive. The strategy puts forward a wide range of actions, mixing broad cross-sectoral measures and actions for specific activities. Among the proposed actions are: the creation of framework conditions for sustainable supply and management of domestic primary raw materials; improving resource efficiency by addressing sector-specific innovation performance, for example in smart manufacturing technologies; and addressing the challenges of energy-intensive activities through actions to improve framework conditions and support innovation. The implementation of this policy uncovers gaps in the skills to fully make it successful, and Talentjourney shall use this report to identify such allowing future curricular developments. Many member states have taken their own initiatives in the transition towards smart manufacturing, with other focusing on resource efficiency etc, it is true to say that no one country could fulfil the policy requirement of Europe 2020 by itself. Finland was the first country in Europe to publish a national AI strategy, in October 2017.

A second report[10] was published in June 2018 and a final version on SMEs will be published this April. Finland, Sweden and Estonia plan to partner to become Europe's top laboratory for AI test trials, this strategy will no doubt uncover new skills that are required within the smart manufacturing sector in Europe.

Employees help companies realise their digital transformation and are the ones most affected by the changes of the digital workplace. Their direct working environment is altered, requiring them to acquire new skills and qualifications. It is critical that companies prepare their employees for these changes through appropriate training and continuing education, so companies require to be informed appropriately. Readiness in the dimension of employees is determined by analysing employees' skills in various areas and the company's efforts to acquire new skill sets that are required to make the companies competitive in the global marketplace.

2.1 The Challenge for the Smart Manufacturing Skills

Realising opportunities for the development of smart manufacturing skill sets requires the smart manufacturing sector to overcome some significant challenges now and in the future. The smart manufacturing sector is changing rapidly to provide two extremely important imperatives: (1) better quality affordable products through 4.0 techniques, and (2) reducing carbon emissions. The first of these is not just about moving to a digitised automated system. Much of the existing manufacturing infrastructure is depreciating and will need to be renewed over the next ten years or so. In addition to investment surrounding manufacturing supply infrastructure, impendent environmental obligations are driving a major shift toward low carbon versions of existing techniques and technologies and the European energy transition, the introduction of the internet of things (IOT), artificial intelligence (AI) and augmented reality (AR), on both the macro and micro scale with the development of smart 4.0 networks optimising supply and managing demand. Investment in technologies is increasing rapidly also for proven machineries such as additive manufacturing (or 3D printing), advanced automation/robotics, cloud computing and big data analytics, machine learning, cyber technologies, blockchain, etc[11]. The manufacturing sector must adapt to the development of emerging techniques during the transition to smart manufacturing. Set against this, there is increasing demand for smart manufacturing skills from other major projects—for example, capital infrastructure projects—all of which are grappling from the same talent pool. Skills development is a critical component of the manufacturing sector's changing circumstances, and immediate action is required to balance the current workforce needs while addressing the long-term shift to digitalised techniques and skills[12].

2.2 Ageing Manufacturing Sector Workforce

An irregular rate of past recruitment has shaped a manufacturing sector workforce with an age profile that is biased to older workers. This presents the manufacturing sector with a major challenge, the increasing loss of skilled workers to retirement. According to Eurofund[8], in 2011 the EU working population aged between 55 and 64 grew by approximately 17% from 2000 to 2010, with manufacturing absorbing the main percentage (14%) of the aged workforce.

In an interview with SATAEDU, the Finnish industrial visualisation and data transfer company, UTU Automation Oy, indicated that nearly 50% of the company's employees are retiring in 5-10 years, with the workers mostly falling within the age range of 45-64 years. ''Some skills can't be transferred,'' a representative from UTU explained. In the case of UTU Automation, job shadowing, a process which takes between one and two years, is the only way to transfer skills within the company.

Furthermore, the manufacturing sector faces this challenge at a time when investment in new and existing infrastructure must rise sharply to meet the needs in the transition to smart manufacturing. Replacing many of the required skills traditionally would involve extensive apprenticeships, and/or graduate training programmes[12].

Implementation of the above does not conclude the matter because many jobs necessitate high levels of experience and know-how, built up over time and, in many cases, are employer specific. New technologies, such as artificial intelligence (AI) and augmented reality (AR), will support the collaboration between people and equipment, helping new members of the workforce learn faster from the immense volume of "institutional know-how" and thus make fact-driven decisions[10].

Finally, involving the retiring workforce in training programmes might prove to be beneficial to transfer this large amount of know-how to young people and to allow a smooth substitution of retiring workforce with young people. Companies like UTU Automation have taken it upon themselves to address the issue of the ageing workforce by directly recruiting bachelor's degree employees like Electrical Engineers (*Sähköinsinööri*) or VET degree Electricians (*Sähköasentaja*). The Estonian company, Baltflex, which operates as sales, service, design and construction of hydraulics systems, relies on employer engagement programmes to address the issue of the ageing workforce. The global Danish pump manufacturing company, Grundfos, and Hubble Oy, a Finnish software development company, incorporate specific transition training programmes into their operations for the same reason. The Finnish companies of Luvata Oy, a global metal manufacturing group, and Pintos Oy, which specialises in the manufacture of reinforcement products and nails for the construction industry, both utilise co-working techniques to engage and train current employees to bridge the knowledge gap between younger and older generations working in their companies. According to Luvata, knowledge is being transferred by co-working, or co-collaboration. On-call duty is also a popular way to engage the new workers. At Luvata, employer engagement programmes are also in place, but these are attached to additional job titles/promotions to be able to gain more hours and earn a higher salary for a given job.

To conclude, it is important to note that in many (smart) manufacturing companies, such as Intra Lighting, it is largely left to individuals to enable knowledge transfer and search for solutions from older generations themselves, with a strong emphasis on self-initiative. In terms of technology, those approaching retirement are powerful building blocks for development: according to the R&D Department at Intra Lighting d.o.o., a global provider of architectural luminaires and smart lighting solutions, older employees are usually able to comprehend the ''big picture''. Older employees are using and know also the latest technologies – this is different for teachers because they have no practical experience and physical displays, or rather lack of challenges. This is an important fact to consider when addressing VET curricula for smart manufacturing, as hands-on company experience and knowledge transfer within the company is usually considered to be most effective by those in the (smart) manufacturing industry.

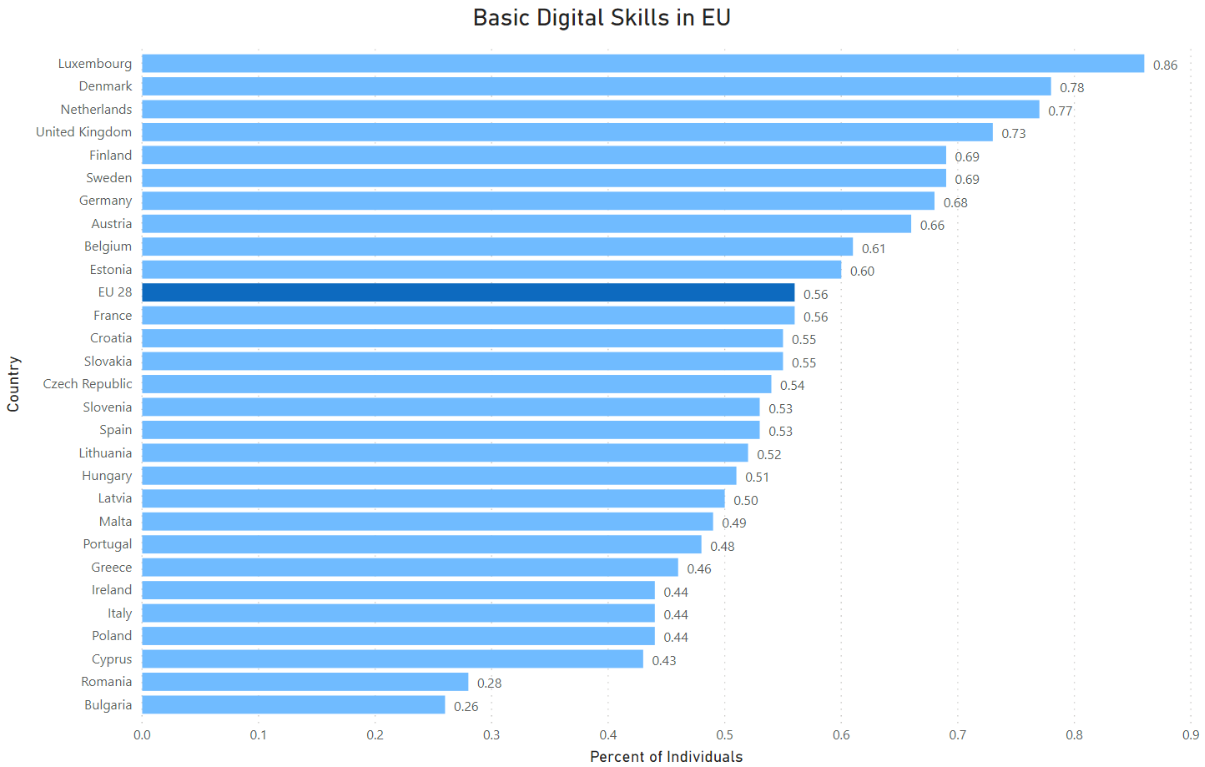
2.3 Manufacturing Sector Skills Shortages

Currently within parts of the manufacturing sector, demand for skill is greater than supply, especially from companies already on the path of transition. Special consideration must be given with respect to recruitment and training programmes as they can be difficult to manage and hard to slow down. In this case, a careful approach is required with intervention, as shortage could quickly turn to a surplus. Skills shortages are evident today with employers choosing to manage the situation by competing for staff within the sector, recruiting only from industry supply chains doesn't add capacity and is not sustainable. As described above, when retirement starts to take hold and demand increases, skills shortages will become more widespread unless recruitment and training is increased to compensate[13].

Previous research reports show, worldwide, almost 60% of business executives from different fields seemed worried about current or future shortages in the technical and engineering fields. Within the EU, 40% of EU manufacturing employers reported a critical shortage of skilled labour force[14]. With the diffusion of smart manufacturing, this scenario might even become worse. In the near future, 9 out of 10 jobs will require digital skills, and currently only 57% of Europeans have a basic level of digital skills, so industries will find it difficult acquiring these skills as they will be recruiting from the same pool[15].

See Figure 4 below for a comprehensive overview of the levels of basic digital skills on average per EU country. Please note that these insights into skill shortages and skill mismatch are based upon Cedefop's European skills and jobs survey (2018)[15] in conjunction with findings from in-depth interviews with stakeholders within the scope of the Talentjourney project.

Figure 4. Basic Digital Skills in EU by Country[15]



2.3.1 Supply Side

For what concerns the supply of STEM (Science, Technology, Engineering, Mathematics) skills in the EU, developing STEM skills in general is considered strategic for a technology-driven economic growth from a European perspective. In 2013, STEM jobs represented 6.6% of the overall EU workforce, with around 15 million jobs, among which 3 million were employed in high-tech companies. It should be noted that there are differences in the size of European STEM professionals due to differences in the definitions. According to Eurostat, the STEM workforce corresponds to 20.7 million people[2]. The definition of STEM professionals is based on qualification levels, while the definition of STEM employment is based on the occupation. In all cases of the various definitions of the STEM workforces, the supply of STEM skills is unevenly redistributed (or skewed) towards the older demographic group, with around 42% of this figure referring to employees between 45 and 64-year old, with Germany and Estonia even reaching 56%.

Figure 5. Number of Workers (in Millions) in STEM by Age Groups in the EU Over Time[2]

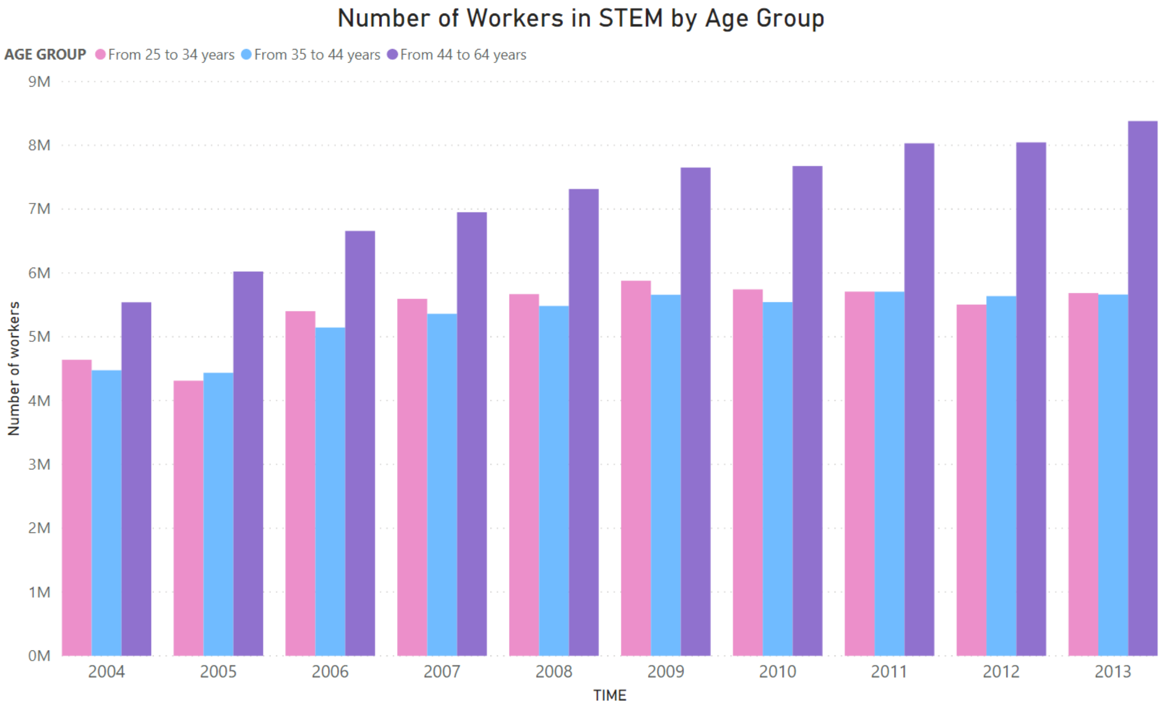
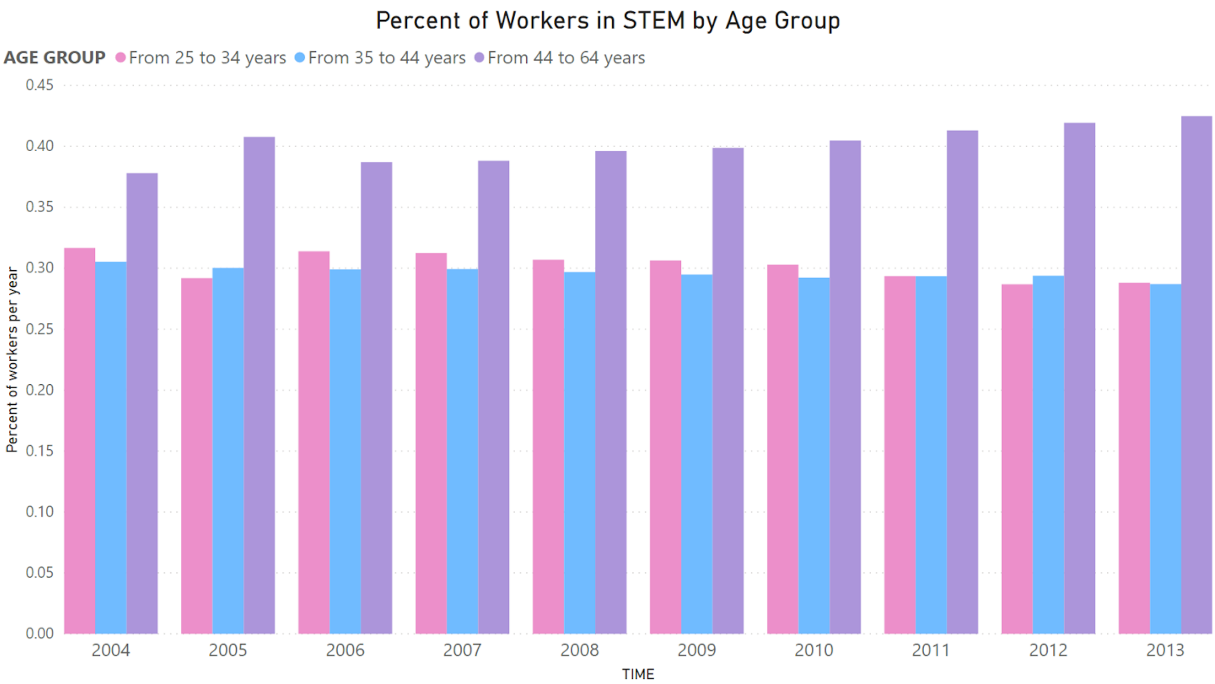


Figure 6. Percent of Workers in STEM by Age Group in the EU[2]



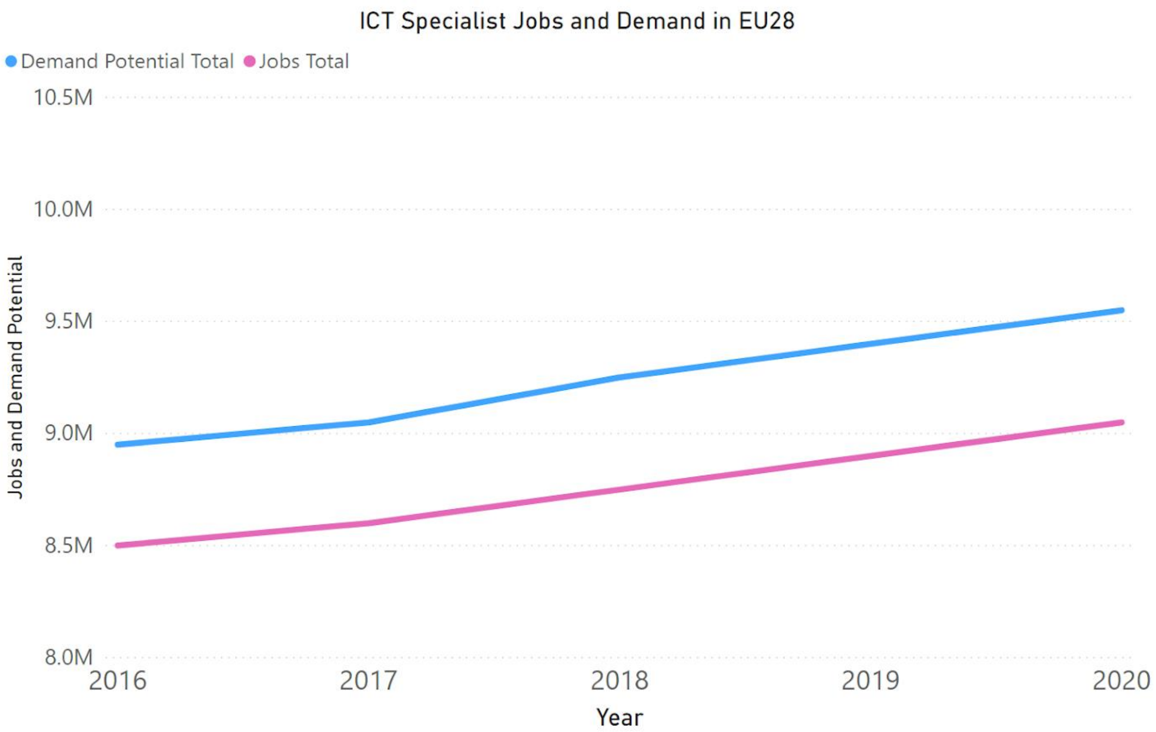
As apparent in the above figures, the EU share of STEM workforce within the age range of 45-64 year had increased by 2.2% in the period 2008-2013. Notably, the number of STEM graduates had increased by an annual rate of 3.8% in the period 2007-2012[13]. However, as a combination of desk research and in-depth interview responses within the Talentjourney has suggested that STEM skills are increasingly relevant within the manufacturing sector, there still exists a significant shortage in the number of qualified young people entering the smart manufacturing job market.

2.3.2 Demand Side

The high demand for STEM skills is reflected in a relatively low unemployment rate (2% in 2013, around 400,000 unemployed people) and in a relatively strong wage premium and wage growth. In the period between 2013 and 2025, CEDEFOP has estimated to be 3.4 million job openings in the field of STEM, respectively 1 million new jobs and 2.4 million replacements for the retiring workforce[15].

Accounting for this increasing demand and for the large share of retiring workforce, in order to avoid a future skills shortage, the number of STEM graduates will need to increase, at least at the current annual growth rate of 3.8%[15]. As an example, the supply of ICT specialists cannot keep pace with demand: it is estimated that there will be over 500,000 unfilled vacancies for ICT professionals by 2020[16]. In parallel, the mobility of young graduates should be encouraged across EU Member States.

Figure 7. ICT Specialist Jobs and Demand in EU (2016-2020 Projected Forecast)[16]



As exhibited by Figure 7 above, the demand potential of ICT specialist jobs in the EU has increased by approximately 6% between 2016 and 2020[16]. To illustrate, if this steadily increasing growth rate were to persist – not to mention, increase – roughly half a million new job positions within the ICT sector are needed to be fulfilled each year, moving forward.

Some projections are optimistic, even expecting oversupply of STEM skills. However, due to a high level of uncertainties and labour market heterogeneities, skills shortages are not excluded for specific STEM profiles or for specific regions in the EU[2]. In order to address skills shortage, private businesses have an important role in structuring educational training/curricula and in increasing the attractiveness of STEM job opportunities.

Indeed, in order to shape “demand-led” skills development systems, businesses must be more proactive in this process by articulating and communicating their current and future skills needs to VET providers. For instance, companies should work closely with VET providers in developing, iterating and validating pilot curricula.

Simultaneously, educational institutions need to adopt effective skills anticipation systems, providing accurate and real-time labour market intelligence[17]. Often companies are not capable to articulate their skills needs (for example, in relation to green skills); hence, VET providers must take the lead in skills development systems in order to be capable to provide those skills at the time industry realises this demand[18].

However, this is still not enough. Businesses, together with vocational education training (VET) providers, need to deliver attractive STEM learning experiences to attract young people by clearly communicating benefits and rewards, such as scholarships, wage premium, wage growth, career pathways, job security, etc. Increasing those benefits, for instance allowing flexibility, and introducing STEM subjects at secondary school level could help in increasing awareness around the industry. Indeed, the general low level of understanding surrounding career opportunities in the field of STEM, together with poor career guidance and communication, are considered major barriers for graduates when considering a career in the field of STEM[19]. A targeted communication strategy and better workforce planning can take advantage of further unexploited talents in demographic groups such as females and migrants[5].

2.4 Cybersecurity

One vital obstacle to address in the transition from manufacturing to smart manufacturing through the implementation of IOT / CDS technologies is the issue of cybersecurity. Cybersecurity refers to the system of technologies, processes, and practices in place to protect networks, devices, programmes and data in general from unauthorised use or destruction. The amount of data being created and stored is increasing exponentially, which in turn poses significant threats to privacy and security relevant across most industries. According to Skills for Australia, an organisation that plays a leading role in the development of training in the cybersecurity, these concerns will grow as increasingly more data is stored electronically[6]. When all data feeds into cloud service, cybersecurity is exceptionally important, according to Luvata, a Finnish company specialising in the production of metal products. Representatives from Luvata have highlighted that as CAN-bus is becoming increasingly relevant in the manufacturing sector, technicians will need an improved understanding of the technology. More so, CAN-bus experts and maintenance teams fully capable of dealing with CAN-bus technology will be needed.

The World Economic Forum reported that, in 2018, over $1 trillion in damages could be attributed to cybersecurity incidents[20]. New job titles related to robotic automation and thus protecting against cybersecurity threats have sprung up in the recent decade, and companies are altering their work activities[21]. These “new-collar workers”, or employees that combine technical skills with a higher education background, are especially relevant in fields such as AI and cybersecurity, according to IBM CEO Virginia Rometty. IBM has therefore partnered with vocational schools to steer curricula and build a pipeline of future new-collar workers[21] – a clear sign that demand for digital skills is increasing and, therefore, so is the demand for works skilled in the realm of cybersecurity.

2.5 Artificial Intelligence

Machines that exhibit a form of intellect can be described as having artificial intelligence (AI). Any device that perceives its environment and takes actions that maximise its chance of success is portraying artificial intelligence; AI is therefore of immense significance within the manufacturing industry with AI & IOT being the catalyst for the transition to smart manufacturing. Similarly, when a machine within a Smart Manufacturing imitates cognitive functions that are often associated to people's operative actions, such as learning and problem solving, AI is applied, therefore the interaction between people and machine is of great importance, when developing vocational education and training programmes of the future.

The roles of an Artificial Intelligence (AI) specialist are broad, meaning there are a variety of directions for a specialist to take. However, all paths have one similarity: specialists program computers to comprehend a diversity of situations, which is particularly true in the dynamic world of IOT & Smart Manufacturing. As an illustration, an AI specialist would program computers to test hypotheses in relation to how the human mind works through cognitive simulation. An example of this can be seen in the emerging world of smart manufacturing: smart manufacturing would use AI for expediating production purposes, to recognise components and identify whether the component is what it should be, which has the added value of greater quality control. Moreover, the role of an artificial intelligence specialist is to enhance the contributions and operations within the smart manufacturing industry, as well as many others.

2.5.1 Artificial Intelligence in Education

Various studies (Laanpere et al., 2014; Luckin et al.)[22, 23], have recently contributed to the ways in which AI can help improve learning opportunities for students and management systems. AI can help advance collaborative learning. One of the most innovative aspects of computer-supported collaborative learning is found in situations where learners are not physically in the same location. It provides students variable choices insofar as when and where they wish to study, thus providing flexible approaches to learning. AI can help personalise learning – it can support an enhanced environment for teachers to work on more tailored methodologies to learners' needs. At this point in time, teachers spend much time on routine and administrative tasks many which are repetitive. AI can provide virtual teaching assistants, which can take over the teacher's routine tasks allowing teachers to fully concentrate on facilitating learning creating the best outcomes for their learners[24].

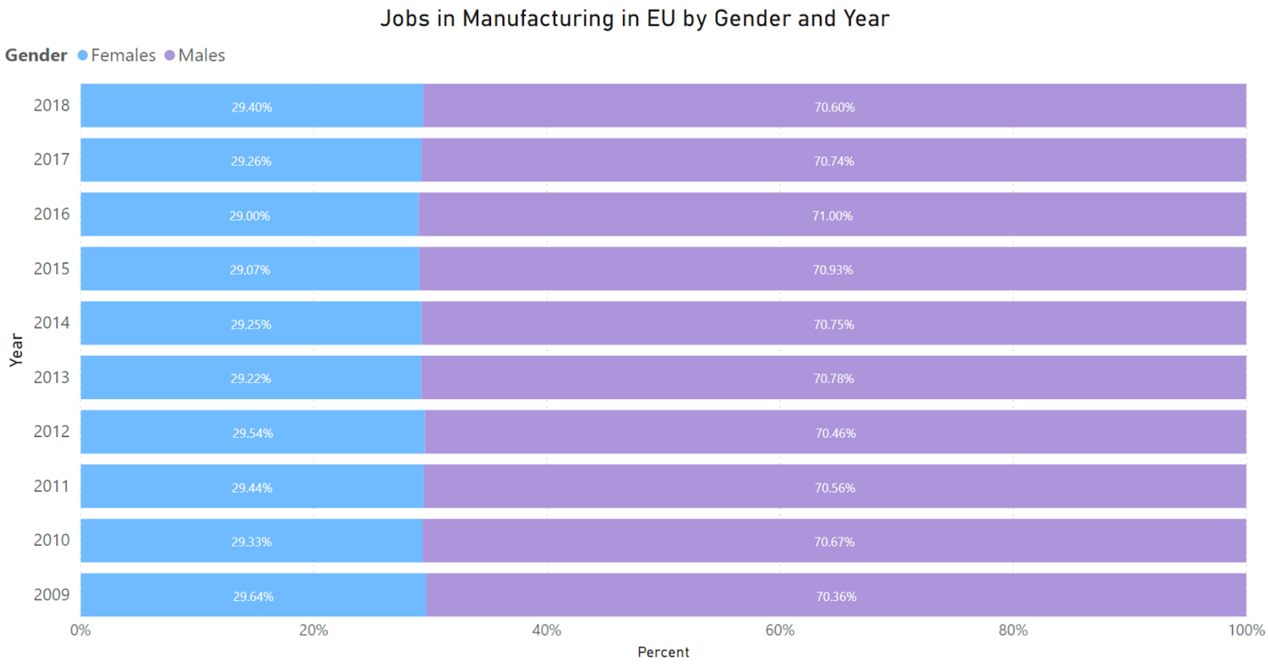
Algorithms can be created which will signpost students through different content pathways, AI can personalise learning and improve opportunities for students, with teachers playing that crucial facilitation role. Intelligent Tutoring Systems are part of the new technological possibilities to expand educational learning as shown in recent reviews[25].

2.6 Gender Imbalance in Manufacturing

A survey conducted by Women in Manufacturing (WiM) reported how three out of four women would not consider manufacturing as a career option. A 2018 study from The Guardian shows how women constitute only 14.4% of STEM workforce in UK. Although, women have proved to be beneficial for companies' profitability, with a 10% increase in gender diversity leading to a 3.5% increase in gross profit[26].

Manufacturing has a large pool of untapped talents. Indeed, qualified female staff is available, however, due to stereotypes linked to the industry, women do not consider this option. This will have to change since their recruitment will become a necessity in the face of the future expected skills shortage in manufacturing.

Figure 8. Jobs in Manufacturing by Gender[6]



In 2018, only one out of three employed in the high-tech sector was a woman[6]. Between 2009 and 2018, the rate at which gender imbalance of jobs in the manufacturing sector persists has remained stagnant, as exhibited by Figure 8.

Taking into consideration both past and current trends of gender imbalance in manufacturing jobs, the future seems more promising. There are already a number of interventions in place to encourage increased gender diversity in IOT and smart manufacturing. For example, in Slovenia, the use of role models is currently employed in STEM and IOT-related industries, such as the current tender/action in which women engineers with special achievements are nationally recognised as the ''female engineer of the year''. The Slovenian electric motor and components company, Domel, which employs a mainly male workforce (only one-third of the employees are women) have prepared leaflets for students in general education (primary and secondary) to encourage young girls to enrol in technical studies for the vocation they lack at Domel.

Further on this subject, the manufacturing industry is moving away from the conventional idea of manual labour, long working hours and rows of assembly lines by increasing the adoption of smart manufacturing techniques. The industry shows great potential for a female workforce, with women increasingly engaging in high-tech manufacturing. Talentjourney will consider all the above and address women in their skills development paths. It will support VET providers in structuring innovative curricula to be more attractive for women.

2.7 Manufacturing Sector Skills Gaps

As well as the age profile, the manufacturing sector is faced with a strategic challenge arising from the industry's changing skills needs, as it changes to smart manufacturing. Thus, skills gaps reflect a changing nature in business models and labour demand. By 2022, global average skills stability (i.e. the proportion of core skills required to perform a job that will remain the same) is expected to be about 58%[27]. Following the introduction of completely new occupations, severe skills gaps are expected in manufacturing sectors such as the automotive, mobility, healthcare, construction and food industries[16].

Today, skills gaps are increasing for a variety of reasons. VET providers often offer standardised learning programmes, which are not capable of keeping pace with fast technological changes and of fostering innovative learning methods, especially in the field of STEM. A mechatronic, for example, may complete his or her VET training in three technical fields, but he or she is not an expert in any of them, according to companies like Domel, a Slovenian company comprised of 1300 employees, specialising in the production of electric motors and components and hiring mainly workers in the field of electrical and mechanical engineering. In the case of Domel, vocational college students are exposed to more practice and basic knowledge than higher education students, but for more complex work assignments, university-educated staff are preferred. In this field, there is a view that the training of recent recruits has narrowed.

In an interview with SATAEDU, the Finnish industrial visualisation and data transfer company, UTU Automation Oy, explained that almost everything supplied from UTU is already IOT related – they have already been embracing Industry 4.0 techniques. Equipment is purchased directly from companies like Mitsubishi Electric, and UTU then gathers different devices and supplies for clients' specific needs. UTU therefore perceives the most significant skills gap in being able to process large quantities of data.

VET providers also are lacking in terms of qualified teachers and financial resources for constantly updating educational curricula. Skills gaps are further exacerbated by a poor workforce planning of companies and by a widespread misperception about the manufacturing industry, not attracting young graduates[28].

Skills gaps are not easy to overcome by recruitment alone. They should be addressed by industry itself, and industry lead programmes with more transition training from other sectors is essential. In general, companies indicate three strategies to tackle skills gaps: hiring new permanent staff already possessing these skills; automating the work tasks completely; and retraining existing employees[12]. At the national level, it could be helpful to introduce a system of credits leading to the award of "certificates" and to introduce adequate funding opportunities to accommodate workforce upskilling[29].

Beside these strategies, businesses also consider turning to external contractors, temporary staff and freelancers doing task-specialised work[12]. However, this sort of short-term approach will not be sufficient for manufacturing skill sets to adapt to the needs of the smart manufacturing skill sets required now and in the very near future. While today companies tend to show a passive/reactive approach towards skills gaps, in the future they are expected to be proactive and faster by the increasing implementation of internal programmes to cope with skills gaps.

The forthcoming investment in new 4.0 infrastructure will require a large addition of new or advanced level skills. Looking to the future, developed smart manufacturing infrastructure, smart networks and quality management will require skill sets, both technical and operational, in combinations that do not exist today. It is, however, difficult to predict the timing of technology development and market demand. Suffice to say, existing industry recruitment and talent attraction strategies need to be challenged to plug these industrial gaps.

3.0 The Internet of Things (IOT) and Connectivity Devices and Services (CDS)

The Internet of Things (IOT), also referred to as Connectivity Devices and Services (CDS), allows for the digital interconnectivity among equipment, connecting embedded manufacturing techniques with smart production processes and IT platforms. Next to IOT/CDS, further technologies are increasing connectivity in manufacturing, such as wired Ethernet connectivity devices, namely Ethernet IP, Profinet and EtherCAT. IOT/CDS are capable of sensing, interconnecting and inferring. This enables improved communication, control and data analytics in order to derive actions. The continuous flow of information on production equipment – for example, about the equipment's conditions, position or other attributes – creates an astonishing rise in data volume.

This enables the development of improved computational power, analytics and business intelligence and human-machine interaction, such as augmented-reality systems. This fosters the development of new products and dynamic business models, while allowing governments to successfully engage with the public through the delivery of efficient services[27].

With the introduction of cheap sensors and low-cost connectivity, IOT devices are increasing at an astonishing rate. According to IOT Analytics, in 2018 there were over 7 billion connected IOT devices in the world. According to PwC[30], businesses, governments and consumers will invest nearly $1.6 trillion to install IOT solutions in 2020, with 6 trillion dollars spent on IOT solutions between 2015 and 2020 (compounded). Software and application development are predicted to make up most of these investments. IOT can foster efficiency and productivity, but it requires great investments in innovation and a large degree of participation between actors. IOT creates value by transforming conventional business models in many sectors, from mobility and energy management to smart manufacturing.

Due to the large diffusion of decentralised IOT systems, IOT needs an appropriate governance to ensure data are used in a balanced and transparent way. This technical governance requires the establishment of a set of common standards across different industries and applications, which is a challenging task. By merging the physical and digital world, IOT poses severe challenges in terms of security. From public infrastructure and manufacturing to private homes, there is a certain degree of vulnerability that must be addressed. Security also refers to the protection of personal identity and information[31]. As the introduction of General Data Protection Regulation (EU) 2016/679 (GDPR) on data protection and privacy proves, regulation and compliance strongly affect industries across the EU and its international partners.

An appropriate governance capable to ensure trustworthy systems and customer protection is still largely missing. Beside governance, security must be integrated in the system architectural design. “Cognitive Firewall” is one method of scalable, upgradable protection; it forms a self-learning system, capable of placing the commands it receives in context, and allowing only safe commands to pass from the cloud to a device for execution[10]. Hence, IOT needs an adequate architecture and standard selection. Companies and governments can develop standards with robust interfaces and ensure healthy environments capable of addressing performance and safety issues. Developing a comprehensive set of IOT standards can in turn address networking, communication, and data handling, and can also help to improve overall interoperability[31].

Another point to address is the responsibility and positioning of the public and private sector regarding this topic. It is a challenge to develop IOT capabilities, stay competitive and innovative, comply with regulations and ensure that all these practices are aligned to a vision that considers people, profit and planet.

IOT needs scalable, future-proof, and cost-effective architectural options and thoughtful standard selection. In this regard, there is no one-size-fits-all solution for IOT architecture, whether it is related to sensing, communication, analytics or actuation. However, two models are the most common. First is digital mirroring, sometimes referred to as digital twins, which duplicates real-world physical objects into purely digital objects. These digital objects are able to interact with the physical world, other digital duplicates and computing services, often using the cloud as a platform, allowing for an increase in computing power. The second approach, called “edge” or “fog” computing, splits processing duties between responsive local computers and the cloud. Dividing up processing like this enables devices and services to provide more prompt responses or perform more data-intensive analysis[31].

In order to successfully implement IOT in manufacturing, Siemens (2019) recommends prioritising change management and cybersecurity. Siemens also identifies five steps for implementation[32], listed below:

- Develop a clear business strategy, considering threats and opportunities stemming from the adoption of IOT.
- Ideate and implement a prototype for the desired process. Consider consulting external experts such as IT and data scientists or marketing professionals. In an interview with Adria Mobil within the scope of the Talentjourney project, it was also stressed that pilot trials will be necessary in the ideation phase of the Siemens five steps for IOT implementation. Some international groups, such as BMW, have dedicated locations testbed location. Within smaller companies such pilots can be departments, certain production lines should utilise testbed/pilot trials during the ideation and prototyping phase.
- Start to connect, adapt and integrate the manufacturing equipment and systems with sensors, devices, communication networks, cloud infrastructure, IOT platforms and applications. The result is a functional system, including data transmission, storage, and processing.
- Analyse manufacturing data to derive actions. According to the business objective, data scientists can choose to develop an advanced algorithm or to derive descriptive statistics.
- Operate the system and maintain it efficient through constant adjustments.

3.1 IOT Implications for Skills

The widespread adoption of IOT will have severe implications for the skills needs of companies. Indeed, the European Centre for the Development of Vocational training (CEDEFOP) and the Organisation for Economic Co-operation and Development (OECD) forecast that elementary, manual, routine and low-skilled jobs will decline, while productivity-enhancing and high-skilled jobs will increase.

The introduction of disruptive skills applicable across multiple fields will lead to an increase in the demand for hybrid jobs[33]. Hybrid jobs combines skills sets that were never found within the same occupation. Examples are skills in marketing combined with statistical analysis or competences in programming linked with design skills[34]. Businesses will also increasingly look for workers with STEM skills that can be easily transferable. In order to implement smart manufacturing and to thrive with IOT/CDS equipment, particular skills are expected to be in high demand in the near future, which are mainly linked to the issues of big data and cybersecurity. Other notable occupations/skills required at each phase of Siemens’s five steps for implementation of IOT in smart manufacturing include AI/AR strategists, AI/AR developers, AI/AR engineers, production/logistics experts, IT hardware and software developers and experts and big data statisticians. This is also supported by the survey findings of the Talentjourney consortium. The interrelatedness of the above fields can help to illustrate the increasing demand for hybrid skills and jobs with the integration of IOT in smart manufacturing.

Employers will need to implement a big data strategy in order to create added value from the exploitation of data. Skills in business development and production process development will be necessary to integrate the big data strategy, the technological possibilities and the core business. Data scientists and programmers capable to collect, structure, clean and storage data for analysis in order to derive data-driven decisions will be in high demand[34].

Software and application engineering skills to build IOT solutions will be required. Similarly, hardware engineering competencies could be requested in order to build the robotics, electronics, sensors, actuators, etc. needed for the implementation of IOT in smart manufacturing. Besides this, skills in interoperable network engineering and system integration will allow to connect the whole IOT system[16].

Cybersecurity skills play a central role in the smart manufacturing industry. Employees will need to have the following competences: risk assessment and management; business continuity management; legal compliance and skills in compliance policy to prevent privacy issues and legal claims; knowledge of network and data protection; access and identity management; security audit; and monitoring and mitigating threats to prevent and solve cybersecurity issues[16].

According to a combination of desk research and in-depth interviews with various stakeholders (VET providers, higher education institutions, companies, Chamber of Commerce), the following is a list of suggested fields and thus skills required for jobs in IOT in smart manufacturing. It should be noted that the list is not exhaustive; it shall change as technology changes:

- AI/AR developers – According to the global metal manufacturing group based in Finland, Pintos Oy, there is a huge amount of data stored in the intranet amount of data will grow even more in the future due to IOT. For this reason, is a significant need for application and software development in smart manufacturing.
- Engineering (skilled, manual) – This will be less significant as we move toward automation, but diagnostic will be needed; hybrid jobs (Leone, Slovenia)
- Engineering management
- Engineering software
- Engineering hardware
- Engineering network development
- Quality engineering
- Robotics engineering
- Statistics
- Data science
- Microcontroller/CDS programming
- App development
- Production process development – From the ordering materials, supplying materials, distinguishing types of production, managing waste materials, identifying supply processes. Leone, a large ice cream supplier based in Slovenia, has explained that the production process management is a highly dynamic process. If there has been a recent significant emphasis on allergens for Leone, the company needs to pivot and treat multiple processes of production differently.
- Cybersecurity
- Cobot engineering
- Logistics
- Data quality administrations – Ensuring that the data is properly collected and processed to obtain useful information, data quality (Hidria, Slovenia)
- Project management
- Next-gen machine-learning engineers – These engineers are fluent in distributed computing techniques, have experience using different machine-learning algorithms and apply them, understand different parameters that affect learning and understand trade-offs between different approaches. They focus not only on technical solutions but are thought partners to the business.
- Scrum masters and agility coaches – 'Agile development', where software is rapidly developed in iterative cycles, is a core capability that drives the technology engine. Great scrum masters need to have the ability to be great people leaders, in order to create sustainable change.

3.2 IOT Skills Gaps and Shortages

Previous studies highlighted the presence of a talent shortage that is hindering IOT development. This shortage could persist through 2025. This does not exclusively refer to a lack of IOT workforce, but a combination of IOT skills, hence also to skills gaps[35].

The difference between a skills gap and a skills shortage, is that a skills gap refers to qualitative skills deficiencies within companies and can be overcome by further training of the existing workforce. On the other hand, a skills shortage refers to quantitative shortages in the labour markets and requires the recruitment of more people into the industry.

According to a survey study conducted by the EU Commission[16], IOT skills shortages are most prominent in the area of business development, strategy making, machine learning, interoperability network engineering, hardware engineering, software and application engineering. The survey respondents indicated critical mismatches between supply and demand for the following occupations: data scientists, software engineers, algorithm developers, programmers, data engineers, data structurers, data architects, data administrators, (AI) developers, product owners and security specialists. These jobs are considered relevant for frontrunners and developers; hence the above skills shortages could hinder EU industrial innovation and competitiveness[16].

Further, the companies and VET providers involved in smart manufacturing who were interviewed within the scope of the Talentjourney project provided that the most severe skills shortages are expected to be within the fields of robotics engineering, data analytics and cybersecurity. More specifically, according to the Finnish smart construction company Pintos, there skills gap in robotics engineering will increase further as automation becomes more prominent. ‘’The only problem,’’ a representative form Pintos explains, ‘’is that if there are approximately five to twenty-five robots per company, and they aren’t using their own robotic engineers to solve problems. They call for the manufacturers engineers and they will either come to the site or they will try to solve the problem by remote access.’’ Additionally, companies and VET providers interview by the pan-European Talentjourney consortium have expressed their concern with skills gaps in the area of data analytics, as the world will becoming increasingly more automated and digital, thus producing more data to be processed.

In the realm of big data, the EU is today facing a severe skills shortage[36]. Data scientists account for far less than 1% of total employment in most Member States[37]. For instance, in the UK, the demand for big data professionals was expected to increase by 160% between 2013 and 2020, adding 346,000 jobs[38]. The major skills shortages are identified in the activities of programming, system architecture, data analysts, data storing and warehousing[16].

Furthering on the need for data scientists is the current and projected skills gap within the subject of AI, which is supported by the combination of desk research and survey findings of the Talentjourney consortium. During the research period of the Talentjourney project, it was found that several new roles would be required to undertake the transaction towards an IOT/smart manufacturing environment, some of which are set out below.

There are a number of roles for Artificial Intelligence Specialists within smart manufacturing. These include but are not limited to:

- Research scientists: responsible for designing, undertaking and analysing information
- Software Engineer: specialise in a few areas of development, such as networks, operating systems, databases or applications
- C# developer: capable of handling many aspects of developing an application, including but not limited to performance, scalability, security, testing, visualisation and more
- Information Security Engineers: help to safeguard organisation's computer networks and systems – this is often referred to as Cybersecurity Engineer
- Software development manager: play a key role in the design, installation, testing and maintenance of software systems
- Java Developer: specialised type of programmer who may collaborate with web developers and software engineers to integrate Java into business applications, software and websites
- Software Analyst: studies the software application domain, prepares software requirements, and specification documents

The Šolski center Nova Gorica has also identified a projected skills gap in project management to develop new models. In anticipation of a skills gap in this area, the Danish pump manufacturer with over 19,000 employees internationally, Grundfos, has established an initiative for how to integrate their suppliers into their digital model, which demonstrates what they have or offer in relation to smart manufacturing and the flow of data between the customer and the customer; e.g. the flow of process data (product data, how it was created, conditions).

Regarding the subject of cybersecurity, corporate demand for skills is rising faster than supply, and this demand is not likely to diminish in the next few years[22]. For example, the EU is expected to face a skills shortage of 350,000 professionals by 2022[10]. According to an EU Commission's survey[16], 66% of professionals in the EU believe there are too few cybersecurity professionals within their department. Also, organisations indicate skills shortage in cybersecurity to be more severe than skills shortage in big data analytics (68% vs 64%). In terms of skills gaps, the survey respondents indicated that cloud security, data protection, threat monitoring and mitigation, and network protection are the major area of concerns.

3.3 IOT Skills in Skills Development Curricula

In-depth interviews with companies and stakeholders through the Talentjourney consortium support desk research findings in that significant skills shortages will exist within smart manufacturing in 5-10 years' time due to lack of meaningful engagement from higher education and VET providers in the realm of smart manufacturing. The Italian applied sciences and technical school, I.S.I.S. A. Malignani, attributes the significant shortage of IOT skills at all levels partly to the fact that the first university courses on these topics were only rolled-out in the last couple of years; another source of this IOT skills shortage is the fact that companies also have only recently started to develop their IT fields in regards to IOT.

VET providers and businesses will need to work collaboratively to constantly monitor IOT skills gaps in qualification and curricula. They will need to be dynamically responsive to address the aforementioned skills gaps in order to keep pace with the latest technological advances, keeping companies industrially competitive in a global marketplace. Beyond the provision of basic STEM skills, companies will need to upskill their workforce(s) by the implementation of tailored bespoke educational programmes. VET providers should be able to answer to local needs of companies, while also offering standardised learning contents in order to promote workforce mobility[13].

When addressing IOT skills gaps in smart manufacturing, VET providers should adopt evolutionary changes built on the today's practice. Examples are the implementation of new training standards and qualifications that are modular and interoperable[16]. The development of *learning factories* is an ongoing international trend. It refers to an authentic production facility to be used for learning purposes. The facility may be physical, virtual or both. It can consist of multiple production equipment and can be extended to include supply chains and customer services[8].

The implication of a shortage of IOT skills and STEM skills at national/regional/local levels has caused employers and companies to consider appropriate strategies to reach a balance between demand and supply of skills. A combination of desk research and survey findings of the Talentjourney consortium have led to identify the main causes of IOT skills gaps in smart manufacturing to be standardised (rather than tailor-made) learning programmes, lack of qualified trainers within VET programmes and larger companies, fast-paced changes in working methods, fast-paced technological changes and lack of strategic direction. According to Italian applied sciences and technical school, I.S.I.S. A. Malignani, only five years ago the IOT field was only at the beginning of its development, but technology changes very quickly and it is has become difficult for schools/VET programmes to update curricula merging the traditional ICT skills with the new IOT skills.

To address the issue of IOT skills gaps in smart manufacturing, desk research and survey findings of the Talentjourney consortium have allowed for the following proposed solutions:

- Implement Labour Market Intelligence tools (e.g. skills anticipation systems)
- Enable better cooperation with VET providers (e.g. demand-led skills development systems)
- Increase attractiveness of related curricula and thus the number of IOT/STEM graduates

Hidria, a world-leading Slovenian corporation in automotive and industrial technologies interviewed by the Talentjourney consortium, offered the additional solution of allowing students to practice and work on joint projects within IOT/smart manufacturing companies whilst still in their studies; these concrete tasks are solutions for the companies and, at the same time, offers a means of acquiring knowledge for students (maybe as future employees). More direct cooperation between VET/higher education and the management of smart manufacturing companies should explore what digitalisation could unleash and trigger, uncovering where are all its benefits could lie. Additionally, the Šolski center Nova Gorica suggested that the shortage of IOT skills and STEM skills at national/regional/local levels could be addressed by establishing a network of relevant experts as individuals at regional, national and international levels to encourage more collaboration between the experts and young people, as well as teachers and VET providers.

The Šolski center Nova Gorica has proposed there should be maximum of 30-40% of fixed curricula within the fields of, for example, literacy, natural sciences, sociology, elocution, basics in professional field. Such curricula should be very interdisciplinary and connective, coming out of life situations and stimulating especially one's creativity, critical thinking and problem solving. The focus of the curricula should be placed on discovering one's own potential/talent. Students should be taught how to:

- learn
- live and deal with problems
- develop core skills
- process and analyse information
- prepare and plan for future
- work more closely with machines (AI)
- develop creative skills, analytic skills, human skills, self-presentation
- connect to the others
- say yes to any opportunity
- try new things to discover new talents inside oneself

The fixed curricula should respect that education systems must be relevant and respond to rapidly changing labour markets, technological advances, urbanisation, migration, political instability, environmental degradation, natural hazards and disasters, competition for natural resources, demographic challenges, widening inequality and expanding threats to peace and safety.

At the same time, education should be inspired by a humanistic vision of education and development, based on the principles of human rights and dignity, social justice, peace, inclusion and protection, as well as cultural, linguistic and ethnic diversity and shared responsibility and accountability, achieving effective and inclusive partnerships. Educational institutions should teach the students about what is happening around them. The stress on the fixed part of curricula should be put especially in the first year to help students to grow in their maturity as a person.

A significant portion of the curricula would offer students an eclectic mix of life and professional disciplinary subjects, including experiences and expertise from the world of business, technology, society and community. The linking factor should be intellectual curiosity, personal drive and a capacity to work as a creative team, while inspiring rather than diminishing each individual's own creativity.

According to the new economy culture and new generations the focus should be put on three main processes, as outlined by:

- The tutoring/mentoring (individual and group): strategically and very cautiously selected tutors from schools, labour market and other VET stakeholders (local/regional, national, international) with lots of pedagogical sensitivity and empathy for students and other learners
- The work-related/real world projects with business partners, community, etc. working in teams
- Networking, in order to develop one's own potential/talent inside the very engaging and collaborative environment

There should be three main actors: student/learner, tutor (VET teacher, career counsellor) and company trainer/company expert or another expert out of school system as additional tutor.

In response to the increasing demand for hybrid jobs, VET providers will need to contemplate further cross-disciplinary programmes in a systematic way. This combination of skills delivery will need better data and planning, hence improved cooperation with companies. Also, since these jobs require skill levels above entry level, lifelong learning really becomes critical.

A combination of desk research and survey findings of the Talentjourney consortium has demonstrated that strategic developments should provide for the increasing demand for hybrid jobs in smart manufacturing; e.g. employer/industry engagement strategies. Additionally, further approaches to addressing the increasing demand for hybrid jobs in smart manufacturing across Europe include the co-creation of curricula and resources, allowing individual learning experiences, the use of alternative learning environments and the use of alternative learning tools. The Šolski center Kranj, a Slovenian VET school with 70 teachers and 650 students, has suggested that cross-disciplinary VET programmes should be systematically structured through tight cooperation between VET organisations and companies in order to take into consideration the rise of hybrid jobs. With these joint cross-disciplinary programmes, skills that are identified to be necessary at the company level should be then quickly integrated in curriculum on national level.

3.4 Impact at National/Regional/Local Level

Companies and VET providers must respond to expected future skills gaps and shortages in IOT and smart manufacturing (including meta skills and green skills) within their respective national/regional/local socio-political settings, which may differ by country or region throughout the European Union.

In Slovenia, VET skills systems are mostly centralised. What is decentralised is the 20% of open curriculum, which VET schools have autonomy to adjust according to the needs of the students, as well as the life-long learning courses for employees (or the unemployed and other interested target groups). The 20% of the curricula that is considered to be open allows a given school the opportunity to independently identify the additional vocational and vocational-specific competences it will offer to its students. In terms of content, these competences may mean expanding or deepening existing content or adding new ones. These competencies should include a record of their knowledge and specific goals. Within the other 80% of the curricula, implementation of practical work depends mainly on teachers – if they follow development in industry, they can adopt teaching methods and content accordingly (for example: to gain competence in making printed circuits can be done in different ways). Additionally, life-long learning courses for employees, the unemployed and other interested target groups that are developed according to labour market (through the use of labour market intelligence tools) and society needs are developed independently of the centralised VET skills system and implemented by VET providers.

In Italy, national agencies outline the structure for a top-down VET skills system approach. The Ministry of Education (MIUR) in Italy has the mission to foster the culture of lifelong learning and to set policies and plans for schools at different levels. Despite this, single institutions are expected to establish a dialogue with other parties – both within the public and private sector – operating in the same areas, and to modify their actions accordingly.

Parallel to Italy, regional outcome agreements with chambers of commerce and all stakeholders in relation to VET skills systems are established in Finland. Estonia has also adopted a top-down approach in that national agencies are responsible for establishing the VET skills systems in place.

4.0 The Skills of the Future: Meta Skills

In the future we can expect an increase of digital technologies across all places and working fields as well as a continuous increase in new ways of connection between people and equipment. This will allow people to cooperate across industries and open new market opportunities. Consequently, the volume of data generated will be immense, requiring people to develop skills to manage this complexity. The smart manufacturing workforce will have to learn how to work alongside these technologies. Beside the technical skills required to thrive in this new working environment, people will need to develop a new intersectional set of skills to be applied to the smart manufacturing sector broadly, called ‘’meta skills.’’

The future skills set will be defined by these so called meta skills, which are considered to be timeless and of a higher order, demonstrating adaptability and transferability. This is because they create adaptive learners capable of thriving alongside future technological uncertainties, typical of the smart manufacturing sector. Meta skills are characterised by a high degree of interdependencies because they support the development of further skills[39].

Meta skills include the following competences: capacity to focus and prioritise, integrity and self-awareness, adaptation and resilience, cognitive flexibility, self-initiative and entrepreneurship, time management, responsibility, empathy (emotional intelligence), communication, collaboration and coordination, leadership and people management, negotiation and persuasion, service orientation, curiosity and creativity, learning-to-learn, sense making, critical thinking and problem solving for societal challenges, judgment and decision-making[39].

Overall, this set of skills will allow people to be successful employees in the future smart manufacturing sector, or indeed entrepreneurs. For example, meta skills will help people to: cope with current and future changes of working environments; successfully engage in non-repetitive tasks; support both the well-being and performance/productivity of workers; connect and collaborate across different industries and backgrounds; promote innovation at individual and corporate levels[39].

Besides meta skills, universal skills, such as literacy and numeracy, today includes digital intelligence, or digital literacy. This refers to general digital skills but also to a computational thinking, such as coding and programming. Digital intelligence holds an increasingly importance in the workplace because it allows workers to be confident in using technology and capable of creating new technology itself[39].

Table 1. Meta Skills[37]

Capacity to focus and prioritising	Empathy (emotional intelligence)	Curiosity and Creativity
Integrity and self-awareness	Service orientation	Learning-to-learn
Adaptability, resilience and persistence	Communication and storytelling	Critical thinking and sense-making
Cognitive flexibility	Collaboration and Coordination	Problem solving
Self-initiative and entrepreneurship	Leadership and People management	Judgment, or ability to connect the dots
Time management	Negotiation	Decision making
Responsibility	Persuasion	Researching (including effective interviewing)
Having impact and having purpose	Prototyping and iteration	Pain-spotting
Co-creation	Lateral thinking	

Further, the above range of meta skills can be categorised according to age of students and their maturity levels; according to practical and life-related examples-problem solving through hands-on projects; and/or according to different profiles and work positions (i.e. adult learners, employees) in order to better assess skills data for CDS/IOT in smart manufacturing.

4.1 Meta Skills in Details

Increasing complexity and information overload in smart manufacturing will require an enhanced capacity to focus on the essential tasks at hand in order to protect productivity and wellbeing. This need of focusing will require to master the ability of sorting information into categories and of understanding their underlying relationships. Focusing also refers to the capacity to filter out useless information and to pay attention to the essential problems of the moment.

Self-awareness, together with a deep understanding of one's personal values, leads to integrity, which allows to act in a consistent and ethical manner in the workplace. Adaptation is tied to the notions of resilience and flexibility. It refers to the capacity of feeling comfortable in learning new skills in order to thrive in an increasingly fluid job market. Self-initiative, considered essential for future entrepreneurs, entails a certain degree of confidence in taking risks. Confidence allows experimentation and adoption of new technologies. It requires independent thinking and trust in one's intuitions.

Empathy, defined as the capacity to deeply understand and connect with others' emotions and perspectives, will be a successful factor in the future workplace, especially in relation to customer-oriented services. Communication will continue to be a key competence. It is defined as the ability to share information effectively and to listen carefully and with interest. This helps in reaching a mutual understanding about, for instance, business goals. Collaboration and coordination will still be required. Technologies will open new forms of collaboration, such as long distance, cross sectoral and across different cultural norms/background. In order to work in this context, people need to convey information and discuss problems effectively. This requires competences as teamworking and relationship building.

Leadership refers to the capacity to manage others by influencing, motivating and inspiring towards a clear vision and goals. This also entails a certain degree of responsibility towards others. Persuasion is convincing others to buy into your idea or a different way of doing things to build consensus or make a decision. Curiosity, as the tendency to observe and question any circumstance, is a key driver of innovation, allowing new ideas and concepts to emerge. This is linked with creativity, or the capacity to imagine and generate innovative ideas for addressing problems. Creativity will be increasingly on demand in the future workplace due to the rising of non-routine tasks.

Critical thinking, or sense-making, allows employees to develop a broad strategic overview of the vast amount of information available. This ability to recognise the "big picture" allows to synthesise patterns and to extract meanings and opportunities. Judgment, the process of forming an opinion after careful thought, and decision-making, the act of making a choice after appropriate considerations, are considered skills to be applied at all levels but within a varying degree of cognitive and skills capability[39]. Pain-spotting is recognising an issue identifying areas for improvement.

4.1.1 T-shaped Skills Definition

T-shaped skills are a method used to describe specific skills and attributes of desirable workers, this is particularly true in technology industries such as IOT and smart manufacturing. The description is thus, the vertical bar of the T refers to expert knowledge and experience in a particular vocational field; this can be seen as competency in a technical discipline. The top of the T refers to an ability to collaborate with experts in other disciplines and a willingness to utilise the knowledge gained from this collaboration; this can be seen as the necessary meta skills.

It is accepted that a T-shaped person has deep knowledge/skills in one technical vocation/profession and a broad base of general supporting knowledge/skills, this is highly desired in the smart manufacturing sector and its associated supply chains.

4.2 Meta Skills in Skills Development Curricula

The inclusion of meta skills and digital intelligence in VET is an important consideration to shape a workforce that is capable of coping with the transition to Industry 4.0, with all the future technological uncertainties.

Meta skills are most effective when learned and developed in the workplace[39]. For instance, meta skills could be learnt through case studies or through real assignments to be carried out at companies. This creates the opportunity for VET providers to work more closely with companies, also stimulating them to be innovative in the workplace, making this an optimal space for skills development; for example, fostering practices such as openness to new ideas or autonomous working. This does not have to preclude academic learning. On the other hand, meta skills are difficult to measure and assess compared to technical skills, so a methodology should be sought before direct implementation[39].

A skills development system capable of delivering meta skills to the workforce will require a collaborative method, grounded on a "demand-led" approach[39]. Talentjourney has categorised the range of meta skills listed at the beginning of chapter 4 according to different job titles required for smart manufacturing in order to better assess skills data for CDS/IOT in smart manufacturing and thus make corresponding recommendations for VET curricula development in smart manufacturing.

Table 2. Meta Skills[39] – categorised by different jobs required in smart manufacturing.

Capacity to focus and prioritising All	Empathy (emotional intelligence) All	Curiosity and Creativity 1, 3-8, 12-16, 18-20
Integrity and self-awareness All	Service orientation 1, 3, 6, 13, 17-20	Learning-to-learn All
Adaptability, resilience and persistence All	Communication and storytelling 1, 7, 10, 13, 16-20	Critical thinking and sense-making All
Cognitive flexibility All	Collaboration and coordination 1-3, 6-8, 12-13, 15, 17-20	Problem solving All
Self-initiative and entrepreneurship 1, 10, 13, 18, 20	Leadership and people management 13, 18, 20	Judgment, or ability to connect the dots All
Time management All	Negotiation 1, 3, 12, 13, 18, 20	Decision-making 3, 13, 14, 18-20
Responsibility All	Persuasion 1, 3, 7, 14, 17, 18, 20	Researching (including effective interviewing) 1, 6, 7, 9, 10, 13-16, 18-20
Having impact and having purpose All	Prototyping and iteration 1-8, 12, 13, 15, 16, 19, 20	Pain-spotting All
Co-creation All	Lateral thinking 1, 3-5, 8, 11-13, 15, 16, 18-20	

Key:

1. AI/AR developers – According to the global metal manufacturing group based in Finland, Pintos Oy, there is a huge amount of data stored in the intranet amount of data will grow even more in the future due to IOT. For this reason, is a significant need for application and software development in smart manufacturing.
2. Engineering (skilled, manual) – This will be less significant as we move toward automation, but diagnostic will be needed; hybrid jobs (Leone, Slovenia)
3. Engineering management
4. Engineering software
5. Engineering hardware
6. Engineering network development
7. Quality engineering
8. Robotics engineering
9. Statistics
10. Data science
11. Microcontroller/CDS programming
12. App development
13. Production process development – From the ordering materials, supplying materials, distinguishing types of production, managing waste materials, identifying supply processes. Leone, a large ice cream supplier based in Slovenia, has explained that the production process management is a highly dynamic process. If there has been a recent significant emphasis on allergens for Leone, the company needs to pivot and treat multiple processes of production differently.
14. Cybersecurity
15. Cobot engineering
16. Logistics
17. Data quality administrations – ensure that the data is properly collected and processed to obtain useful information, data quality (Hidria, Slovenia)
18. Project management
19. Next-gen machine-learning engineers – These engineers are fluent in distributed computing techniques, have experience using different machine-learning algorithms and apply them, understand different parameters that affect learning and understand trade-offs between different approaches. They focus not only on technical solutions but are thought partners to the business.
20. Scrum masters and agility coaches – ‘Agile development’, where software is rapidly developed in iterative cycles, is a core capability that drives the technology engine. Great scrum masters need to have the ability to be great people leaders, in order to create sustainable change.

Possessing meta skills and digital intelligence enables the workforce to cope with future technological uncertainties. According to desk research supported by in-depth interviews with stakeholders within the Talentjourney project, VET providers should absolutely integrate such timeless and transferable (meta) skills in educational curricula. The University of Udine in Italy has recommended that the development of meta skills as those listed in this report can be achieved within existing curricula by changing the way courses are given; in particular, by increasing the time dedicated to collaborative (co-creation) group work, possibly under the supervision of teachers with specific background in these skills. The input of the Šolski center Kranj further supports this approach: according to the Slovenian technical school, VET providers should integrate the beforementioned meta skills in educational curricula by introducing the multidisciplinary modules that introduce ‘’problem learning’’, or learning within professional subjects, as well as “learning situations”, which are simulations of real working environment with real problems.

As stated previously, Talentjourney findings suggest that within many large companies, it is the responsibility of the individuals themselves to undergo the necessary knowledge transfer and search for solutions from older generations, such as the case with Intra Lighting d.o.o.

This demonstrates that there is a strong emphasis on self-initiative at many if not all levels within companies. Thus, individuals working in smart manufacturing even at the level of operating individual machines are, now and in the future, more often expected to demonstrate meta skills such as critical thinking or sense-making, curiosity, self-initiative, adaptation and communication skills.

Much of the literature review supports the opinion that learners have the opportunity to develop these skills and attributes necessary to enable them to thrive in an ever-complex and uncertain world where advances in technology are driving change at pace – this is especially true in respect of IOT and smart manufacturing. With this in mind, it is imperative that Talentjourney develops a more dynamic, responsive skills ecosystem that helps to create a future-proofed workforce. The focus of this work should concentrate on building high performing workplaces and employees by integrating meta skills into practical learning in the workplace; hence a new curriculum offer shall be devised, developed and reviewed.

5.0 Green Skills – Low Carbon Skills

Industrialisation has led to many of the EU's current environmental problems. For example, climate change, unsafe levels of greenhouse gas emissions, overflowing levels with waste on land and in our oceans have vastly contributed to the global climate crisis currently in our hands[40]. As the Fourth Industrial Revolution, or Industry 4.0, picks up the pace, innovations are becoming faster, more efficient and more widely accessible than before. Technology is also becoming increasingly connected.

Disruptive innovation refers to the application of technologies capable to alter the ways industries, companies and consumers operate, also referred to as disruptive technologies. A disruptive technology has the attributes to sweep away previous technologies because recognisably superior. IOT and green technologies can be considered disruptive technologies because they are enabling societal shifts by influencing economics, values, identities and possibilities for future generations. Green technologies, for example, provide products and services in line with new societal values such as sustainability.

5.1 The Definition of Green Skills

In previous years green skills were referred to those working in horticulture or similar activities. However, at present green skills are essential to industry and people due to policy and societal pressure. The term of green skills appeared since the advent of green technologies[1]. Green skills are required to operate and develop green technologies, particularly in industries as fast changing as manufacturing. It was clear from the research conducted by Talentjourney and the responses from questionnaires that the definition of green skills was vague, with several understandings of what is green skills. Most Talentjourney respondent partners knew about generic skills, technical skills and employability skills, but their knowledge on green skill was limited; this was also the view of recent literature[2]. Generally, green skills are regarded as skills for environmental sustainability, resource efficiency and the emerging circular economic thinking, which are related to the technical skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable, environmental and socio-economic outcomes both in industry and the community. CEDEFOP defines green skills as the knowledge, abilities, values and attitudes needed to live in, develop and support a society which reduces the impact of human activity on the environment[41]. By extension of the aforementioned, green skills are generally composed of three dimensions, namely, knowledge (cognitive dimension), skills/abilities (psychomotor dimension) and attitudes/values (affective dimension) needed by workers to promote sustainable development in social, economy and environment[8]. From the cognitive dimension, the knowledge concerning environmental protection can be regarded as an element of green skills. From psychomotor perspective, green skills refer to the ability to, for instance, minimise energy consumption, or reduce greenhouse gases. Green skills also refer to affective aspect; for example, motivation of an individual to conserve natural resources. It is essential to understand that green skills to not sit alone but are an integral component in many of the vocations named in this report, Talentjourney understand the significance of the value of green skills and the need to incorporate these into the preparation of material.

5.2 The Need for Green Skills

Hence, green skills are vital for increasing development of Industry 4.0. The transition to a green or low carbon economy requires a workforce with the right skills in the right place at the right time. Four drivers of skills change in relation to green economy can be identified as the following: environmental changes; policy and regulation; green technology and innovation; and markets and consumer habits[42]. According to CEDEFOP[41], green skills, defined as skills needed in the transition to a low-carbon economy, will be required in all sectors, including smart manufacturing, and at all levels in the workforce as emerging economic activities create new or renewed professions. A review of all economic sectors indicates that there is a growing demand for skills in the context of the low carbon economy. In a recent interview with the Talentjourney consortium, the Slovenian Chamber of Commerce and Industry has highlighted the role of automation/digitisation in decreasing environmental impact of companies, thus stressing the importance of green skills in smart manufacturing: ''Digitisation enables seamless communication between the different phases of the product from development to completion of use – decommissioning,'' explained representatives from the Slovenian Chamber of Commerce and Industry. ''Digitisation enables the company to understand how the product is recycled after use. Two key competences (development of new products and decommissioning of end-of-life products), which have a strong influence, can be combined in this way, and they can be co-responsible, in the understanding of the whole life cycle of a product, [and thus] in influencing the processing of low-carbon companies. By understanding and co-ordinating the communication of these competences and, above all, the flow of information, we can change the impact on the climate load.''

Demand will increase for generic and basic green skills as well as for completely new green occupations and skills, as they emerge. But many others are not so new: they involve executing already established actions and processes, but with a distinctive green economy awareness and understanding, especially regarding resource efficiency in the manufacturing process[42]. With respect to the latter, these skills will still require to be addressed, with consideration given to specific transition training programmes.

Structural changes will realign sectors that are likely to decline as a result of the greening of the EU economy and workers will need to be retrained accordingly. The successful transition to a low carbon economy in the EU will only be possible if workers can flexibly adapt and transfer from areas of decreasing employment to new industries, such as smart manufacturing. The transition to a green economy requires a workforce with the right skills to be in the right place at the right time. This includes not only skills in the low carbon and environmental goods and services sector, but also those needed to help all businesses use natural resources efficiently and sustainably – IOT technology shall support this.

Green skills can be differentiated in the following fields: resource efficiency, low carbon economy, climate resilience and natural assets management. Green skills for resource efficiency range from the application of new business models and accounting methods to technology development – for instance, lean manufacturing – and project management. A low carbon industry will require the following: engineering skills in renewable energy production, competence in the installation of energy efficiency measures and retrofitting, skills in low carbon technology and process development. A climate resilient business will need competence such as climate change modelling and projections, risk assessment and management, climate resilient technology and process development. Natural assets management activities will demand skills in environmental impact assessment, understanding of environmental legislation and land planning, technology and process development for natural resources protection[29].

5.3 The Demand for Green Skills and STEM Skills

When considering demand and development of green skills some barriers exist. First, business risk aversion leads companies to wait for clear signals from governments before investing in green skills. Second, due to imperfect information, businesses do not know their green skills needs and are unaware of opportunities stemming from green economy and workforce.

Third, due to externalities, companies operating in emerging green sectors are not willing to invest in generic, transferable and expensive-to-develop skills, for example renewables production technologies and STEM skills. Indeed, new emerging green industries are characterised by a large number of firms competing for a low amount of skilled workforce, thus leading to high labour turnover. Because of this, the demand for STEM skills in green industries is expected to increase significantly in the near future, leading to skill shortages, which is considered a major barrier in achieving a successful transition to low carbon green economy. Too few young people choose to study this subject because of underestimated growth in certain green sectors (e.g. energy efficiency in buildings) and low reputation and attractiveness of some sectors (e.g. waste management)[29]. With this barrier, there lies an opportunity for VETs to provide awareness and prospects that exist in this exciting low carbon transition. VETs have an opening to embrace the 4.0 technological developments and engage with stakeholders to supply the necessary green skills that will be demanded through governmental policy change and societal pressure.

In an interview with the Talentjourney consortium, the Slovenian Chamber of Commerce and Industry have expanded on the demand for green skills in the future, explaining that environmental awareness is vital for commerce and industry now and in the coming years. According to their interview responses, employees should be properly educated in the subject of green skills – they must understand what consumers really need and how to produce useful and quality products, in addition to maintaining a comprehensive understanding of their environmental impact. Employees in smart manufacturing should be constantly educated and made aware of the environmental burden of individual materials, including how they degrade and in what form(s) they can be reused.

Finally, desk research and in-depth interviews suggest that completely new green occupations shall arise in the near future. Leone, a large ice cream supplier based in Slovenia, anticipates new green jobs such as environmental technologists, or general quality technologists dealing with the environment, will be increasingly relevant in the coming years.

5.4 Cleantech/Consumer Cleantech as an Emerging Sector

Cleantech, and more specifically consumer cleantech, is an example of an increasingly prominent sector worldwide that has emerged in response to the dire need to address global climate issues and the transition to Industry 4.0, which in turn is a driver for more green jobs. Cleantech, in general, is any process, product, or service that alleviates environmental degradation via significant improvements in sustainable resource efficiency, increased energy efficiency or other interventions that aim to reduce negative environmental impact[43].

From a very broad point of view, cleantech represents the convergence of both innovation-driven economic growth and the need to protect the degrading environment[43], and this sector is traditionally based in industrial solutions and innovations in the process industry sector. However, as companies are increasingly challenged by resource scarcity, rising energy and fuel costs, and a climate change-aware consumer population, consumer-focused cleantech startups, or sometimes referred to as SmartUPs have emerged in consumer markets as well[44]. This is called consumer cleantech.

The consumer cleantech ecosystem across Europe and beyond can serve as evidence that there is an increasing need to embrace the future world of circular economy, technology and green jobs. Within this emerging sector, new resources are created through ‘’smarter’’ use – via digitisation and automation (IOT) as in smart manufacturing – or re-allocation of available resources. Consumer cleantech companies integrate not only digitalisation and automation/IOT, but they also have adopted a user-centred design into the production and sale of goods, further increasing the efficiency of the consumer goods themselves[45]. Other forms of technology that consumer cleantech companies have integrated in response to resource scarcity and consumer demand for their goods to have a lower carbon footprint include highly efficient broadband, 5G networks and IOT.

Consumer cleantech companies – ranging from consumer cleantech forerunners Airbnb and Uber[43], to smaller startups that have maneuvered their way into international markets, such as Fourdeg – now use real-time digital communication to optimise the use of physical resources. Fourdeg, founded in 2013, is a B2B SaaS (Business-to-Business Software-as-a-Service) company from Finland for heating optimisation. In other words, companies like Fourdeg have adopted Industry 4.0 and IOT technologies (e.g. Wi-Fi-thermostats and optimal sensors, in the case of Fourdeg) to make the production and ultimately the consumption of goods easier and cheaper[11]. With the emergence of consumer cleantech, companies and consumers are producing and consuming the same goods, from toothbrushes to water bottles to bicycles. It is simply the process of producing these goods that has adapted to meet global demands for improved resource efficiency and the alleviation of climate change, through use of less carbon intensive physical materials (i.e. recycled, upcycled, etc.) in conjunction with smart IOT and Industry 4.0 technologies.

5.5 Green Skills in Skills Development Curricula

Market failures in meeting demand for green skills are linked to the finding that the level of demand for green skills does not correspond with growth towards a green economy and that there is a mismatch between demand and the skills needs that might be expected. This latent demand is not being clearly articulated by many employers, as they may be unaware of these themselves. Consequently, "demand-led" skills development systems face difficulties to respond adequately to business needs[29]. The changing skills content in established jobs and the emergence of new green occupations will require responsive strategies to be adopted by VET providers. Most of the work will need to be done in upgrading the current workforce with basic green skills and environmental awareness[11].

The first step to proceed with the green upskilling of the workforce is to provide basic green skills in order to increase workers' employability and productivity. Basic green skills include transferable green skills, also technical, which can be applied across industries and occupations. This process of upskilling could be implemented by VET providers by the adoption of innovative green skills training programmes[42].

In providing advanced green skills, new learning methodologies should be sought that embrace technological learning environments, facilitated by IOT. However, it is recognised that new green or even blue economy occupations might require completely different training programmes and university degrees[42]. Talentjourney shall consider this in regards to smart manufacturing skills and VET programmes. The responsiveness of VET providers in addressing green skills gaps and shortages also depends upon the adoption of quality and effective green skills anticipation mechanisms, with accurate labour market intelligence assisting with this[42].

While most of EU Member States do not have yet a green skills anticipation system, some countries are moving towards this. Estonia, for instance, recently introduced a comprehensive approach to green skills. In the implementation of skills anticipation systems, the Ministries for Labour and Education involve sectoral experts and stakeholders – for instance, representatives of employers – belonging to green industries. This helps in structuring adequate and forward-looking curricula capable to address future skills gaps and shortages[28].

The few green skills anticipation systems currently operating in the EU base on regional cooperation, directly involving local VET providers in the development of new green qualifications and curricula. Regional cooperation appears more important in the provision of training than in green skills anticipation systems per se. However, regional training provision often involves elements of labour market intelligence. In France, the regional observatories for employment and training (OREFs) regularly release reports on green jobs and skills. In Spain, the National Observatory of Occupations has a regional network. Green skill gaps are analysed by regional groups of experts[28].

Another feature of green skills anticipation systems is being sector-based, involving professionals and experts from specific green industries, hence being demand-led systems. Examples are Estonia, France, Spain and UK[28].

In the UK, for instance, most skills anticipation exercises are carried out by sectoral bodies, such as the sector skills councils (SSCs). SSCs' assessments of labour market intelligence were also provided for emerging green sectors, which helped the UK Commission for Employment and Skills to deepen its understanding of the green economy. An example is the 2013 RenewableUK report that provided an analysis of the total employment in the renewables sector[15].

As previously mentioned, companies are not always fully aware of the scope of the transition to a green economy and do not always clearly articulate their green skills needs. Therefore, VET providers should be involved in the work of skills development systems in order provide their insights.

The involvement of professionals and experts working in the private sector is essential also in delivering the learning opportunities. VET providers' capacity and the quality of training programmes are not always adequate and the availability of qualified teachers with relevant green knowledge is scarce. In Germany, for example, some inter-company vocational training centres (e.g. Überbetriebliche Bildungszentren) develop and provide new advanced green skills programmes to companies, in particular SMEs[36]. Furthermore, the partnerships between VET providers and private sector could be beneficial in reducing the cost of training for companies in transferable and expansive-to-develop green skills, particularly when considering STEM green skills. Indeed, despite this high cost of training for companies, subsidies and incentives targeting the private sector are not present[28]. This presents an opportunity for collaborative working with VETs and private sector companies to share technological resources, as well as knowledge, to improve the skills output and to reduce cost of delivery.

Therefore, the close involvement of all stakeholders concerned is key for an effective response system to green skills demand. Three types of response models were rated the most effective. First, "demand-led" skills development systems are capable of supplying skills matched to current demand. Second, public-private partnerships in VET have proved to be effective in triggering green change on a larger scale. Third, multilevel skills development responses have been considered the most effective. Joint initiatives involving companies, VET providers, universities and research institutes, professional associations and NGOs, raise environmental awareness both on the consumption side and the production side[42].

Talentjourney will consider all of the above and will build a cooperative EU ecosystem of educational stakeholders. Also, so far there has been little or no consideration of the gender balance in filling new green occupations[15]. Talentjourney will support the engagement of the female workforce in greening the EU manufacturing sector, especially with regard to STEM green skills.

6.0 Implications of New Era Society

Currently, ''Generation Z'', identified as those individuals born between 1995 and 2009, entering the labour markets. This generation was born fully immersed in the world of digital technologies, hence in a globally expanding world, with free access to an immense every increasing amount of information—a transparent information society.

This generation is characterised by specific features, having implications for both the labour markets and educational training. These individuals have extensive digital relationships through social media. They have high expectations for online accessibility and convenience of products/services, this applies also for educational learning and training, requesting distant learning and/or learning on demand. Generation Z expects the optimisation of services provision (high-speed) and a deep level of service specialisation to thrive in a globalised and highly competitive world. Indeed, a customised experience is necessary in the current individualising society, which requires the building of a sustainable self-identity.

Their preferable learning method tends to be on an individual basis and on a network/cooperation approach. The role of the teacher has changed from an expert-centred lecturing to being perceived as a facilitator for a self-learning process. Accounting for all the above, in order to structure innovative learning methods and curricula, it could be helpful to integrate new learning tools such as serious gaming, team play, VR/AR and so on.

6.1 The Changing Workplace

By 2025, two billion of the global population will consist of the youngest generation: Generation Alpha – the iGeneration. Generation Alpha is defined by those born between 2010 and 2025[46]. Generation Alpha use IOT technology, such as smartphones, tablets and other AI/AR devices naturally. Their reality has always included the concept of the Internet or AI/AR in the form of smartphones and video games. Some of them live in smart homes and speak with smart voice assistants, such as Amazon's ''Alexa'' or Apple's ''Siri'' as a part of their daily routines.

Consequently, the workplace organisation will move towards a more agile ways of working, with corporate structure having less hierarchy and an increasing use of independent contractors and freelancers[30]. The workplace will also have to become a purpose-driven and authentic environment, reflecting renewed values. It will have to meet three basic human needs, augmented by younger generations: autonomy, sense of belonging and mastery[31].

Autonomy can be defined as the need for control and ownership over decisions and outcomes. This can be achieved by allowing a decentralised working environment and more opportunities for decision making. Sense of belonging represents the need for a deeper connection and shared experience with colleagues, sharing common values. Mastery mainly refers to the need for self-improvement. The workplace needs to become a place for lifelong learning and skills development to allow employees to feel empowered. Indeed, new generations value current employability over long-term employment. Companies are increasingly accounting for this and taking responsibility for talent and skills development[47].

A purpose-driven workplace needs to reflect the intrinsic values of the younger generations – corporate social responsibility towards climate change and circular economy being an example. Indeed, Generation Z has placed a great importance on societal impact of businesses and on their ethical behaviours with respect to all stakeholders[48]. According to Deloitte (2020)[46], 70 percent of businesses that have moved towards Industry 4.0 are increasing profits while contributing to society.

Generation Alpha is accustomed to gaining knowledge and insight through learning-by-doing, screen-touching and using digital tools. Therefore, education institutions should prepare for the influx of Generation Alpha by providing adequate learning environments, complete with digital tools and creating programmes of study that enhance this type of ''deep learning''[46].

When surveyed through the Talentjourney project, various stakeholders (companies) involved in smart manufacturing offered the following suggestions to the change in workplace culture due to Generation Z as well as future generations, such as Generation Alpha:

- Introduce a flexible and agile way of working (co-working, remote working, etc.)
- Increase the number of external contractors and freelancers to get specific tasks done. In an interview with Intra Lighting d.o.o., a global provider of architectural luminaires and smart lighting solutions, it was also mentioned that this method of getting work done will take place even more often with even younger generations entering the IOT/smart manufacturing world.
- Create a purpose-driven and authentic environment based on shared values (e.g. corporate social responsibility, ethics, etc.)
- Establish a lifelong learning culture
- Develop a cooperative approach to work (e.g. project based, teamwork, etc.)
- Introduce less hierarchy; enable the decentralisation of decision-making. Respect is not a given – especially with younger generations, which is reinforced by a statement made by a representative from R&D Development for Intra Lighting d.o.o. as well as other responses of the surveyed companies involved in smart manufacturing.

Talentjourney will take into account the beforementioned future implications for the smart manufacturing sector and skills development systems stemming from the new era society. Specifically, Talentjourney will take into consideration the needs and expectations of the future workforce when structuring innovative curriculum offerings.

7.0 Education and Training Provision In IOT/Smart Manufacturing

Particularly in the last decade, the fast diffusion of IOT, Cloud Computing, Big Data, etc. has created new business opportunities and new job positions, as outlined in chapter 3. However, the new and increasing requests for specialised training on these new technologies has not always matched to qualified training programmes available across Europe, especially in VET. Indeed, this is true also of the Talentjourney partnership, with no specific dedicated programme offering in IOT smart manufacturing. There is, however, expertise contained in the VET sector that is dispersed across different departments with no formal collaboration evident – this would be absolutely necessary for future of IOT smart manufacturing provision and would be true also for other sectors that are disrupted by IOT. Training courses available across the EU are patchy, although there are many relevant modules of learning available in other disciplines that relate to IOT and smart manufacturing. It was found that IOT provision pertained to university students enrolled in technical specialisations, with post graduate IOT courses being easily accessible.

There are many private sector short courses of study with various leading industries heavily invested in the field, such as those offered by Bosch[49]. These courses delivered by many of the major industrial actors cover all aspects of IOT and how these fit into the emerging smart manufacturing sector. The delivery methods are a mixture of online and face-to-face, but notably learners are exposed to cutting edge technological resources.

It is important to note that there are prerequisites to this training, so identifying the level of training is important when developing learning programmes. VETs should consider also a more cohesive educational system in their regions in developing IOT/smart manufacturing programmes, as the pipeline that feeds these programmes should be sufficiently qualified in STEM subjects – this would normally come from the school sector in each region. Since the IOT in smart manufacturing is expected to increase with technology advances, the actual challenge is educate and train as many learners as possible on what IOT can add to their life and future profession, equipping them with a suite of invaluable future skills. It is important to highlight, not only the learners who wish to become engineers or scientists are considered, taking into account that other vocations and professions must introduce related IOT content in formal and non-formal training and educational activities.

Moreover, transferring IoT basic skills to learners, starting from early ages, they will have a considerable benefit helping them to be competitive in the labour market and also individually. IOT technologies represent a great opportunity for schools and VET sectors, since the IOT field will grow significantly in the next years. Therefore, it is a must to prepare young generations for these changes, hence the apparatus of each sector will need to adapt accordingly.

Talentjourney research has found that IOT/smart manufacturing is far more complex, covering many core engineering disciplines in addition to the evolving new technologies such as cloud computing analytics, as an example. For smart manufacturing education and training programmes, it is critical to appreciate the advancement in the area of the Industrial Internet of Things (IIOT), which includes predictive and preventative maintenance, condition-based monitoring of machines, production optimisation, energy optimisation and supply-chain optimisation, to name but a few examples. What is required now with respect to vocational training courses in IOT/smart manufacturing are those that are compliant the European Lifelong Learning instruments, to ensure the recognition and transferability of the competences at a European level. Currently, the ever-changing practices and information available with IOT and smart manufacturing work generate the need to be always updated and to acquire new skills and knowledge. Lifelong learning means that education is diverse, adapted to the individual, continuously updated and always available. Some companies in the Talentjourney research would only benefit from bespoke elements of the offering of IOT/smart manufacturing as their resources and infrastructure is not yet mature enough for fully automated, digitised delivery. So, there exists an opportunity for VETs to coalesce with regional companies in the development of education and training programmes.

7.1 Education and Training Development in IOT/Smart Manufacturing

Education and training programmes should cover the current state of the art with respect to IOT and smart manufacturing. Education and training programmes should cut across multiple technology domains to develop awareness of a given IOT system and its components in a smart manufacturing situation – this could be done through a live demo of IOT applications for smart manufacturing. Machine-to machine communication, or M2M, should be explored to include industrial instrumentation, enabling a sensor or meter to communicate the information it records, such as temperature, inventory level, etc. In doing so, it also introduces the need for green skills.

7.1.1 Outline of IOT Smart Manufacturing Education & Training Provision

It is evident that education and training programmes developed in IOT/smart manufacturing should set pre-requisites in electronic systems, business operation, devices and data systems, etc. As reported earlier, the skill and academic level at which education and training is delivered and assessed to learners is generally on the higher end – this of course must be taken into consideration in the development of VET programmes for IOT/smart manufacturing.

Depending on the disciplines covered in the VET programmes, there should also be an understanding of software and its systems with an appreciation of basic statistics also being important to the development in IOT/smart manufacturing education and training programmes. Research conducted across the partner regions confirmed this, and these findings can be found in annex 1.

Below is a rudimentary outline of a typical programme of study in IOT Smart Manufacturing:

- Fundamentals of M2M Communication: Sensor Network and Wireless Protocols
- Review of Electronics Platform, Production and Cost Projections
- Hardware/Protocol Elements of IIOT for manufacturing
- Machine Learning for Intelligent IIoT
- Analytic Engine for IIoT
- Security in IoT Implementation
- Common IIoT Systems for manufacturing
- Big Data for IoT

It is important to note that during interviews across the partner regions, SMEs have seen new skills acquisition as advantageous as doing so allows them to increase their competitiveness. From a learner's perspective, it boosts their knowledge and competences further whilst learning completely new skills and gaining more experiences, which are also transferable. With that said, it is recommended that a co-creation model is explored in the development of IOT/smart manufacturing curricula, and benefits of this are mentioned throughout this report. The EU has developed several instruments to support the transparency and recognition of knowledge, skills, and competences to make it easier to study and work across Europe. These frameworks aim to enhance the quality of the vocational education and training programmes across Europe through standardisation. It is particularly important that the arrangement of the IOT/smart manufacturing skills supply to the needs of companies and labour markets, as set out previously. Furthermore, they are fundamental for anticipating and preparing for the skills needs of the future – this shall be elaborated on in a subsequent Talentjourney report.

Findings from interviews of companies during the research conducted by Talentjourney suggest that a combination of good quality education and training with certified skills, knowledge and competencies acquired is relevant to the labour market and is in demand now and for the foreseeable future, for those that progress through study of a IOT/smart manufacturing vocational education and training programme as set out above. Companies have also indicated that training offerings need to be tailored to make them useful for SMEs. From a VET perspective, this can be a costly exercise and should be treated with some caution, unless the development costs are shared through a co-creation model. There requires innovation of current approaches to the delivery of education and training with modular, blended courses, targeted at SMEs in IOT/smart manufacturing and taking due consideration of the companies' geography. Training offerings should be delivered with flexible timing, with practical content to enable direct action of companies and more importantly their resources, with co-creation a fundamental driving principle.

The Internet of Things for European Small and Medium Enterprises IoT4SMEs project[50] has been designed in order to raise awareness among European companies and professionals about the potential of IOT technologies and to give evidence of their applications. This Erasmus+ project produced four learning programmes of IOT study and referenced them to EQF, ECVET and EQAVET, thus giving them currency and credibility with industry. One of the courses devised by IoT4SMEs titled the "IoT Decision Maker", which was designed primarily for directors and/or managers of SMEs that intend to deal with IoT technologies. This study provided a solid grounding in the subject matter and would be recommended by Talentjourney for the purposes of awareness to the IOT possibilities.

Additionally, the offering provides micro-companies with an insight to what skill sets they will require and how to move into the path of transition, demonstrating basic competences about IoT, an overview of new business models and basics of legal aspects connected to IOT. By the technological point of view, the course provides fundamentals of data analysis, networking and security, which concurs with the findings of the research, particular with representatives of SMEs.

8.0 Vocational Education and Training (VETs)

Vocational education and training (VET) provide citizens with lifelong learning opportunities, offering knowledge, skills and competences required in the smart manufacturing labour market, in addition to many others. VET providers aid in the transition from education to the labour market, in addition to helping individuals progress in the workplace. VET providers respond to the needs of the economy, fostering workforce employability and productivity, as well as a country's competitiveness and inclusive growth. Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities is included in the 2030 Agenda for Sustainable Development as SDG 4[53].

8.1 Centres of Vocational Excellence (CoVEs)

Centres of Vocational Excellence (CoVEs)[52] are developing into an important component of EU VET policy. During late 2018 and early 2019, an exercise was conducted to delineate CoVEs in terms of their main characteristics, with a view to informing the concept and the development of EU support plans.

Talentjourney will work closely with industry and VET providers, adopting a "demand-led" approach for skills development. This approach has proved to be not always adequate, in particular in relation to green skills, since businesses are not always aware of their green skills needs. Hence, VET providers often need to take the lead in skills development systems. Because of this, Talentjourney will adopt an approach based on a large collaborative partnership with a variety of stakeholders responsible for policies for regional development, innovation and smart specialisation, taking due consideration of social needs sufficiently, as many policies neglect societal issues[52].

When asked how VET providers could address the shortage of qualified trainers and the lack of financial resources for constantly updating training programmes, interviewees (i.e. VET providers interviewed by Talentjourney consortium) replied that improved terms and conditions – such as higher salaries, better contractual conditions, etc. – as well as shared resource training programmes with companies and experts (e.g. commercial/corporate training programmes) should be implemented. Teachers should take part in training programmes held in companies aimed at updating their own IOT-related skills according to higher education technical schools such as I.S.I.S. A. Malignani in Italy. I.S.I.S. A. Malignani stresses that it is also necessary to foster an effective communication between schools and companies themselves, in addition to establishing a point of reference inside the school. Schools should put teachers in charge of illustrating/informing students about the new university courses focused on the IOT skills that are expected to b. The Šolski center Nova Gorica suggests that European Structural Fund (ESF) programmes/funds or similar in the frame of which teachers can go for practical training to companies from 2-4 months, regular accompanying students to work-based learning in the company by teachers to have a regular contact, project work and hands on projects for teachers and company experts or other experts, etc. Common purpose and cooperation will help in connecting separate workforce development initiatives in order to shape a "skills value chain"[18] capable of creating increased value for the end users/learners.

Addressing the skills shortage with respect to STEM green skills at national/regional/local levels should also be a goal of VET providers in relation to IOT in smart manufacturing across the EU. Stakeholders (i.e. VET providers) interviewed by the Talentjourney consortium suggested various strategies to tackle the issue of shortage of STEM green skills:

- Improve cooperation between recruitment and training (e.g. demand led skills development programmes)
- Anticipating green transition before companies fully embrace the green economy, helping them in articulating their green skills needs (e.g. education led skills development programmes)
- Structuring innovative curricula linking STEM skills to green economy
- Improve attractiveness of new occupations and curricula (e.g. waste management), through AI/AR learning tools, for example.

Talentjourney will support businesses to fully commit to the transition towards smart manufacturing and green economy. It will help shape and innovate the workplace to make this an optimal space for skills development. Indeed, with respect to meta skills, a co-creational educational approach based on a blended method of academic learning and real practical assignments is worthy of deliberation.

Talentjourney will help companies in identifying their green skills and in discovering the opportunities stemming from a green economy. Consequently, it will help VET providers in structuring responsive strategies in terms of educational training and skills development curricula. Such programmes will support businesses in providing young people with practical experience. This effort could be beneficial in decreasing the cost of training, for example in relation to STEM skills in emerging green sectors.

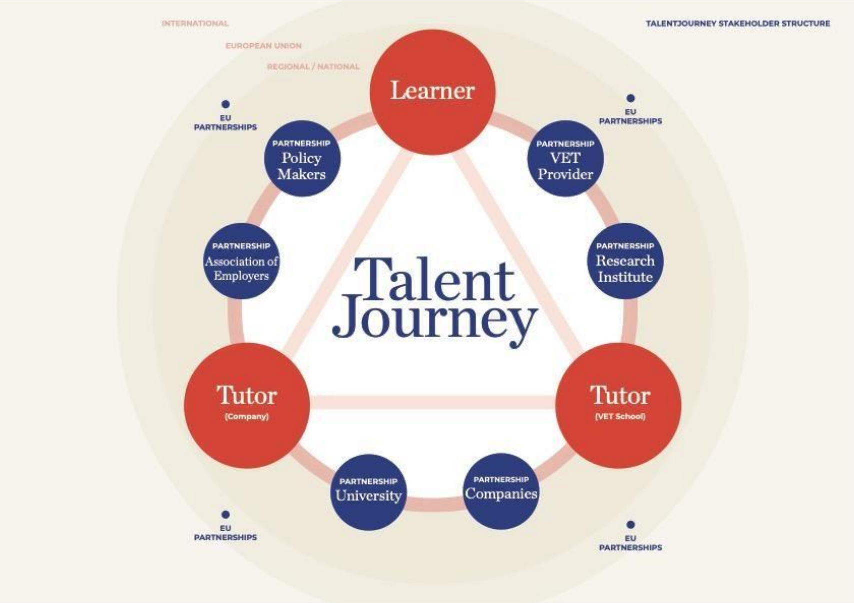
8.2 Talentjourney Proposals

Accounting for the above, Talentjourney will work with industry and other relevant stakeholders to attract new talents to the IOT/smart manufacturing sector and provide a focal point for employers to access support for skills development and training for the entire manufacturing sector, this shall be done through the service blueprint which provides the necessary stakeholder ecosystem at EU level. Talentjourney will take the lead with the approach of working with employers, targeted stakeholders and VET providers across the EU. The objectives are to simplify and improve access to learning and skills provision and to expand the IOT smart manufacturing sectors workforce, including unlocking the potential among young people, particularly women, in this predominantly male-dominated industrial sector. Learning and development are essential to productivity and competitiveness of employers in the smart manufacturing sector, Talentjourney will support organisations to develop their workforce, and thus gain more from the co-investment strategy.

It is important to get the right skills, in the right places, at the right time and in the right quantities. This is a key objective of Talentjourney. Through a strategic collaborative partnership and engagement with partners (as outlined in diagram below), the following goals will be achieved:

- Enable people, especially young people, and more particularly young women, to meet their potential that will develop capability and capacity for the future of IOT/smart manufacturing.
- Provide transition paths to meet immediate need, with existing employees.
- Make skills work for employers by making them industry specified programmes.
- Complementary / collaborative working to improve the smart manufacturing sector skills system.

Figure 9. Strategic and Collaborative Partnership Structure[4]



8.3 Talentjourney Main Priorities

The Talentjourney partnership will work with public / private and academic sector partners across the EU to support individuals into training or employment and to help employers to achieve their ambitions within this globally competitive environment. The development of regional stakeholder groups shall ensure there is shared ownership of goals and activities, and a common commitment to achieving them, by pooling and sharing resources. Talentjourney is aware that coordinated networks of similar themes should be explored allowing division of tasks and reduce duplication. Sharing is clearly a benefit of Centres of Vocational Excellence (CoVE) networks that is probably not available to individual VET providers currently.

8.4 Talentjourney Key Actions

Talentjourney will work with key identified stakeholders to progress the key actions contained below. Talentjourney will engage with business to identify future skills needs through implementation of the Talentjourney recommendations and shall support industry by enabling improvement and access to talent bank and EU skills workforce planning tool. This will run in parallel to major EU workforce planning tools. The Digital Skills and Jobs Coalition brings together multiple stakeholders to address digital skill gaps in the EU[51]. This is done by transforming learning methods into lifelong learning. The Coalition offers, for instance, traineeships to young people and upskilling/reskilling to professionals, such as cutting-edge training to ICT professionals, this is an excellent resource to refer to in the development of the Talentjourney curriculum offer.

- Talentjourney will manage skills shortages to bring supply and demand into balance as smoothly as possible. This will be achieved principally but not exclusively through encouraging and supporting chambers of commerce, related trade associations and their stakeholders meeting industrial requirements.
- Increasing the attractiveness of the smart manufacturing sector to young people, especially women, through targeted campaigns and promotions.
- Continual monitoring for gaps in qualification and training provision. Not only is there growing demand for skilled workers from other industries requiring the same skills, but smart manufacturing skills are in demand globally – this threat will be diverted with implementation of transition programmes from sectors of synergy. Ensuring that a new generation is trained and that the experience and know-how is transferred is a process that must begin, so innovative training methods are therefore required. Talentjourney will stimulate through collaborative partnership developing coherent curriculum offers, creating job ready employees.

9.0 Conclusions

This report makes it clear that significant change within the (smart) manufacturing sector is inevitable, so learners will need to apply their knowledge in unknown and evolving circumstances, and VET programmes will need to reflect this demand. To adapt to the requirements of the smart manufacturing sector of the future, students will need a broad range of skills, including cognitive and meta skills, this shall require careful planning of future curriculum developments of Talentjourney.

The mapping of Centres of Vocational Excellence[52] found that recent evidence supported key elements to be of value, these are endorsed by the research findings of Talentjourney through its desk top research and questionnaires/interviews that were performed. These elements should include strong and enduring relationships between stakeholders – VET providers, higher education institutions and businesses – in which interactions are reciprocal and mutually beneficial, creating the necessary pathways for learner success.

The demand for specific skills will drive the shift of job creation within smart manufacturing requiring more highly skilled employees. The ever-increasing high technology manufacturing environment will need both skilled managerial labour in addition to production labour with expertise to work with new materials, machines, and particularly information, big data. With that said, there will be lower operative labour required, this will be due in part to automation and the embedding of 4.0 technologies driven by IOT. As demonstrated through the table 1 in annex 1, there are a number of skill shortages across a spectrum of vocations and professions with significant shortages in engineering management, robotics engineering, and data analysis and data scientists. These skills are worth noting as emerging skills sets, but interestingly skilled manual engineering, is also in shortage, although the demand for manual engineering will be much lower as digitisation and automations starts to disrupt as the IOT/SM industry. Specifically, in Germany, the main area identified for skills shortages are data analysists. In Italy, skills shortages were found in robotics engineering, software engineering and data analysis alongside skilled manual engineering. In Estonia, the main areas for skills shortages are software engineering and robotics engineering. In Finland, skills shortages are robotics engineering and engineering networks. In Slovenia, the top three areas for skills shortages are skilled manual engineering, engineering management and software engineering. Across all countries surveyed through Talentjourney, the top skills shortages were in engineering management, robotics engineering, and data analysis and data scientists.

Equipping people with required and relevant skills for the current and future IOT smart manufacturing labour markets, through a lifelong learning continuum approach, is essential. To put simply, the shift in learning and training should be focused toward getting a job, keeping a job, and then getting a better job. Cognisance should be given not only in new innovative offers in the new and emerging roles referred to in chapter 3.1 and the facilitation methods expected by Generation Z and Alpha; rather, the focus should also be on enabling upskilling offers for existing labour. It is evident that IOT and smart manufacturing are highly specialised sectors, reliant on a varied range of occupations and a maintainable supply of particular professional, technical and operational skills to service product production in its various forms. As demonstrated through the table 2 in annex 1, there are a number of skill gaps across a spectrum of vocations and professions with significant gaps in AI/AR development, big data analytics and cybersecurity. These skills gaps and expected skills gaps and can be explained by vast amounts of data to process and analyse as industry becomes increasingly digitised. Specifically, in Germany, skills gaps identified through Talentjourney are big data analytics (data scientists). In Italy, skills gaps highlighted were in AI/AR development, big data analytics (data scientists) and cybersecurity. In Estonia, skills gaps appeared to be wide ranging across software, hardware, application, network – engineering, as well as AI/AR development. In Finland, skills gaps were similar to those in Estonia with software, hardware, application, network – engineering being exposed through investigation. Finally, in Slovenia, skills gaps were presented in skilled production process development, AI/AR development, big data analytics (data scientists) and cybersecurity. Across all countries surveyed through Talentjourney, the top three skills gaps were in gaps in AI/AR development, big data analytics and cybersecurity.

This report therefore has aimed to outline the main challenges and key actions required in developing a coherent, complementary/collaborative skills system to ensure the EU's manufacturing sector workforce is competent enough to capitalise on these opportunities, especially in the transition to smart manufacturing and Industry 4.0. As exposed through table 3 in annex 1, when surveyed on how the introduction of IOT/CDS in manufacturing will affect the skills needs of companies and other organisations at national/regional/local level across Talentjourney, partner regions, the most significant results were in regards to cybersecurity, production process development and AI/AR development, from a technical view point this demonstrates companies awareness of how automation and digitisation are disrupting the manufacturing sector.

Results from Talentjourney showed that in Italy, skills needs were required in AI/AR development, cybersecurity and production process development. In Estonia the skills needs requirements were found to be microcontroller/CDS programming and robotics engineering. In Finland, skills needs identified were app development, cybersecurity and production process development. Finally, Slovenia's skills needs were in skilled production process development, engineering management and cybersecurity. There were no specific skills needs identified for IOT/CDS in manufacturing in Germany, although the sample of the finding were small, caution should be paid to this finding. Across all countries surveyed through Talentjourney, the top three skills needs of IOT/CDS were cybersecurity, production process development and AI/AR development.

Further, T-shaped skills are an imperative for not only the success of the smart manufacturing sector, but also the EU's competitiveness now and in the future. The Talentjourney approach to necessary T-shaped skills is focused on education and training offers that combine practical skills with specific complementary meta skills, with clear mapping so that useful assessment and analysis of these skills is made possible. As demonstrated through the table 4 in annex 1, there are a number of meta skills required for the transition into and future of smart manufacturing, all of which cover a spectrum of vocations and professions. As outlined in the report, these skills – most significantly, responsibility, decision making and problem solving – are required at nearly all levels of smart manufacturing. More specifically, decision making in particular is a meta skill that has been identified within the report as most significant to the fields of engineering management, production process development, cybersecurity, project management, next-gen machine-learning engineers and scrum masters and agility coaches.

It was found through the Talentjourney research that meta skills are equally important generally speaking, essentially they are an evolving skill set that requires to be "in tune" with technology developments, hence meta skills are fundamental within an automated/digitised working environment.

The implications of the future of smart manufacturing are that developing STEM skills alone is not the answer – it is, however, a requirement in conjunction with developing the necessary meta skills and attributes. Talentjourney research demonstrated that employer demand is likely to be for highly specialised employees, limiting the opportunities for educational transfer even within a field such as smart manufacturing. As a caveat, special attention should be paid to the age and level of the learner, as STEM does provide a generic, transferable foundation for those looking to gain entry into the IOT/smart manufacturing sectors. From a training perspective, STEM represents too broad a field to guide choice of study and direct labour market entry.

Therefore, technical skills requirements should be co-created with industry with the accompanying STEM/meta skill enhancements coming from CoVEs, the following necessary IOT, smart manufacturing skills represent the literature and the research findings of the report:

- Skills relevant to researching and developing production technologies
- Skills relevant to researching and developing digital technologies such as electronics, artificial intelligence, coding, IOT design
- Skills relevant to researching and developing cyber-technologies such as digital security and connectivity
- Basic digital technology skills, such as digital user skills, as described by DigComp Framework
- Advanced digital technology skills, such as skills relevant to IT professionals' occupations, as described by the European e-Competence Framework
- Green skills relevant to a low carbon economy, such as upskilling of vocational occupations such as electricians, plumbers, mechanics for the installation of solar photovoltaic/thermal systems, wind and other renewable energy sources (RES) at both micro and macro generation.

The specific basic green skills needed to align today's manufacturing occupations to a green economy are outlined by partner region in table 5 in annex 1. As apparent through the table, the most significant green skills currently in demand for smart manufacturing are lean manufacturing, installation of energy efficiency measures, risk assessment and management for climate resilience, technology and process development for natural resources protection and green technology development.

In Italy, the most significant green skills required for smart manufacturing are installation of energy efficiency measures and retrofitting. It was found that in Finland, the most significant green skills required for smart manufacturing are lean manufacturing, low carbon technology (development), risk assessment and management, climate resilient technology, land planning and technology and process development for natural resources protection. In Slovenia, the most significant green skills required for smart manufacturing are installation of energy efficiency measures, followed by green technology development, risk assessment and management, and technology and process development for natural resources protection. In Germany, the Talentjourney findings showed that lean manufacturing was important, this was due in part to industrial supply chains operating on a just in time and other lean manufacturing principles.

There was insufficient data to conclude that there are particularly important green skills required for smart manufacturing in Estonia, within the scope of the Talentjourney project.

It is the conclusion from the research of Talentjourney, a combination of a literature review and the analysis of in-depth interviews with relevant stakeholders, that in creating the aforementioned skills, there needs to be collaboration between vital stakeholders – such as VETs, universities / research institutions and industry – using innovative co-creation models. To ensure a high quality of skill being produced, there requires an equally high-quality curriculum offering, which provides practical real-life settings that are measurable against competency criteria. It is inevitable that in doing so, there shall be specific adjustments of the VET system according to industrial developments – this work shall be undertaken in a later piece of the Talentjourney work. Finally, smart education methodologies and technology-based applications require to be applied, such AI/AR, allowing an increase in the effectiveness of learning and efficiency of administration. Finally, Talentjourney requires to develop a skills strategy that provides a world-class curriculum. The Talentjourney skills strategy requires a recognition and development system both for entry to the smart manufacturing labour market and for those that exit in it.

This report contains the collected data on skills for Connectivity Devices and Services/CDS (IOT in smart manufacturing), which is based on existing needs for the skills of the work force, on trends for the future years, on green skills related to the smart manufacturing sector as well as on data about the influence of new era society on working people (digitalisation, generation gap, behaviours, expectations and perception of different generations of the workplace and working environment). The report also includes data about the existing and the potential occupations. Ultimately, this report serves as a necessary steppingstone toward achieving the overall goal of the Talentjourney project: to lead on innovative approaches to developing the smart manufacturing workforce of the future and develop flexible ways to address these challenges effectively. Finally, this report has contributed to Talentjourney's aim to future-proof industry in order to meet their needs to recruit staff, to upskill staff, to reskill staff and to help organisations in the EU to become globally competitive in the smart manufacturing sector.

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ANNEX 1: Research Findings and Results

Table 1. Results on specific skills shortages in IOT/SM across Talentjourney partner regions

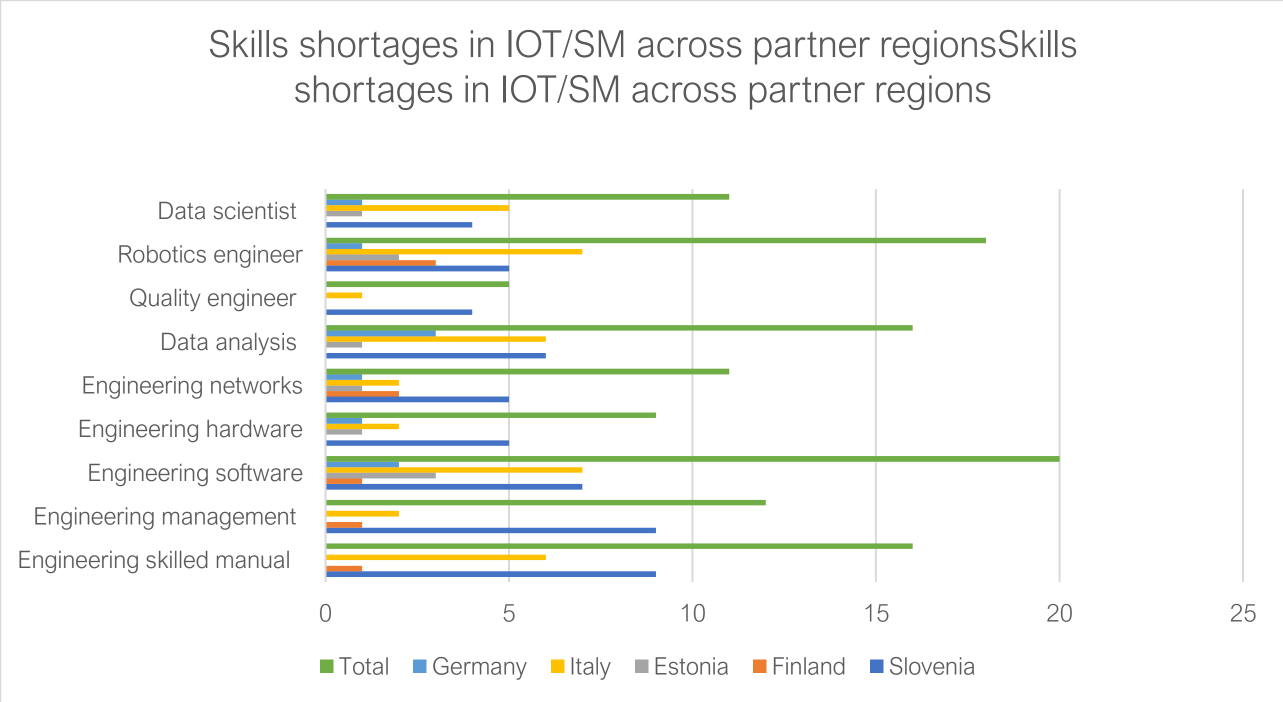


Table 2. Results on specific skills gaps in IOT/SM across Talentjourney partner regions

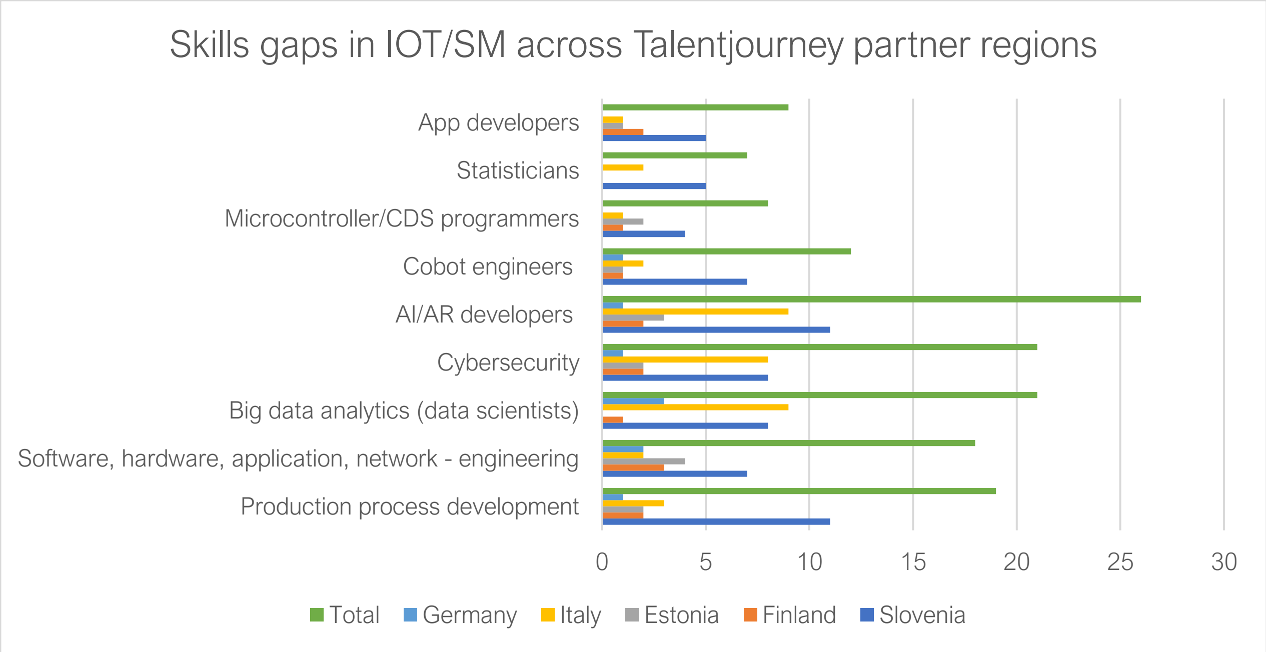


Table 3. Results on skills needs of IOT and connectivity devices and services (CDS) across partner regions

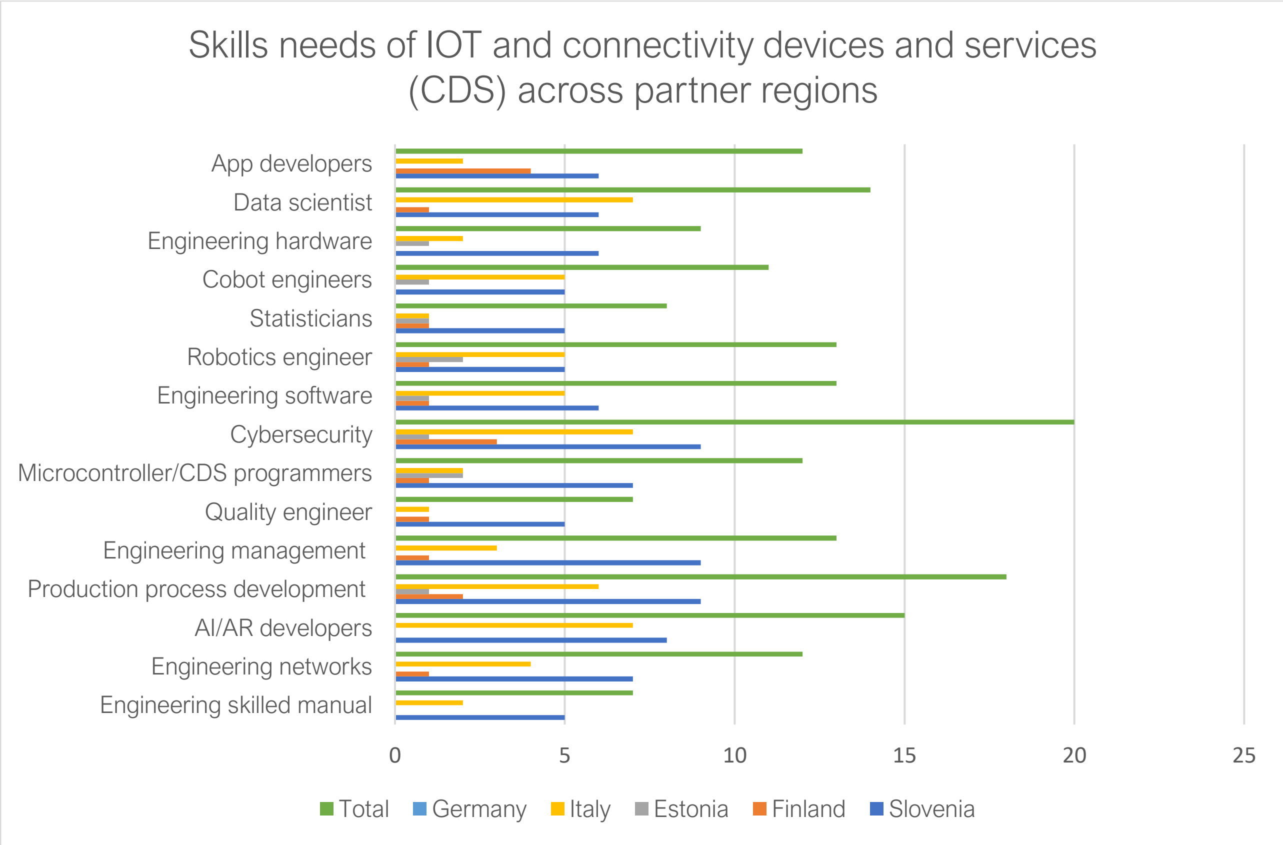


Table 4. Results on meta skills required for smart manufacturing across partner regions

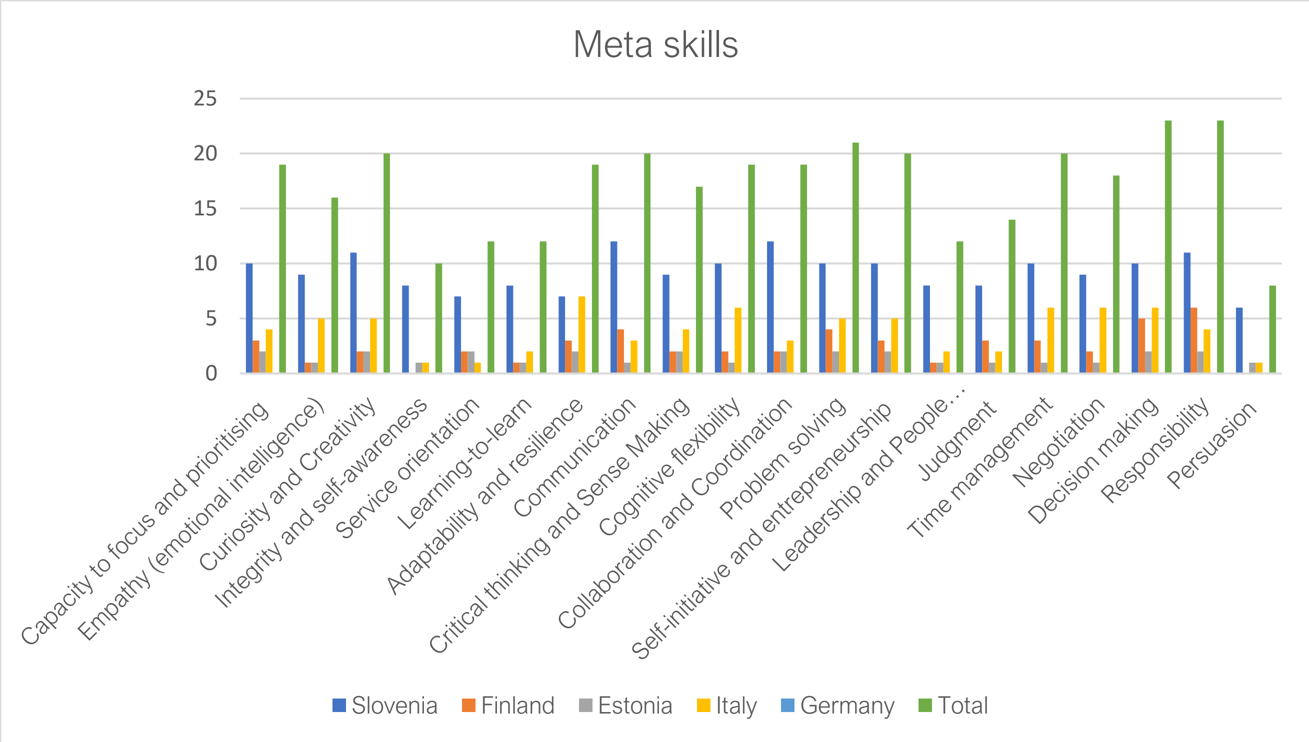
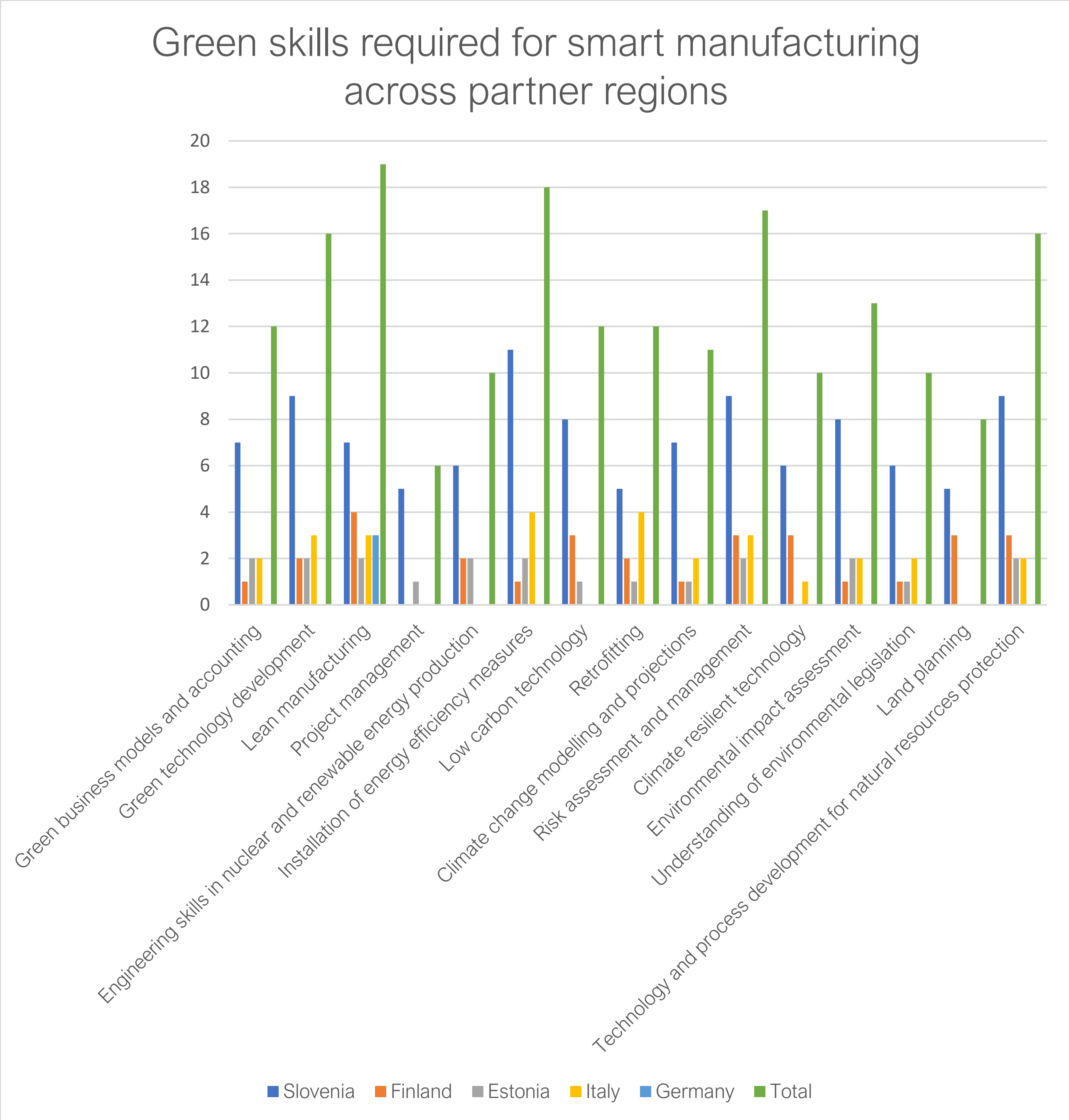


Table 5. Results on green skills required for smart manufacturing across partner regions



ANNEX 2: List of Interviewed Companies/Organisations

Table 6. List of interviewed companies/organisations by partner region

Slovenia	Finland	Estonia	Italy	Germany
Leone	Cimocorp	Artecdesign	Intellimech	Adria Mobil
Hidria	Gripper Tech	Blatflex	Union of Chambers of Commerce	EPOS
Goap	Luvata	Scanfil OU	CNA Venezia	Grundfos
Intralighting	Pintos	Levikom	URES	
Mahle	Stamatic		Fantoni	
Chamber Comm	UTU		Eurotech	
Elaphe	Hubble Oy		ATOMAT	
Final Domel	Utu Automation		DANIELI	
Inden			CONFAPI	
Lotrič Meroslovje				
IskraEmco				
KLS				
Elektro Jezernik				
MEGAM				
MIEL				
SKAZA				