IN4WOOD: DEVELOPING AN ONLINE AND FREE TRAINING COURSE TO ADAPT THE CURRICULA OF WORKERS AND MANAGERS OF WOOD AND FURNITURE SECTOR TO THE SKILLS REQUIRED BY INDUSTRY 4.0

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Abstract

The European Union (EU) is moving towards a new industrial revolution, considered as the fourth, so-called Industry 4.0 (I4.0). In short, I4.0 is characterized by the use of ICTs (Information and Communication Technologies) to transform the way in which companies and manufacturers work; to transform the traditional factory into a smart factory by using Key Enabling Technologies (KET): sensors, wireless communications, last generation networks, intelligent robots and machines, cloud computing and big data analytics, among others. The new digital industry will promise to increase the flexibility in manufacturing, mass customization, better quality and improved productivity. EU is promoting the industrial change through new industrial policies and funding in research and infrastructures. But the change also includes challenges like training workers, update competences in managers, and adjust the curricula of Vocational Education and Training (VET) and Higher Education (HE), to acquire the skills required by I4.0. In this regard, the European Project IN4WOOD, funded by EU Erasmus+ Program, aims specifically to bring this 4th revolution to the specific sector of wood and furniture industry, developing a training course for supporting manufacturers and workers in this sector in Europe to understand, deploy and use the KET of I4.0 in their own businesses, as well as to improve the competitiveness of their enterprises. But the goal is also to train VET and HE level students as the future technicians and workers of I4.0.

In this paper, we present the work is being carried out in IN4WOOD Project. The main goal is to design, develop and recognize a Joint Curricula for filling the skills gaps in I4.0 related to the technologies and topics for production and management of the wood and furniture industry. To do this, we are working on the development of an online and free training course in multiple languages through an online software platform which contains all the materials. These are being designed by using, not only the typical slides and text documents, but also the latest and most revolutionary educational methodologies, such as gamification, video pills and flipped classroom. The training course will be tested by a pilot, carried out in four European countries. The results extracted from the pilot will help us to improve the software platform and materials in order to launch a stable free and online training course.

Keywords: Industry 4.0, online training course, VET, HE, gamification, video pills.

1 INTRODUCTION

The European Union (EU) is moving towards what is already considered as the fourth industrial revolution, the Industry 4.0 (I4.0). I4.0 is characterized by the use of Information and Communication Technologies (ICT) to transform the way the companies work; turning the traditional factory into a Smart Factory that makes use of Key Enabling Technologies (KET) to increase flexibility in manufacturing, mass customization, improve the quality of products and processes, and increase the productivity. The KET of I4.0 includes sensors, wireless communications, last generation networks, robots, additive manufacturing, cloud computing, Big Data, Internet of Things (IoT), large data analysis and cybersecurity, among others.

The EU is promoting this industrial change through new industrial policies and funding in research and infrastructure. Some of its member countries are also encouraging I4.0 through national initiatives such as "Connected Industry 4.0" in Spain [1], or "The Factory of the Future", (FoF) in France and Italy [2]. But the change also includes challenges such as training workers, updating manager skills and...
adapting the curricula of Vocational Education and Training (VET) and Higher Education (HE) studies related to ICTs, to create the future workers with the skills required in I4.0. The IN4WOOD Project [3], funded by the Erasmus + Program of UE, aims to bring this fourth revolution to the specific sector of the wood and furniture industry by developing a training course to support this industrial sector and their manufacturers to understand, deploy and use I4.0 enabling technologies in their own businesses, transforming traditional factories into Smart Factories (Fig. 1), that is, improving the competitiveness of their enterprises. The course has been designed to be adapted to the specific needs of VET and HE students, offering a pioneering training to be the future technicians in I4.0.

This paper presents the work that is being carried out under the framework of the IN4WOOD Project. One of the main goals has been to design a Joint Curricula to cover the knowledge gaps on I4.0 skills related to ICT, logistics and production. To do this, we have taken as an input the results of three different surveys that have been launched to the target audiences: executives and workers in the furniture/wood sector, students, and KET providers. The training materials are being developed to be distributed in a free training course format through an online software platform.

In order to meet the challenge of designing a course for different profiles, a new methodology has been applied in the design of the learning contents: the network path training. This model allows us to adapt the learning contents of the course to the user profile. Educational methodologies such as gamification, video pills and flipped classroom are also being used to keep the student's interest in the learning content, to encourage participation and to decrease the dropout rate. The training course will be tested with a pilot, to be held in Spain, Germany, Italy and Ireland. The results obtained from the pilot will be analysed in order to improve the software platform and the learning contents developed, to offer a stable online teaching platform.

The rest of the paper is organized as follows: section 2 presents the concept of I4.0, its origin, evolution and the KET involved on it. Section 3 analyses the competences required by I4.0. Section 4 reviews the state of art in training courses focused on I4.0. In section 5 the work to build the training course and the IN4WOOD software platform is explained. Finally, section 6 shows the conclusions.

2 THE INDUSTRY 4.0 AND THEIR KEY ENABLING TECHNOLOGIES

The concept of Industry 4.0 covers ICT-based production processes and the ability to create an intelligent factory model based on a Cyber Physical System (CPS) environment where professionals can take business decisions based on the output of such intelligent systems. I4.0 digitizes the industry, and the physical objects that comprise it (machinery, materials, facilities, ...) communicate with each other, Device-to-Device (D2D) or Machine-to-Machine (M2M), and through Internet (Internet of Things) creating a smart environment able to be adapted to scheduled or unexpected changes in real time, and allowing an efficient management to enterprises and factories.

The first time the I4.0 concept appeared was in 2006, but it was not until 2010 that it began to take importance, when Germany took I4.0 as a strategy to improve competitiveness in business production,
weakened by the losses caused by not being able to compete with the low labour costs of emerging countries. The strategy also was focused on developing an innovative industry close to the customers, offering customized and turnkey products and solutions, and minimizing production and service times.

All studies and publications on I4.0 agree with the fact that ICTs are the enabling elements for the digital transformation of factories. The identified technologies of I4.0 are Internet of Things (IoT), Cloud Computing, Big Data, Artificial Vision, Augmented Reality, Simulation and Productive Virtualization, Cybersecurity, Additive Manufacturing (3D Printing), Robotics and sensors, among others (Fig. 2). The classification of these differs according to the context of the study [4-6] and, for example, the Spanish Ministry of Industry, Energy and Tourism classifies them according to whether or not they provide hybridization to the physical and digital world [7]. In this work a similar scheme has been followed to design the learning modules of the training course (see section 5).

Figure 2. Main KET in Industry 4.0 [8]

3 COMPETENCES REQUIRED BY I4.0

The fast integration of ICTs in all sectors of industry has changed the way people work, and the skills and competencies required to the workers. ICTs are leading the current economy and the previsions of European Commission reveal that the future will lead to a fully digitized world, with human capital highly qualified in digital skills. In Europe the demand of workers with multidisciplinary knowledge and ICT profile increases year by year, while the workers with the required ICT profile is dramatically decreasing. In fact, the lack of basic knowledge of ICTs is present in over 30% of EU workers [9]. The European Commission also predicts alarming data, such as in 2020 the number of uncovered ICT profiles could reach 800,000 positions [10]. There is no doubt that a need for training in ICTs to cover the current and future demand exists, and the adoption of I4.0 will generate the need for specific and qualified training on KET.

In 2015 the Association of German Engineers (VDI) and the American Society of Mechanical Engineers (ASME) published the skills and competencies recommended for the qualified worker for the I4.0 [11]. These are summarized in Table I, and are classified with an established priority in "Must", "Should" and "Could"; and, in turn, in technical qualifications and personal skills. In [12] it is also highlighted that the lack of digital skills of employees is one of the challenges to be addressed in the adoption of I4.0.

4 TRAINING COURSES FOCUSED ON I4.0: STATE OF ART

Currently there are only a few European projects working on the development of training courses or teaching materials related to I4.0. PROVET 4.0 [13] is a strategic alliance of three entities focused on the electronics and metalworking industry. Although its results are not yet available, it is possible to think that the capacity for developing teaching materials of I4.0 is not comparable with those in IN4WOOD, where 13 entities are involved, including technical universities (UPCT, KIT, SSSA), expert
companies in ICT and development of learning contents (INDRA, PILDOREA), Technological Centres and Associations related to furniture and wood sector (BFM, CETEM, CSM, iVTH), and VET authorities, business organizations and development and employment agencies (EURADA, SEF, OAL, IONOLOGY) [3]. In other projects such as SO-SMART [14] and HIGHTECH EUROPE [15], the goal is not to develop a training course or learning materials of I4.0, but to identify and evaluate those available and future ICT tools to link needs and knowledge, as well as to design knowledge transfer schemes.

**Table I- Qualifications and skills of workers in the factory of the future [10]**

<table>
<thead>
<tr>
<th>Must...</th>
<th>Should...</th>
<th>Could...</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT knowledge and abilities</td>
<td>Knowledge Management</td>
<td>Computer programming/coding abilities</td>
</tr>
<tr>
<td>Data and information processing and analytics</td>
<td>Interdisciplinary / generic knowledge about technologies and organizations</td>
<td>Specialized knowledge about technologies</td>
</tr>
<tr>
<td>Statistical knowledge</td>
<td>Decentralized knowledge of manufacturing activities and processes</td>
<td>Awareness for ergonomics</td>
</tr>
<tr>
<td>Organizational and processual understanding</td>
<td>Awareness for IT security and data protection</td>
<td>Understanding of legal affairs</td>
</tr>
<tr>
<td>Ability to interact with modern interfaces (human-machine / humanoid)</td>
<td>Trust in new technologies</td>
<td></td>
</tr>
<tr>
<td>Self and time management</td>
<td>Adaptability and ability to change</td>
<td>Minded for continuous improvement and lifelong learning</td>
</tr>
<tr>
<td>Teamworking abilities</td>
<td>Social skills</td>
<td>Communication skills</td>
</tr>
</tbody>
</table>

There is also a wide range of training courses in I4.0 in many European countries. We focus our state of art study on Spain, the authors’ country. Table II is a representative sample of the courses that can be found in Spanish language (developed by Spanish companies, universities or business schools). As can be seen, most of them are not free, and do not offer training courses focused on specific sectors, but on general concepts of the KET in I4.0. Moreover, they do not seem to make use of novel educational methodologies to add value to the training material and keep the students’ interest. Most of them consist of the use of text (in .pdf format), slides (in .pps/.ppt format) and videos (shared in YouTube or stored in local servers). On the other hand, free courses do not issue any certificate or diploma, and most of the courses do not exceed 45 hours length. In other European countries the training courses checked are similar to those in Spain.

After an extensive analysis of the current training offer, we can conclude that, up to the author’s knowledge, there is no training courses focused on I4.0 (free or paid) similar to the proposed in IN4WOOD, devoted to teaching executives / workers in the furniture and wood sector, production / logistics managers, and ICT workers / students on a wide range of topics, to transform a traditional factory into a smart factory with innovative learning methodologies in a free online multiplatform environment, with a final official recognition.

## 5 IN4WOOD: AN ONLINE TRAINING COURSE IN I4.0

The European Project IN4WOOD [3] is a consortium that join experts and companies from the furniture sector, universities, technological centres, business and employment associations and VET authorities, with the objective of designing a Joint Curriculum that solves the lack of knowledge about I4.0, its KET, and the new production models, management and logistics in the factory of the future. The target audience of this course is mainly professionals and managers of the furniture and wood sector from all over Europe, although it has been designed in order to be adapted to the interests of VET and HE students (Degree and Master) whose studies and profiles are related to logistics, production, industrial organization, robotics, manufacturing, telecommunications and informatics, among others. One of the goals of this work is to achieve the recognition of the course complying with the European principles of Credit transfer in Vocational Training (ECVET) [26] and the
recommendations of the European Reference Framework for Quality Assurance in Vocational Education and Training (EQAVET) [27].

Table II- Sample of Training courses of I4.0 in Spain

<table>
<thead>
<tr>
<th>Course</th>
<th>[16]</th>
<th>[17]</th>
<th>[18]</th>
<th>[19]</th>
<th>[20]</th>
<th>[20]</th>
<th>[21]</th>
<th>[22]</th>
<th>[23]</th>
<th>[24]</th>
<th>[25]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>Free</td>
<td>free</td>
<td>6.375€</td>
<td>600€+ 3.500€</td>
<td>900€</td>
<td>240€</td>
<td>240€</td>
<td>380€</td>
<td>No info.</td>
<td>200€-225€</td>
<td>290€</td>
</tr>
<tr>
<td>Duration</td>
<td>No time</td>
<td>No time</td>
<td>Sep.-2017, May 2018</td>
<td>Sep.-Dec. 2017</td>
<td>120 h.</td>
<td>30 h.</td>
<td>30 h.</td>
<td>45 h.</td>
<td>20 h.</td>
<td>30 h.</td>
<td>7 h.</td>
</tr>
<tr>
<td>Mod.</td>
<td>Online</td>
<td>Online</td>
<td>On-site course</td>
<td>On-site course</td>
<td>Online</td>
<td>Online</td>
<td>Online</td>
<td>Online</td>
<td>On-site course</td>
<td>Online</td>
<td>On-site course</td>
</tr>
<tr>
<td>Sector</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
<td>No specific</td>
</tr>
<tr>
<td>Diploma</td>
<td>No</td>
<td>No</td>
<td>Deusto Univ.</td>
<td>Yes. No official</td>
<td>Yes. No official</td>
<td>Yes. No official</td>
<td>Yes. No official</td>
<td>Yes. No official</td>
<td>Yes. No official</td>
<td>Yes. No official</td>
<td>No info</td>
</tr>
</tbody>
</table>

5.1 Joint Curriculum definition and learning contents development

We start from a curriculum with four main axes of knowledge (Table III), showing the application of KET to the industry and businesses with a format similar to that proposed in [7]. In order to offer learning contents fulfilling the needs of the target audience, we take as inputs the opinions of the agents involved in the development and implementation of I4.0, their knowledge in the topic and needs. Three profiles have been defined: professionals of wood and furniture sector, suppliers of KETs and students and future technicians. Three different online questionnaires have been developed, and launched in the Flexmail platform [28]. Questionnaires are available in [3].

<table>
<thead>
<tr>
<th>Learning modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybridization of physical and digital world: sensors, RFID, NFC, 3D printing, Augmented reality, robotics, simulation, modelling, virtual reality.</td>
</tr>
<tr>
<td>Communications and data: Cloud Computing, Cybersecurity, Communications, Internet of Things, Integrated Systems, Big Data</td>
</tr>
</tbody>
</table>

Table III- Learning modules organization

Figure 3: Network path training methodology [3]

The learning contents are being elaborated in multiple languages (Spanish, English, Italian, German and French) through an innovative methodology called network path training, that allows to adapt the learning contents according to the user profile. Fig. 3 graphically shows the proposed model with respect to the traditional learning methodology.

5.2 Education methodologies used in IN4WOOD

Many studies have shown that the use of gamification and short-term audio-visual content (learning pills or video pills) in teaching increases student motivation and the probability the students will finish and pass the courses [29][30]. The use of these methodologies in online teaching is even greater in online courses and in recent years has grown exponentially due to the wide range of Massive Open Online Courses (MOOCs). In MOOCs, there are many different student profiles, being most of them workers, or VET/HE students enrolled in other regulated studies. Then, the probability these students do not finish the course is greater than in onsite courses.

The training course designed in IN4WOOD tries to avoid the MOOC’s problem. To keep the student motivation to minimize the dropout rate is mandatory. To do this, we use a methodology based on
gamifying the contents as far as possible, as well as the use of learning pills. We have taken into account some studies that prove that the optimal size of videos for learning must be of 3 minutes time length; being the time the student’s attention is maximum [30]. In IN4WOOD, Pildorea [31] is in charge of recording the video pills, following this methodology. The commitment with the EU is to offer a minimum of 300 video pills, explaining all concepts of the learning units defined in the four modules (Table III), but summing the whole network path training.

5.3 Developing the online software platform

The course proposed in IN4WOOD changes the paradigm of classic training courses, considering the network path training as the methodology followed to develop and manage the learning contents. This, and the fact that the learning contents require tools to allow their proper execution (gamification software, video players, etc.) and the commitment of multiplatform access (Web and Android / iOS mobile access) and multilingual access have been the reasons why we decided to develop a new online software platform from scratch, instead of working with one of the widely used in education [32]. These usually show some disadvantages in terms of the modules and plugins they offer to insert games and interactive videos, lack of roles, interface stiffness, etc.

Fig. 4 shows the logical scheme of the online software platform developed. In [3] the users can access to the project web interface, with a login space, where the students can access to the training course. The web page and back-end have been developed with Laravel [33] (php) framework, which provides a system of blade templates for developing the front-end. We have also used javascript (with Vue2.js), css (with Bootstrap) and html to have a responsive design, to provide access from any mobile platform.

6 CONCLUSIONS

The goals of this work were twofold: on the one hand, to study the current state of training in Industry 4.0, one of the requirements to adapt workers and students to the challenges presented by the factory of the future, the smart factory. We have focuses this target on European projects and Spanish initiatives. On the other hand, to address the design and development of an online training course to teach about the Key Enabling Technologies of Industry 4.0 under a free and online software platform, taking into account the audience: professional profiles in the specific sector of the furniture and wood, and VET and HE students interested in the topic. To do this, the course has been designed using a novel network path training methodology. The learning materials are being designed using recent and interesting educational methodologies such as gamification, video pills and flipped classroom. The recognition of the course will satisfy the European principles of credit transfer in Vocational Training and the recommendations of the European Reference Framework for Quality Assurance in Vocational Education and Training. The final goal is to offer, at the end of the IN4WOOD project, a pioneering training course to prepare the future technicians and specialists in Industry 4.0.
ACKNOWLEDGEMENTS

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