IO1 - EUROPEAN WELDER REPORT ON EXISTING CURRICULUM AND DIGISATION NEEDS

TASK 6: Compilation of results into 1 Report

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FOREWORD

Intellectual output one (IO1) reports the evaluation of the current European Welder curriculum and its shortages, based on the industry's requirements for qualified personnel to deal with the challenges of Industry 4.0 across Europe.

Its objective is to understand the requirements of the industry at national and European level in terms of the necessary training updates, as well to identify the most relevant aspects to be introduced by the Information and Communication Technology (ICT) tool design.

This report is meant to act as a case study, since the limited amount of data collected by the consortium do not allow to generalise to the European state of the art. The aim is more to give support in understanding Industry 4.0 requirements and its impact in the framework of the project WELD 4.0.

Since, the European Federation for Welding, Joining and Cutting (EWF) is representative of the manufacturing community in Europe - along with its 31 European members, the National Welding Institutes, it was agreed that EWF would have a supporting role within the national compilation of results gathered in Portugal, Germany and the United Kingdom, instead of addressing a unique national context.

INTRODUCTION

Europe is moving toward a more digitised society and economy. In this context, the 4th Industrial Revolution is changing the way people live and do business. The new industrial age we are living in is transforming traditional manufacturing processes and nature of work with potential to drastically improve the flexibility and productivity of business and organisations. [1]

The 4th Industrial Revolution (4IR or Industry 4.0) impacts manufacturing at global level, starting with developed nations and, progressively, spreading to emerging countries. The 4IR is significantly different from the previous three industrial revolutions. It can be defined as a range of new technologies, integrating the physical, virtual and biological worlds. Robotics and artificial intelligence will bring increased intelligence and autonomy in manufacturing. For the manufacturing industry, this means a growing level of manufacturing digitalisation and automation, leading to increased levels of efficiency, quality, integration, adaptability and flexibility. Digitisation/ digital technologies/ Industry 4.0 will enable cost effective customer driven manufacturing. This will be a unique opportunity for Europe to reinforce its already strong position in industrial machinery, automation and digital manufacturing technologies. [2]

Manufacturing is considered the backbone of European economy. It provides 32 million jobs in more than 2 million enterprises, including around 13 million jobs in a growing high-tech manufacturing sector, and around 60 million additional jobs related to associate services.[3]The share of manufacturing in the EU-28 was 16.1 % of GDP in 2016.[4]

Welding and joining are recognised as key enabling technologies for EU manufacturing, contributing to the above statistics and growing at 5% per year, emphasising the fact that the contribution of joining technologies to the manufacturing sector is of major significance, in terms of both added value and jobs. [5]

Although, there has been a significant investment in research for key enabling technologies for Industry 4.0, the investment in human capital does not meet the demand.

In this framework, appropriate training in welding through innovative educational approaches and tools is required.

The European Welder (EW) harmonised training, managed by EWF, ensures that 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.

As mentioned in the foreword, the purpose of the report is to identify gaps in the current Welder curriculum to accommodate industry 4.0, and in addition to this to identify the most relevant aspects to be introduced by the ICT tool design.

[1] And [2] Source: European Commission, Research and Innovation, 2018, Capitalising on the benefits of The 4th Industrial Revolution. Link - https://ec.europa.eu/info/sites/info/files/4threvolution_p4p-report_2017.pdf
[3] Source: Jovane, F. et al., 2009. The ManuFuture Road. Towards competitive and sustainable high-adding-value manufacturing. Springer
[4]Source: Eurostat. GDP percentage of total, industry breakdowns. 10.1.2018
[5] Source: Gattiglio, M. EFFRA Chairman, PPP info day.2013)

The scope of this common report is two-folded (quantitative and qualitative), which is related to the methodologies applied in the current investigation phase.

It was decided to use a combination of approaches in order to guarantee a comprehensive understanding on the state of play of the needs and solutions regarding the EW profile in partners countries (Germany, Portugal and United Kingdom).

The "European Welder Report on existing curriculum and digitisation needs" is structured according to the methodologies applied in the investigation. Meaning, findings are presented following the same sequence as the research has been undertaken:

- 1. Development of workshop with welding experts
- 2. Development of desk review
- 3. Collection of national results through semi- structured interview and the application of survey

Firstly, an overview is given on the main results achieved during the development of the workshop with welding experts.

Then, a summary of the desk review results is provided.

Finally, and the most important part, findings on the national compilation of inputs gathered by each partner. This last part is organised according to the quantitative and qualitative data gathered.

The quantitative scope aims to present and characterise the target audience which was involved in the interviews and survey. While the qualitative scope aims to provide a description on the national situation of WELD 4.0 key subjects:

- Industry 4.0
- European Welder Qualification and curriculum
- Pedagogical approaches and tools for training
- Applicable innovative tools for training

Qualitative data address WELD 4.0 key subjects (e.g. definition of Industry 4.0, EW Qualification and curriculum, and pedagogical approaches and tools for training) which are clustered into four categories:

- Category I – Experience and knowledge about Industry 4.0
- Category II – Experience with EW Qualification
- Category III - EW Training Curriculum
- Category IV – Innovative tools

The conclusion includes a critical assessment about the overall results achieved, thus focusing on the main challenges and recommendations for the future implementation of the project.

WORKSHOP FINDINGS

On the 20th December 2017, a workshop was held in Portugal with the project consortium and invited welding experts and trainers.

The Welding experts were Mechanical Engineers from EWF, which have a long expertise with the EW training guidelines and are aware about Industry 4.0 and its impact on the manufacturing sector. Remaining participants were trainers in the Welder courses and non-destructive testing courses from the Portuguese authorised training centres for EWF Guidelines.

The programme of the working session encompassed an introduction to the Weld 4.0 project, the presentation of the European Welder Qualification, including its structure and main contents, as well an overview on Industry 4.0 and its impact for the welding sector, as detailed in the agenda (ANNEX 1).

The main objective was to discuss the impact of the new industrial revolution, including ICT and digitisation, on the European Welder Profile. In this context, a brainstorm methodology was applied along five slots, targeting to identify the digital skills needed by Welders to cope with Industry 4.0. Specific questions were addressed to trigger discussion based on the next topics:

1- **Welders performance**
2- **Welders working environment**
3- **Welders communication**
4- **Skills for the future**
5- **Welders training**

Participants were organised into three groups. The overall questions and results achieved per group are described and summarized by slot in the next five tables.

SLOT 1 – WELDERS PERFORMANCE

Table 1 - Welders performance results

FOCUS: implications of industrial technology evolution into the Welder professional activity based on the given questions.			
QUESTIONS	RESULTS		
	Group 1 (TR; LM; MO)	Group 2 (AS,TA, BA)	Group 3 (BA; AA, HM, AC)

1.1 Which TASKS performed by the Welder are being targeted by the industrial digitisation? 1.2 Think about the SPECIFIC TASKS that are being affected by industrial digitisation.	Improve the ability to interpret and review/check parameters: - know how to identify those parameters and which aspects can be improved; - more information/data for the welder, enabling to improve the diagnosis Machine (parameters, torch position and thickness deposited) Digital control of parameters (gas,V,A) Virtual training should be mandatory (head up display in real time in the helmet)	Interpretation of drawings Welding process Material interpretation Non Destructive testing (NDT) or acceptance criteria for NDT Terminology Alert mechanisms (applied to NDT/visual testing)	Production time will be different (high - speed processes are expected) It will be required for welders to programme of welding parameters Knowledge about welding will be greater due to the amount of data generated Added value of industry 4.0 is the level of control about the welding process /knowledge that is generated in real time Ability to avoid and predict defects or anomalies "zero defects" – behaviour pattern

SLOT 2- WELDERS WORKING ENVIRONMENT

Table 2 - Welders working environment results

FOCUS: implicationsof industrial technology evolution into the Welder workstation based on the given topics.			
QUESTIONS	RESULTS		
	Group 1 (TR; LM; MO)	Group 2 (AS, TA, BA)	Group 3 (BA; AA, HM, AC)
2.1 How does the current welder WORK ENVIRONMENT will change in the future, in terms of: • Workstation organisation; • Tools • Team structure and communication; • New responsibilities • supervision	Head up display Greater importance/ability on how to react whenever the weld is not according to the parameters Parameters are always available and in real time or information whenever there is a	Workstation/environment will expect to have: _ Sensors for detecting the among of smoke and blow, atmosphere cleaning Equipment maintenance and automatic check Stock management (e.g. base materials and consumables)	More controlled environment; Improvement of the quality of the results Compliance with the Welding Procedures Specification (WPS)

	deviation to the expected parameters Virtual reality Team structure – screen or other communication channel with the welding coordinator / supervisor Communication skills are required	Electromagnetic radiation exposure Regarding, the team structure, digitisation will improve and facilitate team work composition and management New responsibilities will probably emerge and a new attitude from the welders will be required (the attitude of older welders must change in the sense that they have to play a more active role, being critical about the welding process and data generated) Supervision/communication between welder and supervisor is changing	All the welding process and equipment are connected physically, but not informatically Use of new tools – access to terminal /screen with welding information

SLOT 3 - WELDERS COMMUNICATION

Table 3 - Welders communication results

FOCUS: implications of industril technology evolution within the way the Welder relates to information, based on the given questions.			
QUESTIONS	RESULTS		
	Group 1 (TR; LM; MO)	Group 2 (AS, TA, BA)	Group 3 (BA; AA, HM, AC)
3.1 What kind of INFORMATION Welders will need to do their job?	Better Information about the welding parameters; Access to the WPS Better control of parameters (virtual reality and communication with the supervisor)	Learn about reading drawings (necessary training) WPS Inspection plan Acceptance criteria	Initial information – which is presented in the WPS and enables to perform the welding process; Intermediate information- corresponding to real time information on how the welding process is being performed Final information- Data generated after welding takes place. Currently the final information is not

			analysed neither used by the welder. Instead, data generated are used to control the welder
3.2 How will they EXCHANGE AND ACCESS to relevant information to do their job?	Communication channel mediating the shift of information between welder and supervisor	Overall communication between welders and between welder and coordinator is improved	Current information flow in one sense (from coordinator to welder)

SLOT 4 - SKILLS FOR THE FUTURE

Table 4 - Skills for the future results

FOCUS: gaps in the Welder trainng curriculum, according to the given questions			
QUESTIONS	RESULTS		
	Group 1 (TR; LM; MO)	Group 2 (AS, TA, B)	Group 3 (BA; AA, HM, AC)
4.1 What are the DIGITAL SKILLS, when we are talking about Industry 4.0? 4.2 Which are the Welder DIGITAL SKILLS required by the industry 4.0?	Be able to use virtual reality (to have access to the virtual welding before the real welding) In the project stage, have the possibility to simulate the welding process to confirm the welding accessibility It could be interesting to have a tool/mechanism that creates Welder digital profile (allowing the information about the welder/welding position, process, material and quality level); keeping track with the performance, as a means to record a virtual personal CV and record of performed tasks	Recognise and interpret icons/app's (related to the use of intuitive tools) Technical English Cultural level Clients from other country/nationality e-learning/bilingual (how- Module A)	Technical knowledge (about the welding equipment, how to operate, explore and navigate through a terminal); Use the welding machine (how it operates and works); Basic knowledge and access to ICT; Knowledge about welding parameters management; Use the WPS data; Select proper welding piece; Introduce welding parameters into machine;

SLOT 5 - WELDERS TRAINING

Table 5 - Welding training results

FOCUS: gaps in the Welder training curriculum, according to the given questions			
QUESTIONS	RESULTS		
	Group 1 (TR; LM; Manuel)	Group 2 (AS, TA, B)	Group 3 (BA; AA, HM, AC)
5.1 Which are the implications within initial and continuous TRAINING?	Training should include: -specific information about electromagnetic fields, how do they form and consequent health implications; - knowledge about data interpretation and communication skills	The welding coordinator/responsible should be involved in continuous training	
5.2 How could the EW training include digital skills?		To see topic slot 4 (e-learning; English; app's.) Module A should include communication skills/soft skills; Harmonise the language standards "Welders language"	ICT should be addressed in both theoretical and practical training; To add a specific theoretical module focused on digital skills
5.3 Currently, which are the GAPS/shortcomings in the TRAINING METHODS AND TOOLS used in Welders training courses?	Need to improve the use of the welding simulator during the theoretical training as well; Need to maximize the possibilities and what can be done with the simulator;	The equipment/tools used in training should be updated according to what is used in companies (difference between equipment used); To have a digital skills approach through e-learning	The welding simulator doesn't provide the necessary technical knowledge; Simulator is attractive for young people; it is a motivation and competitivity tool used to refine the operative technique;

CONCLUSIONS ABOUT THE DIGITAL SKILLS NEEDS IN THE WELDER TRAINING

The workshop's main conclusions were clustered into three aspects to facilitate the identification of requirements.

The correspondence between the initial slots and the clusters is provided in Table 6.

Table 6 - Relationship between workshop slots and clusters

Slot	Cluser
1- Welders performance	Cluster 1- Emergent needs
2- Welders working environment	Cluster 1- Emergent needs
3- Welders communication	Cluster 1- Emergent needs
4- Skills for the future	Cluster 1- Emergent needs
5- Welders training	Cluster 2 - Curricula gaps Cluster 3 - Innovative training tools

- **Cluster 1- Emergent needs** (addressing the identification of requirements which are emerging because of industry 4.0 and the digitation of workplace and professional activities).

  Findings:

  1.1 Possibility of creating welding data, meaning more **knowledge about welding** processes, welding positions and materials behaviour, thus allowing to avoid mistakes and predict problems.
  1.2 Possibility of creating "Digital Welder Profile" as a track to welder professional activity for hiring and planning job purposes.
  1.3 Possibility of **critical interpretation** and required adaptation of drawings, WPS (welding procedures specification), welding parameters, inspection plans and acceptance criteria.
  1.4 Possibility for greater **skills to apply** ICT and other upcoming **welding technologies**, (e.g. machines: Helmet, simulator, torch, screen, computer, app or terminal), the ability to explore a terminal or screen; the ability to use a to use a welding machine and to introduce welding parameters; Skills to use and interpret a WPS.
  1.5 Possibility for improving **communication skills** with welders and supervisors, as well as with machines.

- **Cluster 2 - Curricula gaps** (addressing the identification of skills shortages and how the current training matches with the market and industrial needs).

  Findings:

  2.1 New training contents related to **technical English**; **welding data interpretation** and **management** and **communication skills.**
  2.2 Improved learning methods, for instance by introducing **e-learning** and explore the **use of simulators.**

- **Cluster 3 - Innovative training tools** (addressing the exploitation of relevant and innovative training tools).

  Findings:

  3.1 The use of **virtual welding simulators** in practical training is recognised and highly appreciated, with some considerations: a) to consider the use of simulators in the

workflow (not just training) such as encouraging practice runs of complex procedures;
b) to improve the pedagogical underpinnings of the course(s).

3.2 The use **of e-learning** to support the theoretical part of the course.

DESK REVIEW FINDINGS

The desk review undertaken during the project is an investigation on former EU funded projects addressing the EW qualification and innovative training tools, and so, the study didn't include a literature review.

The review allowed the identification of EU funded projects developed in the past years addressing similar scope and intentions as Weld 4.0, meaning the same qualification and intention to develop an innovative training tool. The objective of this review was to avoid the duplication of results and to guarantee added value and complementarity regarding the outcomes produced in the past. The analyses focused on comparing the objectives and outcomes achieved by each project as detailed in table 7.

PROJECT ACRONYM	PROJECT TITLE/NAME	AIMS AND RESULTS ACHIEVED	LINK
Virtweld	Implementation of Virtual Technology in Education of Welders and Welding Specialists	Technical Assessment of available Virtual Welding Training Systems on the Market; Recommendation on the implementation of Virtual Welding Training Systems as part of EWF harmonised training;	http://www.ewf.be/upload/processos/d000292.pdf
Accessweld	N.A	Stimulate the interest of young people towards welding training and professional careers in the area The "WELDPLAY" computer game was developed to allow the player to test his ability in managing a small welding company.	http://weldgame.ewf.be/
E-Weld	Distant learning tool for welding	Development of 2 versions of a CD for specific use in training classes in target partnership countries; Improvement of distance learning practices according to the different needs of the partner countries; Increase in the number of welding trainees in the partnership countries; Improvement of the welding activities's appeal to prospective students.	https://www.ewf.be/projects.aspx
InteractiveWeld	N.A	Introduction of Virtual Welding Training System – VWTS as a component in welders' training programmes; The project's main objectives include: The creation of a system for lifelong education of welders – from trainees to professionals on the usage of conventional	http://www.ewf.be/projects.aspx

		and modern teaching methods, based on the EWF system; Introduction of Virtual Welding Training System – VWTS as a component in welders' training programmes; Introduction of psychophysical components related to welders' well-being, in the welders' training programme; Harmonisation of this new system at the European level.	
VirtuWeld	Virtual technology in education of Welders	The objective was to transfer the application of virtual welding training systems to the partner countries. Major results were: Technical Assessment of available Virtual Welding Training Systems on the Market; Recommendation on the implementation of Virtual Welding Training Systems as part of EWF harmonised training	https://www.ewf.be/upload/processos/d000292.pdf
HS - EMFW	Health and Safety in Electromagnetic fields in welding	Development of a new professional profile EM HS Welding officer Implementation of a new ICT training solution (WELD ZONE – Simulator)	http://www.hs-emfw.com/

Table 3 - EU Projects in the field of welding and innovative training

According to the findings, three of the projects aimed at implementing a virtual welding training system into the Welders qualification.

One of the projects focused on distant learning tools and combined approaches of training.

Finally, two of the projects led to the development of a game-based learning approach for specific purposes: one of those projects targeting welding experts and aimed at raising awareness about electromagnetic fields and their impact on health and safety; another targeting general public and aimed at attracting young generation to work in a welding company environment.

The implications of these findings for WELD 4.0 are further explained in the Conclusions.

COMPILATION OF NATIONAL FINDINGS

From March to April 2018, project partners ISQ, BIBA and HighSkillz have conducted 21 interviews and gathered 4 responses to an online survey. Investigation has covered the representative target groups of the project, which were previously identified as welding trainers, shop floor managers, subject matters experts in ICT and welding, companies and other stakeholders from Portugal, Germany and the United Kingdom.

The same template (**ANNEX 2**) was used by each partner to conduct the needs analysis interviews and to report the results in each national context.
The interview template was divided in three sections:

a. European welder curriculum -gaps in the context of Industry 4.0
b. EW Training – Current Gaps
c. Innovative Tools for Training in Welding

The first part of the interview aimed at investigating the participants' experience and knowledge of Industry 4.0, as well as its impact on their professional activities. The second part focused on the EW Qualification, the current ICT use in the curriculum, the training methods and required digital skills. Finally, the last part explored the participants' experience of innovative learning tools and their attitudes towards game-based learning.

As described above, the two out of the three parts of the interview focused on the EW curriculum and training and thus required a specific subject matter expertise from the interviewer. The only partner in the consortium without relevant subject matter expertise, HighSkillz -specialised in the field of game-based learning solutions- asked for the support of EWF in conducting the interviews, leveraging their expertise in the welding sector. Also, HighSkillz due to its profile had no connections to the welding sector and required the mediation of other partners to access relevant participants.

Despite the efforts of HighSkillz and EWF in establishing connections and identifying appropriate participants, the overall process revealed to be time consuming and not effective enough. In order to tackle this issue, in addition to the interviews, in the case of the UK, an online survey (**ANNEX 3**) exploring the same topics was used and the scope of the participants was broadened to include universities and other institutions on manufacturing and engineering.

Further challenges were identified in the remaining countries, thus related to the time interviewees and interviewers needed to devote to the interview. As some interviews were held during the working hours, it became difficult to have the focus of the participants entirely on the interview.

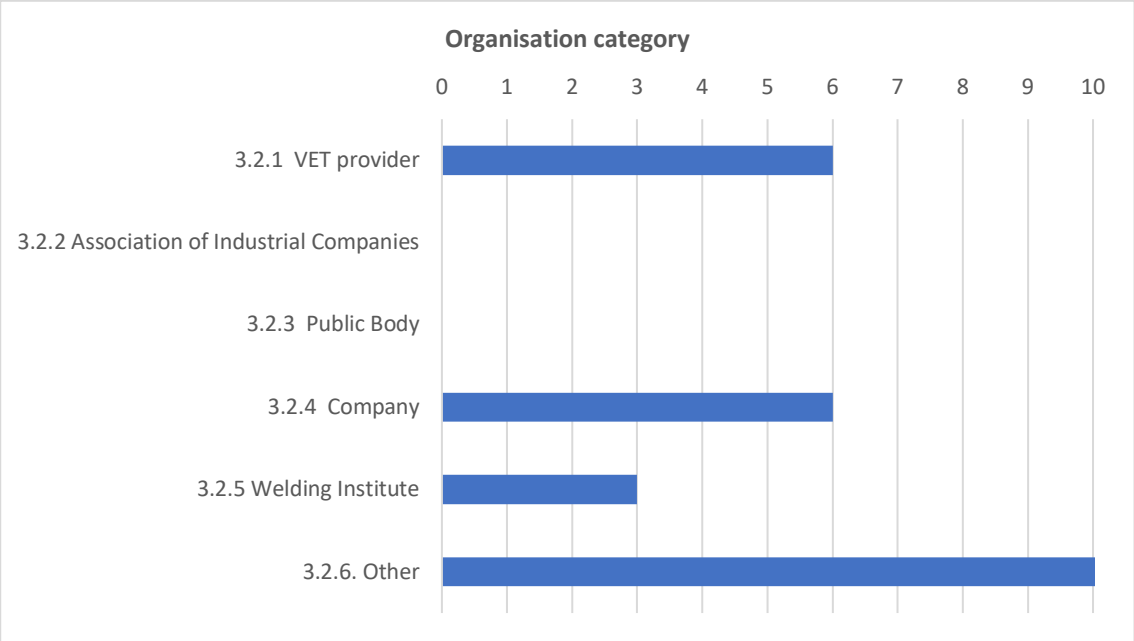
Another challenge was to find the ideal "interviewee profile", meaning someone simultaneously familiar with the concept of industry 4.0 and EW guidelines. This was only possible in Portugal with a reduce number of participants.

Overall, the process revealed to be time consuming and the minimum number of participants was not achieved (25 instead of 30). Despite this, the project partners will continue to identify and engage with appropriate participants.

QUANTITATIVE RESULTS

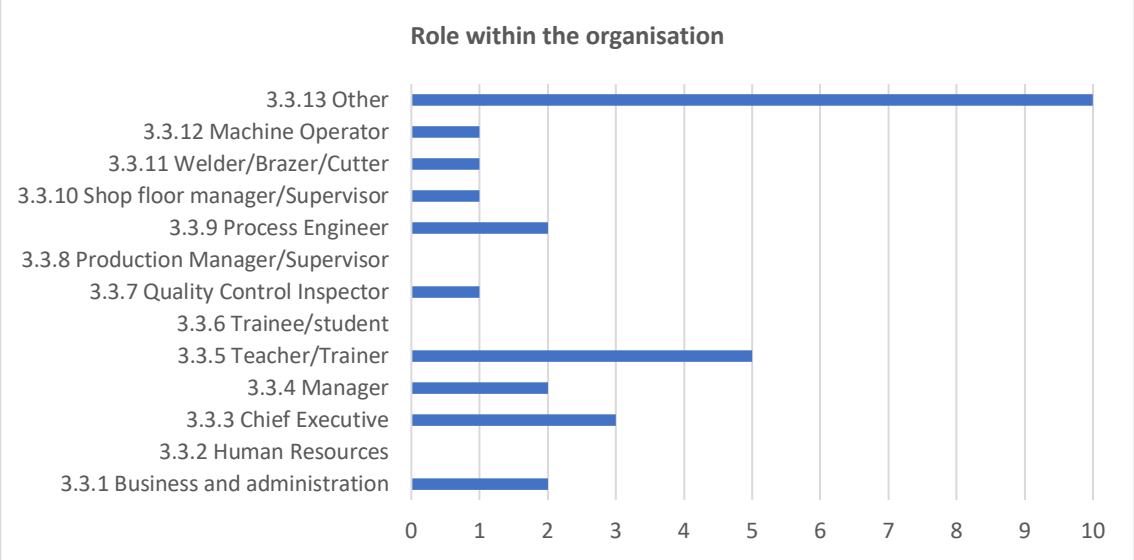
Target audience characterisation

People enrolling in the study belonged to different cities in the UK, from Bremen in Germany and from Lisbon in Portugal. Their profile is diverse when it comes to identify the organisation they belong to. Ten of the participants in the study, belong to "other" organisations specified as Higher Education Institutions and Research institutes/centres. Followed by six people belonging to VET Provider organisation and six people belonging to companies (as detailed in the Graphic 1).



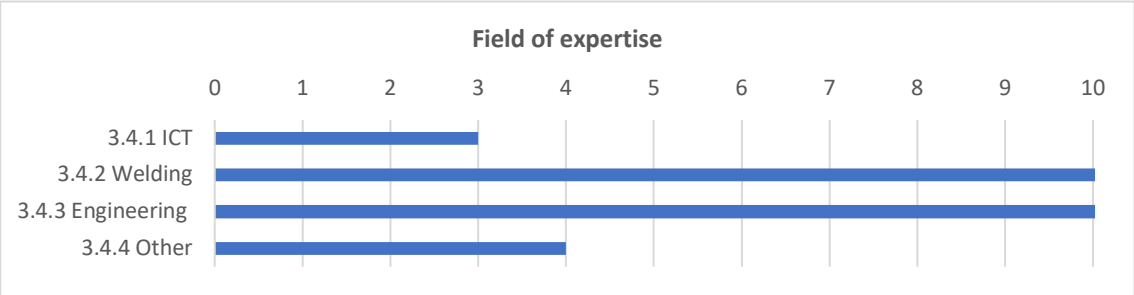
Graphic 1 - Organisation category

The same diversity applies to the roles within the organisation, meaning different roles were identified within the organisation. The sum outnumbers the total number of interviews, since several persons mentioned to work in more than one role. Ten of the participants in the study identified "other" roles, which were specified as researchers (Germany), technical coordinator for Welding Technology training, Welding Expert and Welding Engineer, technical coordinator of Welding Laboratory, senior investigator in Welding related R&D projects (Portugal) and one manager (United Kingdom). Then, the teacher/trainer role was mentioned by 5 people, followed by three chief executive's roles, two process engineers, two roles in business and administration, one machine operator, one shop floor manager/supervisor and one quality control inspector (Graphic 2).



Graphic 2- Role in the organisation

The background and specific expertise ranged between welding and engineering. "Other" fields of expertise were specified as Quality Assurance/quality control, training and manufacturing. Only three people mentioned ICT as expertise. More than one answers were possible to this topic, which explains the total of 27 responses (Graphic 3).



Graphic 3- Field of expertise

QUALITATIVE RESULTS

Category I – Experience and knowledge about Industry 4.0

1.1 Definitions

Globally, the participants in this study knew about Industry 4.0. For instance, it was interesting to noticed that all German interviewees, which were mostly researchers (7 out of 10) were familiar with the concept, while not all Portuguese interviewees (6 out of 10), whose profile ranged between different roles (trainers, manager, chief executive, shop floor manager, among others) mentioned to be familiar with the concept.

According to the responses given (complex versus simple definitions) it was clear that interviewees had different levels of understanding when giving their own definition.

Looking into the examples, two kinds of definitions for Industry 4.0 were provided:

Type 1) Most definitions referred to the introduction of new technologies (e.g. ICT), digitisation and the generation of big data.

- *"Industry 4.0 is to get the help from new technologies to develop practical and theoretical competences. It is related to the use of ICT in Manufacturing, with the main objective of collecting and treating data from the different manufacturing processes"*

- *"Industry 4.0 also represents the definitive entry of IT (information technology) into the factory floor, with implications at all levels of the production system. Real-time and networked data flow between machines, robots and logistics systems, will allow to anticipate equipment failures, adapt production (customized products) to new scenarios and integrate variables into the production process, such as information coming from customers"*

- *"The use of ICT technology to support manufacturing, merging the manufacturing hardware with digital solutions either for control/monitoring of production or to support engineering solutions"*

- *"I4.0 is the new industrial revolution that has brought Digitisation into the world of Manufacturing. It can allow for the integration of new ways to collect and treat data (e.g. with sensors), while giving the possibility of improving the current manufacturing landscape (with new concepts, such as Additive Manufacturing, Augmented Reality, Big Data, etc.)."*

Type 2) Remaining definitions highlighted the connection between systems linked to "smart factories" where everything is predicted and controlled.

- *"A new trend of automation and data exchange in manufacturing technologies, aiming at modular and structured so-called smart factories. Monitoring of processes based on extensive virtualization of the real world and device-level communication over the internet*".

- "Industry 4.0 is the new industrial paradigm that involves the digitization and networking of the entire value chain, including customer interaction"

- "Capacity of having systems linked together, feeding high level decision algorithms residing in platforms hosted in the cloud"

- Industry 4.0 is "the smart manufacturing where everything is planned and actively monitored".

1.2 Examples of impact within the sector and professional activities

General opinion of the participants familiar with Industry 4.0, was that it has an impact on the welding and manufacturing sector. The impact was identified in areas such as: **Training** (related to inclusion of more simulation and technology to attract young people; and increased amount of digital content used and the recording of the lectures); **quality of the product** (weld seam/bead) related to faster image processing and in-time **information and working environment** (related to the presence of collaborative robots, augmented reality, improvement of safety, better material supply, non-ergonomic welding positions manned by machines).

The following examples on how it affects the sector were provided:

- "In Industry 4.0 with the optimization of means, maybe less working force will be necessary in the future, less welders, but these workers will never be completely substituted, at least with the structures we have in nowadays"

- "It has a major impact. Through automation and robotics, its integration into cyber-physical systems"

- "It will have an influence in the Quality assurance processes, by making them more ICT focused, but also in the use of more computerized Manufacturing processes"

- "The information gathered during production will allow to improve welding procedures, reduce waste and improve welder activity"

- "It will impact on many levels like the management of the activities, engineering solutions, control/monitoring of production, evaluation of processes, etc."

- "I4.0 may change the way the welder operates the welding power supply: not only directly at his workstation, but through an app, remotely, for instance"

- "For the time being, the impact is minimal, if there is any impact at all. From the manufacturing environments relying heavily on welding, only those which have long been well-structured and organized and traditionally incorporate a high level of process automation, such as mass production car factories, can find today some potential to optimize manufacturing processes based on Industry 4.0"

- "Improvement in automation manufacturing processes and information management. The application of new technologies in welding is already a reality. It already appears applied in the new equipment, the consumables of manufacture and the software for analysis and follow-up of the processes themselves".

When asked about the influence of industry 4.0 in their own professional activities, different opinions emerged. In fact, the majority of interviewees from Portugal and the United Kingdom referred not feeling any major changes related to digitisation when performing their professional activities.

In Germany, the interviewees mentioned impact on research work related to the training simulation, the provision with higher IT-skills and an increased desk research to stay at the edge within the Industry 4.0 developments. Another impact was identified on costumer's requests to a more digitized production and the way of working, which is linked to more networking and communication, for costumers the content aspect of the project is mostly affected. The interactions with the environment and the machines was mentioned to increase, as expected, but the machines will adapt to the worker needs and not the other way around.

Those interviewees who mentioned being affected by Industry 4.0/digitisation in their professional activity, highlighted the impact on communication and the nature of information received. This last aspect is linked with the kind of documents produced.

The examples on how Industry 4.0 affects communication were the following:

- *"The welding coordination activities are affected, by the use of ICT tools, the communications will be based in intranet systems, users must develop higher knowledge in ICT, new ICT tools and protocols must be developed to have a proper and user-friendly communication between machines-work labour force, the same applies for reporting and monitoring"*

- "*The intention is that in the near future human interaction (among collaborators) will gradually decrease and that much of the communicative process will be carried out in a digital context"*

- "*Greater competition is needed in the digital area, because in almost all areas this relationship begins to be the only way of communication".*

While the examples on how it affects information (e.g. documents) were the following:

- *"It affects the Document Management. As well as monitoring and planning of activities related to Welding activity.*

- "*It is necessary a greater agility in identifying the Qualification needs of welders and Welding Procedures"*

- "*The registration and identification of discrete events in the maintenance of welding equipment, which in turn allows the identification of trends and reformulation of Maintenance Plans"*

One of the interviewee reflected on the impact that it can have on the future stating:

- "*In the future, it can impact, maybe with welding in mass production. The automation and control that this type of industry allows, can have many advantages making more production with less costs."*

Based on the most common responses given by the participants, we conclude that the examples of impact within the sector and professional activities are the following:

- **Quality assurance of processes,** linked to information gathered during welding procedures, reduce waste and improve welding activity and **quality of** products (weld seam) linked to faster processing and in-time documentation.
- **Management of activities**, engineering solutions, control of production, evaluation of processes.
- **Document management** linked to grater agility to identify qualification needs and welding procedures; **registration and identification** of events in the **maintenance o**f welding equipment which allow the update of maintenance plans.
- **Coordination activities** and **communication** (more based in intranet systems, new ICT tools and new protocols should be developed, user-friendly communication), although this question divided interviewees.
- **Working environment**, linked to collaborative robots, augmented reality, improvement of safety, better material supply (e.g operating with welding power supply with apps or remotely).
- **Training/teaching** linked to greater amount of digital contents used in recording lectures.

1.3 Digital Skills required by the Welder

Unanimous expectations of the interviewees were that Industry 4.0 requires new skills from the Welder Profile.

According to them, welders will need a more versatile skill set, like an understanding of ICT, knowledge of controlling the automated processes and understand the captured data and being able to interact with them. Butt, off course, the digital skills in the context of Industry 4.0 depends on the job position.

Interviewees also mentioned Welders' need to learn how to use the (new) welding devices, to better understand the digital media and the related interfaces. Knowledge of special software and analytic tools will also be needed. Some interviewees mentioned, that welders might program welding robots.

Other perspectives about Welders digital skills emerged, focused on the following aspects:

- "We talk about monitoring, data processing and communication, augmented reality, simulation, additive manufacturing."

- "The welder must have skills in ICT, in the use of measuring instruments, in working in simulation environments."

- "Being able to deal with a lot of new data. Welders will have to be able to understand the data collected during their activities"

- "Regarding the Industry 4.0, it is computer programming, networks, database management"

- "Big Data analysis; communication using digital means; using and operating digital equipment"

- "Know how to use and apply the industry's 4.0 digital tools and understand their advantages. Know that there are digital tools on the market that influence the way welding is applied and how processes benefit from it."

- "I don't think welders can play any significant role in Industry 4.0 as it is today. Most general welding fabrication industry can hardly understand and assimilate the concepts behind Industry 4.0, far less extend them to welder level. Even if one takes into account some sophisticated features implemented in modern welding equipment, the welder skills which are required to efficiently interact with the equipment are in the same level that those required by the daily use of an ordinary smart-phone or googling on the web."

To conclude, the welder digital skills can be recognised as being able to:

- Monitoring of data
- Data processing
- Have knowledge of controlling automated processes
- Communication using digital means
- Use of measuring instruments
- Use of digital interface and devices
- Use programs via GUI to understand the process they are working in
- Have knowledge on special software and analytic tools

2.1 Opinion about EW qualification

The majority of the participants were not familiar with the EW Guideline/Qualification, except for the Portuguese interviewees (6 out of 10) due to their background and roles within the organisation (please refer to target group characterization in the quantitative results chapter). For instance, in Germany, where the interviewees were mostly researchers, only one of them mentioned to know the EW guideline. Although, his level of knowledge was basic referring to be aware that the qualification includes all required skills for welders.

The lack of knowledge of interviewees about EW guideline/qualification is probably related to the fact that no training course was attended by them, neither thought, so there is no specific information about it.

Those who were familiar with the EWF Guidelines had a positive impression and recognised its added value for this purpose. In addition, they recognised a good matching between the Welder qualification /training and the labour market requirements.

It was highlighted during the interviews, that in the context of globalisation, harmonization and standardization of qualification, curriculums are important. If all welders have the same qualification it will be easier to get allowances for safety critical products, which are produced in another country.

Some of the opinion about the EW Qualification, where the following:

- *"These guidelines follow a European model and are applied in the same way by the countries that are members. The same is made with the European Welder, these guidelines needs to be followed to qualify and train a welder."*

- *"These guideline aims to assure that it exists a minimum standard in quality, practical and technical knowledge between welders and hierarchically superiors."*

- *"It is a very necessary document since the welder work is extremely complex and this homogenization allows a more control in the quality and also allows the exchange of goods and services between countries that use the same tool in welding."*

- *"This guideline is also really necessary as a guarantee of quality of the welded material and welded infrastructures."*

- *"The European guideline IAB-089 is a guideline in which the various EWF / IIW qualifications and possible levels of achievement for a given trainee are defined after successful completion of the course."*

- *"The courses have a theoretical and practical component with their written and practical assessments (intermediate and final). Although defined in the guideline welding processes and various types of applicable materials, it is up to the trainee / entity to choose the training and EWF level that it intends to attend. It is a guideline with theoretical and practical program content very complete according to the three levels of qualification defined in the guideline."*

- "Implementation of international / European welder courses in training centres. Verification of compliance with the rules defined in the guideline in the various training centres."

- "The guidelines regulate how the different EWF associated members (countries) should qualify welders. They contain the rules and specificities of the qualification, objectives, fields of application, materials and types of welding. They work as a European standard where the requirements for qualification are established. They are important to maintain the quality and levels of demand among all institutions".

Based on the inputs provided, we conclude that the strength of the EW Guideline/Qualification was recognised due to the following factors:

- Harmonised training and assessment - by using the EW Guidelines and a common database for examination, the same level of performance and quality of welders is guaranteed across Europe;
- Quality assurance system - EWF quality assurance system ensures that both theoretical and practical training, as well as the assessment of Welders in each member country follows the same rules, procedures and standards;
- Compliance with industrial standards - meaning training and assessment are underpinned by industrial requirements, which also is a guarantee for the quality and safety of welded fabrication and products;
- Recognition and mobility - EWF members, which are representatives of the manufacturing industry from 31 European countries, recognised the Welder certificate worldwide, which facilitates immensely the mobility and employability of the welding workforce.

2.2 Personal experience as a trainer

As mentioned previously, the overall experience of interviewees reading the European Welder Qualification was linked to the training activity, since most of the respondents were trainers and used the guidelines as a tool.

One of the respondents was actually very familiar with the EW Qualification, being involved in the development and implementation of the EW guideline in several training centres and responsible for the EW training technical management.

Participants linked to research, had less experience regarding the qualification, but revealed to have theoretical basic knowledge about welding processes and materials, since these subjects are thought in depth in mechanical and industrial engineering courses.

In terms of personal experience as trainers, the feedbacks were positive. Trainers mentioned to be satisfied with the teaching activity in the EW courses. Some challenges were mentioned like the lack of interest of the students in the beginning of the course due to amount of theoretical contents, although this is overcome when coming to the practical training. Another challenge was related to the quick speed in which technology is evolving, which makes difficult to provide adequate information about all technologies

and problems a welder may face in the real working context, but it was recognised that the EW Guideline/course gives a good preparation to enter the labour market.

Here are some of the statements of what was mentioned by the trainers:

- "My job is to prepare people with or without experience, with the aim that the welder work may be done accordingly the European Welder Training Guideline."

- "As a welding trainer I would have so much to say but in a brief way I can say that it is a very satisfying work, because I work in the area that I like and that I have choose and it is the best we can have in our lives. Being that the best income is to be able to pass my knowledge to someone and after when I see a trainee that trained by me having a good life and doing a good job, most of the time some trainees have a lot of difficulties before they are in the metal mechanics world, but after the training they became thankful for all that we have done for them, even being boring in the training regarding some technical aspects, then afterwards make perfect sense."

- "Not all trainees have the skills for welding, and these are really challenging, when they achieve something for my it is like a victory, and that what makes me go on… "

- "My experience as a trainer is quite positive, but I think there's some lack of specific/specialized training in "noble materials" or tailored training for the welders in the companies or training recycling and application of the practical and technical skills."

- "In life we are always learning and knowing that the metal mechanics industry is very vast, it is impossible to train learners for all the problems they will find. But I consider this guideline provides a really good entrance in the labour market, trainees finish the training very well prepared and with very good tools to face many professional problems."

2.3 Improvements required in training

The main competence of the EW is to create reliable welding results in different materials for different use cases and using different welding methods. In this sense, the EW training has currently a major focus on technical skills.

Some of the interviewees mentioned that "Probably the EW trainings are focussing too much on traditional welding skills and new skills like collaborations between welder and welding robots, programming welding robots, or welding in additive manufacturing are not considered; Furthermore, software skills or augmented reality applications in welding context play no rules in the trainings."

It was highlighted in one of the surveys, that training and advances in technology are often too far apart, leading to outdated equipment used in training.

Additional areas of improvement in the curriculum were mentioned, such as the need for more investment in theoretical training and more strictness in certification exams:

- "Greater stringency according to EN 5817 and in the certification exams on behalf of certification entities, aiming a good selection and filtering of the welders that enters the labour market."

- "What I am seeing on a daily basis is that the training of welders has a strong influence on the operative technique and neglects something essential such as basic theoretical training. Welders, although good performers, have little critical spirit regarding the suitability of welding procedures to specific situations."

- "A bigger bet on basic theoretical training and periodic recycling to this theoretical training."

Regarding the competences that should be addressed in the EW Profile/Qualification, the opinion of the professionals is that soft and digital skills should be included in the curricula. The need to increase the training for theoretical contents such as standards and drawing interpretation was also highlighted:

- "Maybe some more technical knowledge according the more relevant standards that are applied in the welder profession."

- "The welders should also have some training regarding soft skills (civics) and work-based responsibility in the shop floor."

- "Also, an increasing of training hours of the modules would be more realistic regarding the minimum of demanded quality."

- "A possible improvement could the use of virtual systems for training welders Skills, but the EW guideline already covers this and accept the use of virtual systems."

- "The reading of drawings, it is missing."

- "To my knowledge, there is no mention of digital skills in the current training contents: this could be a valuable addition, including on the new industrial paradigms that are appearing, always with a focus on the practical part of the curriculum".

To conclude, the list of **improvements** required in EW training **were** the following:

- Greater stringency in the Quality level of Imperfections (ISO 5817) and in certification exams
- More focus on theoretical training for development of critical spirit of welders
- Use of virtual systems for training welder's skills
- Periodic recycling of knowledge and skills for older/experimented welders
- Update equipment to be in accordance with industrial reality
- Soft skills development (Adaptability to different situations, civics and work-based responsibility in the shop floor)
- More technical knowledge according to relevant standards applied in the profession
- Develop the ability for reading drawings
- ICT/digital skills development "know how to use and apply industry 4.0 digital tools and understand their advantages. Know that there are digital tools in the market that influence the way welding is applied and how process can benefit from it
- New skills development, like **"**human- robot collaboration, programming welding robots or welding in additive manufacturing"
- Use modern approaches like simulation and game-based learning to foster interest of young people

Category III - EW Training Curriculum

3.1 Coverage of ICT

Participants familiar with the EW Qualification, were unanimously stating that the current EW curriculum doesn't contemplate any ICT. Some suggestions were given to have more ICT related topics included in both, theoretical practical courses.

3.2 Development of the Welder Digital Skills

As it was highlighted in previous chapters (please refer to section 1.3 - Digital skills required by the Welder and 2.3 - Improvements required in training), there is a need to introduce digital skills in the training of welders, which is due to the context of industry 4.0 and to the absence of ICT in current training practice and curriculum.

In this context, participants in the study, were asked to indicate how Welders' skills could be developed, meaning which pedagogical approaches, tools and equipment could be applied for this purpose.

It was mentioned by them, that "modern" approaches like simulation and game-based learning could foster interest among young people and make it easier to enter the practical phase of the professional live. This aspect is important, since we had already seen that the lack of motivation of participants in the beginning of the course was one of the challenges identified by the trainers.

Some participants recognised that there is no perfect training method to be applied, so their selection will depend on factors such as the trainer expertise, motivation, resources and time available:

- *"The answer to this question is very relative, since there is no common method and tools of training. Each trainer uses its own method and educational tools. It is only possible to evaluate some methods and tools of some specific trainers."*

- *"It all depends on the way training is given in different places, the available resources and the motivation of the trainers to make the best of the time they have available to pass on the basic knowledge they are supposed to do. Sometimes, as a trainer I get the feeling that an opportunity to widen up the horizons of the prospective welders is somewhat wasted when, for instance pulsed current, mechanized welding or automatic welding, for example, are not addressed at all. Perhaps that is just because time is always too scarce."*

This last comment reveals some frustration regarding the effectiveness of the course, since trainers have to guarantee that the minimum contents are thought in the given time, meaning there is no time left to approach additional subjects that could be also relevant for the welder.

Regarding the way ICT could be included in the training course, respondents mentioned as best practice to combine theory and practical elements. Nonetheless, the practical part should be in focus of the training. Some additional statements were:

- The theoretical background should be learned first and then applied and trained in practice.
- Could be YouTube-like videos and should be available anytime.
- Basics must be teached theoretically followed by practices.
- Both in context of blended learning.

Some suggestions to include digital skills in EW training were to include tutorial lessons, e-learning platforms, digital media and tools as well as more advanced welding equipment. The use of real problems was also mentioned to be useful to prepare welders to solve simple problems:

- The EW training could include lessons and tutorials in programming welding robots,
- Welding under augmented reality supervision (e.g. follow hints for improvements in glasses).
- The use of eLearning platforms can improve the personal skills in software interaction.
- At least the generally used digital media like email, Facebook, etc. on different devices like smart phone, tablet, PC, etc.
- *"Through problem-based learning, simulations and tutorials, all of them are really useful and important for training. With problem-based learning we can better prepare trainees to the working context, making them think and make efforts to solve a problem that may arise and not only respond to commands. Tutorials can be useful to show them how to proceed when we don't have available in class the proper materials to work. Also, simulation is good to train trainees' technique and skills."*
- *"the use of augmented reality simulators, simulation games, online testing and assessments."*
- *"It could include training on the use of more advanced welding equipment and on evaluating the results of the data collected during their training (at a basic level)."*
- *"I consider all the suggested approaches (problem-based learning, work-based learning, game-based learning, blended learning, simulations, demonstrations, tutorials) can be implemented on the guideline in all training course, both to theory as to practice."*
- *"ICT can be included by the development of reports, charts, tables, graphics, database, excel."*
- *"ICT can be applied to all training course. For example: A trainer of the theoretical part can ask the trainee to deliver a report on a specific practical welding exercise performed in the practical part of the class. In this report the trainee can create a table and develop the specific charts with the results in the excel."*
- *"All of the approaches may be relevant. Since this is a very "hands-on" profession, I would suggest using the learning approach that proves to be more practical and applied. Through the use of newer technologies, games, equipment, etc. in the practical modules."*

Finally, two comments highlighted the importance of addressing theoretical aspects of the curriculum by using "hands on" and innovative training methods:

- *"Work based learning through games should be applied specially to theory. Because in the practice it is better for them to weld with all the real tools."*
- *"At the moment the big challenge it is the introduction of virtual welding and the way to do it including the share between virtual welding training and regular welding training."*
- *"May be on the theoretical syllabus some case studies should be develop".*

To summarise contributions, according to participants opinion, Welder digital skills can be developed through:

- **Problem based learning, tutorials (e.g. lessons on programming robots), simulation, games, online assessments, augmented reality simulators** – meaning the more closed to reality the welder is, the better he will be prepared to solve problems. For instance, in the industrial environment, the welder will be in contact with several equipment and emergent technologies, which will probably require programming parameters and interpreting data, so if the welder is trained before he will be ready for the future.
- **Work-based learning** –since it is, for sure, the most effective method for assimilating information, which implies understanding what is being done and why it is being done;
- **Use e-learning platforms to develop personal skills in software interaction** – one of the benefits of e-learning tools is the possibility of the student to be more pro-active in learning, he can decide what and when to learn. An essential requirement for applying e-learning is that the student should have basic ICT skills, so through is regular use the student is expected to gain and enhanced his/her digital skills
- **Training with use of more advanced welding equipment (basic level**) –this aspect is important to avoid the mismatch between the industrial and training contexts, as it has been highlighted by the participants. Of course some investments are required at this level from the training centres.
- **Development of reports, tables, graphics, database in excel during training**- this can be considered as an additional exercise for welders to train their ability to use ICT.
- **Development of case studies on the theoretical syllabus** - this topic is not directly linked to the development of digital skills, but with the ability to solve simple problems. As it was mentioned by the trainers, it would be relevant that welders could analyse and interpret some situations;
- **ICT approach in training should be to combine theory and practice**
- **Cycles of theoretical and practical training should be shorter** - this aspect is important to enhance the motivation, since the current training foresees long periods of theory followed by long periods of practice
- **Use of general digital media (Facebook, smartphone, tablet, PC**). - as a way to practice digital skills.

4.1 Personal experience with innovative learning tools

Overall experience of interviews reading innovative learning tools addresses the use of welding simulators, which was mentioned by nine of the interviewees. Other methods

cited were augmented reality, online-tools and games. Although the limitations of this solutions must be considered when applied to the welding shop-floor. For instance, augmented reality is highly unlikely due to the risk of electromagnetic fields, but smart glasses could possibly be used.

In terms of personal experience with innovative learning tools, the following was said:

- "ISQ welding simulator, it is a very good tool to simulate real welding. We use it often in face to face courses. A drawback is that the simulator does not take into account some senses that in real life we can count on."

- "I have tried virtual welding equipment, distance learning, PBL, all in training courses. The benefits of learning with these tools it that they are more problem/skills focused. The drawbacks of learning in this way is the access to the necessary tools/resources."

- "Virtual welding, software. I experienced it as trainee and trainer, in regular training, distance learning and blended learning, if there is time these are good tools. But for its use it is necessary more time and higher ICT competences for the trainers."

- "A welding simulator based on augmented reality. I have used on training and as a tool that I implemented on my work. It is a very useful tool because it is like an introduction to welding for trainees. The disadvantage in learning this way is the difference that we have from the real to the virtual, it is still not possible to have the real experience reproduced in a virtual way."

- "Welding simulator, as part of a Welding Engineering course, that allows a trainee to "see" welding for the first time, without the need to consider Health and Safety at work, being a more affordable way to introduce the particularities of the process, while raising the interest of the student. This tool, however, is not enough to foster digital skills in a welder."

Personal experiences address mostly training situations, while others were made as demonstrators in the context of research or distant learning from home.

The added-value of innovative learning tools was recognised by the participants, in the following terms:

- Focus on the process and not only the result - when the tool focuses on a specific problem, the student must analyse the situation (process) and not look exclusively into the outcome.
- Variation of difficulty - according to the student experience and knowledge, he/she can choose the level of difficulty when starting learning and then increase it in line with this progress.
- Learning of work ergonomics - if the working context is properly reproduced by the tool, then the student can have a good understanding on how it works and how to perform on it.
- Lower entry level resulting in less risks and hazards.
- Better resource efficiency - namely no materials are required, and the preparation time decreases.
- Focusing on learning when using augmented reality-based simulations.

- The learning is more effective because of an increased involvement due to interactive components.
- eLearning systems or other online-tools allow a more flexible way to study (besides full-time work or when you are in a good learning mode).
- Direct feedback during the welding.
- Checking the producibility/feasibility of parts.
- Faster understanding of problems.
- Learners get a direct feedback from both, the simulator and the trainer.
- The communication and exchange among trainees is promoted.
- Different materials and combinations of materials can be simulated.

Some participants stated that equipment for simulations is expensive with high requirements and still in the beginning of technology. Others fear that "real world" (e.g. noise, dirt, stress) cannot be simulated.

4.2 Game -based learning attitude

Regarding personal experience with a game-based learning (GBL) approach, only German participants and one Portuguese mentioned its use in training.

Participants described GBL as the application of gamification methods on serious topics to acquire certain skills and knowledge. Some interviewees state, that the focus should be on gaming, with fun and an inspiring environment, while the learning is the by-product. GBL is focussing of dealing with unforeseen events, has a high complexity and is designed for specific situations.

All interviewees think, it would be easy for them to learn with games. They do not foresee any personal difficulties.

Attitudes towards GBL from those who had never experienced this learning approach was globally positive. They see it as an easy tool to use, with the added value of providing an opportunity to deal with "real" welding and with the potential of increasing motivation:

- *"The benefit is that can be a way of having a first contact with welding and some of its theoretical concepts. As a disadvantage, if the trainee is already a welder, it can imply some decrease on its production. I would not have technical barriers, only time constraints."*

- *"No, I have never experienced this. I think I would not have difficulties on it. The advantages are that it can save time and money, reducing the learning time and the materials consuming. I think I would not have limitations or barriers."*

- *"I think there are no technical barriers in my work, but yes, a lot of time barriers, very difficult to deal with."*

- *"Never used, therefore not able to answer. I just figure that in the EW training guidelines GBL should be used for some of the theoretical subjects."*

- *"No, I have never tried. But I think it would not be difficult for me. I would not have much barriers, except if the amount of time spent for it would be too much. It could make the*

learning more interesting and more effective in the overall. It should be really interesting, dynamic, intuitive, interactive and challenging".

The link between GBL and time was mentioned twice, but in different perspectives. In one hand it was said, that games would help saving time and money in training, although some initial investment is required, the costs with raw materials might decrease significantly. One the other hand, games can be very addictive, required more time than traditional methods to gain a certain amount of learning objective.

In comparison to traditional methods, GBL isn't considered to be more useful by most interviewees. It should be used complementary to traditional methods. It depends on the topic and the content, whether it is the best learning option.

Expectations of respondents for a serious game for the welding sector include the following aspects:

- The game should be well designed, intuitive, relevant, useful, matching job reality/give the feeling of real environment, appealing, challenging, interesting, dynamic and interactive;
- It should combine actual products (e.g. emergent technologies and products in current use in the industry) with social and cultural competences (e.g. transversal skills such as soft and digital skills);
- Hand controllers (e.g. Wii controller);
- Mediation of sensorial impressions (heat, noise) and using virtual reality (VR) technologies;
- More advantages regarding theoretical subjects "easier for welders to understand that part"; "theoretical parts are good subjects for gaming";
- Subjects addresses could be: the several manual welding processes; welding and production processes; use of digital welding equipment meaning with a digital interface for the operator; applied to documentation traceability and creation (WPS); industry 4.0 and digitisation**;**
- Training should be embedded in practical problems to allow a better correspondence between industrial environment and training;
- Could be included in the welders' initial training.

Finally, the use of games in the welding industry could have a positive impact on health and safety and global welding performance:

- Reduction and prevention of welding related injuries (burned fingers). Better safety at the work place.
- Better understanding of the welding process and better dexterity resulting in better experience when going practically.

4.3 Gaming Background

Gaming background refers to the assessment of past and present experiences with games.

At this regard, even if in the past there was a tradition of playing games currently only a small number of respondents kept this habit. Interviewees that quitted playing games, stated that they don't have time, in somewhere they lost interest, and it had also the expensive cost of some of the consoles and games. Interviewees that never played games, stated that never had interest on it and they have no time for it.

Examples of games played mentioned were strategy games, role-play games and simulation games. The type of games mentioned were action games, racing, football, adventures and card games.

CONCLUSION

After a critical assessment of the results achieved within the investigation undertaken in this first phase of the project, we conclude that the use of a combined approach of methods (workshop, desk review, interviews and survey) was twofold. On the one hand it led to a comprehensive understanding on the Industry 4.0 requirements and its impact on welding qualification and to a high amount of relevant information. On the other hand, as the information collected relied on topics with rather different nature, which made comparison and interpretation tasks much more challenging.

The results achieved through the workshop and collection of national inputs have pointed general perspectives on what are the concrete needs of Welders within Industry 4.0 and on what should be improved within the EW curriculum. So, the range of possibility of intervention in this field is quite open.

The desk review was an important step to identify what not to do. For instance, although the added value of simulators in practical training was acknowledge on both workshop and interviews, it was clear that previous project had addressed the same topic. So, the decision of the consortium was to avoid the development of any kind of welding simulator.

Based on the results achieved, and since they leave a wide range of possibility open, we can infer some global trends and ideas for the future actions to be implemented within the project.

Results have revealed that:

- The possibly of a module to raise awareness about industry 4.0 would be useful for welders, since not all participants knew about Industry 4.0 and its concrete impact on their own professional activity;
- There is a lack of ICT coverage in the Welder Course/curriculum, which can explain the need for developing the welder's digital skills;
- Welders have a lack of knowledge regarding fundamental theory (e.g. standards, welding processes, materials, consumables, effects and defects), as well as the lack of critical spirit to interpret welding parameters and to solve basic problems, perhaps it would be useful to provide more training regarding this theoretical aspects in a dynamic way;
- Some adjustments would possibly be required in the training sequence, to avoid long periods of theoretical training and practical training, perhaps the introduction of a new learning method could help to motivate and engage students.
- Participants were able to identify innovative learning methods that could enhance welders digital and soft skills, namely work and problem-based learning, tutorials and the interaction with e-learning platforms, digital media and software.
- Participants also revealed a positive attitude towards game-based learning approach, although most of them were not familiar with it.

ANNEXES

ANNEX 1

WELD 4.0 - Redesigning Welding Profile for the Needs of Industry 4.0

AGENDA OF THE WORKSHOP| 20th December 2017

Venue: ISQ, Av. Eng. Valente de Oliveira 19, 2740-254 Porto Salvo

Duration: 3 hours

Goal: Promote reflection and discussion about the impact of the new industrial revolution, including Information and communication technology (ICT) and digitisation, on the European Welder Profile

Participants: Weld 4.0 partner organisations and Welding Experts (among others, including trainers)

9:30	Welcome	ISQ
9:35	WELD 4.0 project introduction	ISQ
9:40	European Welder Qualification	EWF
9:45	Industry 4.0 & Welding sector	EWF
10:15	Think tank - Digital Skills Needs in Welder training (slot 1)	All
10:35	*Coffee – Break*	
10:50	Think tank - Digital Skills Needs in Welder training (slots 2 to 5)	All
12:30	Conclusions presentation	All
13:00	Next steps and closing	ISQ

ANNEX 2

IO1 - EUROPEAN WELDER REPORT ON EXISTING CURRICULUM AND DIGISATION NEEDS

TASK 2: COMMON TEMPLATE FOR NATIONAL REPORTING

Responsible partner: EWF
Contributors: HSZ, ISQ, BIBA

Document status		
Version	**Date**	**Description**
1	08/02/2018	*Draft circulated for comment*
2	12/02/2018	*Draft for approval*
3	15/02/2018	*Final version*

TABLE OF CONTENTS

FOREWORD

The European Federation for Welding, Joining and Cutting (EWF) is a representative of the manufacturing community in Europe - along with its 31 European members, the National Welding Institutes – working in training and education in the field of welding technologies.

In the framework of the WELD 4.0 project, this template is targeted at trainees/students, trainers, shop floor managers, subject matters experts in ICT and welding, companies and other stakeholders.

The template is to be by partner organisations for conducting the needs analysis interviews and/or desk review and reporting the results gathered in each national context.

Its objective is to understand the requirements of the industry at national and European level, in terms of the necessary training updating to address the industry 4.0 specifics, while contributing to improve the curriculum quality of the European Welder Profile by introducing ICT tools.

EWF's network provides training for the European Welder Qualification at three levels for the "Fillet Welder", "Plate Welder" and Tube Welder", offering knowledge of the appropriate welding processes and the materials behaviour including standards and safety regulations.

INTRODUCTION

Detailed description of the technical objectives of the intellectual outputs, methods, results and conclusions used and found in this result.

Reference progress in the tasks you have been assigned and Deliverables List plus any other relevant information. Also, include a description of any milestones achieved and deliverables completed or in progress. The description should detail the work undertaken, problems encountered, decisions made and the reasoning behind them. Data should also be included to illustrate the work.

REPORTING OF RESULTS

1. NATIONAL REPORT ON NEEDS ANALYSIS

Needs analysis details
Select the approach used for the needs analysis **Responsible partner** Click or tap here to enter text. 1.**Methodology applied**: ☐ 1.1 Desk review ☐ 1.2 Interview ☐ 1.3 Other (specify) Click or tap here to enter text. **Date** Click or tap to enter a date. **Place (City/Country)** Click or tap here to enter text./ Click or tap here to enter text.

2. DESK REVIEW

2.1 Reference documents
List the documents, articles, papers or project results used to conduct the desk review (including author(s), year, title, weblink)
2.2 Summary
Short description about the aim and content of document
2.3 Main findings
Describe finding about the European Welder skills gaps and, inclusion of ICT tools /development of ICT training. Examples of gaming/serious games should also be included.
2.4 Implication for the project
Provide concrete inputs for the project

3. INTERVIEW

3.1 Target audience

Identify with whom the interview is conducted

3.1.1Name of organisation: Click or tap here to enter text.
3.1.2 City/Country: Click or tap here to enter text./ Click or tap here to enter text.

3.2 Organisation category

Identify with whom the interview is conducted

☐ **3.2.1 VET provider** ☐ **3.2.2 Association of Industrial Companies**
☐ **3.2.3 Public Body** ☐ **3.2.4 Company** ☐ **3.2.5 Welding Institute**
☐ **3.2.6. Other (Specify)** Click or tap here to enter text.

3.3 Role within the organisation

Indicate the position in the organisation

☐ **3.3.1 Business and administration**
☐ **3.3.2 Human Resources**
☐ **3.3.3 Chief executive**
☐ **3.3.4 Manager**
☐ **3.3.5 Teacher/Trainer**
☐ **3.3.6 Trainee/student**
☐ **3.3.7 Quality Control Inspector**
☐ **3.3.8 Production Manager/Supervisor**
☐ **3.3.9 Process Engineer**
☐ **3.3.10 Shop floor manager/Supervisor**
☐ **3.3.11 Welder/Brazer/Cutter**
☐ **3.3.12 Machine Operator**
☐ **3.3.13 Other (specify)** Click or tap here to enter text.

3.4 Field of expertise

Indicate the field of expertise of the interviewee

☐ **3.4.1 ICT** ☐ **3.4.2 Welding** ☐ **3.4.2 Engineering**
☐ **3.4.3 Other (specify)** Click or tap here to enter text.

3.5 European Welder (EW) curriculum – gaps in the context of Industry 4.0

Select the topics addressed in the interview from the check-list. Examples of recommended questions are given for conducting the interview.

☐ **Experience and knowledge about Industry 4.0**

3.5.1 Are you familiar with Industry 4.0?

If yes:

- What do you understand by industry 4.0?
- How would you define it?

If no, skip to the next section.

Click or tap here to enter text.

3.5.2 In your opinion, does industry 4.0 have an impact on the welding/manufacturing sector?

If yes:
- How does Industry 4.0 impacts welding/manufacturing (give examples)?

If no, skip to the next section.

Click or tap here to enter text.

☐ **Examples of impact of industry 4.0 in professional activities/labour context**

3.5.3 Are you affected by Industry 4.0/digitisation in your professional activities?

If yes:
- Which professional activities/tasks are mostly affected?
- How are those activities/tasks affected (give examples)?
- What is/will change in the way you relate and communicate with the working environment, machines and man?

If no, skip to the next section.

Click or tap here to enter text.

☐ **ICT skills required by Industry 4.0**

3.5.4 Does industry 4.0 requires new skills?

If yes:
-Which are the DIGITAL SKILLS, when we are talking about Industry 4.0?
-Which are the DIGITAL SKILLS required by the Welder in this context?

If no, skip to the next section

Click or tap here to enter text.

☐ **Experience with European (EW) Welder Qualification**

3.5.5 Do you have any experience with the European Welder Training Guideline/Qualification?

If yes:
- Explain what you know about the EW guideline and qualification?
- What is your opinion regarding the EW guideline and EW Qualification?
- Explain how your experience related to the EW Qualification?
- Did you attend any EW training course (e.g Fillet, Plate or Tube)?
- Describe you experience as a trainee in this course?
- Describe your professional experience as a welding Trainer/ manager/supervisor?

If no, skip to the next section

Click or tap here to enter text.

☐ **Matching between EW curriculum and the current labour market needs**

3.5.6 In your opinion, is there a good matching between EW training and the market needs?

If no:

- Explain, in which sense, the EW training courses doesn't prepare/ enables to work in welding/manufacturing industry?
- Which improvement are required in the EW Curriculum/training?

If yes, skip to the next section

Click or tap here to enter text.

☐ **Competencies/activities missing in the EW Profile/Qualification**

3.5.7 In your opinion, are there any competencies / activities missing in the EW Profile?

If yes:

- What are the main competencies of the EW?
- Which competencies should be addressed or could be improved in the EW Profile/Qualification?
- Is there any other aspect to be mentioned?

If no, skip to the next section.

Click or tap here to enter text.

3.6 EW training – current gaps

Select the topics addressed in the interview from the check-list. Examples of recommended questions are given for conducting the interview.

☐ **Current coverage of Information and Communication Technology (ICT) in the EW curriculum**

3.6.1 To what extend does the EW curriculum cover ICT?

Click or tap here to enter text.

3.6.2 Give examples of ICT in EW curriculum?

Click or tap here to enter text.

☐ **EW training methods and tools improvements**

3.6.3 Do you think the EW training methods and tools require improvement?

If yes:

- Which are the gaps/shortcomings in the TRAINING METHODS used in Welders training courses?

- Which are the gaps /shortcomings in the TOOLS used in Welders training courses?

If no, skip to the next section.

Click or tap here to enter text.

☐ **Development of the Welder digital skills**

3.6.4 What learning approach (e.g problem-based learning, work-based learning, game-based learning, blended learning, simulations, demonstrations, tutorials) should be used to develop Welder digital skills?

Click or tap here to enter text.

☐ **Specify desirable coverage of ICT in the EW curriculum**

3.6.5 How could the EW training include digital skills?

Click or tap here to enter text.

3.6.6 Describe the best way to approach ICT in the training Course (if it should be applied to theory, practice or both)?

Click or tap here to enter text.

3.7 Innovative Tools for Training in Welding

☐ **3.7.1 Innovative Tools for Learning Experiences**

- Have you ever experienced any innovative tools in training?

If yes:

- Which were these? (examples, describe purpose)
- In what settings? (training courses at work, distance learning from home etc.)
- What are in your opinion the benefits of learning with these tools?
- What are the drawbacks of learning in this way?
- In an ideal world how should these tools be used in your opinion?

If no, skip to the next section.

Click or tap here to enter text.

☐ **3.7.2 Game-based Learning Attitudes**

- Have you ever experienced a game-based learning (GBL) approach in your training?

If yes:

- What is GBL for you? (Explain in your own words)
- Did you have a positive/negative experience? (Describe in your own words)
- Do you find GBL to be more useful in comparison to traditional methods? Why?

If no, briefly explain GBL and give few examples to them:

- [Game-based learning (GBL) is a type of game play that has defined learning outcomes. Generally, game-based learning is designed to balance subject matter with gameplay and the ability of the player to retain, and apply said subject matter to the real world. (e.g. serious games - games in professional settings)]

- How easy would learning with games be for you?
  - What personal difficulties do you encounter/foresee?
  - Are there any technical barriers in your working settings?
  - Are there any time limitations in your working settings?
- What would be the benefits or drawbacks of learning with games in your working environment in your opinion?
- What would be your expectations from a serious game for the welding sector?
- Which subject or modules of the EW training guideline should be addressed by GBL? To what should it be applied ?

Click or tap here to enter text.

☐ **3.7.3 Gaming Background**

- Have you ever played computer games in the past?

  If yes:
  - When did you play?
  - What kind of games?

  If no, skip to the end.
- Do you currently play computer games?

  If yes:
  - What kind of games? (types of games/particular examples)

  If no:
  - Why?
  - When was the last time you played games?

Click or tap here to enter text.

CONCLUSION

Sum up of findings/main recommendations

ANNEX 3

Online Survey

1. Identification		
Q1	Name of organisation	
Q2	Indicate to which organisation category you belong to	
	Q2.1	VET provider
	Q2.2	Association of Industrial Companies
	Q2.3	Public Body
	Q2.4	Company
	Q2.5	Welding Institute
	Q2.6	Other (Specify)
Q3	Indicate your position in the organisation	
	Q3.1	Business and administration
	Q3.2	Teacher/Trainer
	Q3.3	Trainee/student
	Q3.4	Manager/Chief executive
	Q3.5	Quality Control Inspector
	Q3.6	ProductionManager/Supervisor
	Q3.7	Welder/Brazer/Cutter
	Q3.8	Machine Operator
	Q3.9	Other (specify)
Q4	Indicate your field of expertise	
	Q4.1	ICT
	Q4.2	Welding
	Q4.3	Engineering
	Q4.4	Other (please specify)
2. Industry 4.0		
Q5	Are you familiar with industry 4.0? (If the answer is "no", please move to question 7).	
	Q5.1	Yes
	Q5.2	No
Q6	If you answer "yes" in question 5, please explain/define what you understand by "industry 4.0".	
Q7	In your opinion, does industry 4.0 have an impact on the welding/manufacturing sector? (If the answer is "no", please move to question 9).	
	Q7.1	Yes
	Q7.2	No
Q8	If you answer "yes" in question 7, please give examples on how industry 4.0 affects the manufacturing sector.	
Q9	Are you affected by digitisation in your professional activities? (If the answer is "no", please move to question 11).	
	Q9.1	Yes
	Q9.2	No
Q10	If you answer "yes" in question 9, please reply to the next questions	
	Q10.1	Which professional activities/tasks are mostly affected?

	Q10.2 **Q10.3**	How are those activities/tasks affected (give examples)? What is/will change in the way you relate and communicate with the working environment, machines and man?
Q11	Does industry 4.0 require new skills? (If the answer is "no", please move to question 13).	
	Q11.1 **Q11.2**	Yes No
Q12	If you answer "yes" in question 11, please indicate what digital skills are required by the Welder in this context.	
3. Welder qualification and training		
Q13	Are you familiar with European Welder (EW) guideline/qualification? (If your answer is "no", please move to question 15).	
	Q13.1 **Q13.2**	Yes No
Q14	If you answer "yes" in question 13, please reply to the following questions.	
	Q14.1 **Q14.2** **Q14.3** **Q14.4**	What is your opinion regarding the EW guideline and qualification? Did you attend any EW training course (e.g Fillet, Plate or Tube)? Describe you experience as a trainee in this course (positive or negative aspects). Describe your professional experience as a welding Trainer/manager/supervisor (positive or negative aspects)?
Q15	In your opinion, is there a good matching between Welder training and the market needs? (If the answer is "yes", please move to question 17).	
	Q15.1 **Q15.2**	Yes No
Q16	If you answer to question 15 was "no", please reply to the following questions	
	Q16.1 **Q16.2** **Q16.3** **Q16.4**	Which improvement are required in the Curriculum/training? Which are the gaps/shortcomings in the TRAINING METHODS used in Welders training courses? Which are the gaps /shortcomings in the TOOLS used in Welders training courses? What learning approach (e.g problem-based learning, workbased learning, game-based learning, blended learning, simulations, demonstrations, tutorials) should be used to develop Welder digital skills?
Q17	To what extend does the current Welder curriculum cover Information and Communication Technologies (ICT)? Please, provide examples if possible	
Q18	In your opinion what is the best way to approach ICT in the welder training courses (should it be applied to theory, practice or both)?	
Q19	Have you ever experienced any innovative tools in training? (If the answer is "no", please move to question 21).	
	Q19.1 **Q19.2**	Yes No
Q20	If you answer to question 19 is "yes", please reply to the following questions	
	Q20.1 **Q20.2**	Which were these? In what settings? (training courses at work, distance learning from home etc.)
Q21	Have you ever experienced a game-based learning (GBL) approach in your training? (If the answer is "no", please move to question 23).	
	Q21.1	Yes

	Q21.2	No
Q22	If you answer to question 21 is "yes", then please reply to the next questions.	
	Q22.1 **Q22.2**	Please, describe your experience (was it a positive/negative one? why?) Do you find GBL to be more useful in comparison to traditional methods? Why?
Q23	What are your expectations from a serious game for the welding sector?	
Q24	Which subject or modules of the EW training guideline should be addressed by GBL? To what should it be applied ?	