IN4WOOD: A Successful European Training Action of Industry 4.0 for Academia and Business

Jose Luis Romero-Gázquez, Gregorio Cañavate-Cruzado, and María-Victoria Bueno-Delgado, *Member, IEEE*

***Abstract*—The Industry 4.0 (I4.0) aims to develop a framework where the new technologies interoperate with each other and with employees, creating a smart and efficient environment. Although there are many public and private initiatives focused on boosting the deployment of I4.0 in all sectors worldwide, the adoption is slower than expected. One of the main reasons is the lack of training in those technologies involved in I4.0, the so-called key-enabling technologies (KET). In this article, the current status of I4.0 adoption from the industry, employees, and training point of view is analyzed. The lack of I4.0 competences in the curricula of vocational education training (VET) and higher education (HE) is also highlighted. Finally, the European innovative training action IN4WOOD is presented as a successful open and free training tool developed to offer students, employees, and managers an easy way to learn, use, and deploy KET of I4.0. Although the main target users of the training action are those in the furniture and woodworking sector, it has been designed to be useful also for users in other business sectors. The training tool is composed of more than 300 video learning pills, practical use cases, gamification, and evaluation test for measuring the level of knowledge acquired. The training tool has been tested in a pilot launched in four European countries. The results from the pilot prove that the IN4WOOD training helps to fill the skill gaps identified in the current VET/HE students and improves the competitiveness of employees, managers, and enterprises.**

***Index Terms*—Higher education (HE), IN4WOOD, Industry 4.0 (I4.0), key-enabling technologies (KET), vocational education training (VET).**

I. Introduction

Although the European Commission (EC) has recently published the guidelines with the main strategies for adopting the fifth industrial revolution (Industry 5.0) in Europe [1], the reality is that European countries, companies and employees, are still landing on the Industry 4.0 (I4.0) [2]. The latter consists of the modernization of factories and business processes using a broad set of technologies, the so-called key-enabling technologies (KET). According to the EC [3], KET comprises not only information and communication technologies (ICT) but also micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, advanced manufacturing technologies, etc. They provide innovative competences in a wide spectrum of sectors, such as food, chemistry, telecommunications, or wood and furniture. In 2017, the EC added two new KET to the list: 1) artificial intelligence (AI) and 2) security and connectivity [4]. The classification of KET differs according to the context of the study [5]–[7] e.g., the Spanish Ministry of Industry, Energy, and Tourism catalogues them according to whether they contribute hybridization to the physical and digital world [8], while the World Economic Forum classified them according to their degree of maturity and velocity of adoption [9].

During the past decade, some research works forecasted a notable evolution in the implementation of some specific KET (sensor networks, Internet of Things (IoT), cloud computing, 3-D printing/scanning, robotics, etc.) under the umbrella of I4.0 [10]. Moreover, different initiatives were launched by national and international organizations and governments with the aim of enhancing the industrial change: the European Union (EU) through its industrial policy and financing tools [1], [2], and other European countries, such as Germany with the "Industrie 4.0" initiative, France with the "Novelle France Industrielle," the "High Value Manufacturing Catapult" in the U.K., the "Fabbrica del Futuro" in Italy, the "Prumysl 4.0" in the Czech Republic, or the "Industria conectada 4.0" in Spain. Other countries outside the EU also boosted the I4.0 adoption, e.g., "Made in China 2025" in China, "Make in India" in India, "National Industry 4.0 Policy" in Malaysia, or "Society 5.0" in Japan.

Although there is an evident effort of integrating I4.0 worldwide [11], in the early 2021, its implementation in most of industrial sectors is still poor [12]. The main reasons are: still immature standards, absence of compatibility and interoperability among many technologies, and lack of clearness in most of countries about the current legislation to discern the responsibilities (intelligent devices or humans) when problems or accidents occur. The lack of skills and knowledge of employees and managers about the technologies in the umbrella of I4.0 is also poor in many

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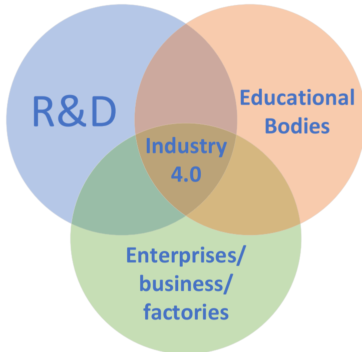

Fig. 1. Main actors for successful Industry 4.0 adoption.

sectors, and it is still higher in small- and medium-size enterprises (SMEs) [13], where most of managers are not conscious about the opportunities that I4.0 could bring to their business.

At educational level, there is a remarkable absence of practical training courses of I4.0 for managers and employees. The vocational education training (VET) and higher education (HE) are also in the way to modernize their degrees. Nowadays, most of them do not provide training contents focused on I4.0. From the above, it seems obvious that the success of I4.0 depends, not only on the initiatives promoted by the governments but on the synergy among three main actors that must work and collaborate each other (Fig. 1): Research and Development (R&D), Educational bodies, and Enterprises (including technology providers).

The goal of this work is twofold: first, to provide a depth analysis of the current status, challenges and needs for adopting I4.0 in Europe are carried out, focused on academia and business. The results of the analysis have reinforced the need of solving the lack of knowledge and competences in the main technologies involved in I4.0, and have inspired the development of an innovative European training action, IN4WOOD [14]. The goal of IN4WOOD is to provide an online and free available training tool [14] that help employees, managers, VET/HE students, and others to acquire skills and competences in the KET of I4.0. In the framework of IN4WOOD, a set of training contents has been developed with real use cases in the furniture and wood sector, but to be applied in any industrial sector. The IN4WOOD training tool has been tested through a training pilot launched in four countries across Europe: Germany, Italy, U.K., and Spain, with around 200 users: employees, managers, VET/HE students, and unemployed. The results gathered from the pilots show the successful evolution of the users' knowledge in I4.0 and point out the need of going for the training in I4.0 for its full adoption.

The remainder of this article is organized as follows. In Section II, the research of the current I4.0 adoption is carried out, in terms of technological problems, roles for employees and managers, and gaps in VET/HE. In Section III, the training tool developed in the framework of IN4WOOD is presented, explaining in depth the joint curriculum, training-learning methodology, contents, the training tool with its novel functionalities, and the testing phase through a European pilot with the main results. Finally, Section IV summarizes the conclusions.

II. Analysis of the Current Adoption of Industry 4.0

This section summarizes a desk-research about the adoption of I4.0 during the past decade from three different points of view: 1) industry; 2) employees and managers; and 3) training. The research is carried out by exploring the state-of-the-art scientific literature, international reports, projects, and current trends. From these, it highlighted the existing problems with the technology (e.g., lack of interoperability and standardization), the competences of the actors involved in the development of I4.0, and the training offer.

A. Industry 4.0 Adoption in Factories and Business

I4.0 was originally coined in Germany in 2011 as a national initiative boosted by the German government with the aim of raising the level of German manufacturing through the use of new technologies [16]. The goal was to provide factories and business with strategic tools for offering new types of services and business models, revolutionizing the concept of production chain [17] and progressively transforming the traditional factory into smart factories, e.g., automation in industrial machinery, enabling self-configuration, self-diagnosis, and self-repair, human–machine interaction, including coexistence with robots or the optimization of production with IoT [18], [19].

Almost a decade later, the forecasts have not been achieved at all. Some studies performed in different European countries show the poor adoption of I4.0 in almost all business sectors. Veza *et al.* [7] analyzed the status of the I4.0 deployment in Croatia. The results show that Croatian factories and business are far from I4.0. Less than 30% of companies are even in the third industrial revolution, and most of companies are anchored in the second industrial generation. In [11], the analysis is focused on factories and business in Catalonia, one of the strongest economic Regions in Spain. The results point out that only 15.7% of them are in an initial (13.4%) or advanced (2.3%) stage of adoption, while more than 61% of them have not taken part in the strategy of I4.0 adoption or consider that it is not feasible due to different reasons. An analysis performed in Turkey [20] remarks that the lack of qualified employees and the economic aspect of the transformation process toward I4.0 are the main challenges that companies must face. They show that only 18% of the companies surveyed have full knowledge about how to implement I4.0 in their organizations, whereas 12% of them are able to implement first measures and/or develop clear business cases based on I4.0. Only 27% of companies currently have implemented an initial I4.0 environment, while the remainder 42% did not make any preparations on it. Other works like in [21] show how the lack of interoperability and the scalability problems slows down the I4.0 adoption. Note that the transformation from the traditional to the smart factory involves the use of technology from different vendors, creating a heterogeneous environment where interoperability is required. Moreover, scalability is another major issue [22] because the IT infrastructure must be able to be adapted to the existing and future data volume and devices to handle.

Standardization is also a constraint in the I4.0 adoption [23]. The reference architectural model for Industrie 4.0 (RAMI 4.0) [24] was presented as the reference model to face with some of the current standardization challenges.

Nowadays, different international working group committees and standardization and normalization institutions are working on a full standardization for all KET involved in I4.0 [25] and [26]. Finally, the industry and business are worried about security and privacy in an I4.0 scenario where high volumes of confidential data must be managed. There are some guidelines for setting cyber security based on the RAMI 4.0 architecture model [27] but they seem not to be enough for ensuring the entire deployment. According to [28], there are no privacy standardization for AI-based technologies, and there are other pending challenges such as physical vulnerability in cloud computing ecosystems.

B. New Roles of Employees and Managers in the Industry 4.0 Era

The integration of the ICT in all industrial sectors have changed the way people work and the skills and competencies demanded for employees and managers. In Europe, the number of job vacancies with ICT profile increases year by year while the number of employees with the required ICT profile decreases. In fact, in 2019, the EC pointed out that 1.6 million ICT professional jobs will need to be filled between 2018 and 2030. This lack of digital skills in employees is also a challenge to overcome for the successful adoption of I4.0 [29], [30]. The reports in [31] and [32] have enumerated the specific skills and competences recommended for the qualified employee in the I4.0 era. Profiles, such as informatics specialist, PLC, robot programmer, software engineer, data analyst, and cybersecurity professionals, are described. But even less qualified employees (e.g., operators in production chains) are expected to have digital skills in order to perform tasks, such as management and maintenance of production or analysis of operations performed by the automated machinery.

Fig. 2 shows a simple data-driving example in a smart factory I4.0, and the key role of the employee with digital skills [33]. The factory is composed of sensorized machinery. The production and operation stages generate events or data, which are sent to central entities (physical site or in the cloud). These collect and produce operation reports based on the data received. The employee checks the data reported and intervenes in the configuration and setting up of industrial machinery with the aim of optimizing its potential, preventing failures, quantifying defects, minimizing operational costs, and optimizing machine maintenance, among other tasks. Finally, once this action is carried out, the production cycle starts again. The above example shows how the migration from the current factories to the smart ones could optimize the capital and labor productivity opportunities. However, it is only possible if the digital skills needed are met by employees. Companies need to employ updated training and workforce development strategies to match with

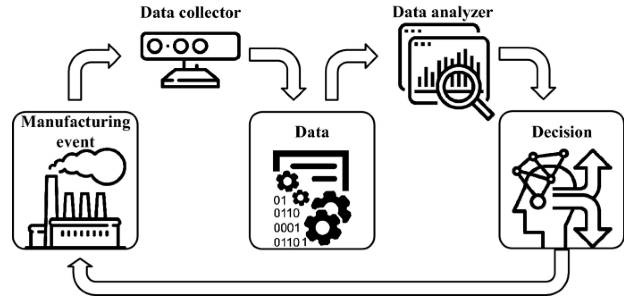

Fig. 2. Example of data driving and human intervention in a smart factory I4.0 [32].

the digital evolution in the industry. Baygin *et al.* [34] showed that this fact is one of the three greatest challenges that companies in Germany and the USA are facing for guaranteeing success transformation to I4.0.

One significant strategy for training employees is through the initiatives learning factory (LF) [35] and teaching factory (TF) [36], [37]. They are not new concepts, since numerous learning factories have been built in industry and academia in the last decades. The challenge is to perform the LF/TF where current future employees can learn about KET of I4.0 deployed and running in a real smart factory [38]. LF/TF is the best way to learn about how to manipulate ICT and technical equipment and check the consequences of their actions in the production process carried out in real smart operating scenarios. However, not all employees can reach training through learning factories. Then, other training options must be considered.

C. Industry 4.0 in Vocational and Higher Education

The demand of digital skills for the I4.0 era must be faced, not only through the update of profiles in current employees but also modernizing the contents in VET and HE degrees. VET/HE curricula must be designed with those contents that enable students (future employees) to reach the skills, knowledge, and competences demanded in the I4.0. Unfortunately, there is a strong absence of VET/HE entities offering official degrees or training courses focused on I4.0 [39]. Moreover, the skills reached through those degrees focused on ICT are a bit far from what I4.0 claims, as some studies point out [6], [40].

VET/HE institutions have to overcome two main obstacles: 1) they spend a lot of time and human resources in the update of their official academic offer and 2) the curricula of most of official degrees have constraints about most of contents, which are determined by national laws and educational bodies.

In [41], a review about the available I4.0 training in a set of EU countries is reported. The results show the lack or poor training about I4.0, and the need of an update by the educational bodies, not only to offer a complementary and efficient training for employees and managers but also to modernize current VET and HE training.

III. European Innovative Training Action IN4WOOD

IN4WOOD is a European project funded by the EC. The main goal of IN4WOOD is to design, develop, and recognize a joint curricula and a training course for filling the existing gaps of the skills required by the I4.0, focused on those related to the KET identified by the EC. The result of IN4WOOD is a free training tool that enables users to learn, understand, deploy, use, and take decisions about the KET of I4.0 in their business sectors, improving the competitiveness of their enterprises. The training tool is composed of a set of training units where the most relevant KET are explained, with hundreds of examples about their use in the industry. The training is supported, not only with slides, pdf documents, links, and exercises but also with a set of 300 video learning pills of 3 min' length, where experts in KET explain key concepts. A set of evaluation questionnaires for testing the level of knowledge acquired is also available. The work developed is hosted in a dedicated training software platform developed from scratch, available through app (IOS/Android) or via Web browser. It uses gamification and a recommendation system based on machine learning, which adds personalized training paths to users. The training platform and contents have been tested with almost 200 users in a set of pilots launched in four European countries: 1) Germany; 2) Italy; 3) U.K.; and 4) Spain. The following sections get in depth with some key features performed in the IN4WOOD framework.

IN4WOOD was primarily focused on the wood and furniture sector because it was identified with a shortage of professionals with high qualification in ICT. However, the final joint curriculum is designed to offer training to different target users through a set of training paths. The target users are VET/HE students, employees, and managers from different business sectors and level of knowledge in ICT.

In this section, the work performed in the framework of IN4WOOD is explained in depth, structured in a set of sections following the chronological order in which the work was performed.

A. Key-Enabling Technologies for IN4WOOD Training Course

The first step in the design of the IN4WOOD joint curriculum is to determine the set of KET to be considered. The opinion of the VET/HE providers and representatives, stakeholders, potential students (employees and managers), technicians, etc., can help in this issue. Then, a set of questionnaires was designed, following the EC guidelines and similar approaches. The final questionnaires, the full campaign for gathering the responses, the analysis, and final conclusions are summarized in [42]. From the analysis, it was concluded that nine KET were primarily identified as mandatory for being trained. They were included in the training course (Fig. 3), and are briefly introduced as follows (in alphabetical order).

Additive manufacturing is characterized by making parts based on superposing layers of material. It is not a single technology but covers different processes depending on the material, technique, and its state and the source of energy. In all of them, there is a file in a specific format that the 3-D printer can read and understand. Additive manufacturing makes it possible to manufacture low-cost parts to have models and prototypes before their real production, as well as easy

Fig. 3. KET identified for the IN4WOOD training course.

customization of the product, assembly, and weight reduction, among other advantages.

Augmented reality (AR) is based on the combination of digital content with the real world to build a mixed reality. Reality is increased through the incorporation of additional information by placing it in space. For this whole process, it is necessary to provide intelligence to the systems so that they recognize what they are seeing. The use of so-called markers is necessary.

Autonomous robots are becoming more autonomous, flexible, and cooperative, so that they can interact with each other and work safely together with and learn from humans. These will be cheaper and are also expected to have a wider range of possibilities than the current ones, causing the replacement of the current workforce and reinventing jobs.

Big data refers to the massive treatment and management of information. Some of the characteristics of this technology are the large volume of all types of structured and unstructured data, the specific storage for this volume, a fast processing of the information, as well as a good tolerance to failures and scalability.

Cloud computing is equivalent to having computers and servers in the cloud, that is, on the Internet. Cloud computing has several advantages over the traditional model, for example, it is not necessary to invest large amounts of money in infrastructure, you simply rent the necessary resources and only pay for them you use. In addition, the connection to cloud services can be made from anywhere, simply an Internet connection is necessary. The cloud service can be of different types, such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) or Software as a Service (SaaS).

Cybersecurity is the set of techniques for prevention and action against malicious processes that violate the security of computers and devices. In other words, it is the protection of the information contained in a device through the treatment of threats that put it at risk, such as malware, viruses, and ransomware or techniques, such as phishing or Man in the Middle.

IoT is a term used to describe all those devices capable of communicating with each other wirelessly or not and through

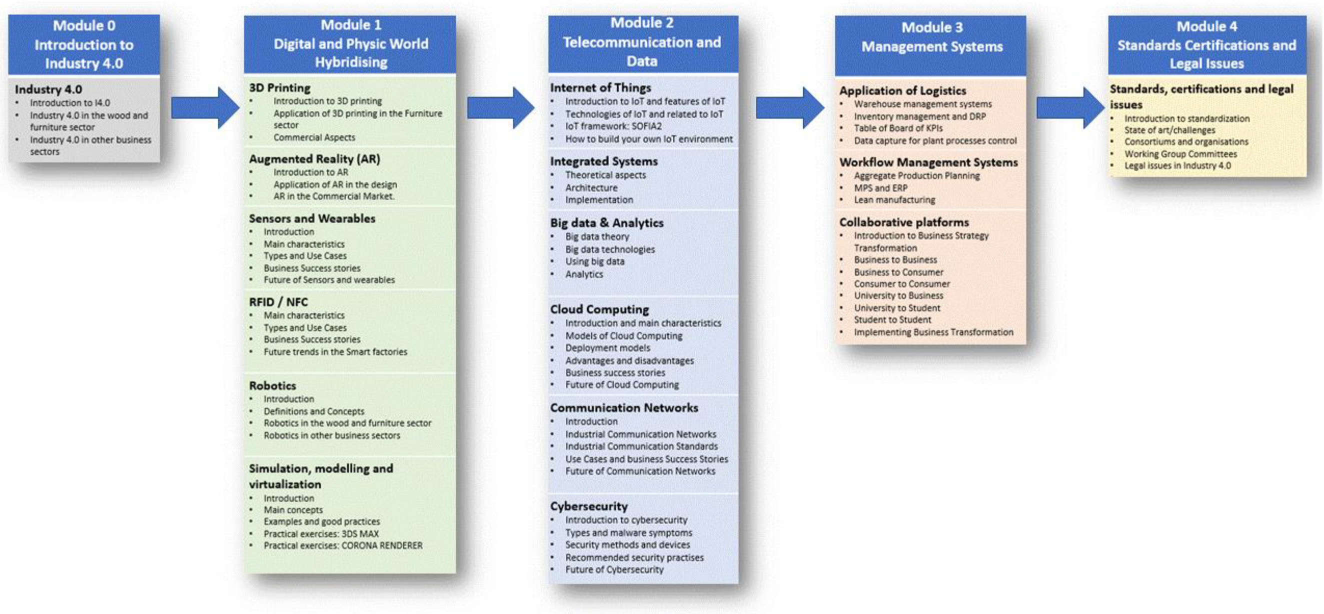

Fig. 4. Flowchart of learning modules in IN4WOOD training course.

the Internet. A device can be a sensor that detects external signals and carries out an associated process. Each of these objects connected to the Internet has a specific address on the network that provides identification to the object for communication. These devices also communicate through different protocols and can form different ranges or action areas, such as the personal area network (PAN), local area network (LAN), or metropolitan area network (MAN).

Simulation helps to represent physical reality using virtual elements, trying to reproduce or predict behavior in different situations and scenarios using a model. This technique is used in a wide variety of disciplines, such as education, medicine, engineering, or architecture, allowing decisions to minimize or practically eliminate errors through a virtual model.

System integration is applied by manufacturers, suppliers, and customers, which will be closely linked by computer systems, facilitating a truly automated value chain. The same applies to the different departments of the company, such as management, engineering, production, or logistics.

B. Joint Curriculum

The joint curriculum is designed following the European qualification framework (EQF) recommendations and identifying the learning outcomes following the European skills, competences, qualifications, and occupations (ESCOs) classification [43]. Fig. 4 shows how the training contents were organized in five learning modules. These are organized in a recommended path, starting in Introduction to Industry 4.0, and ending in Standard Certifications and Legal Issues. All modules are detailed as follows.

Introduction to Industry 4.0: It introduces the I4.0 concept and its current status in the furniture sector and the industry in general.

Digital and Physic World Hybridizing: It includes the KET that connects the physical and the digital world, gathering information from the physical world or transforming the digital information into a physic element. The courses included in this module are: 1) sensors and wearables; 2) 3-D printing and additive manufacturing; 3) AR; 4) robotics; 5) simulation, modeling, and virtualization in the design.

Telecommunications and Data: It is composed of some KET focused on communications and information management in different industrial scenarios: 1) cloud computing; 2) cybersecurity; 3) communications networks; 4) IoT; 5) integrated systems; and 6) big data and analytics.

Management Systems: It comprises a set of learning content about different and useful management systems for furniture and woodworking industries, but also applied to other industrial sectors: logistics tools and management systems for inventory; different planning approaches and workflow management systems according to production processes and collaborative working environments according to the actors that can interact. Courses in this module are: 1) applications of logistics and 2) workflow management systems.

Standards Certifications and Legal Issues: It includes the context of standardization in I4.0, the international consortiums and organizations working on it, the different types of working groups and committees, and the current and future standards about the KET. The legal issues behind I4.0 are also reviewed, paying attention to data protection authority, current regulations, and liability. The concepts of this module are transversal, although it is recommended to train at the end of the course, as Fig. 4 shows, that is, once the student has learned of all technologies.

C. Educational Methodologies and Training Contents Development

Some scientific studies show how the use of gamification and small pills of training content can help the students to remain motivated during the online training, promoting its

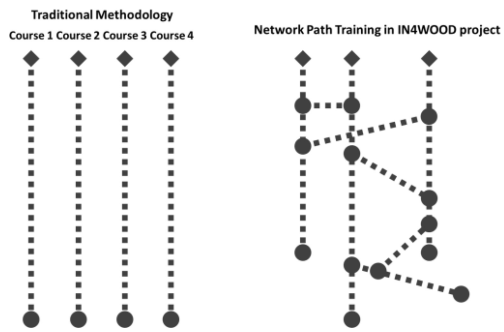

Fig. 5. Training path network implemented in the IN4WOOD platform.

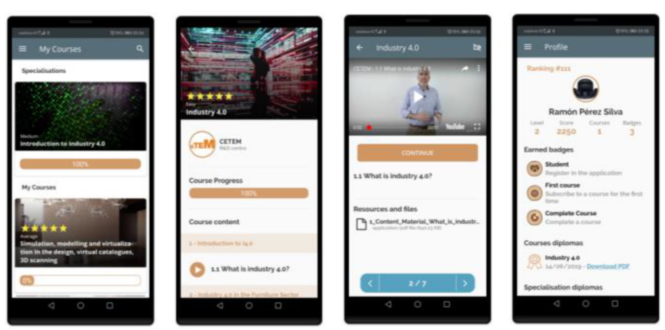

Fig. 6. Android mobile application of IN4WOOD training tool.

completion [44]. Although the drop out of face-to-face courses is significant, it can be even higher in online courses where there is no continuous physical supervision by the instructor. The IN4WOOD training course tries to minimize this problem by adding multimedia resources and gamification as much as possible. Based on some studies that suggest that the optimal video length should not exceed 3 min to an optimal engagement [45], 300 video learning pills focused on training the KET were developed. The videos are offered to users in the IN4WOOD platform following a recommendation algorithm, fed by the user profile.

The video learning pills are cataloged in a relationship system, which offers an innovative network path of training and allows users to adapt the training in a personalized way according to their interests and profiles. This feature is a novelty that breaks with the traditional methodology offered with lineal training paths (Fig. 5).

The knowledge acquired by the users is measured by trainers through a set of online questionnaires, one per training unit. The evaluation test of each training unit is available when the user watches all video learning pills comprised in the same training unit. If the user passes the test, a diploma certifies the acquisition of the knowledge. Otherwise, a reinforcement algorithm is executed to offer users the possibility to review those concepts in which he/she failed. Moreover, trainers have a backend tool to list the progress of users, organized by modules, courses, video learning pills consumed, etc.

The total learning contents developed, together with the educational methodologies explained, result in the following.

1) More than 300 video learning pills of 3 min' length. These short videos help users to complete the training course in an easy way. They can watch the videos in any place and with any device. They only need Internet connection.
2) Slides, text, audios, etc.
3) Tests after a set of different training material to validate the knowledge acquired.
4) All the material in four available languages: a) Spanish; b) English; c) Italian; and d) German.

All training courses include a guide of teachers for opening the door to those professionals that want to use the training material for face-to-face teaching, in formal or nonformal training courses.

D. Online Software Platform

The requisites of the training tool (personalized training paths, gamification, recommended algorithms, and high volume of data due to the 300 video learning pills) derived in the need of developing the training platform from scratch and the use of a dedicated server. The training tool is also easily accessible by Web browser from any platform, whether desktop, mobile, or tablets. It has been developed as a multiplatform to reach the maximum audience and try to avoid technological barriers. Fig. 6 shows a set of snapshots of the Android mobile app of IN4WOOD training course, as example of the powerful of the application. It can be downloaded, not only for Android [46] but also for iOS [47].

The training tool also includes other useful sections, such as interactive teacher–learner chat, ranking of best users (level recognition), or the possibility to comment and rate courses, among others. As example of the main functionalities of the students, the navigation flow is plotted in Fig. 7.

A simple schema about the platform architecture is also included in Fig. 8. The communication flow is based on REST API calls with a server and two different databases: one as training content and video learning pills repository and one for storing the users' profiles and progress. The server hosts the Web platform and runs the gamification tools and recommendation algorithms.

E. Testing IN4WOOD Training Course in Europe

The training course was tested to experience and get feedback about the training material, tools and software platform developed in the framework of the project. Four pilots were organized in the partnership countries: 1) Germany; 2) Italy; 3) U.K.; and 4) Spain. During ten weeks, almost 200 users, with different academic profile and status (Figs. 9 and 10), were enrolled in one or more training modules, field-testing the actual compliance of the defined professional profile and the related training to the needs of the market, as well as the effectiveness of teaching material and the specific training paths. Users were free to choose in which courses they wanted to be enrolled, although it was a guide for users, where a training path was recommended, starting with the *Introduction to Industry 4.0* module. Users were tutored through the platform by partners in charge of the training units developed. It was done using a specific module for launching and managing questions, also forwarded to email. Users were monitored

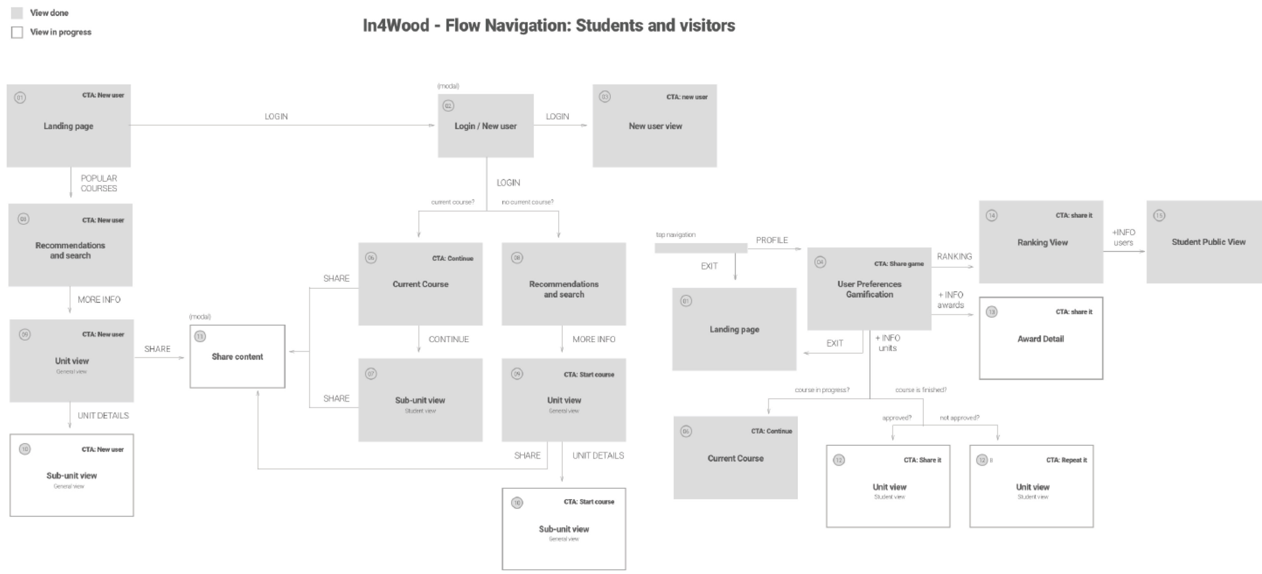

Fig. 7. Flow navigation of students and visitors in the IN4WOOD Web platform.

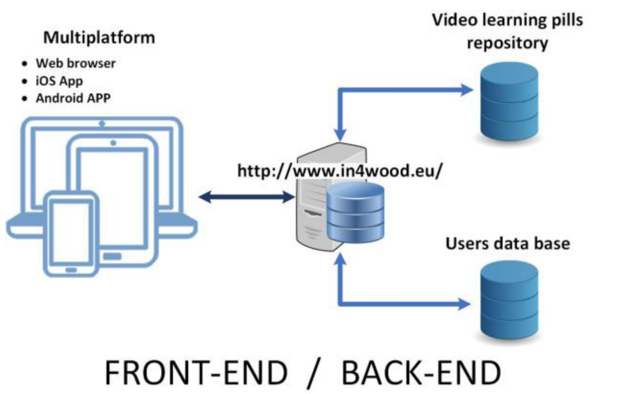

Fig. 8. Online platform of IN4WOOD training tool.

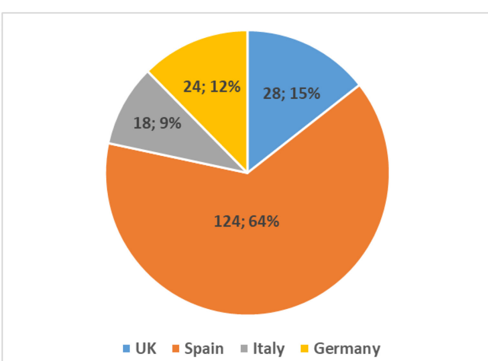

Fig. 9. Students enrolled per country in IN4WOOD pilots.

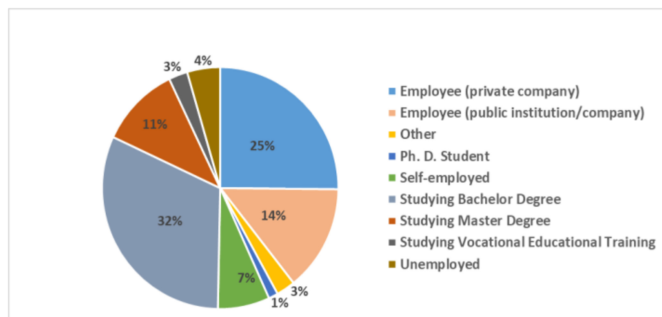

Fig. 10. Academic/professional profile of users in IN4WOOD pilots.

weekly, checking their satisfaction and to encourage them to continue with the training. In addition, some face-to-face meetings were organized to solve doubts and concerns about the platform, its content, and the evaluation method.

During the pilots, three surveys were launched to users with the aim of gathering their feedback about training: opinions, suggestions for improvements, progress in their knowledge acquired, etc. They were designed as follows.

1) *Initial Survey:* It is designed to capture the profile of the users, their knowledge of KET before the training, and their expectations with the training course.
2) *Intermediate Survey:* It is designed to gather the opinion of users during the pilot execution in terms of scheduling, planning, training methodology, duration, quality of training material, tutoring, and knowledge of KET acquired.
3) *Final Survey:* It is developed to collect the experience of the users during the pilots once they finished, with the same questions as the intermediate survey and some extra questions about suggestions of improvement.

In all surveys, users were asked about their knowledge of those KET in the training, ranking from 1 to 5, their knowledge: nothing (1), basic (2), average (3), high (4), and expert (5).

After the pilots' execution, the data gathered were analyzed and compared. A sample of them is plotted in Figs. 10–12.

Fig. 11 shows the evolution of knowledge acquired, reported by users, for each technology trained. Note that each bar represents the mean of the score obtained for each training unit. The

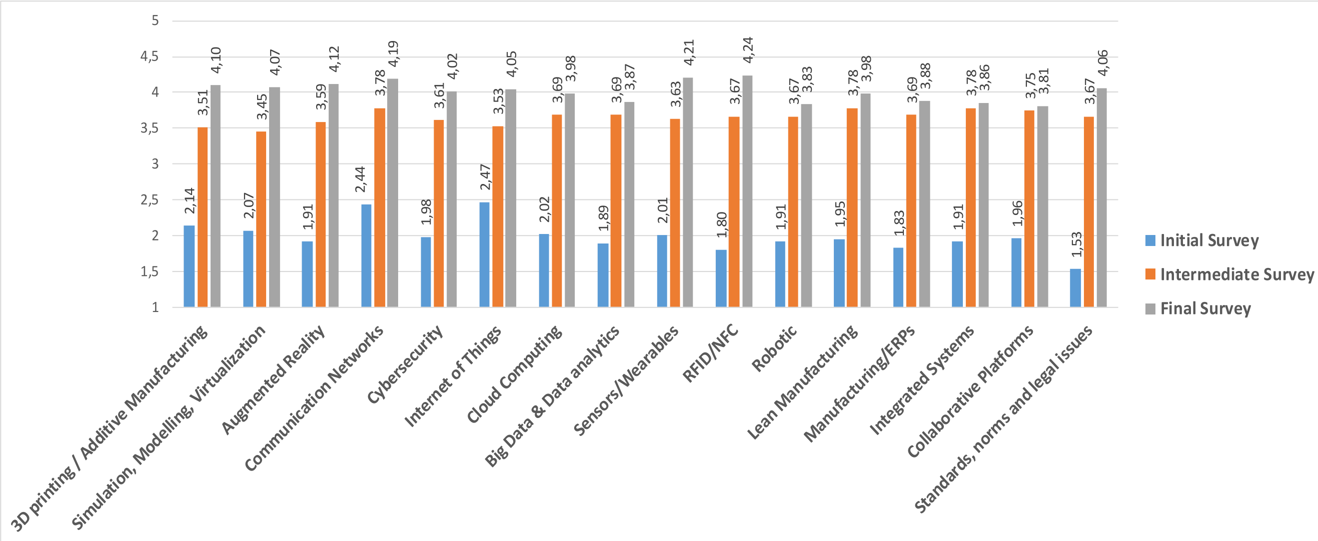

Fig. 11. User's opinion about their own evolution in the knowledge acquired during the IN4WOOD pilot execution, ranked from 1 (nothing) to 5 (expert).

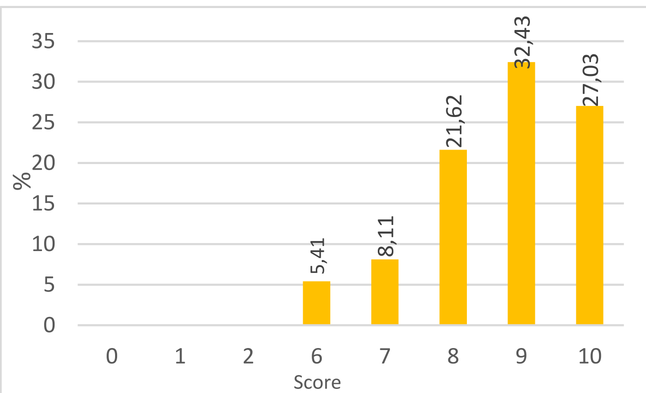

Fig. 12. Users' overall evaluation of the IN4WOOD course (out of ten points).

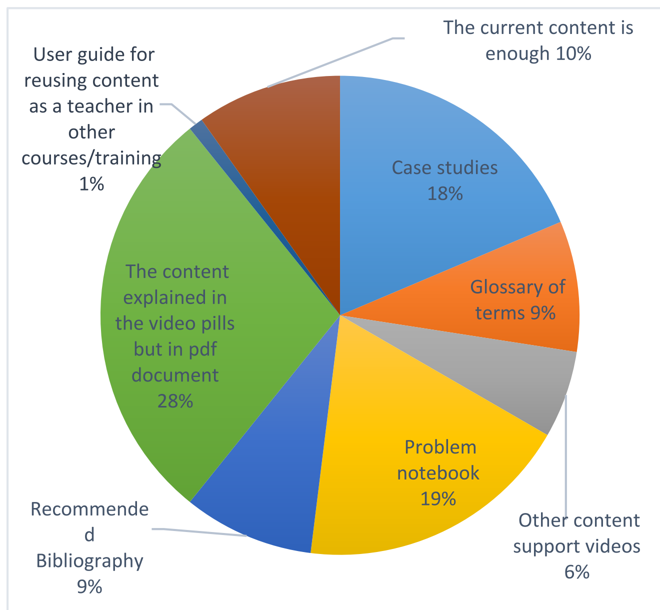

Fig. 13. Feedback about improvements to be done in the platform.

results in Fig. 11 show the average about the users' knowledge. In most of KET, users started with a very low initial knowledge. This was improved during the execution of the pilot in all disciplines, being the highest improvement in communication networks, sensors/wearables, and RFID/NFC. In average, the level of knowledge acquired about KET by the users was duplicated after the IN4WOOD training pilot.

Fig. 12 shows the overall evaluation of the training course. The lowest score is 6, and the average of the scores collected is 8.51. Fig. 13 shows the set of improvements suggested by users during the pilot. Some of the most demanded improvements are: 1) to provide the content explained in the video learning pills available in text in pdf for its later reading (28%); 2) to have a problem notebook (19%); and 3) to add more use cases (18%) in which to show how to put into practice the knowledge acquired.

IV. Conclusion

In this work, a desk-research about the current status of the I4.0 adoption in Europe has been carried out from the point of view of the current technological problems, the new roles of employees and managers in factories and business, and the training in VET/HE. As the main contribution, an innovate training tool developed in the framework of the European project IN4WOOD has been developed and tested. The IN4WOOD training tool is offered as a free access, multiplatform and multilanguage, and it allocates a complete set of training materials, including more than 300 video learning pills with key concepts of the main KET of I4.0. A novel teaching-learning methodology has been designed focused on personalized learning paths through recommendation and reinforcement algorithms and the use of gamification to improve the efficiency of the learning process. The IN4WOOD training tool has been successfully tested through a pilot launched in four European countries in which almost 200 users have increased their knowledge in the most relevant KET of I4.0, getting a remarkable overall evaluation from users enrolled. User's suggestions have been also collected with the aim of improving the tool and training contents, in a new version to be launched, open to new users.

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