Co-funded by the
Erasmus+ Programme
of the European Union

INDUSTRIAL EXPERT COMPETENCE PROFILE

By INDEX project

Acronyms

Desk Research	D
Intellectual Output	IO
Industry 4.0	I 4.0
Knowledge, Skills and Competences	KSC
Online Survey	O
Phone Interview	I
Project Management	PM
European Qualification Framework	EQF
Skills, Knowledge and Competencies	SKC
Small and Medium Enterprises	SMEs
Vocational Education and Training	VET

Table of Contents

List of Tables and Figures

1. Introduction

This Intellectual Output (IO) 1 Industrial Expert 4.0 Competence Profile (hereinafter the Profile) is designed within the project "INDEX - industrial expert" funded under the Erasmus +, Key Action 2 Cooperation for innovation and exchange of good practices. The INDEX project aims to develop an e-learning educational resource for professionals in application-oriented areas to learn innovative solutions of Industry 4.0 concept.

In particular this paper is an open and flexible tool, the result of field and desk research, which outlines the professional figure of the Industry 4.0 (hereinafter I 4.0) expert, its training objectives, job opportunities, relevant applications in companies and areas of work.

The Profile is based on a detailed study that helps to identify more specific needs regarding I 4.0 technologies and product/process innovation management in companies, branch association and consulting firms and to precisely define these needs and aspirations in each partner country.

The completed Profile is fully structured according to ECVET and serves the fundamental basis for structures in learning outcomes (e.g., what an INDEX trainee should look like, understand and be able to do on completion of the learning process in terms of knowledge, competence, skills, and attitude).

During the designing phase of the Profile, unforeseen changes were pursued regarding the ECVET guideline that was foreseen as a part of the Industrial Expert Competence Profile. Updating was done according to the "Council Recommendation of 24 November 2020 on vocational education and training (VET) for sustainable competitiveness, social fairness and resilience 2020/C 417/01"

The ECVET recommendation has been repealed and ECVET principle have been included in the Council Recommendation of 24 November 2020 on vocational education and training (VET) for sustainable competitiveness, social fairness, and resilience 2020/C 417/011. The Recommendation states that "During the ten years of its implementation, ECVET has largely contributed to the development of a better-quality mobility experience through the use and documentation of units of learning outcomes. However, the concept of ECVET points has not been generally implemented and ECVET has not led to the development of a European credit system in vocational education and training. Therefore, for vocational qualifications at post-secondary and tertiary levels, the European Credit Accumulation and Transfer System already in use can be applied. This Recommendation replaces the Recommendation of the European Parliament and of the Council of 18 June 2009 on the establishment of a European Quality Assurance Reference Framework for Vocational Education and Training (EQAVET), and the

[1] Council Recommendation of 24 November 2020 on vocational education and training (VET) for sustainable competitiveness, social fairness and resilience 2020/C 417/01

Recommendation of the European Parliament and of the Council of 18 June 2009 on the establishment of a European Credit System for Vocational Education and Training (ECVET).

In light of this change, that occurred while the INDEX project was already taking place, the coordinating committee, advised by experts from CEDEFOP and the German National Agency, decided to not to assign ECVET points as obsolete, but to indicate in the final certificates issued to the students, the description of the KCS obtained and the EQFs achieved at the end of their training.

Based on the first-hand official information from CEDEFOP the ECVET principle has been repealed and included in the Council Recommendation of 24 November 2020 on vocational education and training (VET) for sustainable competitiveness, social fairness and resilience 2020/C 417/01. Hence, the Profile was adapted to the European Qualification Framework (EQF) including Knowledge, Skills and Competences (KSC) that corresponds with the objectives of the Profile.

The innovative approach is the focus on necessary, practical skills, rather than demands in theoretical knowledge. The Profile describes key activities (units of competence) for each activity, skills and knowledge needed: *Augmented Reality/Virtual Reality; Sensors and Automation; Additive Manufacturing; Internet of Things; E-TRIM.*

The paper starts from a discussion on the Industrial expert within 4th Industrial Revolution and then examines the competence profile from the concept and development point of view. It is followed by the main activities performed by the Industry 4.0 experts and how the smart technologies implementation process looks like. Despite of the established benefits of the I 4.0, the paper looks into challenges caused by Industry 4.0 related technologies implementation as well. Furthermore, there is a description of the Competence elements needed to perform main activities. Before going the description of the gained results during the online survey, phone interview and desk research, the current paper sates the identification strategy, methods and limitation of the research. It is summarised by the competence elements mentioned throughout the paper, elaborated competence profile and findings as a conclusion.

1.2 Why Industrial expert 4.0?

I 4.0 is not only technology and of the transformation of the production line. It includes the digital transformation of the whole business as such. This implies that companies must rethink a*) the digitization and integration of vertical and horizontal value chains and b) of the business model in general by optimizing the customer interaction and access.* This is an important shift from a linear, sequential supply chain operation to an interconnected, open system, known as the digital supply network, that will lay the foundation for how companies compete in the future. This applies as well to SME manufacturers [2].

Furthermore, I 4.0 is the new industrial revolution as a worldwide implementation of cyber physical systems in manufacturing processes, which are not only in charge for certain manufacturing stages but are able to monitor and optimize manufacturing processes completely on their own. The rapid pace of technological development makes it almost impossible for existing vocational education and training to provide adequate and timely solutions. All studies concerning the future development of I 4.0 state a fundamental change of tasks and requirements in the working world[3].

Thus, it is vividly shown that there is a need for the implementation of corresponding technologies and the use of market options in practice is to build a digital culture and **hire, train, retrain the personnel in the field of Industrial expert 4.0**. Irrespective of numerous technical innovations, learning in the field of VET often continues to take place in the classical analogue way.

This document is aimed to address this problem by designing the Industrial expert 4.0 Profile that is based not only on the I 4.0 requirements, but on demands of companies in partner countries and other target groups presented underneath.

Target groups:

- Companies, in particular SMEs, engaged in modern technology or related industries, and relevant key staff in those industries, e.g., project managers, business development managers, innovation managers. Professionals of companies and enterprises that are already using I 4.0 technologies and equipment for certain areas of application but are interested in exploring the new areas of application.
- Professionals interested in opportunities to apply I 4.0 technologies in their area of expertise. The course will provide them with practical skills to make use of I 4.0 technologies in their areas of expertise and lead to a strategic labour market advantage and a competitive advantage for their company.

[2] https://stumejournals.com/journals/i4/2018/3/130.full.pdf
[3] https://vet-4-0.eu/CompetencesProfile.html

- Intermediaries and intermediary organizations, professionals (including managers) of business development departments, who are interested in opportunities and I 4.0 technologies relevant to their area.
- Tertiary/post-tertiary graduates- in the fields of mechatronics, design, medical technics, engineering, architecture, natural sciences, medicine, who are willing to enhance their knowledge and skills base before starting their career in industry.
- Trainers and lectures who want to design and offer qualified advanced training courses on I 4.0 technologies for companies, professionals associations and educational institutions.
- VET providers – training and apprenticeship centres, VET-colleges, etc.
- Other stakeholders: regional development agencies, political decision makers, chambers of commerce and industry, industrial associations, foundations relating to I 4.0 capital investors, patent attorneys etc.

1.3 The concept of competence

The concept of competence as such has reached a great attention during the past decades and has appeared as the most arguable ongoing topic in management literature.

Various researchers provided different definitions over the years. The first definition of competencies was delivered by McClelland, who defined a competency as "a personal trait or set of habits that leads to more effective or superior job performance". Later, Klemp defined a competency as "an underlying characteristic of a person, which results in effective and/or superior performance on the job". With regards to Spencer and Spencer, "competencies are skills and abilities; things you can do; acquired through work experience, life experience, study or training". Bartram, Robertson and Callinan state that competencies are "sets of behaviours that are instrumental in the delivery of desired results or outcomes".[4]

The concept of competence used to design the Profile is based on empirical findings (*see 2.2.2 Methods*), rather than on theoretical statements due to its debating nature. As well as on unified KSC approach and recommendation of the European Parliament and of the Council of 23rd April 2008 on the establishment of the European Qualifications Framework for Lifelong Learning:

"Learning outcomes" means statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence.

[4] https://www.wi2017.ch/images/wi2017-0262.pdf

These terms have been defined as follows in the same Recommendation on KSC:

- "knowledge" means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories, and practices that is related to a field of work or study
- "skills" means the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive or practical
- "competence" means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.[5]

1.4 Why Industrial Expert competence?

Since, this document has an empirical purpose to be used for supporting development of MOOC -based open educational resources on I 4.0 and focused on professionals in application-oriented areas, it is not possible to define the absolute industrial expert competence that would fit the needs of all target groups. Otherwise, lots of variables shall be considered that differ from company to company, such as organizational strategy, skills need, organizational environment, workforce segments.

Thus, the industrial expert competence profile shall focus on **key factors in I 4.0 and core competencies for industrial experts to perform tasks effectively and efficiently in the area of I4.0.** It is done by analysing the broad spectrum of competencies on **functional level** based on organizational needs. There is no defined list of skills for fulfilling a certain task. Moreover, there is an overview of the industrial expert competencies that should be taught to individuals to work successfully in I4.0.

2. Development of the competence profile

Defining the competence in the previous chapters follows that the Profile is a document that captures and identifies the competencies for a given work function. The aim of a competency profile is to identify the KSC (knowledge, skills, and competence) required to be able to perform I4.0 work.

Competence profiling is the process of selecting I 4.0 relevant competencies at a specific level of proficiency required for successful performance in I 4.0. Thus, to collect an input data for analyse and selection relevant I 4.0 competences, an **online surveys and phone interviews were** conducted in partner countries.

[5] https://eurspace.eu/ecvet/pedagogicalkit/framework-for-defining-learning-outcomes-knowledge-skills-competence/

To design the Profile, it is important to understand what specific tasks are asked of an employee in each position. Here, it is crucial to underline the difference between task and competence. A task is a function to be performed, something that must be done. Whereas **competencies are related to ability to perform that task in an efficient way**.

Thus, to develop the Profile, **desk research** was conducted as well, where job descriptions, tasks and responsibilities required for the I 4.0 are identified and defined.

2.1 Main activities to perform by Industrial expert

A very wide range of activities and skills is required for implementing I 4.0. There will no longer be the traditional clear division of labour in manufacturing. There will be new operational and organisational structures requiring more decision making, coordination, control, and support services – a much more complex environment. There will also be a need to coordinate between virtual and real machines and plants in production management systems.[6]

Regarding to the implications of the I 4.0 development to the structure and contents of occupations and work processes, firstly there can be discerned emergence of the new technological processes, such as:

- Digitalisation and virtualisation of industrial production by applying and developing of cyber-physical systems
- Networking of all processes of production and logistics aimed to optimize the usage of resources, reduce the costs and increase the effectiveness of production process and its capacity to serve to the needs of customers
- Individualisation of the production process and increasing its flexibility through direct involvement of customers and users in the design and production process, what leads to the integration of production and consumption processes (prosumers)
- Facing new challenges and problems of safety and security of society and economy
- More intensive and close integration of the production and transport /logistics systems, what can reduce the demand of intermediating occupations in these fields
- Planning, design, and implementation of the intelligent work processes. It is also related to the changing understanding of the production process from the isolated and narrow understanding of process executed by the concrete groups of operators to the distribution of the know-how on the equipment and materials, expanding of the understanding of the partial production processes and their

[6] https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

interrelations leading to the holistic understanding of all work and business processes in the chain of production
- Changing of the quality assurance and management of the production process

In general, this means that there are significantly higher demands placed on all members of the workforce in terms of managing complexity, higher levels of abstraction and problem-solving. Employees will be expected to act more on their own initiative, have excellent communication skills and be able to organise their own work.

2.1.1 Overall smart technologies implementation process

Nowadays, the industry is facing considerable challenges. These are competition among global companies, individualised approach demanded by customers, products with shorter lifecycle. Industrial revolution 4.0 aims to deal with those challenges and includes technologies that will meet the new needs. Smart factory is a central concept in I 4.0, which involves smart technologies of various kinds[7]. Such as *augmented reality technology, 3D printing, internet of things, sensors and automation technology* and other areas. Implementing such technologies shall improve efficiency, effectiveness, quality, and productivity of manufacturing processes. At the same time, utilising smart technologies brings challenges for companies to integrate them into the implementation process. One of the major reasons is insufficiency of the I 4.0 industrial expert competencies of workforce performance.

Implementation process of smart technologies brings main benefits, such as:

- Efficiency. Smart technologies use data to understand how to improve the implementation. It analyses an ongoing process to deliver better results.
- Convenience. Smart technologies are designed to understand preferences and to personalise services.
- Sustainability. The use of smart technologies helps to avoid high energy costs and ensure a "green" approach for industrial and domestic sectors.
- Security. Smart technologies make data secure, usable, and substantial.

Thus, the key is smart technology integration and establishing an implementation process. It consists of following steps:

1. Awareness. Raise awareness of smart technology.
2. Strategy. Define improvement points, e.g. improved efficiency, shorter product lifecycle, increased quality.

[7] http://www.iiis.org/cds2009/cd2009sci/imeti2009/PapersPdf/F788TV.pdf

3. Framework. Evaluate existing IT infrastructure and identify which and how smart technology shall be adopted in the implementation process.
4. Invest. Involve an industrial expert into the implementation process or provide the relevant training for the personal to gain necessary competence.

Implementation of smart technology by a company depends on its ability to respond to change and innovation management and financial capacity. In that respect, the I 4.0 industrial expert profile shall provide the sufficient overview on the competences needed to fulfil the above-mentioned 4th step.

2.1.2 Challenges caused by Industry 4.0 related technologies implementation

As it was described in the previous chapter, Industry 4.0 is coming fast to the companies' world that must adopt their processing and integrate smart technologies. Although the benefits of Industry 4.0 are well established there are still challenges involved.

For a developed country, the implementation of 4.0 systems involves several challenges:

- The need for experimentation and learning, to give a way for companies to strengthen their business
- Data explosion, to send information more and more quickly and increase data volume
- Transformation of the workforce, integrating the system operators with new skills that enable it to manage work digitally with the help of cyber-physical systems.[8]

This paper tackles the last point by identifying the competences of the industrial expert as well as providing a solution by designing the INDEX – Industrial Expert 4.0 course.

Moreover, there are major stages required to ensure appropriate skills of industrial 4.0 expert defined in the 4th Industrial Revolution: *Current Practices, Challenges, and Opportunities:*

1. School. To attract attention and raise awareness of computer science as well as smart technologies already at school to give a glance on the future possible work.
2. University. To ensure professional development courses and workshops to provide technical qualification to future workers. The collaboration of university

[8] https://www.intechopen.com/books/digital-transformation-in-smart-manufacturing/fourth-industrial-revolution-current-practices-challenges-and-opportunities

companies that allows them to adapt the student profiles with the demands of the companies is very important. Students will be in contact with companies through their university. Developing professional bachelor's degrees to train the intelligent factory operator and give more insights than those already provided in high school and to develop technical skills and soft skills.

3. Continuous Professional Development. It involves the training of the employees in the workplace. Companies can only be competitive by investing in continuous training and improvement. Nevertheless, the prices for the training courses might be out of the financial range for the SMEs.

Considering all above listed, **Industrial Expert 4.0 Competence Profile** along with the **INDEX – Industrial Expert 4.0 course** are seen as the crucial source not only by its content but by its affordability.

2.2 Competence elements needed to perform main activities

New activities brought by the I 4.0 and implementation of smart technologies logically require certain competences. Competence elements may vary depending on smart technology processes, its activities as well as work related needs. Nevertheless, the report done by the Erasmus + project, "Vocational Education and Training 4.0" in 2018 disclosed following an overall key competency for Industry 4.0:

- Ability to optimize the workflow (planning skills)
- Reading and assessing the data
- Securing the data
- Using data for optimisation of work process
- Usage of knowledge and documentation systems
- Cooperation and communication in teams
- Use system know-how for optimization of processes
- Decision making skills

The main conclusion on the Industrial expert 4.0 competence profile is based on the findings done during *online company survey, phone interviews and desk* research *(see 2.2.2 Methods)*, however the overall key competence elements as a threshold is needed to conduct the comparison analysis and to draw the conclusion.

2.2.1 Identification strategy

Despite numerous researches done in the field of I 4.0, including data on competences, there is still a gap in the identification of Industrial expert 4.0 competence in regard to the target groups and INDEX – Industrial Expert 4.0 course training objectives. In this regard, the result is unique and serves a profound input for further research in the I 4.0. Documents dealing with Industry 4.0 suggest that the official view is that the

skilled labour force required to underpin Industry 4.0 is not yet in existence, and a good deal needs to be done to create it.[9] Moreover, the rapid development pace of the I 4.0 required the ongoing research process, where up-to-date data are collected and analysed. For that reason, the Profile is relevant for the moment of time when the data was collected, and conclusion is drawn.

The identification strategy of this paper suggests field experiments that examine the data collected from the relevant organizations to make the comparison analysis with the "laboratory" / hypothetical assumptions on the required key competences and the empirical assumptions obtained from the "real world".

Hence, the strategy design consists of *collecting, organizing, and analysing data that are described in the 2.2.3 Chapter.*

2.2.2 Limitations

As it was underlined before, the research on identifying the Industrial expert 4.0 competence profile is a pioneer in terms of target groups and its objectives. It is important to list the limitations that design the research method and influence on the impact:

- **Target group.** The research is focused on obtaining data from the specified stakeholders
- **Target countries.** The project partner countries are used in the data collection: *Germany, Italy, the Netherlands, Poland, and Romania.*
- **Skills.** Soft skills are noted but not considered in the research
- **Target industry.** Broad variety of industries are involved to obtain needed data
- **Number of respondents.** The collected data from the online survey, phone interview and desk research are limited by the number of companies participated in the survey and interview, as well as number of information gained during the desk research.

2.2.3 Methods

The methods used in the current research paper is based on the collection of the **secondary data** – theoretical study, that involves literature and review on the existing research done in the field of I 4.0 by deriving the key competences of the Industrial 4.0 expert. As well as on the **primary data** – empirical deep analyse study.

The primary data collection involves:

1. Online company survey. It consists of a long and a short version of the online survey at EU Survey Platform, translated into 5 languages to gather the

[9] https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

information relevant to Industrial Expert 4.0 SKCs, challenges and motivation related to the I 4.0 technologies implementation[10].

2. Phone Interviews. In-depth 40-minutes interviews with the representatives of large corporations and SMEs from Germany, Italy, the Netherlands, Poland, and Romania. It is designed in the form of open questions that enables one to get a comprehensive understanding of the situation around mastering and implementation of I 4.0 related topics
3. Desk research. It includes qualitative analysis of the job postings at companies' websites and online job posting platforms, open results of previous company surveys, interview and journal articles dedicated to the implementation of I 4.0 technologies in business practice.

The final stage of the research is to conduct the comparison analysis and to draw the conclusion.

2.2.3.1 Online Survey

The online survey is a part of the Profile methodology and serves as an input data source to collect information from the 'first-hand' companies. The online survey was conducted in partner countries **Germany, Italy, the Netherlands, Poland, Romania** and other countries of the EU, such as Bulgaria, Portugal, Sweden. The survey was conducted by using EUSurvey platform tool and collected **114 feedbacks as a total**. The survey questions included a wide range of questions regarding the I 4.0 solutions to cover as many 'blind' spots as possible and be able to draw the 'whole picture' conclusion based on it. The online survey included set of questions under **3 parts: Industry 4.0; Innovation Management; Trainings within I 4.0 solutions.**

The companies participating in the survey represent different types of industries **(Table 1)**. That provides the wide and sufficient perception to analyse collected data. As it can be observed the highest number of companies belong to the *Manufacturer field* followed by the *Development/Engineering*. It stands in line with other research results, underlining that despite the increased use of I 4.0 solutions within all company's types and spheres of industry, nevertheless, the leading interest goes after Manufacturing industry, where optimization of the production line is at stake.

Industry	No
Manufacturer	39
Development/Engineering	23

[10] https://ec.europa.eu/eusurvey/runner/INDEX_SURVEY_2021

Healthcare & Medicine	8
Technology service provider	12
Consulting company	8
Continuing educational institution	1
Other educational institution	1
Technology transfer agency	2
Other brunch	13

Table 1. Number of companies' type participated in the online survey

Nowadays, customer-oriented is a leading approach among not only service providers but the production industries as well. A target market becomes a 'lighthouse' for any industry type organization to reach a group of people, potential customers with some shared characteristics. It has a direct effect on the company's decision-making process, its design, and products. Hence, the highest % of target market today is *Automotive industry, Health/Medical Technology, Energy, Information Technology, Chemical & Pharmaceutical Industry, Materials* **(Figure 1),** *which* is one of the world's largest industries by revenue.

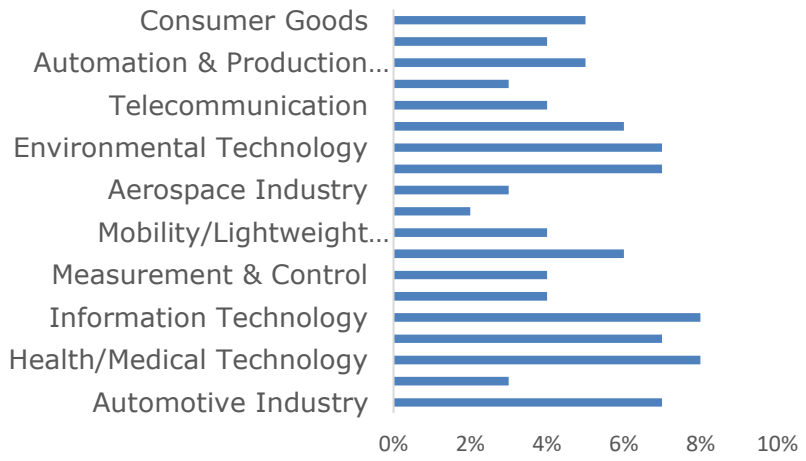


Fig 1. *Division in % of the target market today*[11]

Nevertheless, the estimation of the target market division (%) in 5-10 years **(Figure 2)** based on the survey results has shown that the % range stays the same, with the slight change shift to the *Health/Medical Technology and Environmental Technology* in addition to what is already relevant nowadays. One of the factors of such a shift is Covid-19 caused challenges.

[11] At the moment of conducting the online survey. Data are collected within period January – August 2021

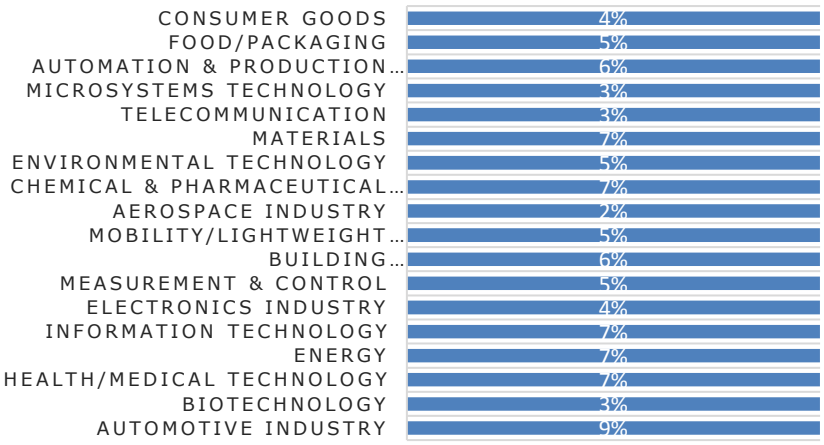


Fig 2. *Division in % of the target market in 5-10 years*

Most survey questions were dedicated to the I 4.0 solutions: *Augmented Reality; Sensors and Automation; Additive Manufacturing; Internet of Things,* that are field of interest of the current research.

What comes to the companies' expectations concerning I 4.0 for the next 2-5 years **(Figure 3),** the highest number of estimations are being placed on the *We will intensify our engagement in Industry 4.0 (27), Industry 4.0 will bring us competitive Advantage (27), We will gain new knowledge/skills/abilities from Industry 4.0 (26).*

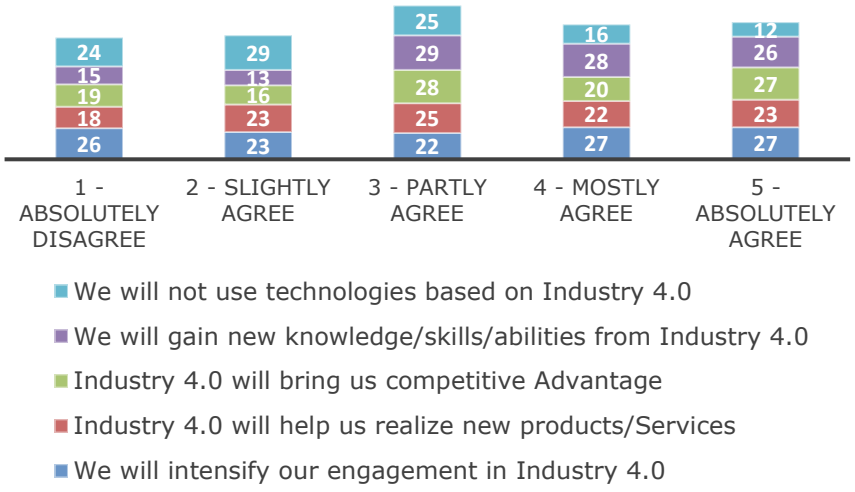


Fig 3. *Number of companies' answers regarding their expectations concerning Industry 4.0 for the next 2-5 years*

Furthermore, the starting point to draw the overall view on the use of I 4.0 solutions by the companies is to research and analyse on what I 4.0 solution does companies use. Hence, the survey results explicitly showed that that all I 4.0 solutions are used to some

extent, rather than not used at all. An exception is only the *Augmented reality and Autonomous robots'* solutions where the answer 'not used' outweigh the sum of answers 'actively used', 'often used', 'rarely used', 'fairly used' **(Figure 4).**

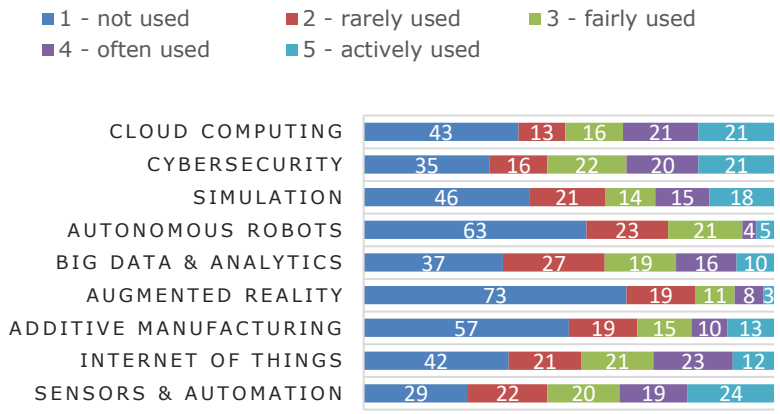
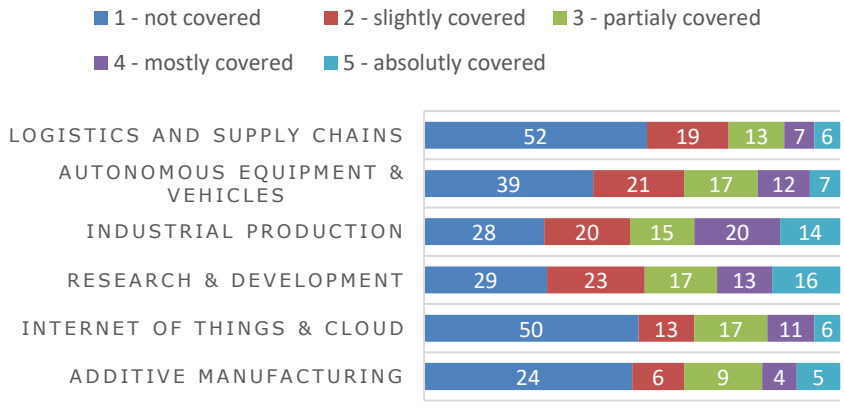


Fig 4. *Number of companies' answers on what industry 4.0 solution they use*

The range of 'grey area'[12], where companies are not actively using I 4.0 solutions, but still, they are at place, have various factors behind this fact. One of them is the lack of knowledge on the I 4.0 solutions that does not allow to use it to its full capacity. Moreover, the lack of trained personal with I 4.0 competences might be another reason of not integrating smart solutions into the production process chain fully, considering the established benefits.

Regarding the I 4.0 value chain (**Figure 5**), the survey identified that the top three covered by responded companies are *Research & Development (69[13]), Industrial production (69), Autonomous equipment & vehicles (57), whether Internet of Things & Cloud (50) and Logistics and supply chains (52) are detected with 'not covered' answer.*



[12] Answers 'actively used', 'often used', 'rarely used', 'fairly used'
[13] Sum of answers 'actively used', 'often used', 'rarely used', 'fairly used'

***Fig 5**. Number of companies' answers regarding the covered I 4.0 value chain steps*

Based on the gained data from the survey, the responded companies' justification of not using I 4.0 (**Figure 6**), are almost 80%[14] belongs to *Too expensive, Lack of experience, Lack of Technology, Lack of knowledge on Industry 4.0.*

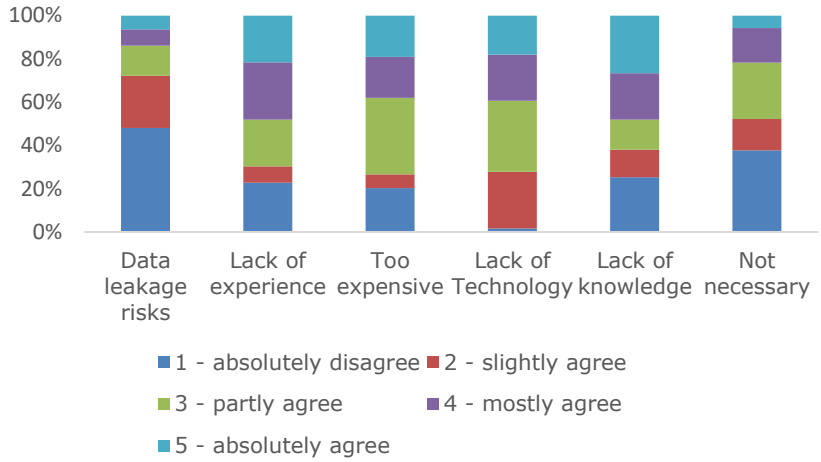


***Fig 6**. Number of companies' answers regarding the reason behind the use of I 4.0 technologies*

Furthermore, on the question *Do you plan to allocate (more) human resources in the field of Industry 4.0 in future?* 37 companies answered with 'yes', 21 with 'no' and 41 with 'don't know' answer.

Following the previous findings, the highest reaction with 'very important' answers were under *Cloud computing (25), Big Data & Analytics (23), Cybersecurity (22*). On the contrary *Augmented Reality (34), Autonomous Robots (32), Additive Manufacturing (31) received 'no important' answer* (**Figure 7**). That corresponds with the previous gained survey data on the % division of the target market relevant today and in 5-10 years.

[14] Sum of answers 'slightly agree', 'partly agree', 'mostly agree', 'absolutely agree'

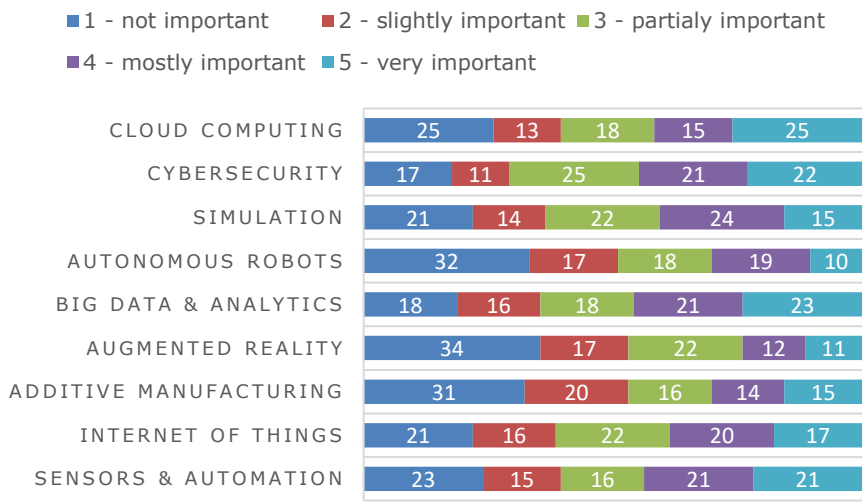


Fig 7. *Number of companies' answers regarding the consideration of acquire basic knowledge/skills/abilities in technologies, methods, or elements of the following Industry 4.0 by employees in their companies*

Moreover, the perception of companies on the benefit from employees gaining KSC in I 4.0 technologies are as following with the up-to-down number of 'absolutely agree' answers:

- We would enhance staff creativity and their professional visibility (18)
- We would analyse the general feasibility of using technologies, methods, or elements of the specified Industry 4.0 components in our business Environment (16)
- We would use the technologies, methods & elements of the specified Industry 4.0 components in our business environment (15)

As it was already stated, I 4.0 has become a driven factor to improve the company's performance to be comparative on the market. As a result, the integration of I 4.0 smart solutions into the operation processes are structured and managed through approaches such as innovation management. Thus, one of the interest areas of the online survey was *innovation, innovation process and innovation management.*

Based on that, companies participated in the survey evaluated *Market opportunity identification and evaluation (38), Market opportunity identification and evaluation (33), Project management: concepts, models, procedures, standards, selected tools (25)* with the 'very important' skills for innovation management.

The innovation process is a path of translating new and/or existing knowledge into marketable solutions. Companies that pursue a successful innovation process have something decisive that puts them ahead of others - they have designed the path of an idea from generation, through development, to market entry.[15] Nevertheless, the innovation

[15] https://www.lead-innovation.com/en/innovation-process

process as such is initialised by companies. Under the 2nd part of the online survey on the Innovation Management, the answers came from the survey results (**Figure 8**) with the highest number of companies respondents marked *'mostly'* answer to all reasons with the highest number to *Demand-oriented approach ('Market Pull') (35).* That's also match the highest number of *'very actively'* answer under the same reason Demand-*oriented approach ('Market Pull') (23).*

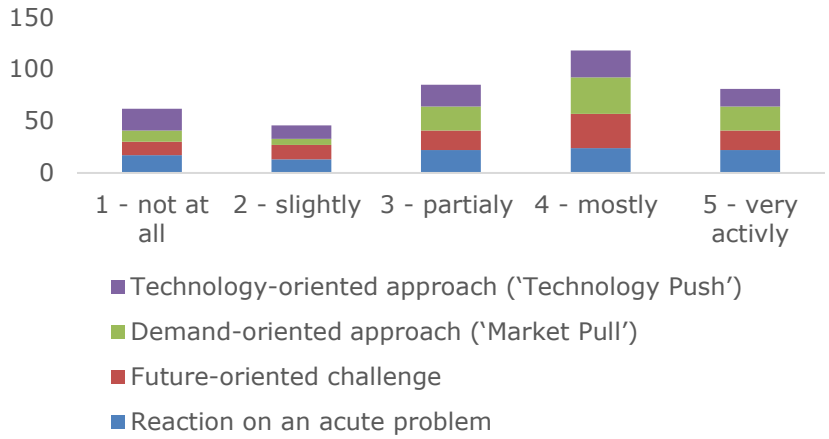


Fig 8. *Number of companies' answers on how the innovation processes is initialized in their companies*

It is an obvious but at the same time a complex finding to draw the conclusion on in the current paper. From one point of view the *Market demand* is an obvious explanation to lean to the use of the I 4.0 solutions. However, considering leading answers indicated above, namely *Lack of Knowledge on Industry 4.0*, the driven factor of companies to use I 4.0 not because they use I 4.0 technologies having the sufficient knowledge on all benefits that I 4.0 may provide for their companies but because they must use it not to be behind of other companies on the market.

To look at the innovation process more precisely, there are certain steps to be taken. The survey findings (**Figure 9**) showed that most of companies' answers (18%) underline *Evaluation and selection of ideas* as an important step in the innovation process. It is followed by *Creating/ gathering ideas (17%), Identification of problems (16%).* All these steps are the initial phase of any project development and thus, confirm the need of companies in the innovation management.

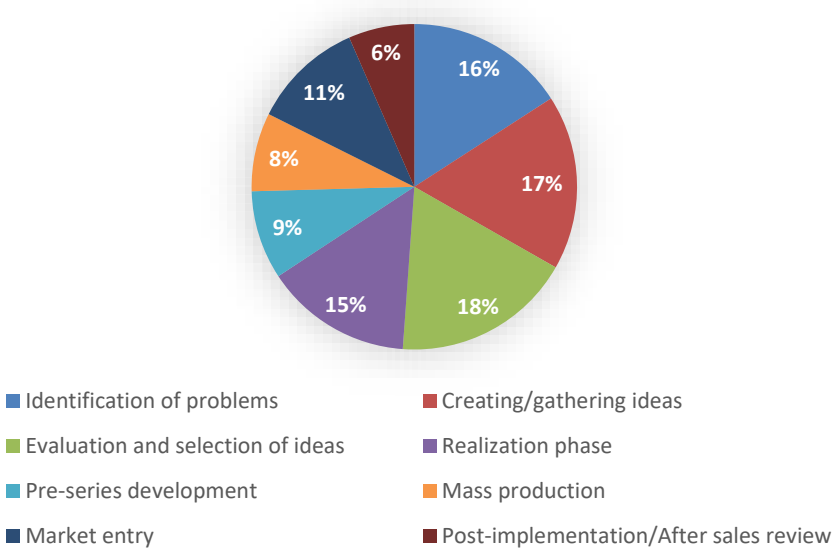


Fig 9. *Number of companies' answers regarding the considered innovation steps*

Knowing the needs, expectations, knowledge of the companies in the I 4.0 including innovation management, the 3rd part of the survey was dedicated to gather the data on the participation in the trainings within I 4.0 solutions.

Hence, regarding the question *Does your company offer internal training programmes in the field of the following Industry 4.0 technologies or innovation management?* under:

- Sensors and Automation (16)
- Internet of Things (11)
- Innovation Management (16)
- Additive Manufacturing (7)
- Augmented Reality / Virtual Reality (9)
- None of them, but in the next 2 years (9)
- None of them (55)

Most answers belong to *None of training programmes are offered by companies*. Nevertheless, *Innovation Management* as well as *Sensors and Automation* are with highest numbers among I 4.0 technologies and Innovation management.

That provides the starting point to move forward to the next question on the *Interest of using the results of the edX-based open educational course "INDEX- Industrial Expert" on Industry 4.0 focused on Industry 4.0 smart solutions* (**Figure 10**).

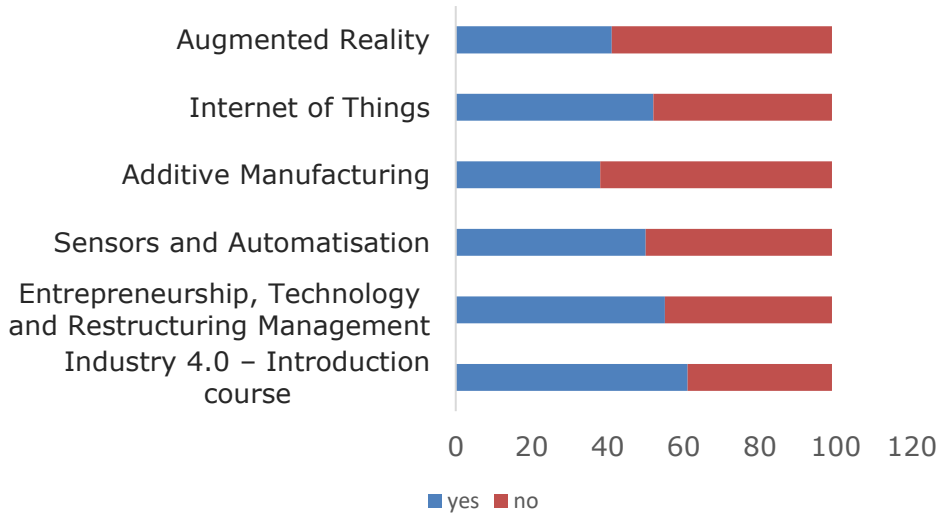


Fig 10. *Number of companies' answers expressing the interest of using the results of the edX-based open educational course "INDEX- Industrial Expert" on Industry 4.0 focused on Industry 4.0 smart solutions*

The answer '*yes'* overweight towards *Industry 4.0 Basic course (61); Entrepreneurship, Technology and Restructuring Management; Internet of Things (52); Sensors and Automatization (50).* However, *Additive Manufacturing (61)* and *Augmented Reality (58)* got highest *'no'* answers from companies participated in the online survey. Only, based on these results, there is clear demand on having an online course in I4.0 solution.

2.2.3.2 Phone Interviews

The overall goal of the in-depth interviews carried out in the context of the Intellectual Output (IO) 1 was to gather as much information as possible about qualification needs in target companies in the fields of Industry 4.0 technologies. Furthermore, the quantitative and qualitative questions used in the interview aimed to understand the existing companies, interest, needs, motivation, and challenges in the field of Industry 4.0 technologies.

The information retrieved from interviews complemented the findings of the INDEX online company survey. In particular, it contributed to defining the competence profile of the Industrial Expert 4.0 - INDEX (e.g., knowledge, skills and competences the Industrial Expert should have in order to be able to apply I 4.0 related technologies in the company business processes) and provided significant input to refine the curricula and learning outcomes targeted in the INDEX course.

As a result, **21 interviews** were carried out in the following countries: *Italy, Germany, Poland, Romania, Sweden*. For the purpose of the thorough data collection different *types and sizes* of organizations were taken into account, which already apply 4.0 technologies or interested in opportunities to apply them in their area of expertise (**Figure 11**). It allowed to provide deep insights from different target groups of the INDEX course. Additionally, in that regard interviewed companies vary by industries (*valves and fittings, consulting, clothing, education, construction, energy, development & measurement equipment, data management, resistance thermometers & monitoring systems*) as well as their roles (*system provider, manufacture, software development, research*).

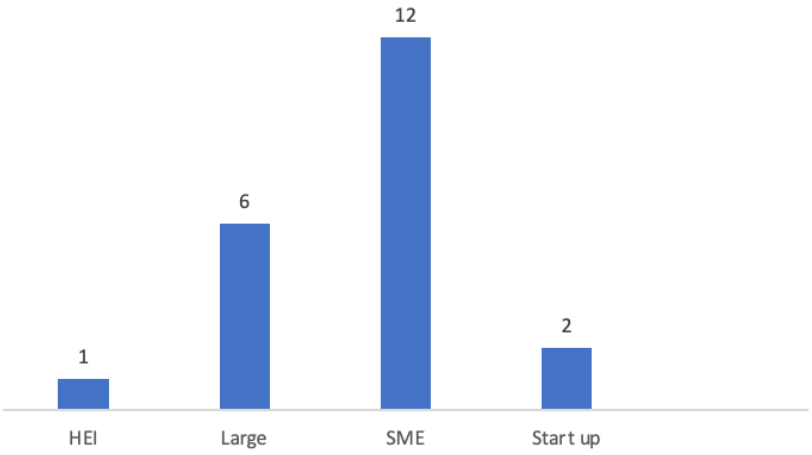


Fig 11. *Number of interviewed companies by its type*

As could be expected, the information and comments provided by the interviewees varied substantially from company to company, not only due to its different type and size, but also due to the use/ not use of industry 4.0 solution (**Figure 12**)**.**

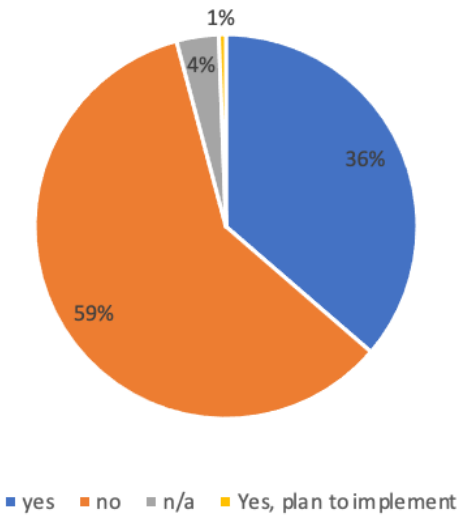


Fig 12. *Percentage of responses to the use of industry 4.0 solution*

36% of interviewees responded with a **"yes"** answer to the use of industry 4.0 solutions: *Sensors & Automation, IoT, Additive Manufacturing, Augmented Reality, Big Data & Analytics, Autonomous Robots, Simulation, Cybersecurity, Cloud computing, Simulation, Big Data and Analytics.*

Nevertheless, most answers include **59% of responses** with a **"no"** answer to the use of industry solutions 4.0. It can be explained by the fact that the biggest number of interviewed companies (14) are SMEs and Start-ups having the **funding challenge** in implementation of industry 4.0 technologies. For instance, hiring industrial 4.0 experts are seen as one of the financial obstacles for above mentioned companies (**Figure 13**).

Fig 13. *Number of interviewed companies that hired industrial expert*

It's a crucial key finding of the survey in question, since one of the INDEX course goals is to provide SMEs interested in opportunities to apply 4.0 technologies with elementary opportunity, practical skills to make the use of 4.0 technologies in their areas of expertise and lead to strategic labour market advantage and a competitive advantage for their countries. Moreover, most **interviewees (17 out of 21 interviewed companies)** expressed the need to have industry 4.0 related training

Where there is the need, there is a motivation to use industry 4.0 solutions (**Figure 14**) that is driven by the top three justifications: *management-led changes; respond to internal needs, issues; need to adapt to market requirements.*

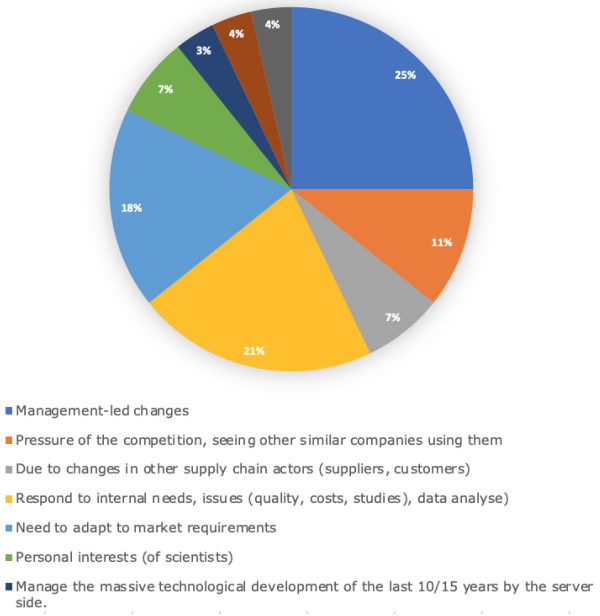


Fig 14. *Motivation justification to use Industry 4.0 solutions.*

Further **challenges** highlighted by interviewees along with **knowledge, skills, and competences** (KSC) are perfectly cross-matched and reflected by the INDEX course / Intellectual Outputs (IOs) **providing an overview on the industrial expert 4.0 profile (Table 2).**

Challenges	KSC	Intellectual Outputs (IOs)
• Unreadiness of market and customers for innovative solutions • Concepts of Industry 4.0 are not well known	• Market knowledge of products and available software tools	**IO3:** • Knowledge and skills about the key aspects of the 4th industrial revolution

• Comfort zone mindset of the employers is seen as an obstacle to use industry 4.0 technologies • Poor awareness of industry 4.0 solutions economic value	• Good evaluation of features of available software tools • Predisposition, receptivity, and willingness to acquire new information	• Ability of defining entrepreneurship and its core concepts • Developed ability of understanding what is commercialisation and technology transfer **IO5:** • Knowledge and skills about classification of sensors and actuators based on their operation principle • Knowledge and skills about features/functionalities needed to achieve a complete working system • Knowledge and skills about analysis of systems and selection of proper types of sensors and actuators that are needed to realize such systems based on required applications
• Lack of business-oriented people who could help to elaborate an efficient business model • Lack of people with skill in project management, fund raising, both public and private	• Knowledge on business model • Technical skills of personnel which allow to evaluate technical side of the new idea/technology • Cross-sectional vision and management skills • Project management skills	**IO4:** • Ability to develop a business model • Ability of identification and evaluation of the market opportunity • Ability of identification of stages of innovative company foundation • Ability to conduct a simple market analysis for innovative products

		• Ability to select methods entering international markets • Ability to apply selected techniques to evaluate risk of innovative projects • Ability to identify funding sources for innovative projects • Ability to interact with investors
Inability to train personnel in a resource-saving and efficient way	• Basic preparation combined with constant updating (independent but also with training courses) is crucial	**IO3 - IO8**
Challenge in selection and acquisition of the equipment and materials for AM	• Knowledge of the installation design software (CAD)	**IO3:** • Able to decide if additive manufacturing technologies are potentially interesting for his intended application • Ability to choose the proper devices and configuration of an IoT infrastructure to match the specific application requirements and to prevent the most common threats in such application field • Ability to explain the AR concepts **IO6:** • Ability to decide which of the different AM technologies will be the

		best for their use case and what problems and opportunities will occur **IO7:** • Knowledge of the key features of the principal kinds of transports in communication technology • Ability to manage simple IoT projects based on Microcontroller Units **IO8:** • Ability to highlight the differences between augmented reality and virtual reality • Skills to develop AR applications using ZappAR
• Inability to adjust constantly improved technology to the clients need • Challenge to match the existing technology with real-life applications suitable for a small company in terms of budget, personnel, ROI • Significant problems caused by the different standards	• Ability to integrate systems analytics and data reporting • Ability to monetize the project • Ability to choose the optimal solution from a technical and economic point of view, depending on the requirements and needs of the client, the type of installation and its location • Ability to create integration and dialogue between the machines and the world of management • Skills of advanced mathematical and statistical methods	**IO3 - IO5**

	and integration of systems and software • Skills of safety procedures for new programmer tools (software), testing procedures, cost analysis	

Table 2. Challenges and KSC in respect to IOs

Additionally, soft skills were among the KSC mentioned by interviewed companies, such as *communication skills, curiosity, problem solving skills, creativity, adaptability, and open-mindedness.* Though, this type of KSC is not provided by the INDEX IOs. Nevertheless, they are seen as important, since soft skills are recognized as skills of the 21st century and often serve as decisive criteria for hiring. It shall be taken into account for possibly future projects in the field of Virtual Reality (VR).

2.2.3.3 Desk research

The desk research is a part of the primary data collection performed for the purpose of the current research paper. It consists of job posting and article research & analyse. The main idea behind the desk research is to detect the demand of the labour market within the I 4.0 solutions and create a final competence profile for each specialization of the INDEX course, namely: *Basic INDEX course (IO3); E-TRIM (IO4); Automation (IO5); Additive Manufacturing (IO6); Internet of Things (IO7); Augmented Reality (IO8).*

The following criteria were set for the desk research resource selection:

- Target countries: Germany, Italy, the Netherlands, Poland and Romania
- Target industry: all, min. 3 examples from different industrial areas
- Target companies' size: start-ups, SMEs, large corporations
- Relevant positions: digital transformation consultant, change manager, innovation manager, analysist, growth Manager, etc.

- Key search words: industry 4.0, IoT, Additive Manufacturing, Augmented Reality, Innovation, Sensors and Automation.

The highest number of jobs posting are identified in Poland and Romania as shown in the **Figure 15.**

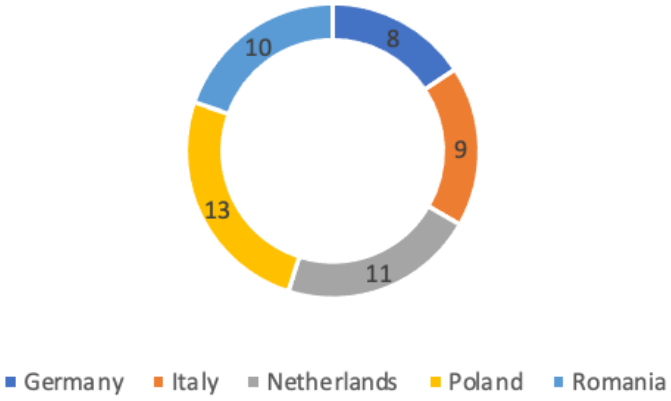


***Fig 15**. Number of jobs posting by Partner Country.*

Findings derived from the desk research complemented phone interview results presented above in the current research paper, namely equal number of 17 Large and SME types of companies are the source of job posting within Industry 4.0 solutions (**Figure 16**).

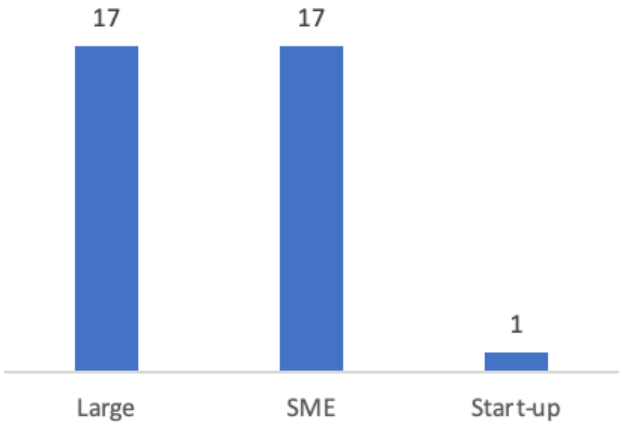


***Fig 16.** Number of company's type*

The **Table 3** shows elements of the Industrial Expert competence profile, consisting of competencies and underlying competence elements for performing the main activities, including effectively dealing with the challenges, have been identified during desk research (D).

Variable	Description	No
Sector	Information Technology & Services / Information Technology / IT developer / Computer Software / IT services / Automotive software	7
	Food industry / Packaging / manufacturer of high-quality chocolate and cocoa products / Beverages manufacturer	6
	Automation & Production Technology / production of automotive components and industrial engineering	5
	Consulting / Technology and IT consulting / company operating in consulting and assistance to companies in the field of subsidized finance and access to calls for industry 4.0 / platforms used by engineers to solve the customers' problems	4
	Healthcare / pharmaceutical / Medical Technology / manufacturer of medicines and pharmaceutical substances	4
	Construction / Building technology/ products for construction	3
	Measurement & Control / global technology company shapes digital transformation and continuously innovates in the fields of Augmented Reality, Internet of Things or Artificial Intelligence.	3
	Aerospace	2

	manufacturers of hydraulic die-casting machines / manufacturer of fibre optic cables and telecommunications equipment	2
	Consumer Goods / online stores	2
	Engineering Services Provider	2
	Materials / 3D printers/additive manufacturing solutions	2
	Tech-savvy integrated HR-solutions provider	2
	Research Institute / Environmental, Social and Corporate Governance (ESG) research and ratings / designing and manufacturing of marine winches and naval equipment	2
	Legal	1
	Retail	1
	Biotechnology	1

Table 3. Composition of the job postings by sector.

As it can be observed from the **Table 3.** the highest number of jobs posting are under the *Information Technology & Services sectors (7). Food and beverage industry (6)* are the following sector with reached number of jobs posting as well as *Automation & Production Technology (5)* got the hight number compares to the rest.

Moreover, the major share of job posting and labour market demand as such belong to the *Information Technology & Services sectors.* Following, *Food Industry* and *Automation & Production Technology* are sectors where specialists in Industry 4.0 are in demand as well. Found results are foreseen regarding the manufacturing type of

production used in those sectors were optimizing the usage of resources, reducing the costs, and increasing the effectiveness of the production process is needed.

Additionally, finding presents numbers of job titles (**Figure 17**) that correlates with the Competence elements needed to perform main activities, *such as ability to optimize the workflow (planning skills); reading and assessing the data; securing the data; using data for optimisation of work process; usage of knowledge and documentation systems; cooperation and communication in teams; use system know-how for optimization of processes; decision making skills*. Thus, the highest number jobs available on the labour market is **Engineer** (Industry 4.0, data, research, process, automation, application, solution delivery, software, sales) and **Managers** (innovation, production line, agile project manager 4.0, service delivery, IT).

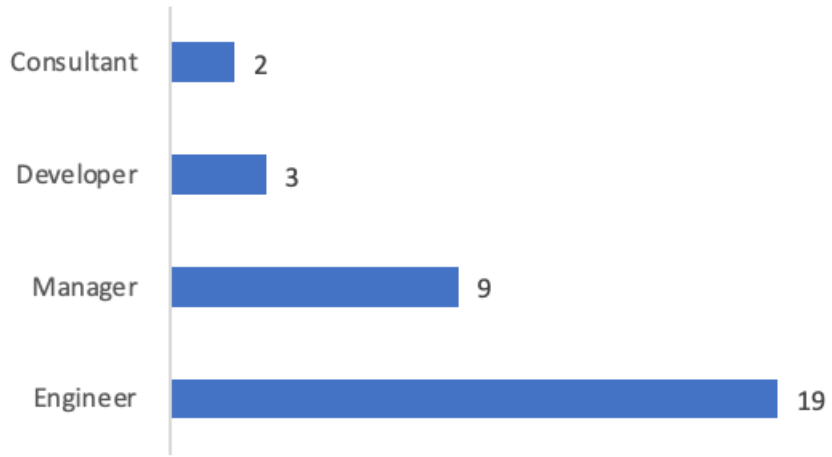


Fig 17. *Number of job titles*

The comparison analyses of required functionality/ tasks described in the jobs posting and related to it Industry 4.0 SKC (Skills, Knowledge and Competences) has shown that many (26) jobs posting contains tasks with corresponding cross sectoral Industry 4.0 SKC within IO3 – IO8. Some examples are presented in **Table 4.** Composition of the job postings functionality/ tasks by SKC and IO3 – IO8, below:

Functionality/ tasks	SKC	IOs
• Support the Innovation Team's research on six main technologies: Artificial Intelligence, Internet of Things, Blockchain, 3D printing, Robot Process Automation, Augmented and Virtual Reality	Understanding of Artificial Intelligence, IoT, Blockchain, 3D printing, Robot Process Automation and Virtual Reality	**IO3 – IO8**

• Shape customers digital transformation in the areas of IoT, Industry 4.0, Digital Twin and Digital Thread	Knowledge of agile development methods, Augmented Reality, Virtual Reality, IoT, advanced analytics or data transformation/migration	**IO3 – IO8**
• Gain special expertise within a certain innovation field by observing current market trends and new technologies on a global scale	Understanding of global trends in Industry 4.0, Distinct knowledge of innovation methodologies (e. g. design thinking, rapid prototyping)	**IO3 – IO8**
• Involvement in engineering, product customization and R&D projects with high innovative content, related to Industry 4.0, AR/VR and IoT topics • Be responsible for Management and coordination of PLC program development projects • Analysis and implementation of new solutions and applications • Supporting product engineering activities • Management and analysis of technical and project documentation • Support and assistance to customers and internal functions • Verification and validation of specifications and technical requirements	Skills Automation Engineering, Electronics or similar; Prior experience in the role, in the Industrial Automation industry; Knowledge of Siemens S7 and/or Rockwell Automation; Knowledge of SCADA systems and HMI controls; Knowledge of National Instruments LabVIEW development environment; Knowledge of scripting with Visual Basic (preferred)	**IO3 – IO8**
• Part of transition of the factory to Industry 4.0 • Specializing in digitalization and automatization	Early Equipment Management, World Class Manufacturing. From design to implementation of projects with respect to automatization, digitalization, processing, and sustainability	**IO3 – IO8**

• Improving of manufacturing processes for next gen products	Manufacturing Development, New Product Development, Design for Manufacturability. Strategies/Tactics/Execution of data analytical tools towards Industry 4.0	**IO3 – IO8**
• Development of innovative plastics production technologies • Process design to handle the complexity of cost-effectively making and assembling highly customizable products	Prototyping and testing of machine parts and modular assemblies. 3D printing and casting. Design for Manufacturing. Smart-agile Manufacturing, in line with Industry 4.0 principles	**IO3 – IO8**
• Designing and developing innovative and engaging Industry 4.0 based solutions • Unlocking new operational benefits for manufacturers enabled by Industry 4.0 Technologies • Engaging with clients to understand and interpret business challenges into functional design specifications, through to iterative rapid prototyping solutions • Working alongside a team of functional consultants to support the successful design, development, and implementation of solutions in line with implementation methodologies • Working alongside Solution Architects and developers to interpret business requirements and create the technical solution • Supporting business development opportunities	Industry 4.0 based solutions; Industry 4.0 Technologies (e.g. Improved asset efficiency, Improved quality, reduced cost, Improved safety and sustainability)	**IO3 – IO8**
• Design and development of applications in the process control system environment (SCADA/MES) and connectivity solutions for PLC	Industry 4.0 based solutions; Industry 4.0 Technologies; Design and development of applications; Develop solutions to cover actual and future	**IO3 – IO8**

integration for process control systems • Develop solutions to cover actual and future concepts and trends (Industry 4.0, IIOT etc.) • Gather, analyse and document user requirements and ensure the system meets user expectations in constant dialogue with stakeholders • Develop software following agile methodologies and align solutions with other teams in an international environment • Assist users and stakeholders in commissioning of the system and support fixing potential problems • Design, execute and supervise automated software tests	concepts and trends (Industry 4.0, IIOT etc.); Software development and testing	
• Integration of Industry 4.0 strategies • Rollout/integration/commissioning of machines, assembly lines critical production systems and control technology • Supporting standardization efforts concerning ZF plant floor applications (MES, SCADA, Connectivity) • Ensuring compliance to SLA and service continuity • Collaborating with internal and external IT professionals on technical issues and developments Managing outsource relationship for 3rd party application (please explain it)	Integration of Industry 4.0 strategies	**IO3 – IO8**

• Remote delivery for projects, responsible for low level network solution design, review and implementation • Migration design, competitor's configuration translation or configuration script development for a large diversity of scenarios • Remote maintenance including software installation, remote upgrading, configuration change, remote inspection etc. • Assistance and troubleshooting guidance for field engineers during implementation or maintenance activities • Provide detailed information on how to set up, configure or upgrade IP products and their features • Use trouble ticketing system for tracking customer interactions and fault analysis	TCP/IP & OSI protocol stack skils; Knowledge of routing protocols (OSPF, BGP, IS-IS); Knowledge of switching technologies and protocols (Vlans, STP); Knowledge of security features and protocols (IPSec, NAT, Radius/Tacacs, Dot1x); Knowledge of network monitoring applications and protocols (SNMP, NMS); Strong troubleshooting skills (able to analyse debug outputs and packet captures)	**IO3 – IO8**
• Develop, plan, and execute search and display campaigns in EMEA and APAC markets to drive demand and adoption for the TeamViewer product range • Manage and optimize campaigns on a day-to-day basis and guide the agency to deliver on clearly set performance targets • Set KPIs and allocate budgets across various products and markets • Measure performance and help build a stable, future-proof tracking environment	High-volume search and display advertising campaigns preferably within a high-growth, B2B SaaS company or on agency/platform side Ad-tech knowledge, global outlook, and customer/product mindset	**IO3 – IO8**

Table 4. Composition of the job postings functionality/ tasks by SKC and IO3 – IO8.

As it can be tracked from the survey results, that job position, e.g., *Process Development Engineer, Front-End Developer, IoT Digital Orchestrator* with the I 4.0 cross sectoral SKC sets are in the highest demand compared to the relevant sector with limited skills. It allows to understand the operation of each manufacturing step and fulfil

given tasks by taking it into account. Industry 4.0 cross sectoral SKC is also beneficial, because:

- provide a more complex tasks execution
- bring a diverse way of thinking
- enhance skills pools in the organization.

It is also related to the job positions that include Project Management (PM) tasks within Industry 4.0 sectors. It is not enough anymore to have the PM skills, but also to have the essential smart technologies knowledge, as examples listed in the **Table 5.** Composition of the job postings functionality/ tasks by SKC and IO3, IO4, where IO3 INDEX: Industrial Expert Basic module provides basic knowledge about the key innovative concepts and technologies in five areas: *Entrepreneurship, Technology and Restructuring Management; Sensors and Automation; Additives Manufacturing; Internet of Things; Augmented Reality/Virtual Reality.* The IO4 E-TRIM, intermediate level, provides more specific application-oriented areas. The INDEX Course covers information about entrepreneurship and company organisation, commercialization of innovative projects, innovation marketing, project, and risk management and finally policy, legal aspects, and funding. It also gives insight into best practices of innovative companies' operation.

Functionality/ tasks	SKC	IOs
• New and further development of IT applications including optimisation of the associated business processes in the finance area in the context of new technologies (e.g. RPA, AI)	Optimisation of business processes, knowledge of new technologies (e.g., RPA, AI), initial experience in the implementation of IT (sub)projects incl. project management methods and process tools	**IO3, IO4**
• Analysis of business requirements with an end-to-end focus and (partial) project collaboration in business conception through to technical implementation	Project management from business conception through to technical implementation	**IO3, IO4**

• To accompany the digital transformation by identifying (strategic) options for action and prepare analyses regarding strategic fit and optimisation potential.	To identify (strategic) options for action and prepare analyses regarding strategic fit and optimisation potential, to be able to examine processes, identify potential for improvement and solve problems creatively	**IO3, IO4**
• Lead multidisciplinary team from initial phase until introduction (end2end) • Drive development and realization of IoT & Industry 4.0 solutions	Lean/agile software development, project management. Digital, embedded software, connectivity and analytics.	**IO3, IO4**
• Lead the implementation of strategic and core projects and programs for a functional area with routine monitoring, measurement, and reporting of performance to budget, schedule, and business objectives • Analyse the structure and flow of the business work to identify possible application solutions and enhancements	Competences to manage a portfolio - time management, prioritization, setting customer expectations; Identify and mitigate risk, status reporting, and operations; Competences to identify renewal and add-on opportunities, using lessons learned and looping them back into our internal best practices; Proven ability of technical hiring, forming and developing technical teams; Deep software development & program management experience managing multiple projects varying in size at one time; PMP/Scrum master/ SAFe Agilist certifications preferred	**IO3, IO4**

Table 5. Composition of the job postings functionality/ tasks by SKC and IO3, IO4.

2.2.3.4 Competence elements mentioned

As it was stated at the beginning of the current paper, the **online survey, phone interview and desk research** were conducted within the competence profiling to select I 4.0 relevant competencies at a specific level of proficiency required for successful performance within I 4.0. It shall be mentioned that, selected I 4.0 relevant competencies are limited by the number of *interviewed companies and their specific needs at the certain moment of time.*

The mentioned competences needed for the benefit of interviewed companies are being already mentioned, partially analysed under above under the relevant paragraph (*see 2.2.3.1, 2.2.3.2, 2.2.3.2*). Moreover, they were cross-checked with the KSC of the INDEX course modules.

In addition, the key competency for I 4.0 were listed based on the report done by the Erasmus + project, "Vocational Education and Training 4.0" in 2018 (*see 2.2*).

Thus, the following paragraph (*see 2.3.3.5*) shall sum up the whole data collected during the competence profiling, as well as crossmatch with the KSC of the INDEX course modules:

- Basic INDEX course (IO3)
- E-TRIM (IO4); Automation (IO5)
- Additive Manufacturing (IO6)
- Internet of Things (IO7)
- Augmented Reality/Virtual Reality (IO8).

2.3.3.5 Elaborated competence profile

Since **competencies are related to ability to perform that task in an efficient way**, the **Table 6** presents the Industrial expert elaborated competence profile, consisting of competencies underlined during the competence profiling mentioned in the online survey (S), phone interviews (I) and desk research (D).

Key competency for Industry 4.0[16]	Competences mentioned	Source (S, I, D)	INDEX course
• Decision making skills • Ability to optimize the workflow (planning skills) • Usage of knowledge	• Basic preparation combined with constant updating (independent but also with training courses) is crucial • Usage of market knowledge of products and available software tools • Ability to evaluate available software tools and business models for the new idea • Have the ability for cross-sectional vision • Ability to manage and monetize I 4.0 Project through business conception to technical implementation	I	IO3-IO8

[16] Erasmus + project 'Vocational Education and Training 4.0, published 2018

and documentation systems • Usage of knowledge and documentation systems • Cooperation and communication in teams	• Usage of knowledge of agile development methods • Ability to understand global trends in I 4.0, • Ability to distinguish innovation methodologies (e. g. design thinking, rapid prototyping) • Ability to identify strategy for action and prepare analyses regarding strategic fit and optimisation potential • Ability to examine processes, identify potential for improvement and solve problems creatively • Ability to manage a I 4.0 portfolio - time management, prioritization, setting customer expectations; Identify and mitigate risk, status reporting, operations, using lessons learned and integrating them back into our internal best practices • Ability of technical hiring, forming, and developing technical teams • Ability to manage projects varying in size at one time by using PMP/Scrum master / SAFe Agilist	D	IO3 – IO8
• Reading and assessing the data • Using data for optimisation of work process • Securing the data	• Ability to integrate systems analytics and data reporting • Ability to choose the optimal solution from a technical and economic point of view, depending on the requirements and needs of the client, the type of installation and its location • Ability to create integration and dialogue between the machines and the world of management • Usage of knowledge on advanced mathematical and statistical methods and integration of systems and software • Ability to develop, install and test the software	I	IO3 – IO7
	• AR/VR, IoT, advanced analytics or data transformation/migration • Ability to understand Artificial Intelligence, IoT, Blockchain, 3D printing, Robot Process Automation and Virtual Reality	D	IO7 – IO8

	• Ability in Automation Engineering • Usage of knowledge of Automation systems and controls • Usage of knowledge of scripting with Visual Basic (preferred)	D	IO3, IO5
	• Usage of knowledge of the safety procedures for new programmer tools (software), testing procedures, cost analysis • Usage of knowledge of the security features and protocols • Usage of knowledge og the network monitoring applications and protocols • •	I	IO3, IO7
• Use system know-how for optimization of processes	• Ability to optimise of business processes • Usage of knowledge of Manufacturing - strategies/Tactics/Execution - (from design to implementation of projects with respect to automatization, digitalization, processing, and sustainability) • Ability to prototype and test 3D printing • Usage of knowledge on I 4.0 based solutions to e.g., Improve asset efficiency, quality, safety, and sustainability, reduce cost • Ability to integrate of Industry 4.0 strategies • Ability to conduct display advertising campaigns within an agency/platform	D	IO3 – IO8

Table 6. Competence Profile

The competences listed in the **Table 6** should not be taken as the ultimate one, but rather as the input data for the further research due to the rapid pace of I 4.0 development and up-to-date information changing with every day. The concluded Competence Profile base on the research conducted within the INDEX – Industrial course, combining the newest academic know-how and entrepreneurial needs.

3. Conclusion

You want to be working with machines,
not competing with them."
Erik Brynjolfsson, director
at the MIT Initiative on the Digital Economy

The 4th Industrial Revolution has the dramatic influence of the way we live, work, and think. We are in an era of the Fourth Industrial Revolution, where computers are connected to a platform to facilitate communication with one another to eventually accelerate decisions without any human interference[17]. Companies have a great possibility to collaborate and share data within the production process chain, considering suppliers, manufactures and customer. It shall improve productivity and the competitiveness above all.

Nevertheless, to be able to shift to the digitalization towards reaching growth and sustainability, there is a need not only to transform the production chain but to change the way companies think, build strategies, use tactics, and manage their projects. This is an ultimate change that companies are 'fighting' with and not always having victory at their side, despite of the established benefits of the I 4.0 solutions. New changes always bring new challenges, that are often not an easy task to overcome.

The Industry Expert Competence Profile along with INDEX course came at stake to assist in managing those challenges connected with Vocational Education and Training (VET) and continuous professional development. With the 4th Industrial Revolution, work is not seen just as a place to go, but a place that requires SKC to work successfully with I 4.0 technologies. Lack of knowledge, better say **lack of companies' awareness** on I 4.0 smart solutions was one of the main findings in this paper. It brings companies to the point where they are 'playing blind' at the target market without being aware on *how to examine processes, identify potentials of I 4.0 solutions, integrate it into the best practices and solve problems creatively.* It is directly connected to another finding, which is **lack of expertise in Industry 4.0.**

Implementing new approaches are often connected with risks. Not every company, especially SMEs or start-ups are ready to take those risks even considering an advantage that global trends are able to bring to the company. Implementation of smart technology by a company depends on its ability to respond to change, innovation management and financial capacity. Companies are 'forced' to **hire, train, or retrain** their staff to be proactive in upskilling and benefit from the I 4.0. technologies.

[17] https://www.forbes.com/sites/forbesbusinesscouncil/2020/07/24/the-fundamentals-and-impact-of-industry-40/?sh=7289d881a331

Effectiveness and efficiency become driven factors for companies while choosing course or training programme. It shall correspond to the business needs, be time and money friendly, provide new business opportunities for its further growth and development, and be affordable. The **high cost** of I 4.0 solutions as such, as well as that of the relevant required qualifications trainings is another driven-away factor of not exploiting it.

It imposes an additional requirement to the I 4.0 competences to be able not only to use system know-how to optimise the process, but have the ability for cross-sectoral vision, to manage and valorise I 4.0 Projects varying in size and tools. **Project Managers and Innovation Managers** seem to be at the most demand on the job posting market along with I 4.0 technology Engineers. Without having company's human resource capacity to be able to evaluate software tools and business models through conception to technical implementation, vainly attempt to integrate the I 4.0 solutions into the production process.

In the wake of change, governments, business, and educators shall cooperate in unison for the sake of the better future. It is also about assuring young generation to have the I 4.0 skills starting from school level, to attract attention and raise awareness of computer science, smart technologies etc. already, to give a glance on the possible future employment opportunities. Businesses must step in within cooperation with universities and other educational institutions to ensure high-quality professional development courses and workshops to provide technical qualification to future workers. It will allow to adapt the student profiles to the demands of the companies.

In this regard modularized short cycle VET programmes offered digitally shall serve as one of the relevant instruments, to provide companies and its employees with required SKC in I 4.0 smart solutions. Based not only on educational standards of the smart manufacturing technology, but on actual demands of companies and other target groups in partner countries, the Industrial Expert Competence Profile was designed to shape the basic requirements for the INDEX - Industrial Expert OER.