GUIDE FOR THE IMPLEMENTATION OF WELD 4.0 METHODOLOGY TO OTHER INDUSTRIAL SECTORS
This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.
The Guide for the Implementation of the WELD 4.0 Methodology to Other Industrial Sectors aims to provide information on other industrial sectors in Europe with digitisation needs. This guide reflects the approach taken in WELD 4.0 project to redesign the Welder professional profile in the context of the 4th Industrial Revolution through appropriate educational approaches supported by innovative training methodologies and tools. It focuses on the modular approach of the developed Competence Unit (CU), which contents can be applied to other industrial sectors, thus increasing the overall impact of the WELD 4.0 results.

The Guide will be available to all industry sectors, allowing several other companies to use it as a good practice for their own specific sector.

To guarantee the transfer of the WELD 4.0 results from VET delivery in welding sector to other industrial sectors.
Industry 4.0 is a concept first launched in 2011 at the Hannover Technology Fair, as a strategic initiative of the German government to establish Germany as a lead market and provider of advanced manufacturing solutions and internet-based production technology. The idea behind this term is that a world where intelligent ICT-based machines, systems and networks are capable of independently exchanging and responding to information to manage industrial production processes, would pave the way to a new industrial age, the 4th Industrial Revolution which will radically transform industry, production value chains and business models in tomorrow’s “smart factories”.

Industry 4.0 comprises the digitization and integration of supply chains, products and services. IT, machines and humans are connected, interacting in real time thus creating a more flexible, resource-efficient, customized way of manufacturing – the Smart Factory. The integrated analysis of data and collaboration form key value drivers. Smart production involves the digitization of all physical elements in an enterprise, the interconnection and integration of processes into vertical and horizontal chains.

**Vertical integration** involves the digitization and interconnection of essential internal functions within the same entity, going through all stages of product design, supply, production, logistics and service. All information on planning, production, management, efficiency, or quality management processes is available in real time, the data being analysed and optimised within an integrated network.

**Horizontal integration** involves the digitization of external processes to the production entity, the availability of real-time information, and the analysis of data from customers, suppliers and other key partners in the value chain for the purpose of integrating them into internal processes.

The **Value Chain** represents all the activities of an enterprise to achieve a product or service that has a market value.

The smart factories that are already beginning to appear employ a completely new approach to production. Smart products are uniquely identifiable, may be located at all times and know their own history, current status and alternative routes to achieve their target state. The embedded manufacturing systems are vertically networked with business processes within factories and enterprises and horizontally connected to dispersed value networks that can be managed in real time – from the moment an order is placed right through to outbound logistics. In addition, they both enable and require end-to-end engineering across the entire value chain.

Smart factories allow individual customer requirements to be met and mean that even one-off items can be manufactured profitably. In Industry 4.0, dynamic business and engineering processes enable last-minute changes to production and deliver the ability to respond flexibly to disruptions and failures on behalf of suppliers, for example. End-to-end transparency is provided over the manufacturing process, facilitating optimised decision-making. Industry 4.0 will also result in new ways of creating value and novel business models.

Innovative businesses digitize their products and services by adding intelligent sensors, communication devices or other digital functionality that facilitate long-term interaction with customers, gathering a large amount of information (big data) that can be used by applications of professional data analysis to provide a valuable insight into how products and services are being used, how to improve and adapt to consumer requirements, how to create new digital products and services, with a focus on integrated platform digital solutions access and ongoing interaction with consumers within distinct digital ecosystems.

According to the Industry 4.0 working group report - “Securing the future of German manufacturing industry: Recommendations for implementing the strategic initiative Industry 4.0”\(^1\), eight key aspects are highlighted:

1. **Value Chain**
2. **Vertical Integration**
3. **Horizontal Integration**
4. **Smart Products**
5. **Smart Services**
6. **Smart Production**
7. **Smart Business**
8. **Smart Education**
• **Standardisation and reference architecture:** Industry 4.0 will include networking and vertical and horizontal integration of different companies through value networks. To enable such collaborative partnership a set of common standards should be created as well as a reference architecture to describe these standards and ensure their implementation.

• **Managing complex systems:** With the advent of new technologies manufacturing models and products are becoming more intricate which requires thorough planning and explanatory models which could provide basis for managing this growing complexity. Therefore, engineers should be aware of relevant methods and tools to create explanatory models.

• **A comprehensive broadband infrastructure for industry:** Secured, comprehensive and high-quality communication networks are a key prerequisite for successful transition to Industry 4.0, therefore broadband Internet infrastructure should be extended on a massive scale.

• **Safety and security:** This aspect is considered essential for the success of smart manufacturing systems. The Industry 4.0 working group has concluded that it is of utmost importance to be ensured that production systems as well as products do not pose threat to people or environments, but at the same time has to be ensured that sensitive information and data contained has to be protected from unauthorised access or use. As an effective solution are deemed implementation of integrated safety and security architectures and unique identifiers combined with relevant training and continual professional development content.

• **Work organisation and design:** Industry 4.0 will significantly change the role of employees as it is related with real-time control that will transform work in terms of content, processes and the working environment. A social-technical approach towards work has to be adopted in order to enable workers to have more responsibilities and create opportunities for personal development. To achieve this, participative work design and lifelong learning measures have to be set in place as well to launch model reference projects.

• **Training and continuing professional development:** The fourth industrial revolution will entirely change workers’ job as well as the required skills and competences. In this regard, companies will have to change their training strategies and organize the work processes in a manner which encourages learning, lifelong learning and enabling continuing professional development at work. According to the Industry 4.0 working groups in order to achieve this, model projects and “best practice networks” need to be promoted and online learning techniques should be analysed.

• **Regulatory framework:** Whilst the new manufacturing processes and horizontal business networks found in Industry 4.0 will need to comply with the law, existing legislation will also need to be adapted to take account of new innovations. Taking into account the changes due to Industry 4.0 in manufacturing processes and horizontal business networks have to be implemented in accordance with the law. However, existing law also has to be somehow adapted taking into account the innovations and changes brought by Industry 4.0. Some of the issues at focus are: data protection, liability issues, personal data and trade restrictions. To address these issues not only legislation, but also other types of measures will be required on the part of businesses such as regular self-check initiatives such audits, guidelines, model contracts, etc.

• **Resource efficiency:** Manufacturing industry consumes large amount of raw materials and energy resources which has negative impact on the environment and poses threat to the security of supply. Industry 4.0 –based solutions will result in higher resource efficiency for companies and therefore companies will have to compare the gain from potential savings generated by smart factories solutions against the additional resources that they need to invest to have such solutions in place.
IMPACT OF INDUSTRY 4.0 IN OTHER SECTORS

GUIDE FOR THE IMPLEMENTATION OF WELD 4.0 IN OTHER SECTORS

CONSTRUCTION  AUTOMOTIVE  MANUFACTURING  LOGISTICS  EDUCATION
CONSTRUCTION

The construction industry is very important to the EU economy. The sector provides 18 million direct jobs and contributes to about 9% of the EU's GDP. It also creates new jobs, drives economic growth, and provides solutions for social, climate and energy challenges. The goal of the European Commission is to help the sector become more competitive, resource efficient and sustainable. Training is one of the challenges faced by the construction industry: improving specialised training and making the sector more attractive, in particular for blue-collar workers, technical colleges and universities.

The impact of digitisation can be felt across all industries, including construction. Enthusiasts see digital transformation as a chance to drive a step-change and recapture EU countries’ industrial strength. But with innovations such as robotics, artificial intelligence and the Internet of Things poised to turbo-charge productivity, efficiency and speed, there is also concern that advances could put an express percentage of construction roles at risk. Mature and emerging digital technologies will disrupt the entire supply chain and the interactions and exchange of information therein. Examples of this ongoing digital transformation include 3D scanning, Building Information Modelling (BIM) or use of automated equipment. It will also impact the final products of construction, for example smart connected cities and smart homes that adjust their functioning according to the needs of citizens and inhabitants. More specifically, four key technological trends concern the construction value chain. These include digital data and access, networks and connectivity, automation and robots, and new emerging technologies such as virtual and augmented reality, 3D printing and geolocalisation.

As companies deploy solutions, all functions must be involved, from the front line to top management. That means leaders will need to assess their organisations realistically, determining whether they have the capacity and skills needed to implement new tools. They must also incorporate digital solutions into their internal processes, since employees might otherwise stick with their familiar routines. Similarly, leaders must examine their current IT systems, determine whether new tools can be integrated smoothly, and make any necessary upgrades or changes before a program begins. Construction and Engineering companies with strong digital skills might have an advantage when implementing complex solutions across their organisation. Other players might find digital initiatives more challenging and should consider implementing individual solutions in sequence, rather than undertaking a more comprehensive digital transformation.

GUIDE FOR THE IMPLEMENTATION OF WELD 4.0 IN OTHER SECTORS

Digital skills are currently often perceived as assets with increased specific characteristics, and access is usually granted through outsourcing processes. As the digital transformation of the European industry advances over time, it is expected to observe insourcing trends, provided that the EU continues its efforts to implement policies and initiatives aiming at making it easier to upskill, reskill and train the population.

Digital transformation relies heavily on the ability of businesses to obtain and develop the right talent with the required skill set to fully participate in the digital economy. Consequently, combined efforts from both public and industry players are necessary to upskill the working population: “more than one in three companies in construction industry in Europe struggle to find the human resources needed to exploit the opportunities offered by the digital economy. Such a digital skills shortage is likely to reduce the competitiveness of European business.”

Tomorrow’s construction sector is likely to necessitate an extensive array of roles, including virtual reality experts, robotics engineers, modular designers, data analysts and planners for prefabrication factories. For organisations, this means it’s vital to not only attract new talent but also to provide comprehensive training that will help current employees enhance their capabilities and master the skills that emerging positions require.

At the centre of development programmes should be tailored learning and support. After all, there is potential for those heavily impacted by automation — the employees who must work with new technologies — to feel demotivated or resistant to change if they don’t understand its benefits, or how to adapt. Therefore, firms need to ensure educational initiatives offer continuous support, flexible practical and theoretical training, and specific direction about using advanced tools on a day-to-day basis. For instance, this might entail a blend of instructional sessions and augmented reality experiences where employees can safely test their skills in virtual workspaces and build confidence.
The automotive industry is crucial for Europe’s prosperity. The automotive sector provides direct and indirect jobs to 13.8 million Europeans, representing 6.1% of total EU employment. 2.6 million people work in direct manufacturing of motor vehicles, representing 8.5% of EU employment in manufacturing. The EU is among the world’s biggest producers of motor vehicles and the sector represents the largest private investor in research and development (R&D). To strengthen the competitiveness of the EU automotive industry and preserve its global technological leadership, the European Commission supports global technological harmonisation and provides funding for Research & Development.

Governments and industry need to act quickly to ensure that the automotive workforce is equipped with the necessary skills to support digitalisation. Companies should adopt a digital strategy which includes consideration of the new skills that will be needed, what training should be offered to existing employees and what recruitment strategy is needed to fill the remaining skills gap. The sector should also consider how it can work together to ensure that it has a digitally capable labour market to draw upon. This could mean developing new technical accreditation and standards.

Industry 4.0 is ready to reshape the automotive industry. From smaller equipment to a more dynamic supply chain and the reshaping future vehicles. It brings opportunities that will shape the future of the auto industry with 3D printing, robotics, and collaborative IT that can aid Original Equipment Manufacturers (OEMs) to enhance product design and transform traditional production and supply chain inefficiencies. As the automotive industry’s needs shift toward complex products, minimal lead times, raw materials and custom products, it is certain that most of the industry participants will adopt this transition. For example, the automotive industry is expected to account for 20% of the 3D printing market by 2025.

This industry transition will create a platform where labour will account for a smaller proportion of overall manufacturing costs, and cost advantages in low-cost countries will rapidly decrease. Advanced robotics is starting to play a key role in supporting human operators. While robots could take over some of the more routine tasks, interaction between them and human workers will become more seamless, enabling production line operators to collaborate with, train and manage robots on the production line.

The most preeminent barrier to implementation pointed out by automotive industry is the lack of knowledge and digital capability among human resources. In the more advanced companies, pockets of digital expertise are found in most of the main functional areas such as manufacturing, engineering, production planning, procurement and finance. However digital skills are not sufficiently spread within the functional area nor were the different functional areas sufficiently integrated and working together.

Governments and industry need to act quickly to ensure that the automotive workforce is equipped with the necessary skills to support digitalisation. Companies should adopt a digital strategy which includes consideration of the new skills that will be needed, what training should be offered to existing employees and what recruitment strategy is needed to fill the remaining skills gap. The sector should also consider how it can work together to ensure that it has a digitally capable labour market to draw upon. This could mean developing new technical accreditation and standards.

Governments should undertake a comprehensive review to assess the prevalence of critical digital skills within the labour market and set out an ambitious strategy to address the skills gap.
Manufacturing is one of the social and economic engines of Europe, accounting for 15% of value added and playing a key role in driving research, innovation, productivity, job creation and exports. Manufacturing generates 80% of the EU’s innovations and 80% of its exports – yet the sector has lost many jobs over the last decade. According to a report by Roland Berger, European manufacturing can achieve growth from 15% to 20% (sector’s share of GDP) by 2030 and by taking into account the value-added services generated by the fourth industrial revolution, widely known as Industry 4.0.\(^9\)

In the manufacturing sector, the Internet of Things is reshaping processes and products: smart machines and objects communicate with the main ‘players’ (such as humans, intelligent machinery and robots) in the business and along the value chain, sending information, responding to changes and adjusting processes in real time. This industrial revolution is leading to smart, automatized, more efficient and responsive to change production process, and to new models for the management of the value chain, with smart logistics systems able to supply, produce and distribute products and optimise all stages. A 2018 McKinsey survey of global manufacturers,\(^10\) a large cohort of companies have taken significant steps toward a digital transformation. The survey found that 64% of respondents have connectivity programs in the pilot phase, while another 23% are beginning to experiment with connectivity. 70% are piloting intelligence programs, and 61% are already piloting flexible automation. Of those that responded, only 30% have achieved Industry 4.0 impact at scale. What this means is that a majority of manufacturers are taking steps to integrate digital technologies into their operations. They’re making their factories more connected, smarter, and increasingly automated.

A manufacturer can create an integrated, automated, and optimized production flow across the supply chain, as well as synthesize communications between itself and its suppliers and customers. This end-to-end integration will reduce waiting time and work-in-progress inventory and, ultimately, may even make it possible for manufacturers to offer mass customization at the same price as mass production. Digital creates new production technologies, new materials and new ways of storing, processing and sharing data, and new relationships with supplier networks and customers. And it affects all processes. New manufacturing devices, such as 3D printers, are speeding up product development cycles and making new collaboration processes possible by supporting rapid prototyping and customisation, with fewer errors and enabling a faster time to market. Data gathered from customers allows manufacturers to create tailored products, while crowd-sourcing platforms engage customers as inventors or co-producers.

Plants are increasingly becoming “digital factories”. Production processes will use fully automated systems, complete with interconnected machines and devices that can communicate with each other and autonomously perform work processes along the value chain. Even the products they produce will be able to communicate with the machines and send information.

As adoption of Industry 4.0 proceeds, the profile of the workforce will change. The critical Industry 4.0 jobs - such as for data managers and scientists, software developers, and analytics experts - require skills that differ fundamentally from those that most industrial workers possess today. Manufacturers will need to take steps to close the skills gap, such as retraining the workforce and tapping the pool of digital talent. Moreover, manufacturers will need to create new jobs to meet the higher demand. Companies need to create a cross-functional innovation team that is free to act independently from the main organization. In the initial phase of incubating ideas, the innovation team should adopt a “fail fast” approach, conducting a series of controlled experiments that aim to achieve rapid strides in value creation instead of incremental improvements. Innovation teams should include members from a wide variety of disciplines. It is essential to include product designers, data scientists, digital specialists, and user experience experts, among others, in addition to representatives from business units, R&D, and marketing. Managers should also gain hands-on experience in how Industry 4.0 technologies can be deployed. For examples, during a customized visit to a model factory, managers can participate in capability-building sessions, discussions with Industry 4.0 experts, and hands-on testing of technologies to see the related benefits.\(^11\)
There are many types of logistics and there are many definitions of logistics. In the Industry 4.0 context, it’s in the latter sense of moving things (goods, assets, materials, data and more) around in a business and/or supply chain. Logistics make up 14% of total gross domestic product in EU countries. More than 11 million people are employed in the European logistics sector and almost a quarter of these jobs can be found in the post and courier branch.

The emergence of the Industry Internet of Things (IIoT) promoted new challenges in the logistics domain, which might require technological changes such as: high need for transparency (supply chain visibility); integrity control (right products, at the right time, place, quantity condition and at the right cost) in the supply chains. These evolutions introduce the concept of Logistics 4.0.

From driverless transportation to intelligent containers, smart warehousing, smart ports, smart shelves to the human and information exchange in all possible logistical chains and contexts, and several other components in the supply chain, that without a digital supply chain Logistics 4.0 simply isn’t possible.

As the technologies brought by Industry 4.0 are deployed in factories and throughout the supply networks. The forth industrial revolution has reshaped not just which products manufacturers make, but also how they make and, ultimately, deliver them. It has also changed the relationships customers and suppliers have with these manufacturers to something more continuous and open-ended. In many downstream uses of Industry 4.0, technologies can fundamentally change how companies connect with their clients, through deeper customer relationships and enhanced efficiency.

Logistics and distribution (L&D) sector is experiencing some challenges: shortage of skilled labour, high employee turnover, and an aging workforce. These challenges seem further exacerbated by the advent and incorporation of new technologies that are reshaping the sector. The disruptive technologies, which are part of the Industry 4.0, are leading to shifts in demand for skills and even refining traditional job functions, as organizations are asking new and different things of their workforce.

Industry 4.0 could have a profound effect on the industrial workforce. Orders can come in and be processed at any time, while inventory, too, can be in constant motion. The real-time tracking of trucks on the road and planes in the air means that continuous planning can optimize routes during the day to minimize empty legs and lost revenue. Even the role of picking goods to be packaged together has changed dramatically: paper lists have been replaced by voice picking in many warehouses, and a further shift to augmented reality is already underway. In other warehouses, robots bring the right shelf to the pickers, who remain stationary. In fact, automation may take on the whole of picking tasks; or even drone-based wireless system that can scan and locate items in warehouses faster than any human. The transition can span the full range of the L&D value chain. Indeed, L&D professionals would require new skillsets to manage and operate alongside emerging technologies.

At the most basic level, new technology in the workplace typically forces workers to learn the skills necessary to work with that new technology. Secondly, individual workers would need knowledge of the organization spanning the entire value chain. Organizations should cultivate leaders, project teams, and individuals with strong change management insight in order to develop and communicate the transition strategy to employees and potential union stakeholders, an important group within L&D. Emerging technologies can require L&D organizations to be proactive and agile in preparing their employees for the future of Industry 4.0.
Digital technologies are dramatically changing the education sector and offering new ways to provide education and training. The rise of innovative business models and services, in areas such as life-long learning, e-learning, learning apps and gamification, are offering new opportunities for organisations to reach their customers. To make the most of the opportunities digital offers, the sector needs to rethink its business models, reconsider its relationships with its main stakeholders, and understand the potential of technology to transform what it does. It also needs to form strong partnerships with business to build digital learning into classrooms and curricula.

Future workers will need to be highly trained in the emerging technologies but also, as importantly, in the values associated with using those technologies. In the future, we must not only possess the ability to develop the technology but also to know whether, when, and where to use that technology. That kind of thinking is both reflective and interdisciplinary. Tomorrow’s industry leaders and managers must possess new skill sets to adapt, to manage, and to take advantage of Industry 4.0. They must be critical thinkers, problem solvers, innovators, communicators, and provide value driven leadership. They must be able to see beyond the technology at play to the implications for society for the use of that technology. These traits define the knowledge worker. They must know the technology but be able to meet and solve all aspects of the challenges engendered by this technology.

To train workers to be ready to Industry 4.0 will require a new approach to education. Schools must reinvent themselves quickly. They need to adapt to the demands of the Industry 4.0 and have the obligation to come out of its shell, its hermetic spaces and try to give as many opportunities as possible by creating the adequate contexts for students to be prepared for the future jobs. The problem in the future could not be the lack of employment, but the shortage of skills that the new jobs will demand.

But education institutions are facing challenges. The sector moves slowly, and is resistant to changing its content, systems and methods, which prevents digital technologies from spreading rapidly. To prepare youngsters for the digital world we need teachers with the necessary digital skills. Raising the digital competence level of EU teachers will be essential if we are to get good results from the investment in teaching e-skills.

Several authors underline the need to teach everything related to the ability to come up with creative and unusual ideas on a given topic or situation. Work that requires empathy, teamwork, coaching or other types of human interactions will continue to be done mostly by humans.16 Brynjolfsson and McAfee (2014)16 stress the fact that the majority of the western education systems still include many features of 19th century education systems with their focus on three basic skills: good handwriting, good reading, and multiplication, division, addition and subtraction in the head. A focus on memorising facts and calculation should not be the first priority of future curricula. This may be a big change for some education systems: this implies not only a change of the contents, but also reform of the educational.

Alex Gray, in the article “The 10 skills you need to thrive in the Fourth Industrial Revolution”17 states that “change won’t wait for us: business leaders, educators and governments all need to be proactive in up-skilling and retraining people so everyone can benefit from the Fourth Industrial Revolution”. So, we have the obligation to create the models and contexts to allow it to happen, otherwise we will have a generation with no skills shortage for the new demands of the labour market and that will become a big problem to society.
SKILLS IN CHANGE

According to the EU study “The impact of new technologies on the labour market and the social economy” the new technologies that will deeply affect the labour market. All these technologies may replace routine activities through the application of ICT, which will affect millions of jobs, such as:

- **Autonomous vehicles**: support and/or substitution of human drivers in private cars as well as in passenger and freight traffic. Autonomous driving could replace a considerable number of professional drivers.
- **Additive manufacturing (3D-Printing)**: a technology that allows production of three dimensional artefacts by adding successive layers of material. A blueprint at a computer determines the final shape of the object. Additive manufacturing is already used to produce a variety of manufacture.
- **Algorithmic decision-making (Big Data)**: substitution and/or support of human decision making by algorithms based on large data sets and probabilities. Examples include credit ratings, planning processes, summarising of documents etc. Experts regard algorithmic decision making as one potential tool to substitute a number of routine office occupations.
- **Industrial and service robots**: machines that perform physical tasks without the need for human intervention may take over a number of manual, routine tasks in manufacturing but also in services and substitute workers in these activities.
- **Bitcoin and block chain technologies**: electronic money created by the private sector on the basis of a database that records transactions and ensures ownership titles. This technology could be the basis for a number of new entrants that challenge traditional banks.
- **Digital factory ('Industry 4.0')**: network connectivity embedded in production equipment allows to exchange production data, a better control of the manufacturing process, a higher degree of customisation of the products and more integration with suppliers and customers along the value chain.
- **Smart home and Active Assisted Living (AAL)**: ICTs provide assistance and/or supervision for people with disabilities. AAL is related to home automation, but also various supervision technologies and also includes rudimentary decision-making, for example in the case of an emergency.

And accordingly to the whitepaper “Skill Development for the Industry 4.0” the following image presents some examples of changes that will occur with the adoption of Industry 4.0:

The EU concludes in its study that “in a world where skills levels are closely related to inequality, because skilled-based technological change continuously increases the demand for skilled labour, it seems essential to invest in education, regardless what future will become reality”. And, what skills should be taught? “Non-routine skills.” These skills are, on the one hand, related to human interaction and social perceptiveness, and, on the other hand, complement ICT applications, so that technology can augment human abilities.
Industry 4.0 is bringing many changes for the industry and the current manufacturing systems, it is crucial to know and be aware of what new tasks the employee needs to perform, what is the impact in its job, what is going to change from its performance now and what new or supplementary skills would be required to carry out those tasks successfully.

With the implementation of new machines and new challenges it will bring a change in work environment and tasks expected to be carried out by workers, the know how and the skills required will accompany this change.

These new skills will be necessary to be complementary to the already existing skills, it will not be simply a replacement on its own. Professionals with the skills necessary in the industrial field will still be essential and will have to be updated with the evolution of industry technology. According World Economic Forum, core work related skills can be classified into 3 categories and 9 sub-categories.
In this new context, a shift in the skills requirement is expected with increased digitalization, employees will have to gain new skills. According with Roland Berger new important skills that will be required to have with Industry 4.0 can be classified into four main categories:

- **Up-skilling**: Companies will have to up-skill their workforce via in-house or external training centres. For example, an assembly line worker involved in manually fitting a part will be required to operate a robot or other tools to do so. He/she should develop the skills to be able to operate the new tools efficiently.

- **Re-skilling**: Industry 4.0 is expected to result in job displacement to a certain extent. A number of jobs will cease to exist. And a number of new jobs will be created. Companies will have to make the investment in re-skilling of the labour force to prepare for this expected shift.

- **Continuous Learning**: Technologies will become obsolete at a faster rate. Continuous professional development strategies will be required to easily adapt to the changes that technological advancement brings.

- **Mindset change**: Given that the labour force will have to adapt to a number of changes, they will resist and oppose implementation of newer technologies. This will require companies to plan for mindset change of its employees to facilitate smooth transition to advanced manufacturing processes.

Accordingly with the BRICS Skill Development Working Group, with the arrival of Industry 4.0, “the companies will not only face challenges in finding the skilled employees but also a few other challenges related to their exiting workforce and skill development programs” as stated in the following bullets:

To tackle these challenges, WELD 4.0 partnership share the methodology used for the development of the WELD 4.0 project that aim to address the striking skills shortage in the manufacturing sector, most specifically in the welding area, so that other industrial sectors can be inspired and follow a similar path.
The European Federation for Welding, Joining and Cutting (EWF) Training and Qualification System is a harmonised scheme for the education, training and examination of personnel involved in welding, joining and related technologies. Its success is supported by a robust and transparent quality system which is developed, implemented and recognized by the complete chain of individuals and organizations involved in the process, from training institutions to national certification bodies, companies trainers and trainees.

EWF Qualification System is aligned with the European Qualifications Framework (EQF) through Proficiency Levels and can be transferred to other International Qualifications, covering different processes and/or industrial sectors.

The European Welder (EW) Guideline, part of EWF Training and Qualification System, ensures trainees gain minimum knowledge of the appropriate welding processes and the materials’ behaviour, including standards and safety regulations, for the three levels of the qualification: “Fillet Welder”, “Plate Welder” and “Tube Welder”. The EW Training Guideline and Professional Profile is recognised by the European industry and relevant stakeholders.

In the scope of Intellectual Output (IO) 1 European Welder: Report on existing curriculum and digitisation needs, of which EWF was the leading partner, an evaluation of the current European Welder curriculum and its shortages was carried out, based on the industry’s requirements for qualified personnel to deal with the challenges brought by Industry 4.0 across Europe. The purpose of this IO was to understand those requirements at European and National levels in terms of necessary training updates, and to contribute to quality’s improvement of the European Welder curriculum by introducing an innovative learning approach: the usage of an Information and Communication Technology (ICT) tool in future Welders’ training.

In order to achieve these purposes and to perform the analysis of relevant needs, most critical points and skills gaps in the digital world to be overcome during European Welder training, WELD 4.0 partners used a combination of approaches that included activities targeting trainees, shop floor managers, subject matters (ICT & Welding), welding trainers and, if necessary, stakeholders. Those tasks/activities allowed to reach a comprehensive understanding on the state of play of the needs and solutions regarding the EW profile, which included a Desk Research to identify previous EU funded projects that addressed similar scope and intentions as WELD 4.0 project’s and to prevent any duplication of results, guaranteeing added value and complementarity regarding outcomes previously produced.
QUALIFIED PERSONNEL FOR INDUSTRY 4.0 CHALLENGES

In addition to this Desk Research, other activities included the participation of stakeholders from Education and Industry, namely Interviews/Surveys and Co-creation Workshops, which allowed to collect their feedback on the following matters:

<table>
<thead>
<tr>
<th>Interviews/Surveys (Template divided in three sections)</th>
<th>Co-creation Workshops (Brainstorm methodology)</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Welder curriculum’s gaps in the context of Industry 4.0</td>
<td>Welders' performance</td>
</tr>
<tr>
<td>Current gaps on European Welder’s Training</td>
<td>Welders working environment</td>
</tr>
<tr>
<td>Innovative Tools for Training in Welding</td>
<td>Welders communication</td>
</tr>
<tr>
<td></td>
<td>Skills for the future</td>
</tr>
<tr>
<td></td>
<td>Welders’ training</td>
</tr>
</tbody>
</table>

The results from IO1 granted the possibility to conclude that:

- Not all welders know about Industry 4.0 and its concrete impact on their professional activity,
- There is a lack of ICT coverage in the European Welder curriculum,
- There is a lack of knowledge regarding fundamental theory (e.g. standards, welding processes, consumables, etc.),
- There is a lack of critical spirit to interpret welding parameters and solve basic problems.

For the involved welding experts, the Welder Profile must evolve with the industrial revolution due to digitisation of professional activities, being need for welders to use virtual reality as an in-process monitoring tool or post-processing tool one of the main identified industry demands. Other feature of Industry 4.0 that can be exploited by the welder envelope is the quick access to welding data and environment monitoring, as well as communication with the supervisor.

In face of these conclusions, the WELD 4.0 consortium discussed the possibility to develop a European harmonised Competence Unit (CU) that would have Learning Outcomes which would allow EW training course’s trainees to be aware of Industry 4.0 and its impact on Welders’ daily activity, in addition to the ICT training solution planned to be developed in the scope of the project (explained moreover, in this document). This work was the basis for WELD 4.0 project’s IO2 Update of the European Welder Curriculum, which resulted in a new Competence Unit to be considered for the EW curriculum, entitled “Introduction to Industry 4.0”.

GUIDE FOR THE IMPLEMENTATION OF WELD 4.0 IN OTHER SECTORS

Co-funded by the Erasmus+ Programme of the European Union
This Competence Unit was developed having in consideration the stakeholders’ feedback, collected in several Workshops carried out after each step of the development process was achieved. This approach ensured that “Introduction to Industry 4.0” would reply to industry’s requirements and to the success of Welders’ training.

Not only was the “Introduction to Industry 4.0” Competence Unit’s structure (Subject Title and Contact Hours) developed using this approach with help from Validation Workshops’ participants, but also the elaboration of its Learning Outcomes, written in terms of Knowledge and Skills trainees would acquire after concluding the Competence Unit. In a Capacity Building workshop, participants were asked to fill in a Questionnaire that allowed WELD 4.0 partners to understand if the Competence Unit developed replied to industry’s requirements and needs and achieved its purposes (Annex 1 - Questionnaire to Capacity Building Participants | Structure of CU “Introduction to Industry 4.0”).

The result from this Questionnaire showed participants agreed with “Introduction to Industry 4.0” structure and contents. Its Subject Titles (or contents) are here listed, as well as the Contact Hours and Workload (i.e. combination of training and self-study hours) dedicated to each Subject Title. Because WELD 4.0 project developed this Competence Unit in line with European tools, it mentions the European Credit System for Vocational Education and Training (ECVET), that promote mobility to trainees and workers in the EU. ECVET points allocated to “Introduction to Industry 4.0” depend on the number of hours of Workload: 24 hours correspond to 1 ECVET point.

<table>
<thead>
<tr>
<th>SUBJECT TITLE</th>
<th>CONTACT HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 4th Industrial Revolution</td>
<td>1</td>
</tr>
<tr>
<td>Equipment 4.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Digital Competences†</td>
<td>2.5</td>
</tr>
<tr>
<td>Information Digitally Stored</td>
<td>3</td>
</tr>
<tr>
<td>Tracking &amp; Monitoring</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
</tr>
<tr>
<td><strong>WORKLOAD</strong></td>
<td><strong>24</strong></td>
</tr>
<tr>
<td><strong>ECVET</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qualification</th>
<th>European Welder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KNOWLEDGE</strong></td>
<td>Elementary principles of:</td>
</tr>
<tr>
<td></td>
<td>• The 4th industrial revolution terminology and its implications in the welding processes</td>
</tr>
<tr>
<td></td>
<td>• New welding equipment design and features</td>
</tr>
<tr>
<td></td>
<td>• Handling and storing of data in welding applications</td>
</tr>
<tr>
<td></td>
<td>• Digital information tracking &amp; monitoring methods</td>
</tr>
<tr>
<td><strong>SKILLS</strong></td>
<td>Identify the basic aspects defining of the Industry 4.0 paradigm</td>
</tr>
<tr>
<td></td>
<td>Identify the European Welder job activities influenced by the 4th Industrial Revolution paradigm</td>
</tr>
<tr>
<td></td>
<td>Recognise the changes imposed by digitisation in welding equipment and its benefits</td>
</tr>
<tr>
<td></td>
<td>Handle digital welding equipment</td>
</tr>
<tr>
<td></td>
<td>Recognise the need to safely handle and store digital data</td>
</tr>
<tr>
<td></td>
<td>Use software relevant for the European Welder job (e.g. weld monitoring, tracking, DWPS)</td>
</tr>
<tr>
<td></td>
<td>Use industry 4.0 modern devices to improve the quality of the welded piece</td>
</tr>
</tbody>
</table>
The Competence Unit developed in the scope of WELD 4.0 project is not only transversal to EW Guideline modules (meaning it is applicable to all levels of EW Qualification - Fillet, Plate and Tube Welders), but also to other professions from several Industry sectors that feel the impact of Industry 4.0 in its activities, once its contents enable an overview about the new industrial paradigm.

By assessing their need for a better prepared workforce to deal with the innovations brought by Industry 4.0, SMEs and other companies can enrol their workers in this Competence Unit, providing them with tools to understand the impact of Industry 4.0 on their daily work and to use its benefits towards effective and efficient results.
In the case of the WELD 4.0 project, a Game-based Learning approach was followed for the design and development of a training solution for welding professionals. Game-Based Learning was chosen as a design approach for several reasons, such as its ability to increase learner’s engagement, enable higher levels of retention of information and the problem-solving possibilities offered. Also, the literature indicates the successful application of Game-Based Learning in VET settings in the form of a collaboration between learners and educators.

Games have been linked with aspects of peoples’ everyday lives since ancient times. On top of the entertainment-related aspect of games, they have always been considered as an effective teaching tool, due to their potential to engage learners. However, there is a popular notion associating games only with enjoyment and clearly distinguish them from work.

The current advances in instructional theories and technologies enabled the rise of an innovative learning approach derived from the use of computer games, Game-Based Learning (GBL). GBL uses different kinds of software applications that reclaim games for learning and education purposes. GBL adds educational value to gaming concepts and allows learners to explore playfully different parts of a scenario providing: learning support, teaching enhancement, assessment and evaluation of learners.

Most researchers conceptualize learning as a multidimensional construct of learning skills, cognitive learning outcomes, such as procedural, declarative and strategic knowledge, and attitudes. GBL incorporates all the elements above and several design models have been created by researchers in order to visualise the learning process. The GBL model has been used in formal education very successfully, in particular, in military, medicine, physical, etc. training (Pivec et al 2004).
The first step, before the design of the solution is the exploration of the field which in WELD 4.0 was welding training. A desk research was conducted identifying both commercial ICT solutions used in the training of welding professionals (Table 1) as well as solutions created in previous EU funded projects (Table 2). The results of the desk researches revealed the existence of several commercial solutions offering simulators for hands-on training on different welding processes. However, there were no commercial GBL solutions and only a couple ones that were created in previous research projects.

<table>
<thead>
<tr>
<th>Simulator Name</th>
<th>Reference</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simufact.welding</td>
<td><a href="https://www.simufact.com/simufactwelding-welding-simulation.html">https://www.simufact.com/simufactwelding-welding-simulation.html</a></td>
<td><img src="image" alt="Simufact.welding" /></td>
</tr>
<tr>
<td>Arc+</td>
<td><a href="http://jbhtech.com/WWW/802-2/">http://jbhtech.com/WWW/802-2/</a></td>
<td><img src="image" alt="Arc+" /></td>
</tr>
<tr>
<td>Osons Intervenir - TOTAL</td>
<td><a href="http://www.2jprocess.com/portfolio/osons-intervenir-serious-game-total/">http://www.2jprocess.com/portfolio/osons-intervenir-serious-game-total/</a></td>
<td><img src="image" alt="Osons Intervenir - TOTAL" /></td>
</tr>
<tr>
<td>SORPAS</td>
<td><a href="https://www.swantec.com/products/sorpas-2d/">https://www.swantec.com/products/sorpas-2d/</a></td>
<td><img src="image" alt="SORPAS" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Acronym</th>
<th>Project Title</th>
<th>Link</th>
</tr>
</thead>
</table>

Table 1 - Welding Simulators Examples

Table 2 - Welding EU Projects
In the WELD 4.0 case, the design and development entailed several cycles. The ideas, needs and feedback of the end users were incorporated into the solution through an iterative process, comprised of three phases:

- **Design**: Use of visual mock-ups of the interface, capturing key functionalities, definition of usage scenarios;
- **Implementation**: Iterative releases of the tool for experimentation and feedback, shaping the final solution;
- **Testing and validation**: Aligned with multiplier events, basis for validation and further improvement of the tool.

**Structure**

The WELD4.0 ICT solution is an interactive training solution for the support of welding training of entry level personnel. It is meant to be used as part of the theoretical training of the European Welder Guideline. It should be noted that all its contents are produced by welding experts and end-users. For the purposes of the project we’ve implemented two welding scenarios, each of which is structured in four episodes, following a real-life welding approach:

- Episode 1 – The Warehouse
- Episode 2 – Welding preparations
- Episode 3 – Setting parameters
- Episode 4 – Imperfections detection

The structure was decided based on the inputs of welding experts and end-users that participated in co-creation workshops. The structure and number of episodes may vary according to the field and learning objectives.
Technical Features

After conducting a technology analysis based on the requirements of the proposed learning scenarios we concluded on the most appropriate technology for the development of the solution, which in our case was Adobe Captivate. Among the solution’s technical features is the ability to support multiple scenarios/episodes and the ability to support multilanguage versions.

Gameplay Features

- Multilanguage

The solution is currently available in English, Portuguese and German in order to facilitate the use of the solution in multiple countries.

- Multiple levels of difficulty

The solution currently covers for two different levels of difficulty depending on the welding expertise level of the learner.

  1. Scenario A
     - Type: Fillet Welder
     - Level: 2 EQF
     **Start**
  2. Scenario B
     - Type: Tube/Pipe Welder
     - Level: 3 EQF
     **Start**

- Narrator

A narrator greets the learner/player and gives them the storyline and explains the tasks to be completed.

- Real life features

The training solution is heavily based on real life processes and features, such as the use of realistic welding documentation - Welding Procedure Specification (WPS) - and real-life representations of equipment and materials. All contents and pictures were developed or selected by welding experts.
**WELD 4.0 ICT TOOL CO-CREATION APPROACH**

- **Info buttons**
  Throughout the solution and next to each option, info buttons provide additional learning context to the learner, enabling their choices and enriching their knowledge.

- **Task List**
  In order to guide the learner through the tasks that need to be performed to complete each episode, a task list is provided indicating the tasks already performed and the remaining ones towards the completion of the episode.

**Evaluation approach**

After the completion of each episode the learner/player is evaluated on their choices. A positive evaluation outcome leads to the next episode and a negative one requires them to replay the same episode.

Each evaluation screen is comprised by a task list with hints on overcoming mistakes that were made.
Another way of providing useful technical information on correct choices made is through a set of info buttons that the learner can choose to view if they wish to.

- **Timeline**

On the bottom of the evaluation screen a timeline is provided in order to allow the learner to always know how far in the process they are and of the next steps towards the completion of the scenario.

- **Learning Points and Badges**

After the evaluation of each episode the learner gets the opportunity to go through the achieved learning points. With the assistance of welding experts these learning points are linked to the Learning Outcomes of the newly developed module on industry 4.0 of the European Welder Guideline.

Finally, each successful completion of an episode is awarded with a badge.
WELD 4.0 methodology and know how can be of a great added value to other industrial sectors also influenced by Industry 4.0.

As previously researched, in the other industry sectors the impact and challenges of industry 4.0 are quite similar according to sectorial needs.

The new Competence Unit developed in the scope of WELD 4.0 is based on a modular approach and transversal to all industry sectors and to several levels of qualification. The training contents can be developed and adapted according to all sectorial needs.

Contents related the 4th Industrial Revolution, Equipment 4.0, Digital Competences, Information digitally stored and Tracking & Monitoring are not limited to the welding industry, they are also necessary to all industrial workers that are impacted by Industry 4.0. Attending this training, it is hoped to be an asset for employees who works with new technologies, in that way they can understand the benefits of the changes in their work and how to adapt to it, leading to and decrease of demotivation or resistance to change.

Employers and companies need to assess their staff’s needs in terms of training and take measures for providing them with qualified training. “Introduction to Industry 4.0” Competence Unit would offer them knowledge and tools to understand Industry 4.0, its impact on their tasks and prepare them to deal with the related challenges.

A strength of WELD 4.0 project is the introduction of an innovative ICT training solution, consisting of an interactive support for welding training of entry level personnel. It is meant to be used as part of the theoretical training of the European Welder Guideline. It can be used by other industrial sectors that have welders in their workforce needing some up-skilling following a real-life welding approach.

Other tools are also being developed in other European projects, some related to welding can be found in this guide and many more can be found online through a more exhaustive research. These type of tools are very effective in encouraging workers to use new equipment and devices.

Using WELD 4.0 outcomes becomes more relevant due to the work being done at European level to ensure that companies across Europe provide their workers with tools to understand the impact of Industry 4.0 on their daily work and to use their benefits towards effective and efficient results.
REFERENCES

1 - https://www.din.de/blob/76902/e8cac883f42bf28536e7e8165993f1fd/recommendations-for-implementing-industry-4-0-data.pdf
4 - https://ec.europa.eu/growth/tools-databases/dem/monitor/scoreboard
5 - https://ec.europa.eu/growth/sectors/automotive_en
6 - https://www.automotiveworld.com/articles/industry-4-0-digital-transformation-automotive-industry/
8 - https://assets.kpmg/content/dam/kpmg/br/pdf/2016/12/smmtdigitalisation-automotive-industry-report.pdf
11 - https://www.i-scoop.eu/industry-4-0/supply-chain-management-scm-logistics/
17 - https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

Other resources
http://induce-project.eu/
https://www.hr40.digital/en/what-type-of-competencies-will-industry-4-0-require/
https://www.weforum.org/agenda/2017/01/promise-or-peril-decoding-the-future-of-work/
https://www.futurereadyedu.com/what-is-education-4-0-how-you-can-adapt-this-in-the-learning-environment/
https://www.futurereadyedu.com/what-is-education-4-0-how-you-can-adapt-this-in-the-learning-environment/
Questionnaire to Capacity Building Participants | Structure of CU “Introduction to Industry 4.0”

**Competence Unit “Introduction to Industry 4.0”**

Considering the presentation of the Competency Unit “Introduction to Industry 4.0”, please answer to the following questions:

The Competence Unit (CU) “Introduction to Industry 4.0” has the purpose of enabling and overview about the new industrial paradigm and reflection about its impact on the Welding activity in terms of required environment, equipment and skills. Do you think it fulfils this purpose?

Yes [ ] No [ ]

If No, what in your opinion could be different for the CU to fit that purpose?

________________________________________________________________________
________________________________________________________________________

Are the identified skills adequate for the training of Welders?

Yes [ ] No [ ]

Are there any skills missing?

Yes [ ] No [ ]

If Yes, please identify the missing skills.

________________________________________________________________________

Is the coverage of subjects foreseen in the CU suitable?

Yes [ ] No [ ]

Are there any missing subjects?

Yes [ ] No [ ]

Are the foreseen contact hours appropriate for each topic?

Yes [ ] No [ ]

Is the scope of the detailed knowledge adequate?

Yes [ ] No [ ]

Comments/Suggestions

________________________________________________________________________

Thank you!