Meeting *Industry 4.0* training needs: e-learning sets out the way to move forward

Arturo Lavalle, *Università degli Studi Guglielmo Marconi, Rome, Italy*
Christian-Andreas Schumann*, West Saxon University of Applied Sciences of Zwickau, Germany*
Robert Pucher*, University of Applied Sciences Technikum Wien, Austria*
Eric Forkel, Julia Kauper*, West Saxon University of Applied Sciences of Zwickau, Germany*

ABSTRACT. *Industry 4.0* is an expression that more frequently than others like *industry of the future*, *digital industry*, *advanced manufacturing* and so forth, is used to indicate a series of rapid technological transformations in the design, production and distribution of systems and products. The term, initially referred only to the manufacturing sector, has been progressively extended to the digital revolution which is involving all domains and that is entailing a rapid change of job requirements and skills. As a consequence, new professions are arising but existing jobs are also going through a modification in the skill sets required to perform them. The demands on employees will increase because processes become more complex, interconnected and digital. Currently and in the future, lifelong learning, the ability to think interdisciplinary as well as the development of IT competences will be basic requirements of employees in order to ensure the employability of working people, not only in technology-oriented careers (Richert, Behrens, Jeschke, 2016). Moreover, disruptive changes to business models are producing and will have a profound impact on the employment landscape over the coming years. In such a rapidly evolving employment scenario, the ability to anticipate and prepare for future skills requirements, job content and the aggregate effect on employment is increasingly critical for businesses, governments and individuals in order to fully seize the opportunities presented by these trends (World Economic Forum, *The Future of Jobs,* 2016). Education has to adapt to the changed conditions and should probably re-think the current model of pedagogy aligning it with the potential of digitization. The use of new didactic methods and the exploitation of multimedia and technological solutions such as virtual laboratories, video-based learning, augmented reality, collaboration and communication in virtual environments and others are already key factors developed in the e-learning sector and present several matches and connections with the most important aspects related to Industry 4.0. This paper intends therefore to highlight the main links between the development of Industry 4.0 and the need to provide a proper and fitting education able to favour its implementation, emphasizing why e-learning could play a crucial role in the development of what has been called the *Fourth Industrial Revolution*. A particular attention will be paid to the variety of challenges that are emerging and which cover different educational dimensions and targets. As a matter of fact, like the previous industrial revolutions, the new paradigm needs a change not only in the competences of managers, employees and workers operating in the future *smart* factories but also in the cultural approach of people of all ages thus encompassing all levels of education, from university to secondary and even primary school.

KEYWORDS: *Digitization, E-learning, Employment; Industry 4.0, Job skills*

Introduction

Manufacturing provides about 20% of all jobs in Europe, which correspond to more than 34 million persons employed over 2 million companies in 25 different industrial sectors. The turnover in 2010 was approximately EUR 6 400 billion (Eurostat).This explains why this domain is still considered among the most crucial ones for the European Union economy and why the political, social and economic debate about the *Industry 4.0* phenomenon is so dominant within and outside the EU.

The transformations on the way of producing goods and services, the new relationships between men and machines and the implementation of new business models are all aspects contributing to make Industry 4.0 a fundamental cornerstone for structuring the future development and growth of many countries. Indeed, the emergence of those new disruptive factors and their impact, *inter alia*, on society, employment, public administration and culture have pushed to talk about the "Fourth Industrial Revolution". Actually, the scope of the digital transformation justifies such a definition but it is important to underline that this Revolution presents specific features which, compared to similar situations in the past, delineate a diverse scenario since:

a. it is not characterized by new technologies but rather by existing technologies combining and operating in a joint way
b. the rapidity affecting the way in which technologies evolve and produce innovations has increased
c. it has a pervasive dimension involving the whole supply chain and the relationship among the different actors, including consumers
d. it is a transformation that does not affect manufacturing only but also other sectors of economy such as agriculture, services and tourism as well as public administration and education (Cervelli, Pira, Trivelli, 2017).

Anyway, before being technological, this revolution is firstly cultural, since it concerns the way of thinking about the industrial goods, the system of working in the offices, the modality of operating in the factories. It affects the relationship and interaction between people and machines and the structures of factories that are increasingly flexible, sustainable and intelligent. It finally regards the relationship among enterprises since this transformation, born in the big industry, is also permeating the small and medium enterprises (which are the core of the European economic system), modifying the supply chain and the set of competences which are necessary to compete in the market. Surely, who is going to work in this innovative context will not have simply a technical preparation and, above all, will not refer to the traditional learning methodologies (Magone, Mazali, 2016).

The european and national approaches to Industry 4.0

With an investment of 50 billion Euros, the European Commission has launched a funding program aiming at increasing the technological innovation and supporting the advance of the digital single market among the EU countries. Funds mainly come from Horizon 2020 and Juncker Plan and are addressed to a series of measures for sustaining national initiatives for industry digitization.

The European Commission objective is to push companies, regardless their size, to fully exploit the opportunities offered by digitalization, particularly focusing on six key points:

- help the coordination of national and regional initiatives for industry digitalization
- channel the investments towards the public-private partnerships
- create digital innovation hubs throughout Europe to favour the use of digital technologies
- sustain pilot projects on the Internet of Things, advanced manufacturing, smart cities and homes technologies
- favour the circulation of data generated by sensors and smart devices within the European space
- develop a European Agenda for digital competencies

The theme of competencies is particularly important since the consequences of digitalization on employability are still uncertain. Most occupations are indeed undergoing a fundamental transformation. While some jobs are threatened by redundancy and others grow rapidly, existing jobs are also going through a change in the skill sets required to perform them. The debate on these transformations is often polarized between those who foresee limitless new opportunities and those envisaging massive dislocation of jobs. In fact, the reality is highly specific to the industry, region and occupation in question as well as the ability of various stakeholders to manage change.

In many industries and countries, the most in-demand occupations or specialties did not exist 10 or even five years ago, and the pace of change is set to accelerate. By one popular estimate, 65% of children entering primary school today will ultimately end up working in completely new job types that do not exist yet. In such a rapidly evolving employment landscape, the ability to anticipate and prepare for future skills requirements, job content and the aggregate effect on employment is increasingly critical for businesses, governments and individuals in order to fully seize the opportunities presented by these trends and mitigate undesirable outcomes (World Economic Forum, *The Future of Jobs*, 2016).

A study conducted in Italy by a interuniversity consortium named CRISP together with TAbulaex, a spin-off created by Bicocca University of Milan, has analyzed 121000 job advertisements in the manufacturing sector over the last five years concerning the region of Milan identifying 65 new professional profiles that can be ascribed to the 4.0 technological revolution (Il Sole 24Ore, *Nuove* *professioni da Industria 4.0*, 2016). Moreover, even the existing jobs are going through a change in the set of competences needed. Tomorrow workers and employees will be requested to do more in terms of managing complexity, problem solving, acting autonomously, possessing communication skills and being able to organize work activities with their colleagues. Shortly, they will be asked to put in place more and more their own potentialities and abilities which appear necessary for improving the quality of their work, ensure a more interesting environment and facilitate their professional experience (Magone, Mazali, 2016).

It is very clear that this revolution will generate a deep modification of the geography of the labour market. Certainly, from the point of view of general tasks, soft skills and flexibility, the landscape is going to change if not to completely turn upside-down. After all this is what happened even in the past, each time significant technological and lifestyle changes had arisen.

According to a study prepared by *Policy Department A of the DG for Internal Policies of the European Parliament*, there are some necessary preconditions to be satisfied in order to fully implement Industry 4.0. Certainly, countries will need a standardization of systems, platforms, protocols and interfaces as well as the development and implementation of a EU legal framework enabling the digitalization of industry. But what will be crucial is the availability of skilled workers that should be prepared to operate in Industry 4.0 establishments.

National Plans for implementing Industry 4.0. A brief overview from Germany, Austria and Italy

Industry is one of the pillars of European economy, a strategic component which is much more important than its GDP may suggest. Indeed as Chrisophe Sirugue, the French Secretary of State of Industry declared, industry accounts for 64% of European R&D, and economists estimate that each additional job in the industry creates between 0,5 and 2 jobs in other sectors. Therefore, reindustrialize Europe must stand at the top of EU leaders' agenda.

That is why the evolution of the economic system towards the adoption of Industry 4.0 technologies is supported by diverse policies in many industrialized countries. Many governments have recognized the scope of the digital revolution and have designed specific programs for the development of Industry 4.0. Obviously, the referential concept as well as the implementation modalities differ in each country reflecting the related industrial, cultural and economic diversities. Each nation in the world has its own industrial tradition, its own way of doing business, its own approach to data privacy and so on. More than 30 national and regional initiatives for digitizing industry have already been launched across Europe in recent years. Examples at national level are *Plattform Industrie 4.0* in Germany, *Produktion der Zukunft* in Austria and *Piano Nazionale Industria 4.0* in Italy.

Concerning Germany, Industrie 4.0 was one of the future projects adopted in the *Action Plan High-Tech Strategy 2020* by the German Federal Government in 2010. This encouraged the business associations BITKOM, VDMA and ZVEI to establish the *Plattform Industrie 4.0* in 2013. In 2015, the Plattform Industrie 4.0 was expanded with support of the Ministry for Economic Affairs and Energy and the Ministry of Education and Research. More actors from the private sector, business associations, unions, research organisations and political institutions also joined. Today, a total of over 300 players from 159 organisations are active in the platform (Henning Banthien, Secretary General of the Plattform Industrie 4.0, Germany).

As already underlined before, Industry 4.0 will have a major impact on working environment. In particular, cyber-physical systems (CPS) as enabling technologies for the fusion of the virtual and the physical world will require the pooling of knowledge and good practices on processes, models and technologies in all industries. Hence, it is important to prepare these information for the development of the competences required within the digital transformation. In this context, current research and projects in Germany can be fundamentally divided in two approaches:

1. either they consider primarily the economic aspects of the digitization and cross-linking of the industrial value chains
2. or they focus on technical-organizational aspects

An example of the first approach is the Reference Architecture Model Industry 4.0 (RAMI4.0), developed by the German Associations VDI/VDE/ZVEI, which is a standardized and common architectural model for semantic technologies and their particular benefits for automation. Also, the "Capgemini Consulting Industry 4.0 Framework", as another defined example of this approach, concludes how to transform corporate structures to Industry 4.0 readiness, especially in the domain of manufacturing companies. The second approach (technical-organizational) focuses on qualification requirements and the derived vocational education and further training requirements of the employees within cyber-physical production systems (CPPS) and Industry 4.0. A specific example of this approach is the study Industry 4.0 - Qualification 2025, commissioned by the German Engineering Federation (VDMA), the Mechanical Engineering Industry Association. Among other things, this study also examines the meaning of qualification needs and different paths and places of learning.

The German industry sector is characterized by 99 % of SMEs which face a difficult situation when approaching industry and working environment 4.0. Main goals in vocational education and training are lifelong learning and development of entrepreneurial competence in the digital age.

Therefore two important skills will also be addressed:

1. Competences for the digital society and
2. Working environment in the digital age

An another approach for supporting the SMEs and skills in the digital age the German Government – especially the Federal Ministry for Economic Affairs and Energy – has provided funding for a lot of different activities. One funding activity is the so-called "SME 4.0 - Competence Centre". Actually, 11 centres are located on Germany universities. These competence centres should support SMEs in digital transformation and new working environments. The concerning universities offer a lot of different trainings, workshops and information and networking events for SMEs and interested institutions. The goals are knowledge transfer and support to SMEs in R&D and in any Industry 4.0-related aspect (e.g. digitalization in production, applied smart factory, collaborative development, flexible working time and place, smart materials etc.).

Manufacturing industry is a key sector also in the Austrian economy. It employs around 640,000 people in some 29,000 companies, generating an annual gross value added of €50 billion per year. Approximately over two thirds of all employees in Austria are either directly or indirectly dependent on the domestic manufacturing industry. The capability to produce products that are internationally competitive is central to the economic growth of an industrialized and knowledge- driven country like Austria. Industry 4.0 is therefore of critical importance.

Innovative technologies, processes and new materials are key issues for the industry of the future.

To retain manufacturing in Austria and secure a high level of competence and competitiveness in the long term, the Austrian government launched the *Produktion der Zukunft* initiative in 2011.
In an iterative process involving all the relevant Austrian private and public stakeholders, the following industrial challenges have been identified:

- Use of different technologies
- Versatile and flexible production
- Vertical integration of various network techniques and processes
- Interdisciplinary approach
- Internationalization and globalization

Starting in 2011 with the first call for R&D&I project proposals, 20 million have been invested annually to achieve the following strategic and operational goals:

- Increasing the innovation capacity in the national production of real assets
- Establishing research competencies in research institutions
- Strengthening European networks and international cooperation
- Using resources and raw materials efficiently
- Having a flexible line of production
- Manufacturing high quality products
- Accessing relevant research competence at research facilities and companies

Within the past three years, more than 600 projects related to manufacturing were funded by BMVIT (Austrian Federal Ministry for Transport, Innovation and Technology) and managed by the Austrian Research Promotion Agency (FFG).
Italy is the second manufacturing country in Europe after Germany from which it differs in several aspects from an industrial point of view. The Italian industrial sector main peculiarities are:

- Few large industrial and ICT private players able to lead Italian manufacturing transformation
- Limited number of industry champions able to coordinate the evolution process of value chains
- Industrial sector deeply based on Small and Medium enterprises
- Key role of renowned universities and research centers in development and innovation
- Strong cultural traits of finished products

In order to face the digital transformation, the country has launched in 2016 the *Piano Nazionale Industria 4.0*, a plan allocating 13 billions of Euros aiming to:

1) reinforce innovative investments (by increasing money in research and development activities and by strengthening financial services supporting start-ups and innovative companies)

2) enhance the relevant public instruments (in order for example to strengthen and renew the international market penetration)

3) favour the development of the enabling infrastructures (through a plan for developing the ultra-wide band and the collaboration at a European level to defining standards and criteria of interoperability, especially in the expansion of IOT)

4) develop competences (through the creation of competence centers and digital innovation hubs, by increasing PhDs and disseminating a 4.0 culture even at a school level).

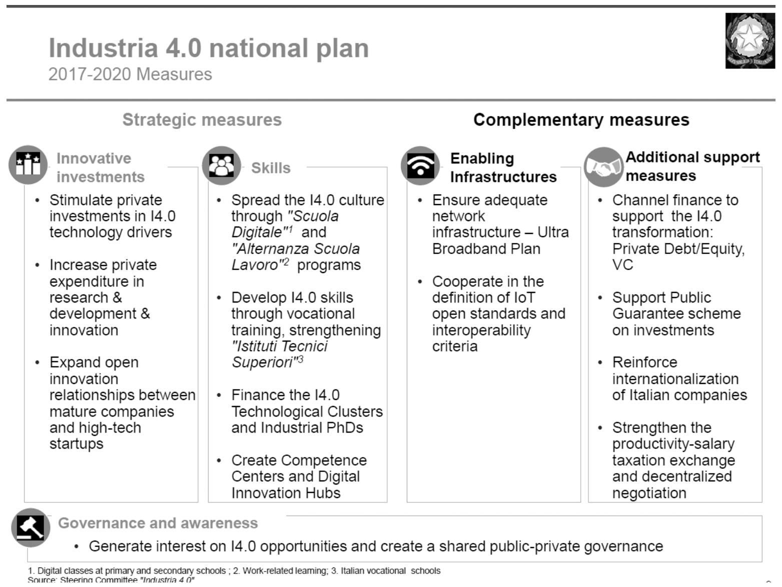

Figure 1. Italian National Plan pillars. Source: Steering Committee *"Industria 4.0"*

Despite education is one of the main pillars of the national plan, it is still very hard to notice a real focus on the training process of the operators and the workforce that will be involved in Industry 4.0 for the years to come. This is due to many reasons:

- the lack of funds
- a "traditional" cultural approach of many stakeholders
- a lack of awareness of the importance to develop new competencies
- the extreme variability due to the rapid evolution of technology and the dynamics of the knowledge in many sectors which force to elaborate training strategies in conditions of high complexity and uncertainness (Lombardi, 2017)

In any case, in all the three plans, the theme of building new competencies is an undisputable part of the general strategy.

Building new competencies and the role of e-learning

It is very hard to predict and develop training contents and profiles for the population affected by present and future transformations.

The questions arising are: *what contents and profiles should be developed? And from a pedagogical point of view, what is the best methodology to convey this innovation?*

Education has to adapt to the changed conditions and should probably re-think the current model of pedagogy aligning it with the potential of digitization. In this changing, dynamic and rapid context, a central role is played by universities, especially by those that, driven by the digital transformation, have understood the need to modify university teaching by integrating the traditional learning paths with a set of multimedia, digital and interactive technologies. In this respect, Industry 4.0 can be seen as a further confirmation of the value and importance of E-learning, a modality that could give a decisive contribution to accompanying the development of Industry 4.0 by providing the skills that will be vital in the world of work. The use of new didactic methods and the exploitation of multimedia and technological solutions such as virtual laboratories, video-based learning, augmented reality, collaboration and communication in virtual environments and others are already key factors developed in the E-learning sector and present several matches and connections with the most important aspects related to Industry 4.0.

If we compare Industry 4.0 with E-learning, it comes as no surprise to observe the several parallelisms which emerge and that can be briefly itemized as follows.

Use of different kinds of media services, software and innovative hardware solutions

Different kinds of media services, software for teaching and learning as well as innovative hardware solutions not only become a bigger part in higher education and the workplace. A common and frequently cited example is the use of learning management software, based amongst others on the open-source management system Moodle (Haerdle, 2013). Today, Moodle counts 53.738 registered installations with 68.7 million users of 226 countries in 7.7 million courses (Moodle Statistics, 2015). Platforms like Moodle have different functions, which can also be viewed as E-learning solutions themselves. Through chats, forums or messenger systems, students or workers can communicate in synchronous or in asynchronous ways. (Schuster et al., 2015).

Collaborative learning and working in virtual environments

People in the firm or in the factory collaborate most of the time with peers in other offices and branches located in different parts of the world or cooperate with researchers, universities and other bodies through collaborative platforms. The work will increasingly be based on collaboration and on communities and co-sharing. Workers will be trained more and more in virtual worlds. Students, as workers, go through contents together, support each other in the search of solutions, exchange experiences and knowledge.

Interdisciplinarity

The last example points out the importance for engineers to link their own specific technical expertise with expertise of other domains. Working in interdisciplinary teams situated all over the world is standard practice. The increasing digitalization of economy and society links knowledge over borders of time, space and system (Federal Ministry of Education and Research, 2015).

The absence of constraints related to time and space limits as well as the interdisciplinarity of the contents provided online (which include a transversal knowledge of teachers since it implies a mix of pedagogical and digital skills with the expertise on the subject provided) is a basic feature of e-learning.

Virtualization

In the factories several processes are realized in virtual environments. Let us think for example about the simulation of a production process or the development of a product before it is realized for real so identifying and solving beforehand potential issues. The same happens with virtual laboratories that are more and more developed and used in education allowing new learning experiences. Thus, it is possible to introduce students to learning settings which would otherwise be too dangerous (e.g. an atomic power plant), too hard to access (e.g. the surface of mars) or too big a risk for ongoing production (e.g. in a factory) (Ewert et al. 2013). Moreover, they can foster planning and group activities, problem solving, autonomy and self-assessment and collaboration.

Augmented reality

It is not fully exploited yet but it is able to improve information available to users in real environments like, for instance, in some sectors of the factory or, going beyond manufacturing, in the healthcare in a surgery. In the e-learning sector, as well as in traditional lessons by now, the augmented reality is already used to make students gain a better understanding of the concepts they are studying. This is a fun way to engage students and reinforce concepts they have seen during class lectures. Students can access models from any device at any time. Whether they are at home or in the classroom, students can study and interact with the course materials.

Customization

Industry 4.0 technologies allow a stronger customization of products. Similarly, E-learning enables the personalization and customization of learning paths which are more and more tailored to the students' needs. According to Scott Winstead, "*Relevant knowledge needs to be channeled and delivered right to the recipient rather than dispersed with no specific targeting or further retention*".

Interoperability

Technologies used in E-learning present the same features of interoperability and integration among the different devices as it is required more and more in the industrial sector, especially in IOT where systems and objects have to communicate and exchange information through different platforms.

Modularity

The flexible adaptation of smart factories to changing requirements by replacing or expanding individual modules can be found also in the structure and flexibility of e-learning programs that can be modified and replaced easily depending on new training needs.

Use of artificial intelligence

In many industries, artificial intelligence is already an everyday reality. The pace of artificial intelligence development is amazing. Google estimates robots will reach levels of human intelligence by 2029, and IT research firm Gartner estimates that by 2025, one-third of jobs will be replaced by robots and smart machines. The main areas which are being largely impacted are manufacturing but also healthcare, transportation, customer service and finance. In education, both face-to-face and online, this is aspect has started to be developed since traditionally, schools and universities adopt a one-size-fits-all approach to teaching even though students learn at different paces and have different progress rates. Meanwhile, teachers often find it hard to identify and deal with the educational needs of students attending their classes. This is a problem that Artificial Intelligence is solving since machine learning algorithms will help teachers to find gaps in their teachings and identify where students are struggling with subject matter (Dickinson, 2017).

Surely, the list above is not exhaustive but it represents a suitable evidence of how education has already undergone significant changes in the digital age and how technology-mediated learning can be a convenient modality for providing the new skills needed by companies.

Academic initiatives for building Industry 4.0 competences

Learning increasingly becomes collaborative as the rate of digitation increases. Collaborative learning in many cases creates knowledge through a linkage of different groups of people. One example can be the usage of eye tracking technology, to learn more about common tasks in factories, thus opening a new area of research for usability experts. Using eye tracking technology is relatively easy to answer questions like:

- Are warnings understood and do they trigger the intended reaction?
- Are people picking up the correct information and who long does it take them to do so?
- Do professionals perceive all relevant information from a display?

Figure 2. Mobile eye tracking glasses used to study where people are looking at. Image source SMI Inc.

Skills needed in the area of Industry 4.0 are a special mix, like in all fields. Especially in computer sciences it is very difficult to educate for a specific job profile, as these profiles are changing at a fast pace. Nevertheless, educational institutions need to be aware of the special needs in that field. The vision of Industry 4.0 is characterized by highly individualized and at the same time cross-linked production processes. Physical reality and virtuality increasingly melt together and international teams collaborate across the globe within immersive virtual environments. In Austria at University of Applied Sciences Technikum Wien, cooperation between courses in computer science and mechanical engineering allows teams of students to work together in a special lab designed for robotics in Industry 4.0. This allows a better preparation for the future needs. For computer science students this means that in the 5th semester they are offered three elective courses (9 ECTS) plus a project (6 ECTS) to deepen their knowledge in Industry 4.0. In the 6th semester students can choose to do an internship in the area of Industry 4.0. In general terms, the whole course design and all-embracing curricula development is and should be influenced by digitalisation as the all-pervasive mainstream and dominating innovation technology of the recent development era. All stakeholders related to education should take account of this fact in order to adequately focus learning and training of all disciplines in education and sciences on the requirements of future professional and working environments. Therefore, the proven concepts and the new opportunities are to be combined in the sense of innovative approaches. The key challenge is to enrich, extend and pervade the latest and approved study programs with digitalisation as methodical enabler and learning content. Complex digitisation in industrial applications leads to cyber-physical systems as core components of the digitalized and highly-automated industry in the present and in the future. The challenge is to educate and train the professionals for the future in this field with the knowledge of today. They have to be digital learners as well as digital workers of the future in their specific profession but also in the more and more required interdisciplinary and transdisciplinary context of the digital world. Therefore, the digital transformation of a study program such as, for instance, Business Administration and Engineering (BAE) or Industrial Engineering with Engineering Studies is an ideal use case for educate and train the future professionals for Industry 4.0 as part of the digital economy. At the West Saxon University of Applied Sciences of Zwickau, the development has been based on case studies which are to be explained by the example of the modification of existing study programs in BAE related to Industry 4.0 requirements. An iterative approach has been chosen for the case studies. The first case study focuses on the complex interpenetration and supplementation of an existing study program with the Industry 4.0 philosophy and the Industry 4.0 content over the entire course concept. The second case study is rather based on the approach of minimal invasion of classic study subjects by Industry 4.0 topics in the basic training period but exclusive and very complex profiling in Industry 4.0 and digital transformation in the second part involving the professional training.

In the first case, the existing modular curriculum of a full-time course is extended by the enrichment and modification of modules of classic business and engineering subjects as well as the supplement of specials modules containing new subjects of digitalisation and cyber-physical systems (Industry 4.0) including the following modifications such as:

- the change of the subject of basics of economy to basics of digitalised economy
- the change of the subject of theory of design to theory of digitalised design
- the extension of the classic subject of ergonomics to the work environment 4.0

- the extension and strengthening of factory planning to the digital factory
- the change from production management to the production management 4.0
- the supplementary subject of digital communication
- the supplementary subject of digital transformation
- Etc.

The new course is part of the international academic cooperation of a network of German Universities of Applied Sciences with global international top universities for double degree programs in Industrial Engineering with Business Studies. The main objective is to train professionals in this additional field specialised in mechanical engineering and Industry 4.0. Existing educational profiles are replenished and supplemented by an all-embracing penetration of study modules and subjects with Industry 4.0 knowledge and skills in order to meet the requirements of the future Industry 4.0 professionals in industrial engineering extended by business competences.

In the second case, a correspondence training course is fundamentally redesigned in order to fulfil the future requirements of digital transformation and Industry 4.0 as well as of embedded digitalised learning and online education. A traditional advanced distance education study program in BAE is transformed into an undergraduate distance education course in BAE including the profiles of Digital Transformation and Industry 4.0. General aspects of digitization and their impact on the subjects are taken into account in the basic course, but without too many references to a specification with regard to the later profiling. The rather generalist approach of the basic training opens the chance for more flexibility of the design and implementation of different profiles in the specialised studies in the second part of the course.

The new redesigned study program in BAE is characterised for instance by the following innovations:

- the enrichment of basic modules such as logistics by general aspect of digitisation
- the substitution of obsolete content (Technical Drafting) by the modern digital option (CAD)
- the integration of traditional contents (logistics) and digital supplements (e-logistics)
- the extension of the basic program by new subjects such as interoperability and digitalisation
- the complex knowledge transfer of digital transformation, Industry 4.0 or other profiles
- the general renewed undergraduate course as basis for several profiles of digital systems

The course is part of the distance and online educational portfolio for national and regional study programs focused on business, management, and engineering with regard to digitisation, digital transformation and smart and cyber-physical systems in industrial environments. The main objective is to offer a contemporary undergraduate program enabling students as well as participants of advanced studies to qualify in digital transformation or Industry 4.0. The subjects of digitisation are generally taken into account in the basic program. The main digital business and industrial specialisation is realised in the framework of the advanced studies, the profiling.

The redesign of both programs is used for renewing the methodology and integrating new forms of (digitalised) training and education. The learning and training technology and methodology are changed step-by-step according to the innovative development of educational systems. Methodological improvements will be obtained by strengthening the self-controlled training of the learners, the asynchronous and flexible learning independently of fixed schedules,

the problem-solving learning, the competence-oriented output, the coached activity-based learning, the balance between formal and informal learning, etc. The percentage of simulation, game-based learning, practical experiences, learning projects, use studies, etc. will be increased. These ambitions are facilitated by digital and mobile technologies and methods. The teaching and training is based on learning platforms, learning management systems, social communications and networking and all services of the internet of things. The digital education includes and provides the use of digital contents, online courses, application of VR and AR, cloud learning, etc. Recently, one of the main challenges is closer brought to a solution: the web-based access of distance learners to virtual labs or to real labs, respectively. Especially, the distance and mobile access in engineering, informatics and automation is necessary for the success of the programs using the required laboratory facilities for the trainings.

The described case studies reflect the actual development stage of the Industry 4.0 oriented study programs of training and further education in Germany. Of course, there are also numerous special courses and learning modules, which focus exclusively on topics of digitalization and digital elements of Industry 4.0. But an exclusive focus on the topic of digitization in industry, would too much emphasise their aspects and neglect essential factors of the real systems. Exclusively, balanced and harmonised approaches including all aspects of the further industrial development regarding the influence of digitalisation corresponds to the real circumstances and challenges. Education and training for Industry 4.0 must be appropriate for this.

Based on its long experience on digital education, the Italian Università degli Studi Guglielmo Marconi has developed an internal strategic plan for implementing Industry 4.0 themes at different levels, i.e. training, research, communication and networking.

The first phase of this plan has been characterized by the release of a free course named *Marconi Industry 4.0 - Innovation Training Lab* whose aim was to spread and make awareness of the Industry 4.0 culture. The program, which targeted both university students and people outside the institution, addressed the topic Industry 4.0 from different perspectives being transversal to the six schools of the university. This is because the digital transformation interests all the training sectors. Besides topics like additive manufacturing or Big Data indeed, the program addressed subjects like digitalization of artistic and cultural heritage (School of Arts) or the legal framework in Italy and EU for implementing the digital agenda (School of Law). Taking into account its features and objectives, the program is quite unique in the Italian educational landscape and a second edition is foreseen to be released by the beginning of 2018.

After the provision of *Marconi Industry 4.0 - Innovation Training Lab*, the university has started phase 2 of the plan which will have a strong focus on training. In this respect, the initiatives undertaken by USGM will be implemented at different scale addressing diverse targets:

1. Students
2. Companies
3. Schools
4. USGM faculty staff

With reference to *Target 1. Students*, the actions USGM intends to undertake are:

a) Development of programs to train the professional profiles indicated by the Industry 4.0 national plan able to meet the training needs required by enterprises

In this respect USGM is closely working with important players from the industrial sector in order to create courses presenting contents coming directly from the field. In particular, the university signed in October 2017 an agreement with Baker Hughes, a General Electric Company® aiming at creating three new courses developed by a joint team formed by Marconi professors (in this case from the Faculty of Applied Sciences and Technologies) and people from the company. The courses, namely Product definition for Industry 4.0; Digital Models for Industry 4.0 applied to work stations; Lean Manufacturing for Industry 4.0 will be part of a new curriculum orientation to be included in the third year of the Bachelor's degrees in Industrial Engineering and Computer Engineering. The choice of this specific study cycle (Bachelor's degree, 1st cycle) is to realistically give students the chance to access the world of work after three years of study thanks to the acquisition of concrete competencies, in line with which was the objective of the Bologna Process Reform when launched.

b) Development of short programs for the acquisition of digital competences

Basic digital skills represent the ability to be familiar with the use of information technology for work, communication and leisure time. They are essential to all citizens to take part in the knowledge and information society and exercise their rights of digital citizenship.
According to the European Commission's Digital Economy and Society 2017 Index, which ranks the innovation among the Union countries, in Italy only 44% of the population own basic digital skills against a EU average of 56%.
So, providing the instruments to get those skills is an objective which will be pursued by USGM.

c) Advanced Training Programs

Face-to face training lecturers to be integrated, where appropriate, with an e-learning part focusing on specific contents, form the educational model concerning this typology of programs. An example in this regard is the course in Data Innovation Manager, which is expected to start in February 2018.

d) 2nd edition of Marconi Industry 4.0 - Innovation Training Lab

After the positive results of the first edition, *Marconi Industry 4.0 – Innovation Training Lab* will be provided again properly enriched and modified in its contents.

Concerning training for managerial and administrative staff enterprises, *Target 2. Companies*, USGM intends to develop short programs which will focus on skills relating to the following professional profiles:

- - Marketing Manager 4.0
- - Innovation Manager

- - Data Scientist
- - Systems Engineer
- - Expert in Neuromarketing and Neurosciences
- - Expert in Additive Manufacturing

Referring to *Target 3. Schools*, the University aims to make a selection of schools at regional and national level to verify their interest in collaborating with USGM and co-organize a series of meetings to discuss and present the new professional profiles courses as well as the opportunities of future traineeships given by the partnerships with companies. In this respect the *alternanza scuola/lavoro* projects, i.e. the work-related learning programs envisaged by the government and compulsory for schools, will be implemented.

Finally, as regards *Target 4. USGM faculty staff*, USGM is going to organize a series of internal seminars for updating teachers' digital and curricular competences through the support of the companies cooperating with the university in a perspective of training for trainers.

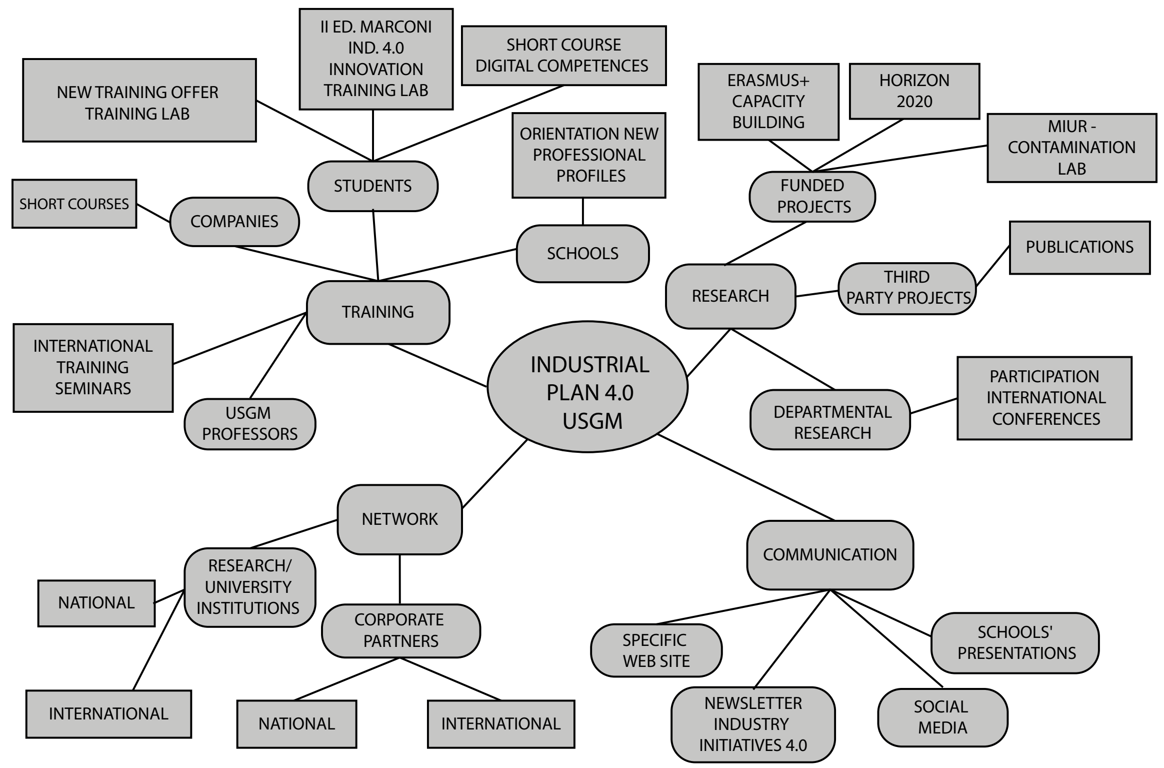

Figure 4. USGM Industry 4.0 Strategic Plan (Courtesy of Prof. Alessandra Pieroni, USGM)

Conclusions

Technology is probably the major agent of change in the modern world. A change which is happening at a pace that we have never experienced before in human history.

The evolution of technologies has always requested the development of new competencies and abilities but, differently from the past, the ongoing digital acceleration has nothing evolutionary or linear, it is exponential. That is why the work of those who are in charge of creating new knowledge is particularly hard. Schools, universities and public and private training institutions are called to combine their traditional capability to provide a basic cultural education with the ability to deliver new contents with a rapidity of change today still unknown.

People able to analyze and manage big amount of data, design advanced modelling systems, operate and interact with robots and so on will be more and more needed. What is more, in the future work environments, the possession of mathematical and vertical technological competences will not be enough since it will be crucial to combine them with social skills. Future workers will be asked to cope with different tasks and diverse projects at the same time. Consequently, not only specific technical competences will be important but also soft skills helping in the phase of collaboration and negotiation.

Apart from a few excellence centres, schools and universities have not put in action yet a unique and systemic approach. Of course, this is also due to the fact that the new generation of knowledge has a rapidity incompatible with the timing of the traditional training and with the generational replacement of teachers.

Universities have to face the change, then absorb it and finally modify their model accordingly. As in the previous industrial revolutions indeed, the adoption of the new paradigm is not simply a technological fact since it entails a cultural transformation that directly invests the providers of education at all levels.

In this respect, technology-mediated education seems to have the right features for developing a fitting training for Industry 4.0 implementation as it contains the adoption of the digital paradigm in itself. Defining and perfecting proper E-learning solutions, doing that in a perspective of collaboration which overcomes national borders, is probably the key of success for sustaining countries' Industry 4.0 development policies and creating growth in the future.

The initiatives undertaken by the Universities of Zwickau, Wien and Marconi are valid examples of how academic institutions, through the integration of new contents, the use of innovative educational modalities and the reinforcement of international cooperation, can achieve the common objective of reskilling the existing workforce and preparing the new generations for tomorrow's jobs.

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Sintesi

Industry 4.0 è un'espressione che sempre più frequentemente di altre come, l'industria del futuro, industria digitale, la produzione avanzata e così via, viene utilizzata per indicare una serie di rapide trasformazioni tecnologiche nella progettazione, produzione e distribuzione di sistemi e prodotti.

Il termine, inizialmente riferito solo al settore manifatturiero, è stato progressivamente esteso alla rivoluzione digitale che sta coinvolgendo tutti i settori. Ciò comporta un rapido cambiamento delle esigenze e delle competenze professionali. Di conseguenza la nascita di nuove professioni è inevitabile e al contempo i lavori esistenti modificano le competenze necessarie per eseguirli. Le richieste ai dipendenti incrementeranno perché i processi diventeranno più complessi, interconnessi e digitali. Attualmente e in futuro, l'apprendimento lungo tutto l'arco della vita, la capacità di pensare interdisciplinarmente e lo sviluppo delle competenze tecnologiche saranno requisiti fondamentali dei dipendenti al fine di garantire l'occupabilità dei lavoratori, non solo nelle carriere orientate alla tecnologia. I dirompenti cambiamenti ai modelli di business oltre che produrre, avranno un profondo impatto sul panorama occupazionale nei prossimi anni. In uno scenario di occupazione in rapida evoluzione, la capacità di anticipare e preparare i futuri requisiti in materia di competenze, contenuto lavorativo e l'effetto aggregato sull'occupazione è sempre più importante per le imprese, i governi e gli individui al fine di cogliere appieno le opportunità offerte da tali tendenze.

L'educazione deve adattarsi alle mutate condizioni e dovrebbe probabilmente ripensare l'attuale modello di pedagogia allineandolo al potenziale della digitalizzazione. L'uso di nuovi metodi didattici e lo sfruttamento di soluzioni multimediali e tecnologiche come laboratori virtuali, apprendimento basato su video, realtà aumentata, collaborazione e comunicazione in ambienti virtuali e altri sono già fattori chiave sviluppati nel settore dell'e-learning e presentano diverse corrispondenze e connessioni con gli aspetti più importanti relativi a Industry 4.0.

Si rende necessario, in sede accademica, da una parte evidenziare i principali collegamenti tra lo sviluppo di Industry 4.0 e la necessità di fornire un'istruzione adeguata, in grado di favorire la sua attuazione, dall'altra sottolineare perché l'e-learning può svolgere un ruolo cruciale nello sviluppo di quella che è stata chiamata la "Quarta rivoluzione industriale". Complessivamente, un'attenzione particolare dovrà essere rivolta alla varietà di sfide che stanno emergendo e che coprono dimensioni e obiettivi educativi diversi. In effetti, come le precedenti rivoluzioni industriali, il nuovo paradigma ha bisogno di un cambiamento non solo nelle competenze di manager, impiegati e lavoratori che operano nelle "smart factories" future, ma anche nell'approccio culturale a tutti i livelli di istruzione, dall'università alla scuola secondaria e persino alla scuola elementare, poiché la nuova rivoluzione riguarda persone di tutte le età.