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Romero Gázquez, José Luis; Bueno Delgado, María Victoria; Ortega Gras, Juan José; Garrido Lova, Josefina; Gómez Gómez, María Victoria; Zbiec, Marcin

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Monográfico

Lack of skills, knowledge and competences in Higher Education about Industry 4.0 in the manufacturing sector

Falta de habilidades, conocimiento y competencias en la Educación Superior sobre la Industria 4.0 en el sector manufacturero

José Luis Romero Gázquez 1
Universidad Politécnica de Cartagena, UPCT, España
josel.romero@upct.es

María Victoria Bueno Delgado 2
Universidad Politécnica de Cartagena, UPCT, España
mvictoria.bueno@upct.es

Juan José Ortega Gras 3
Centro Tecnológico del Mueble y la Madera de la Región de Murcia, CETEM, España
jj.ortega@cetem.es

Josefina Garrido Lova 4
Centro Tecnológico del Mueble y la Madera de la Región de Murcia, CETEM, España
josefina.garrido@cetem.es

María Victoria Gómez Gómez 5
Karlsruhe Institute of Technology, KIT, Alemania

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Author notes

1 **José Luis Romero Gázquez** received the bachelor's degree in Telematic Engineering in 2015 from the Technical University of Cartagena (UPCT, Spain). In 2017 he received his Master of Science in Telecommunications Engineering from the same University. Since 2017, he works as researcher and Ph.D. Student in GIRTEL group of UPCT. His research interest includes the Internet of Things (IoT), network optimization and the Industry 4.0, its digital transformation, and its adoption in education.

2 **María Victoria Bueno Delgado** is Associate Professor in Universidad Politécnica de Cartagena (Spain). She received BSc. in Telematics Engineering (2002), MSc. in Telecommunications Engineering (2004) and European Ph.D in Telecommunications (2010) from the same University. She has participated or led more than 20 Spanish and European projects, and a dozen projects with companies. Her research interests include network optimization, wireless technologies, Industry 4.0, digital transformation, new technologies for education.

3 **Juan José Ortega Gras** has bachelor's degree in environmental science and Master in Integrated Management: Quality, Environment and Occupational Safety and Health, with extensive knowledge in the areas of sustainability and circular economy in the industry. He currently works in the International Projects Department at CETEM, where he has participated in several European projects (H2020, FP7, Erasmus+, etc.) related to digitalization and sustainability in the furniture and wood industry.

4 **Josefina Garrido Lova** has PhD in Communication and Documentation, is head of the Area of R+D(+i) at CETEM as well as senior advisor in project management. She has experience leading and supporting work teams, coordination of projects, exploitation activities, and in tasks related with planning, execution and dissemination plan in projects. She also works on topics with Erasmus+ such as: EQF frame, ECVET system in relation to mobility, recognition of Informal and non-formal learning, etc.

5 **María Victoria Gómez Gómez** studied Building Engineer at the Technical University of Cartagena (UPCT, Spain). After her studies, she obtained the Certificate of Pedagogical Aptitude (CAP) at the University of Murcia (Spain). Over several years she acquired further knowledge in the areas of product design, product development and CAD programs, and studied a vocational training in Design and Furnishing. Since 2016, she works at the BLM department as part of the European funding program Erasmus+.

6 **Marcin Zbiec** is Head of Division of Construction and Technology of Final Wood Products of Faculty of Wood Technology, Expert on woodworking of Association of Foresters and Wood Technologists. PhD obtained in 2004 on the topic of "Tool wear diagnosing in milling of wood-based materials" Lecturer on Production Facilities, Exploitation of Woodworking Machinery and Computer Aided Design. In 2015 awarded in "Top 500 innovators" program (amongst the top five hundred innovators of Poland).

maria.gomez@kit.edu

Marcin Zbiec 6
The Warsaw University of Life Sciences, WULS, Polonia
marcin_zbiec@sggw.edu.pl

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Abstract:

In this paper, the authors present a complete analysis carried out for reporting the lack, needs and requested competences and skills on the Key Enabling Technologies (KETs) of the Industry 4.0 (I4.0) in both Higher Education (HE) as well as in the wood, furniture and manufacturing sector all over Europe. Moreover, this analysis evaluates the level of implementation in this specific sector considering latest technological trends. The analysis was performed within the framework of the European project MAKING 4.0, where a complete set of surveys were launched to agents who were directly involved in the wood, furniture and manufacturing sector to find out what their impressions are about the current knowledge and the one demanded by the I4.0, obtaining results where the low level of competences and qualifications in this industrial sector is demonstrated, both in education and in industry, as well as the poor training offered in I4.0 and its KETs. It is concluded that there is an evident technological skills gap between those acquired by workers and by Vocational Education Training (VET) and HE students regards the demands of the I4.0, which must be covered within the next years, through training initiatives, enabling and acquisition of needed competences such as, for example, MAKING 4.0.

Keywords: industry 4.0, KETs, enterprise 4.0, HE, VET, manufacturing, training, curriculum, qualification, skills, competences, labour market, knowledge, employment.

Resumen:

En este trabajo, los autores presentan el análisis llevado a cabo para evaluar la falta, las necesidades y las competencias y habilidades requeridas sobre las tecnologías habilitadoras clave (KETs) de la Industria 4.0 (I4.0), tanto en la educación superior como en la industria del mueble, la madera y la manufacturación en Europa. El análisis también evalúa el nivel de implementación de las últimas tendencias tecnológicas en este mismo sector. El análisis se realizó en el marco del proyecto europeo MAKING 4.0, donde un completo set de encuestas se lanzaron a agentes directamente involucrados en el sector del mueble y la madera para conocer, de primera mano, cuáles son sus impresiones acerca del conocimiento actual y el demandado por la I4.0, obteniendo resultados donde se demuestra el bajo nivel de competencias y cualificación en este sector industrial, tanto a nivel educativo como en la industria, además de la falta y necesidad de adaptación de la oferta formativa actual sobre la I4.0 y sus KETs. Se concluye que existe una disparidad evidente entre las competencias actuales de los trabajadores y aquellas que adquieren los estudiantes de ciclos formativos (VET) y educación superior (HE) con respecto a lo demandado por la I4.0, debiéndose cubrir y solventar en los próximos años a través de nuevas iniciativas de formación, capacitación y adquisición de competencias necesarias, como por ejemplo, el proyecto MAKING4.0.

Palabras clave: industria 4.0, KETs, empresa 4.0, HE, VET, manufactura, enseñanza, curriculum, cualificación, habilidades, competencias, mercado laboral, conocimiento, empleo.

The concept Industry 4.0 (I4.0) was created and enhanced by Germany in 2010 as a strategy to improve competitiveness in business production, weakened by those emergent countries with low labour costs. The goal was to offer an innovative industry close to the customers, with customized and turnkey products and solutions, and minimizing production and service times (Petrillo et al., 2018). This was possible thanks to the use of the Information and Communication Technologies (ICTs) in the manufacturing, business and industrial processes. The main ICTs of the I4.0 are the so-called Key Enabling Technologies (KETs). They are, among others, cloud computing, big data, cybersecurity, robotics, artificial ingelligence, additive manufactuting, augmented and virtual reality, etc.

During the last decade, the European Commission (EC) has launched different strategies to promote the industrial change towards I4.0, funding in technologies, research and infrastructures (COSME, 2018; SL

Smart-City, 2016). Some European countries have also enhanced I4.0 through national initiatives (Anitec-Assinform, 2018; Klitou, 2017; Estrategia, 2015; Industrie 4.0, 2017; Novelle France Industrielle, 2017; Prumysl 4.0, 2015). Currently, the EC is driving the deployments of I4.0 in different sectors through the European Technology Platforms (ETPs) (Reillon, 2017). This is composed of forums of industry stakeholders, recognized by the EC, which are formed to support the development of innovation agendas and technology roadmaps for several sectors, at national and EU levels. One of these platforms is Manufuture (Manufuture, 2020), the ETP dedicated to improve the competitiveness of European manufacturing, launched the European Factories of the Future Association (EFFRA) (EFFRA, 2020), a Public-Private Partnership (PPP) of industrial associations which regularly publishes strategic technology roadmaps that form the basis for research and technology development call topics.

It seems clear how the fast integration of KETs in all sectors of industry in EU, promoted by the adoption of I4.0, is changing the way the European people work, and the skills and competencies required to workers (Cañavate-Cruzado et al., 2020). KETs are leading the current economy and the previsions of EC reveal that the future will lead to a fully digitized world, with human capital highly qualified in digital skills. In fact, in Europe the demand of workers with multidisciplinary knowledge and KETs profile increases year by year, while the workers with the required KETs profile is dramatically decreasing. The lack of basic knowledge of KETs is present in over 30% of EU workers (European Commission, 2009). The EC also predicts some alarming data: in 2020 the number of uncovered KETs profiles could reach 800,000 positions and highlights that the lack of digital skills of employees is one of the challenges to be addressed in the adoption of I4.0.

There is no doubt that the change towards the digital transformation and I4.0 must include challenges such as training workers, updating manager skills and adapting the curricula of VET and HE studies to create the future workers with the skills and demand required by the I4.0. This must be performed for each industrial sector, firstly through the analysis of skill gaps and needs of workers and current students. The results of these analysis will help to identify the training contents needed and the way for the design of a joint curriculum, distinguishing among Vocational Educational Training (VET), Higher Education (HE) or unofficial training, as well as following the European Skills, Competences, Qualifications and Occupations (ESCO).

In this regard, some European Projects like MAKING 4.0 (Making, 2019) or IN4WOOD (In4wood, 2016, Bueno-Delgado et al., 2017a) aim to bring this fourth revolution to the specific sector of the wood and furniture industry by developing training courses or training materials 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, that is, improving the competitiveness of their enterprises.

In this work, the authors summarize the work carried out in the framework of the MAKING 4.0 project, where a full analysis was performed for reporting the lack, needs and requested competences and skills with specific attention to KETs of I4.0 in the European HE and in the wood, furniture and manufacturing sector all over Europe, as well as to know the level of implementation in the industry of last technological trends. The work has been also performed with Malaysian HE and Industry (Ratnasingam et al., 2020; Zainal et al., 2020).

The results of the analysis show the current competences and qualifications in furniture and woodworking training offered by European universities and compare these with European industry requirements. The analysis remarks the current gaps in European HE offer and the needs that the wood, furniture and manufacturing industry have to cover in the next years, through training initiatives like MAKING 4.0 (Romero-Gazquez et al., 2020).

THE KEY ENABLING TECHNOLOGIES OF INDUSTRY 4.0

In 2009 the EC identified at first time six KETs: photonics, industrial biotechnology, nanotechnology, advanced materials, micro/nanoelectronics and advanced manufacturing systems (EC-KETS, 2009). In 2017 EC added two new KETs to the list: Artificial intelligence (AI) and Security and connectivity (EC-KETS (b), 2018). In the classification, the EC also advised that biotechnology should be broadened to 'life sciences' and to regroup in single KETs advanced materials and nanotechnologies, and micro-/nano-electronics and photonics.

In 2018, a report of the independent High Level Group on Industrial Technologies of the EC reviewed the current KETs identified by EC for the future, so-called KETs 4.0, regrouping the six sets of KETs into three different categories: Production technologies, Digital Technologies and Cyber Technologies (HLG-IT, 2018). They also remarked that the advances in technologies such as the Internet of Things (IoT), 5G, Cloud Computing, Data analytics and Robotics are transforming products, processes and business models in all sectors of the economy, ultimately reshaping global value chains and patterns of industrial specialisation.

Currently the KETs are also the key drivers for the I4.0 adoption. Nowadays a complex debate is open on the need of changing from the concept of I4.0 to the wider and more complete concept of Enterprise 4.0 (E4.0) (Moreira et al., 2018). There is an evident need of enlarging the concept from the core idea of industrial/factories production to the more inclusive idea of how all enterprises may apply digital technologies in their processes (commercial, marketing, approach to client, management of supply chain, etc.) for entering a digital transformation without the need to implement robotics in production lines.

Some of the KETs identified in the paradigm of I4.0/ E4.0 are: RFID, IoT, Ubiquitous Computing, 3D Printing/Scanning, Cyber Physical Systems (CPS), Big Data, Cloud Computing, Advanced Automation, Additive Manufacturing or System Integration, among others.

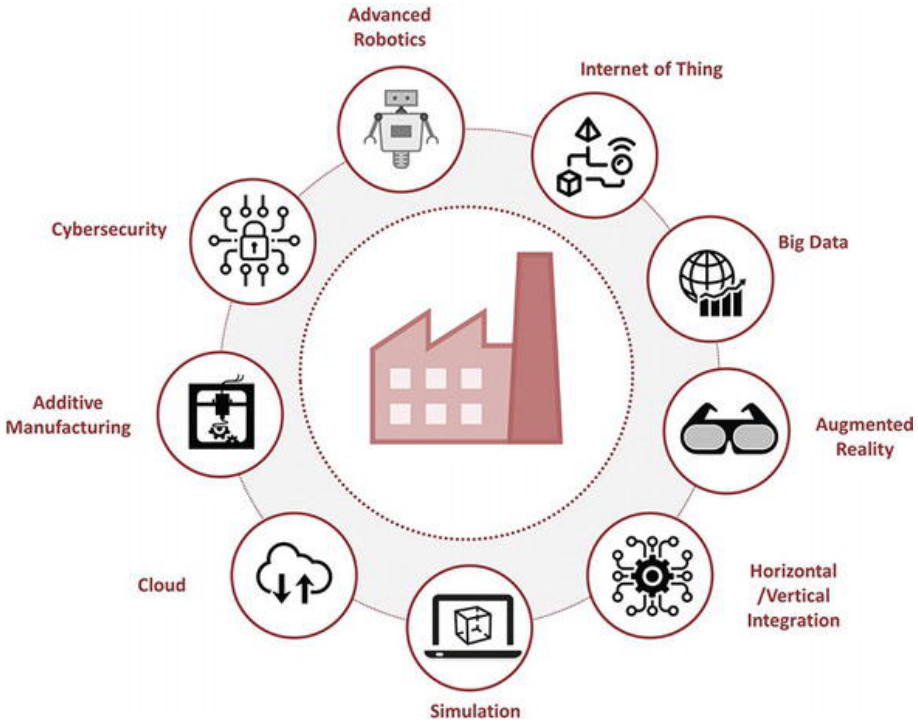

FIGURE 1
Key Enabling Technologies in the Industry 40 paradigm

HOW TO CAPTURE THE GAP AND NEEDS OF KETs COMPETENCES: DESIGN OF METHODOLOGY, TOOLS AND KEY QUESTIONS?

The first step when an analysis must be performed is to decide the methodology to apply, as well as the tools for gathering and processing the data collected. There are different methods for gathering the data: onsite and online questionnaires, seminars and workshops with teachers, students, representatives of the industry, etc. Since the target respondents are most of them familiar with ICTs, online surveys were decided as the most suitable option, Moreover, online surveys permit to reach higher audience.

Two types of survey had to be designed: for entrepreneurs/managers/CEOs of manufacturing industries and for students/researchers/teachers in HE.

In order to design the online surveys, the authors followed the recommendations of the report "developing and running an establishment skills survey", by the European Centre for the Development of Vocational Training (CEDEFOP) (Mane, 2017). This report is a practical guidance in the task of developing and implementing an establishment skills survey. It is focused for employers, but can be also applied to students/teachers.

FIGURE 2
Steps in the development and implementation of an establishment skills survey (Mane, 2017)

A brief analysis was performed for deciding which free and online survey tool available in the Internet was going to be used. Ten tools were evaluated, focused on the following indicators:

- Number of surveys: maximum number of surveys that can be launched simultaneously.
- Number of questions: maximum number of questions per survey.
- Number of responses gathered: maximum number of responses that can be gathered in each survey.
- Custom design options: level of customization in surveys: colour, format, type of questions, images, synchronization, etc.
- Data export: set of export options available.

The results of this evaluation are summarized in Table 1.

TABLE 1
Comparison of free and online survey platforms

Tool name	Number surveys	Number questions	Number responses	Custom design	Data export
Google Forms	Unlimited	Unlimited	Unlimited	Yes	Yes
Survey Monkey	Unlimited	10	100	No	No
Typeform	Unlimited	Unlimited	100/month	Yes	Yes
SurveyLegend	3 per account	Unlimited	Unlimited	Yes	No
Polldaddy	Unlimited	Unlimited	Unlimited	No	No
Survey Planet	Unlimited	Unlimited	Unlimited	No	No
SurveyNuts	Unlimited	10	Unlimited	No	No
Zoho Survey	Unlimited	15	150	No	No
Free Online Surveys	Unlimited	20	100	No	No
Survs	Unlimited	10	200	Yes	No

Google Forms was selected because it is free with no constraints about the number of surveys to create, number of questions per survey, or number of responses to collect. Moreover, it offers the possibility to automatically export the results to .xls files or to Google Sheets for online access and sharing. It also permits to add collaborators and disseminate surveys with a simple URL link. Finally, Google Forms fulfils the requirements of data collection process defined in (Mane, 2017).

The design of the surveys for industry and HE students/teachers was performed with aim of capturing two key indicators:

- To evaluate the awareness and willingness to adopt the concept of Industry 4.0 in the manufacturing industry.
- To identify the most relevant technologies that could be implemented in HE curricula.

Key questions were designed, organized in four categories, as follows:

TABLE 2
Questions' categories in industryHE surveys

	Industry	HE students/teachers
1	general information of the company and its employers	general information of the universities and their students
2	Industry 4.0 in general and its KETs	
3	current and future technologies in the companies and KETs	
4	company's opinion regarding a further HE studies focused on Industry 4.0 in the manufacturing sector	student's/teachers opinion regarding further HE degree programs focused on I4.0 in the manufacturing sector

Once the surveys were designed, they were launched in January 2019 and promoted in HE institutions with specialization in the wood/furniture/architecture/manufacturing/ICTs, etc. The survey was available for gathering data during two months. The data collected were analysed in depth. The following sections summarize the analysis performed.

ANALYSIS OF RESPONSES FROM HE STUDENTS AND TEACHERS

In the next subsections the responses from the HE are analysed, highlighting in bold the questions launched. Questions have been grouped in categories, like was explained in Table 2.

Respondent's profile

82 responses were collected from 25 **HE institutions** placed in 11 different EU countries: Austria, Croatia, Estonia, Georgia, Ireland, Germany, Italy, Poland, Portugal, Slovenia and Spain. The highest percentage of respondents correspond to Spain (38%-31 responses), Germany (37%-30 responses), and Poland (12%-10 responses).

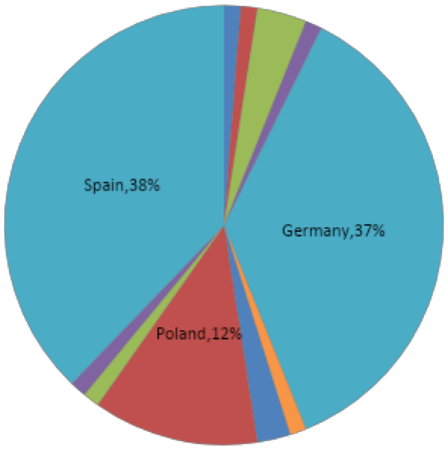

FIGURE 3
Distribution of responses from HE by countries

The **educational level** of respondents was Bachelor's degree (48.78%), Master's degree (29.26%) and Ph.D. level (13.41%). Only 8.53% of respondents have Professional Qualification or Diploma/equivalent. As can be seen, almost all of the respondents had HE studies (around 92%). Since such a small proportion of the students had a high school or VET education, the study of the entire sample was considered the only option, from the perspective of a subject who completes his or her studies and believes to be prepared for the labour market.

The **program specialization or field of expertise** of the respondents was very diverse. Respondents indicated ten different specialities. They were shortened into three topics: Wood/furniture/architecture/etc. comprises 51.21% of responses and Computer Science/ICTs/Informatics, comprise 39.2% of respondents. Other engineering and science fields are the specialization of 9.75% of respondents.

Employment interest and knowledge about KET of I4.0

Respondents were asked about their **interest in seeking employment in the wood/furniture/manufacturing industry when they complete their studies**. Only 45% of people surveyed are interested in this field. Surprisingly, these results analysed in depth show that 35.71% of respondents in a program specialization of wood/furniture/architecture, etc., are not interested in seeking employment in that sector. The reasons of that may vary, but most probably come from the fact that most of respondents are running for a HE degree, and employ in wood and furniture industry are typically known by the high percentage of low qualification jobs. However, 31.25% of respondents with a program specialization focused on ICTs, Computer Sciences or similar field are interested on that. This result could reflect the fact that the area of

expertise in ICTs is transversal to all industrial sectors, and students in this concern are open to job vacancies where they can apply their knowledge.

Respondents were asked if they think **automation and mechanization is important to manufacturing industry**. 99% think that automation is mandatory in this industrial sector. This feeling is shared by the society in general. However, although most of them are conscious about the need of transforming industry to the digital evolution through automation and mechanization, a 57% of respondents are not aware of which technologies are used in the industry presently. These results are analysed in depth to know if the field of expertise in their program specialization affects to their knowledge in that. Results, plotted in Figure 4, pointed out that the area of expertise has not influence, a priori. In fact, negative responses in the program specialization of wood/furniture have a similar result (in percentage) than those in the field of ICTs, 59.52% and 59.37% respectively.

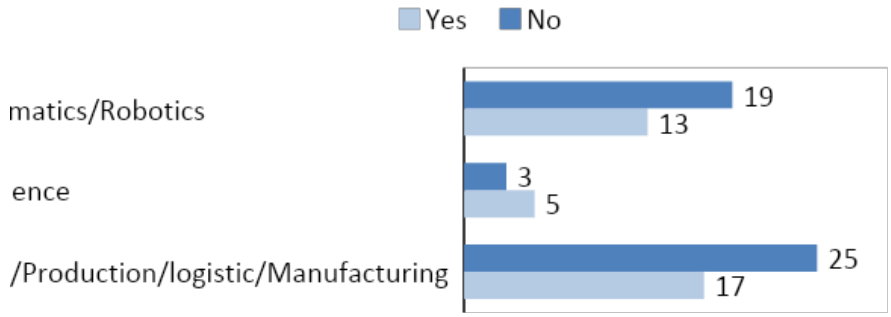

FIGURE 4
Feedback to question about if respondents are aware of automation technologies used in the industry presently, filtered by program specialization of respondents

It is quite surprising that those respondents in the field of ICTs have no knowledge about how to apply automation technologies in the industry. The study of the resulted responses has been studied in depth, where 94.37% of negative ones come from people with Diploma/equivalent or Bachelor's degree. We cannot confirm the respondents have been graded with that level of education or they are running for that. Hence, it is not unreasonable to think that those respondents have not enough knowledge about automation and new technologies if they are running the first courses of a bachelor's degree. Anyway, the lack of knowledge detected in this question could be given by other factors, not measured in this survey, such us: HE programs with obsolete contents (Bueno-Delgado et al., 2017b), contents in subjects with low examples of application in industry, respondents with no experience in industry, etc.

Those 43% of respondents that said yes to the question above, were also asked about **what technologies they are familiar with**. The results are plotted in Figure 5, and analysed following the learning branches followed by the authors in the European project IN4WOOD (Bueno-Delgado et al., 2017a): Digital and physic world hybridising, Telecommunication and data and Management systems. These are summarized in Table 3.

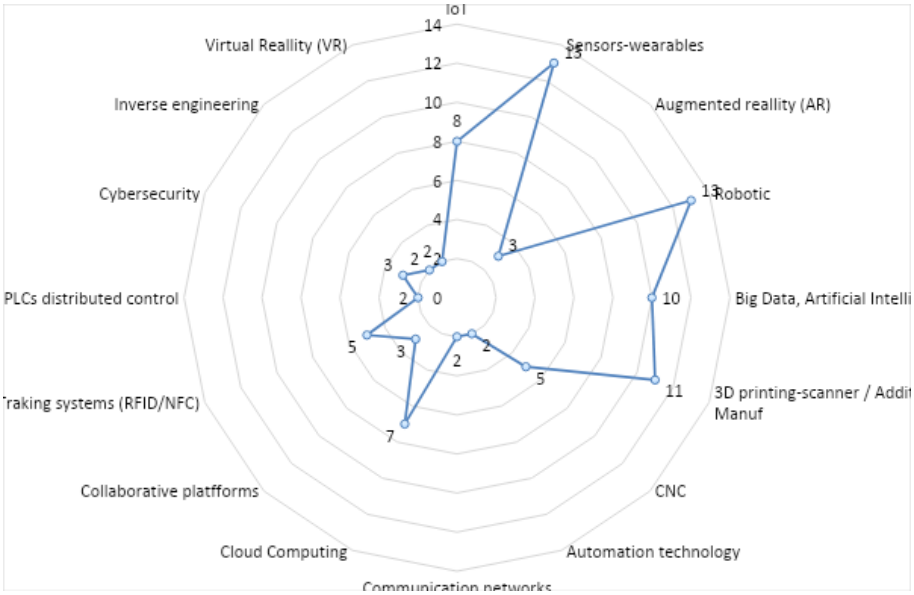

FIGURE 5
Technologies in which respondents are familiar with

TABLE 3
Summary of responses about those KETs in which respondents are familiar with

Industry 4.0 technologies	KET	Who knows
	RFID/NFC	14.28%
	Sensors-wearables	37.14%
	Augmented reality	8.57%
Digital and physic world hybridising	Virtual reality	5.71%
	Robotic	37.14%
	3D printing/ additive manufacturing	31.42%
	CNC	14.28%
	Cloud Computing	20%
	Communication Networks	5.71%
	Cyber-security	8.57%
Telecommunication and data	Internet of Things	22.85%
	Big Data	28.57%
	Artificial Intelligence	28.57%
	PLCs distributed control	5.71%
	Collaborative platforms	8.57%
Management Systems	Automation technology	5.71%
	Inverse engineering	5.71%

As can be seen, there are two KETs that are the most familiar for respondents: Robotics and sensors-wearables (37.14%). This seems obvious because both technologies are being integrated in the daily life. On the other hand, 3D-printing/ additive manufacturing is known by 31.42% of respondents. A high rate taking into account that 3D-printing is a quite new technology not included in most of HE degree programs. From these respondents, 63.63% of them are from field of expertise wood/furniture/manufacturing, which

seems normal because it is a KET more used in those sectors. The previous KET are three of the seven catalogued in the Digital and physic world hybridising. The remainder have less interest for respondents, reaching 14.28% RFID/NFC and CNC, and virtual reality (VR) and augmented reality (AR) only 5.71% and 8.57% respectively. These last results seem coherent because these are emerging new technologies, missing in almost all HE degree programs. In the range between 20%-29% are found most of KET focused on Telecommunication and Data, but cyber-security and communication networks decrease up to 8.57% and 5.71%. These values show that people are familiar with IT but not from the technical point of view.

Finally, all KET in Management system classification, have a rate lower than 10%. This result could come from the fact that these technologies are not usually taught in conventional HE degrees, but in specialized courses.

Respondents were also asked about if **they are familiar with the principles of I4.0 in general**. 66% said yes and 34% no. Results have been also filtered by field of expertise, with the aim of extract conclusions about if this is a topic more promoted in specific sectors, confirming that in the field of ICTs, the I4.0 principles are known (71.87%) more than in Wood/Furniture/manufacturing field (64.28%) or other fields of expertise like chemistry, bioscience, industrial engineering (50%).

Respondents were asked about if **they believe that I4.0 is applicable to the wood/furniture/manufacturing industry**. Results show that, although a notable amount of respondents are not familiar with the principles of I4.0, most of them (96%) think that I4.0 can be applied to these sectors. Only three respondents, with field of expertise different from wood/furniture/manufacturing industry, think I4.0 is not applicable to that sectors.

Contents in current HE degree programs and future of I4.0 in HE

In this section, responses about the **contents of the current HE degree programs in topics related with I4.0** and wood/furniture/manufacturing field are analysed, as well as the interest of respondents in a HE program focused on I4.0, and what teaching-learning mode is the most desirable.

One of the goals of this question is to detect if current HE degree programs include those key contents focused on KETs, needed to address the industrial revolution, as well as contents focused on wood/furniture/manufacturing industry. Moreover, this question tries to know the level of knowledge of students/researchers in those topics. This will help to identify gaps in the current European HE degree programs and competences of students.

First, respondents were asked about which topics are addressed in their current study programmes and the level of knowledge required, with five options: not addressed, low level, basic knowledge, advanced level and expert level. Seventeen topics were included in the survey for being selected by respondents. For the analysis, they were organized regarding the close relationship between the topics into:

- Topics focused on wood/furniture/habitat: wood science, wood and material processing, wood production and management, Ecodesign.
- Topics focused on KET of I4.0 (no management systems): Cloud Computing, IoT, ICT/Networking, AR, CAD/CAM/3D printing, Additive manufacturing, Simulation, Robotics.
- Topics focused on enterprises: management, integration, surveillance: Lean Manufacturing/MRP, Risk Analysis, System Integration, Low Cost Automation, System Management, Technological Surveillance and Competitive Intelligence.

% of responses are summarized in Table 4 as follows:

TABLE 4
Summary of responses about the contents of the current HE degree programs in topics related with I4.0

		Low level / Not addressed	Basic level	Advanced level /Expert
Topic wood/furniture/design/etc	Wood and material processing	53.65	28.06	18.29
	Wood production and management	60.97	19.51	19.51
	Ecodesign	56.09	21.95	21.95
Topics focused on KET of I4.0 (no management systems)	Cloud Computing / IoT	41.46	23.17	35.36
	ICT / Networking	43.90	21.95	34.14
	AR	60.97	31.70	7.31
	CAD/CAM/ 3D printing	35.36	20.73	43.90
	Simulation	47.56	30.48	21.95
	Robotics	64.63	29.26	6.09
	Additive Manufacturing	59.75	34.14	6.09
	Lean Manufacturing / MRP	64.63	29.26	6.09
	Risk Analysis	41.46	41.46	17.07
Topics focused on KETs of I4.0 regarding management system and integration in enterprises	System Integration	47.56	30.48	21.95
	Low Cost Automation	68.29	25.06	6.09
	System Management	42.68	40.24	17.07
	Technological Surveillance and Competitive Intelligence,	65.85	21.95	8.2

A deep analysis of results in topics focused on wood/furniture/design shows that the option not addressed is chosen in all topics by a high percentage of respondents. It seems coherent because 48.78% of respondents have a program specialization different from these topics, that is, Engineering, Computer Science, ICTs, informatics, etc. On the other hand, those respondents in the field of expertise of wood / furniture / habitat industry (51.22%) pointed out they have advanced level or expert level in most of those topics; concretely between 42.85% and 61.90% of them.

A deep analysis of the results in topics focused on KET of I4.0 (no management systems) show that, although 39.02% of respondents are in HE programs with specialization in ICTs and technologies close to KET in I4.0, most of them don't acquire knowledge in those competences at high level. Moreover, those respondents in the field of wood /furniture/ habitat (51.21%) are typically familiar with technologies in the field of CAD / CAM/3D Printing, while those in the field of ICTs/Computer Science/Informatics (48.78%) are close to those topics in Cloud Computing / IoT / ICT / Networking, etc.

A deep analysis of the results in topics focused on KET of I4.0 (management system) show that most of topics have a low rate in advanced and expert level and have low and basic level gets (joined) in more than 50% of responses. In this set of results, seems that the field of expertise of respondents do not affect to the level of knowledge in most of topics, except Low Cost Automation, System Integration and System Management, where respondents of ICTs/Computer Science/ etc. are more familiar with.

Finally, two questions were launched with the aim of gathering their **opinion about to be enrolled in a HE degree program which includes contents about I4.0 KETs and what type of teaching-learning mode is the most suitable for them**.

Results showed that 78.04% of respondents could be interested in a further degree in M.Sc. program focused on I4.0. On the other hand, about teaching-learning mode, 52.43% of respondents prefer as first option, online while 15.85% prefer combination (face-to-face, online) and only 9.75% prefer on-site.

Regarding the scheduler of the program, 14.63% of respondents prefer modular-based, and 3.65% prefer to be scheduled in weekends. Finally, only 3.65% of respondents prefer a research-based program.

ANALYSIS OF RESPONSES FROM INDUSTRY

Respondent's profile

100 responses were gathered from workers in the European industry. The position of the respondents was very varied (see Figure 6): Sales Manager with 26% of the respondents, followed closely by the CEO with a 25% and followed by far in third place by 9% of Marketing Managers. The first two categories represent approximately 50% the ones who participated in the survey. Managerial positions (Product Manager, Project Manager, Sales Manager, Financial Manager) predominate with 57% of responses whereas remaining 33% held executive positions and 10% technical positions.

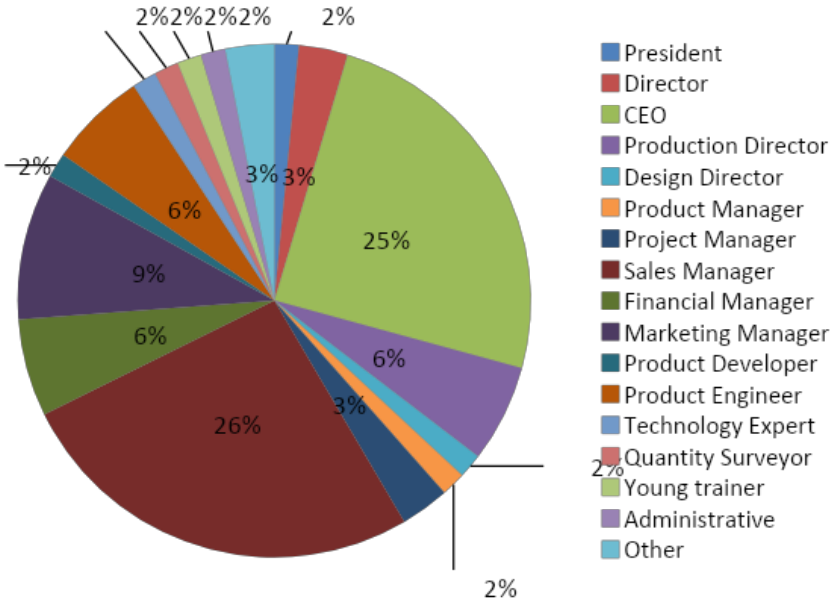

FIGURE 6
Distribution of responses by position of respondent

Respondents were also asked about their **education level**. Half of respondents had Diploma degree or equivalent educational background whereas 30% had additionally a Bachelor degree. 15% of respondents had a Master level and only 5% held a doctorate. Therefore, the respondents were equally distributed between those with university degree and those with non-university degree.

When asked for their courses or **specialization programs** their responses were very dissimilar (Figure 7). The answers indicated up to 10 different categories ranging from technical categories (i.e. 40% indicated sectors such as design, engineering or ergonomics) to business categories (60% indicated financial, marketing, human resources or management).

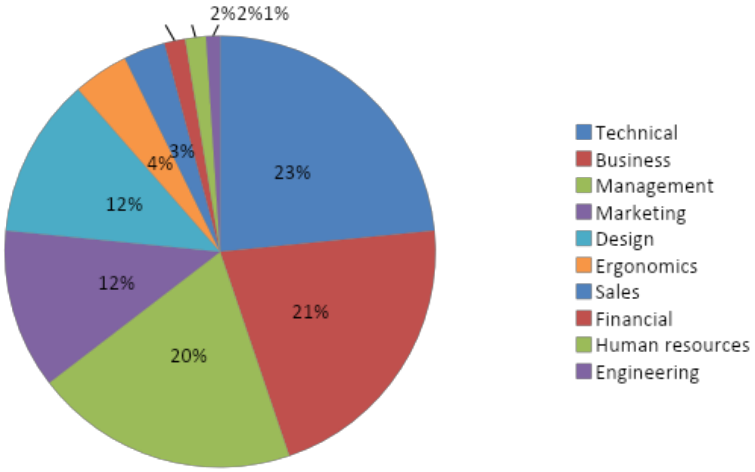

FIGURE 7
Program specialization of respondents

Respondents' opinion about training and I4.0 in companies

The opinion of respondents on the **training needs and the concept I4.0** in the companies was also analysed (Figure 8). Support for training and education of employees among those surveyed is remarkable enough since 63% indicated Yes while 37% said No. Many of respondents were familiar with the concept of I4.0 (with a 72% claiming to know it) and firmly believe that it is possible to apply it to the wood and furniture manufacturing

To those who answered positively to the previous question, were also asked to specify a bit more the reason for his belief. The results are shown in Figure 9. About one-third of those surveyed, they expected an increased productivity of its manufacturing processes and an increase in benefits. Also, a quarter of them indicated the possibility of introducing new products and opening up new markets (innovation in general) while one out of five respondents indicated as positive the development of the industry in general. Surprisingly few of them pointed out to cost or workforce reduction.

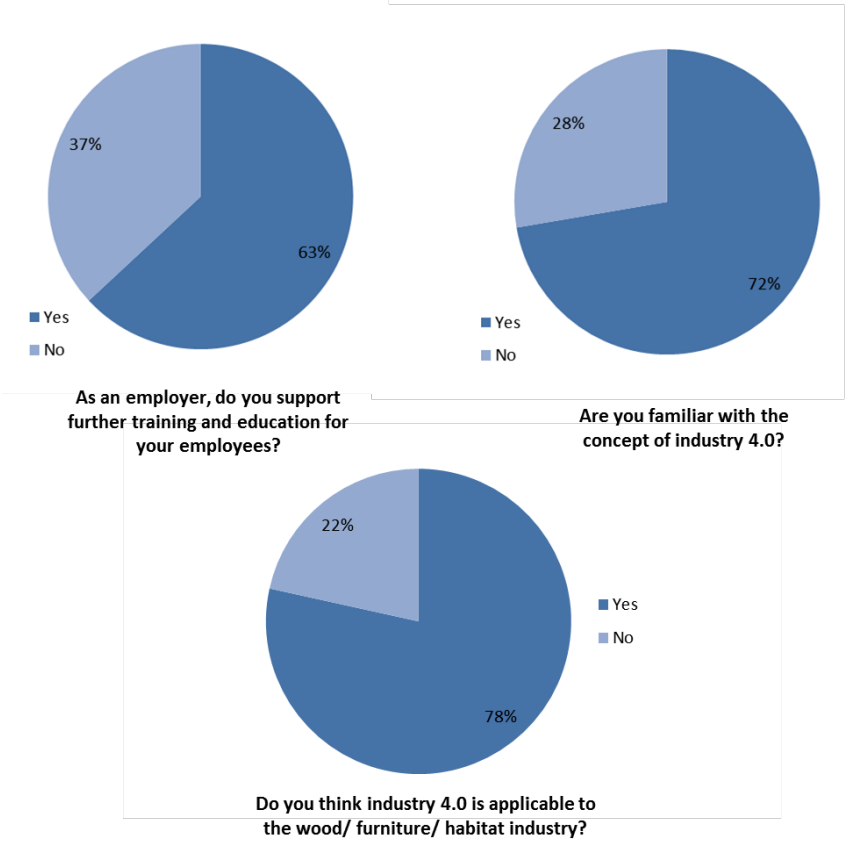

FIGURE 8
Distribution of responses by educational level

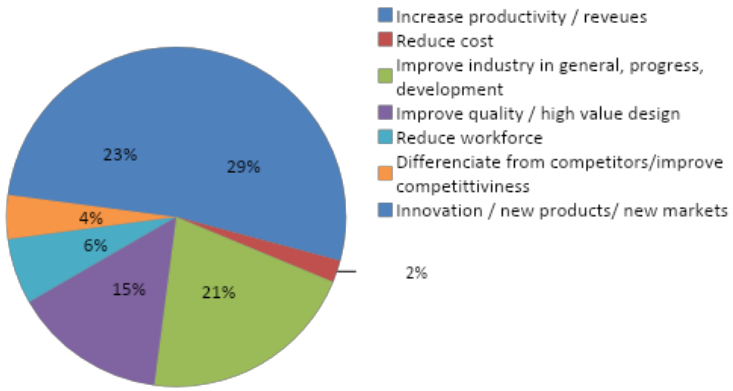

FIGURE 9
Reasons for applying I4.0 to wood/furniture/manufacturing industry

Those who replied negatively were asked to know the reason of their answer. The results were the difficulty of implementation (35%), especially in small factories with traditional production methods, followed by the concern on the lack of knowledge and skills for workers and managers (17%). 12% claimed that I4.0 requires larger investment and has no added value for small factories. This analysis is displayed in Figure 10.

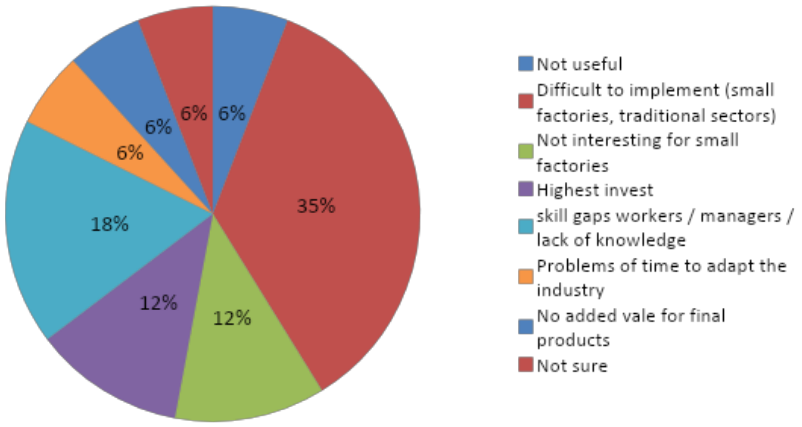

FIGURE 10
Reasons for not applying I4.0 to wood/furniture/manufacturing industry

Company profile

65 companies were collected from 9 different **EU countries**: Bulgaria, France, Germany, Italy, Slovenia, Spain, Sweden, Poland and United Kingdom. Majority of respondents (72%) came from only three countries: Spain, Italy and UK with 37%, 23% and 22% respectively. Surprisingly, fewer responses were obtained in comparison from countries with a strong wood, furniture and manufacturing industry such as Poland, Germany or Sweden.

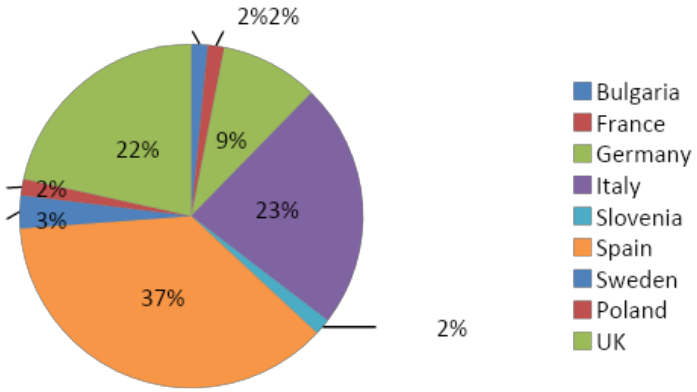

FIGURE 11
Distribution of responses from countries in the wood/furniture/manufacturing industry

Size of the companies is also gathered. Small businesses with less than 50 employees (25 replies, 38% of respondents) and companies of medium size (19 companies, 29% of respondents) are the main components of the businesses surveyed. These companies (67% of total) are fairly representative of the size of this sector in European companies. Also draws attention a significant number of micro-enterprises with less than 10 employees (23%). However, large companies with more than 250 employees were only 10% of respondents in this survey.

With regards to the **type of products manufactured** by these industries a significant majority of respondents were engaged in furniture fabrication (40%) followed by the sector of the upholstery (20%), chairs manufacturers (9%) and wood/furniture/manufacturing (8%).

On the other hand, 52% of respondents do **business** both in the **domestic and international markets**, 36% are devoted exclusively to the domestic market and the lowest proportion is businesses that are dedicated only to export (12%).

With regards to the **formal education level of employees**, the results gathered, summarized in Figure 12, show that in companies with 0-99 employees, the percentage of graduates is 29.25%; 27.96% in companies with 100-199 employees; and when the number of employees increase, the rate decreases down to 16.06% (200-299 employees) and 17.64% (300-399). Regarding big size companies, only three companies with 400 employees or more answered, indicating that all of their employees are graduated. Although it could be true, the authors believe that the veracity of this answer should be double-checked because it could be possible that the respondents were not understand that graduate in this case refers to HE level.

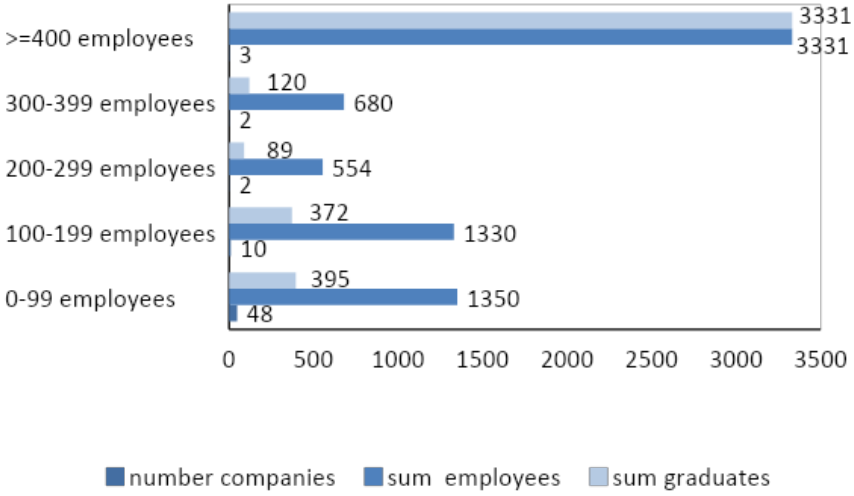

FIGURE 12
Results to question "how many employees have formal education/graduates in your company?"

Companies' adoption to I4.0 and training support

In this section, the degree of adoption and training support of Industry 4.0 is surveyed and discussed. Survey respondents were asked about **which of the I4.0 technologies were already implemented in their respective companies**.

Results are shown in Table 5 and analysed in detail. Three technologies were considered "important" or "very important" for the sector: Cloud Computing/Internet of Things, Automation and Mechanization and Materials Processing with 70% of answers each one. These technologies were important enough to be implemented in their businesses already. On the other side some of these technologies were regarded as "least important" or "less important" for the sector: They were Risk Analysis (35% of both answers), System analysis (31%) and CAS/CAM/3D printing (29%).

TABLE 5
Summary of responses about the KETs in use in the industry

		Important / very important % (in use)	Neutral/less/least important, % (not in use)
Topic wood/furniture/design/etc.	Wood and material processing	55.38	44.61
	Automation and Mechanization	70.76	29.23
	Ecodesign	41.53	58.46
	Cloud Computing / IoT	70.76	29.23
	ICT / Networking	49.23	50.76
	AR	58.46	41.54
Topics focused on KET of I4.0 (no management systems)	CAD/CAM/ 3D printing	30.76	69.23
	Simulation	46.15	53.84
	Robotics	46.15	53.84
	Additive Manufacturing	44.61	55.38
	Lean Manufacturing / MRP	58.46	41.53
	Risk Analysis	38.46	61.53
Topics focused on KETs of I4.0 regarding management system and integration in enterprises	System Integration	30.76	69.23
	Low Cost Automation	53.84	46.15
	System Management	49.23	50.77
	Technological Surveillance and Competitive Intelligence,	61.53	38.46

Respondents were also inquired by the **technologies that they considered essential to be implemented in the next 5 years**. Results are illustrated in Table 6. In bold are remarked all KETs with more than 70% of responses with high priority. Respondents identified as "important" or "very important" (86% of both responses) KETs such as Robotics, Automation and Mechanization (82%) and Augmented Reality (75%). This could give us a clue in the areas of training that the sector will need for upcoming graduates. At the other extreme, enterprises considered with a big difference (46%), that the knowledge in Wood Science will be “less important” or “least important” to the sector. This result is striking, because apparently, in this new era this knowledge seems that it will be relegated to the HE environment and it will not be strictly necessary for industrial practice.

TABLE 6
Summary of responses about the KETs essentials to be implemented in the next 5 years

		Important / very important %	Neutral / less important %
	Wood Science	44.61	55.39
	Wood Products and Manufacturing systems	78.46	21.54
Topic wood/furniture/design/etc.	Wood and material processing	61.53	38.47
	Automation and Mechanization	81.53	18.47
	Ecodesign	83.07	16.93
	Cloud Computing / IoT	78.46	21.54
	ICT / Networking	70.76	29.24
	AR	75.38	24.62
Topics focused on KET of I4.0 (no management systems)	CAD/CAM/ 3D printing	76.92	23.08
	Simulation	53.84	46.16
	Robotics	86.15	15.85
	Additive Manufacturing	78.46	21.54
	Lean Manufacturing / MRP	64.61	35.39
	Risk Analysis	44.61	55.39
Topics focused on KETs of I4.0 regarding management system and integration in enterprises	System Integration	58.46	41.54
	Low Cost Automation	52.3	47.7
	System Management	84.61	15.39
	Technological Surveillance and Competitive Intelligence,	89.23	10.77

When they were asked if they would **support their employees if they decide to pursue a program about Industry 4.0** the response was nearly unanimous: 89% of respondents said yes and only 11% said no. This response encourages us to think that the results of this program will be of great interest to the sector and that any training resulting from it will have an acceptable demand.

Respondents were also asked about **which areas should be the priority focus on the development of new training programs**. These results are shown in Table 7. In bold are remarked all KETs with more than 70% of responses with high priority. As can be seen, the respondents gave priority to matters such as Additive Manufacturing, Robotics, Ecodesign and Augmented Reality, with more than 90% of respondents.

TABLE 7
Summary of responses about which KETs should be a priority on the development of new training programs focused on I4.0

		Important / Very important %	Neutral / Less important %
Topic wood/furniture/design/etc.	Wood and material processing	75.38	24.62
Topics focused on KET of I4.0 (no management systems)	Automation and Mechanization	90.62	9.38
	Ecodesign	89.23	10.77
	Cloud Computing / IoT	87.69	12.31
	ICT / Networking	76.92	23.08
	AR	89.23	10.77
	CAD/CAM/ 3D printing	80	20
	Simulation	50.76	49.24
	Robotics	90.76	9.24
	Additive Manufacturing	92.3	7.7
	Lean Manufacturing / MRP	76.92	23.08
	Risk Analysis	56.92	43.08
Topics focused on KETs of I4.0 regarding management system and integration in enterprises	System Integration	44.61	55.39
	Low Cost Automation	58.46	41.54
	System Management	84.37	15.63
	Technological Surveillance and Competitive Intelligence,	86.15	13.85

Finally, Table 8 shows a comparison about the opinion of industry in the three previous questions. Only "important or very important" results. are compared. The goal is to understand if there is a relationship between whether the technology in use is also demanded to be trained, or just in case the technology is expected to be implemented, then must be trained.

There are some technologies that, although are in a high percentage in use or are promoted to be implemented, are also considered to be trained due to their importance. They are: Automation and Mechanization, Cloud Computing, ICT, ICT/Networking, AR, 3Dprinting, System Management and Technological Surveillance.

TABLE 8
Comparison of responses from industry about KETs implemented, KETs to be implemented, and KETs to be trained

		In use %	To be implemented %	To train %
Topic wood/furniture/design/etc.	Wood and material processing	55.38	44.61	75.38
	Automation and Mechanization	70.76	78.46	90.62
	Ecodesign	41.53	61.53	89.23
	Cloud Computing / IoT	70.76	81.53	87.69
	ICT / Networking	49.23	83.07	76.92
	AR	58.46	78.46	89.23
Topics focused on KET of I4.0 (no management systems)	CAD/CAM/ 3D printing	30.76	70.76	80
	Simulation	46.15	75.38	50.76
	Robotics	46.15	76.92	90.76
	Additive Manufacturing	44.61	53.84	92.3
	Lean Manufacturing / MRP	58.46	86.15	76.92
	Risk Analysis	38.46	78.46	56.92
Topics focused on KETs of I4.0 regarding management system and integration in enterprises	System Integration	30.76	64.61	44.61
	Low Cost Automation	53.84	44.61	58.46
	System Management	49.23	58.46	84.37
	Technological Surveillance and Competitive Intelligence,	61.53	52.3	86.15

CONCLUSIONS

In this work a depth analysis have been performed to know the lack of skills, knowledge and competences of the KETs of I4.0 in students and workers in EU and to detect if it is necessary to perform training about the KET in HE. The work has been carried out through the study of responses from 82 students from different European countries. The study does not distinguish between men and women, which could be an interesting indicator to extract the digital gap between sex roles as well. This could be addressed in further analysis. Almost 92% of respondents are HE students (Dipl., Msc, PhD). The remaining 8% of respondents, with VET degree, were also included in the study, because they could give useful information about those also ready for the labour market

The results extracted showed that the lack of skills, knowledge and competences is a fact, and the need of training in those KETs of Industry 4.0 is mandatory, at least in HE for manufacturing sector. If future workers and industry want to be ready for the I4.0 revolution, both must work together under the same goal: to promote the training in the KETs of I4.0. This is only possible if HE and VET institutions design training degrees (official or unofficial) with the learning outcomes, path and contents for having future competitive workers and companies, with the skills and competences demanded by the globalized world. The European project MAKING 4.0 has set this as the starting point for designing a new Master degree focused on I4.0 in the wood and furniture sector in Malaysia.

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Additional information

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