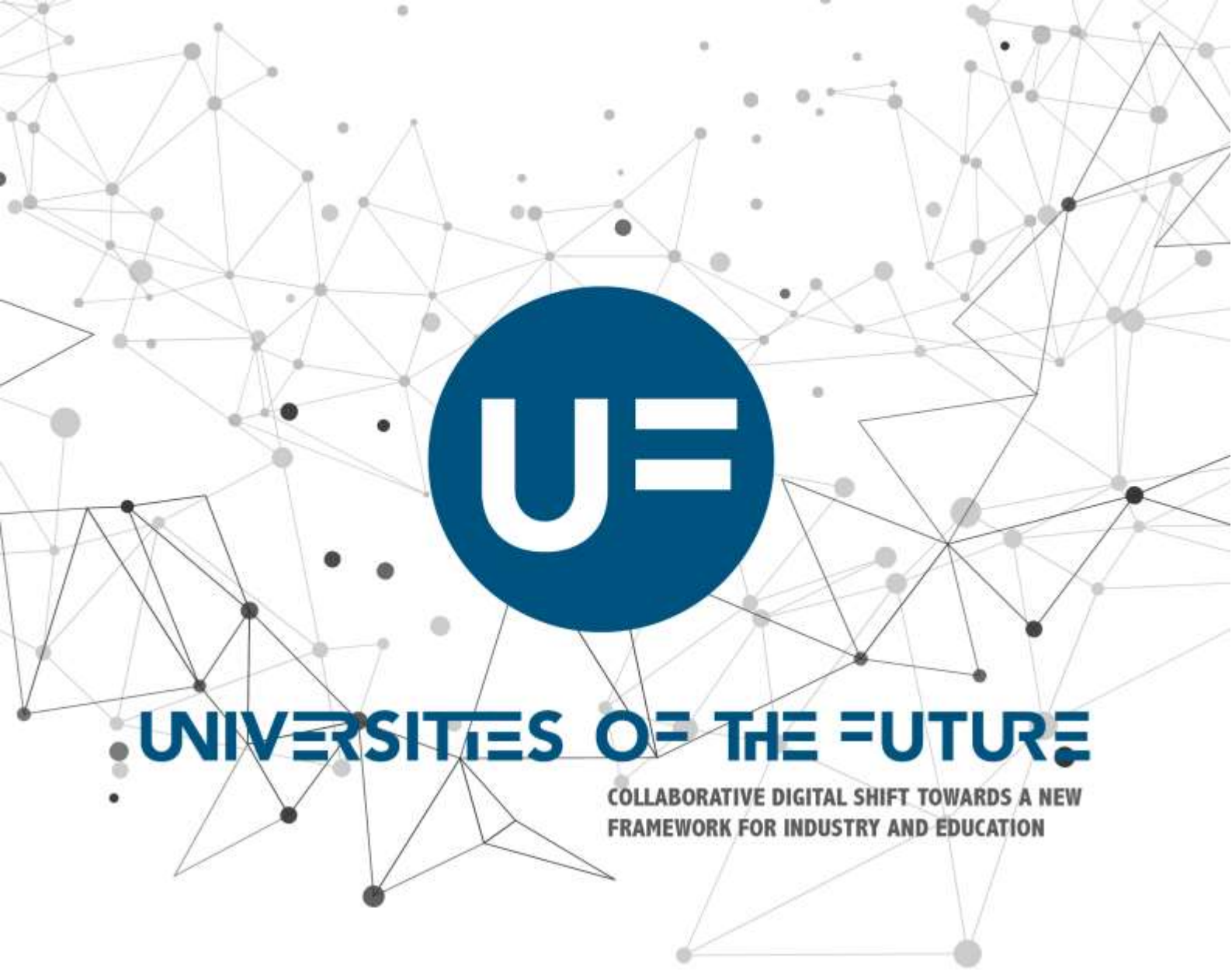

Blueprint for Universities of the Future

Enhancing cooperation between higher education institutions, businesses, and public bodies

www. universitiesofthefuture.eu

Co-funded by the
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of the European Union

HIGHER EDUCATION INSTITUTIONS	COMPANIES	PUBLIC BODIES
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1. Universities of the Future

Universities of the Future (UoF) is an Erasmus+ Knowledge Alliance project funded with support from the European Commission. UoF aims to create a paradigmatic change in the way higher education institutions (HEIs), industry, and public bodies collaborate around education for Industry 4.0.

The duration of the UoF project was 2018–2021, during which the consortium organised events for fostering a community of practice for the creation, implementation, and dissemination of collaborative educational solutions around Industry 4.0. The consortium also produced three research-based reports with a focus on education for Industry 4.0: state-of-the-art, best practices, and this Blueprint for the Universities of the Future. Furthermore, the consortium created a Virtual Teaching and Learning Factory to provide a virtual platform for the piloting of new collaborative teaching and learning activities around Industry 4.0.

Universities of the Future was coordinated by the Polytechnic Institute of Porto (Portugal) in partnership with Aalto University (Finland) and Warsaw University of Technology (Poland). The industry partners were the IKEA industry (Portugal), Consair Patented systems Ltd. (Finland), and Willson & Brown (Poland). Public bodies involved were Portugal's National Innovation Agency (ANI), Academic Engineers and Architects in Finland (TEK), and The Polish Accreditation Committee (PKA). In addition, the consortium had as supporting partners Platoniq, an expert on facilitation, Aalto University Student Union with contacts to students across Europe, Junta Digital responsible for the creation of digital outcomes, and Inova+, an innovation agency.

Industry 4.0 context

Many countries have entered the stage of the Fourth Industrial Revolution, also referred to as Industry 4.0, in which technological advances enable significant changes in the industry. The Revolution will not only increase efficiency concerning the use of resources and time, but it will also change the way people work.

In this report, Industry 4.0 is defined as *the larger transformation of work enabled by technological advancements*. The transformation is addressed by developing national policies and innovation strategies for supporting industry. If Industry 4.0 is to become the standard in production, every professional will need the expertise to work in such an environment. A better understanding of the skills required in Industry 4.0 are necessary to create the change, benefit from it, and democratize the knowledge among the future workforce. Professionals need to learn to work with, and complement, the new technology utilising the most important factor: the human skills that cannot be replaced. This Blueprint examines the role that higher education institutions (HEIs) will play in the industry 4.0 transformation.

Creation of the Blueprint

This Blueprint provides a strategic plan including actionable recommendations on how to solve the educational challenges around Industry 4.0. It is divided into four sections: background, evolution scenarios, strategic goals, and recommendations. The background section presents the findings from the previous two reports, state-of-maturity, and best practices. In evolution scenarios, a picture of the desired future is painted, to give a vision for the strategy. The strategic goals provide guidelines for all stakeholders on how to reach the preferred future. Finally, actionable recommendations on how to proceed in the short term are given separately to each player.

Two previous reports by the Universities of the Future consortium provide the groundwork for this Blueprint. The first of them is the *State-of-Maturity on Education from an Industry 4.0 Perspective* report. It discusses the maturity of the three

consortium countries, Finland, Poland, and Portugal, to drive the Fourth Industrial Revolution, through the lenses of digitalisation and education. The report also investigates the skills needed for Industry 4.0, along with related societal and industry challenges that need to be solved to be able to fully adopt and benefit from Industry 4.0.

The second report, *Best Practices in Education from Industry 4.0 Perspective*, is focused on best practices in education on Industry 4.0. The best practices were identified through desk research as well as by interviewing governmental, industry, and higher education representatives[1] with experience and knowledge on education and the Industry 4.0 context. The selected best practices (see Appendix 2) range from national strategies to private companies and from universities to workshops. The practices cover cases led by different players (governments, industry, HEIs, or individuals), pedagogical trends, continents, skills to teach and types of cases. Multidisciplinary, multi-stakeholder and perceived first movers were prioritised in the case selection. Through the best practices, the report identifies educational challenges that complement those identified in the State-of-Maturity report and gives recommendations on how to improve education. The description of the data set is presented in Table 1.

Table 1. Data from the previous reports

State-of-Maturity on Education from an Industry 4.0 Perspective

- 30 interviews of experts on education and Industry 4.0
- Literature review of 137 scientific journal articles

Best Practices in Education from Industry 4.0 Perspective

- 56 interviews for identifying potential best practices (205 potential cases)
- 74 interviews and online material on 35 selected best practices

The most pressing educational challenges and best practices identified in the previous reports were further developed in various co-creation and dissemination events organised by the consortium. The results of the events and focus groups are integrated into this Blueprint and excerpts from the discussions during the events are presented in the report. The three types of events are described below.

Igniting events were organized once in all three countries during spring 2019. The goal of the igniting events was to raise motivation, interest, awareness and to know and to acknowledge that authorities, HEIs and businesses are first moving towards a change in the model and achieve a better position in Industry 4.0.

The Blueprint enabling events were organized altogether 15 times. The expected results of the Blueprint Enabling Events were to have a clear overview and strategy of relevant content that would be used to develop the educational assets and the learning units of the HEI, the learning lessons training courses.

Focus group workshops were organized for experts. The objective of these events was to discuss the first version of the Blueprint and get expert input and suggestions for the further development of the Blueprint.

[1] The informants included educational researchers, educational influencers, the Universities of the Future consortium members, and the Design Factory Global Network (DFGN) members and affiliates on five continents. This resulted in identifying both potential cases and further people in the field of education or working in companies within Industry 4.0, who were contacted for further interviews. The total number of interviewees in this phase was 56, including professors, industry experts, teachers, and active students.

Co-creation units were organized by the consortium members to support the development of hands-on challenges/projects and pilot projects by exploring key components of industry 4.0.

Forward-looking events organized by the three universities gathered representatives of different sectors to discuss the emerging subjects of the project results and how they would intersect with new trainings and offerings.

Table 2. Event participants during the academic year 2018–2021.

	Finland	Poland	Portugal	Total
Igniting events:	28	26	100	154
Enabling events	45	59	45	149
Focus groups in Portugal, Finland and Poland, BEST for students*:				42
Co-creation events	26	48	55	129
Forward-looking events	91	102	110	303
Total	190	235	310	**735**
*BEST focus group. 20 students from the following countries: Belgium, Germany, India, Italy, Latvia, Poland, Portugal, Russia, Spain, Sweden, Ukraine				

2. Background

This chapter sets the background for the evolution scenarios, strategic goals, and recommendations presented in this Blueprint.

State-of-maturity for Industry 4.0 in Finland, Poland, and Portugal

The maturity of Finland, Poland and Portugal to prepare for the Fourth Industrial Revolution is discussed through the access to digital technologies and digital skills of the populations, identified through desk research. Also, expert insights from the consortium members were used for creating the State-of-Maturity report, which serves as a basis for this discussion.

Economically, socially, and politically, Finland, Poland, and Portugal are stable countries. Their economic situation has improved over the past two years, and in general, the business environment is friendly, with a certain level of transparency that permits investment in technology and human resources. In addition, all three countries have national initiatives for the implementation and development of Industry 4.0, with Finland framing this as a more general focus on the transformation of work.

Figure 1. European national initiatives on Industry 4.0

Digitisation and digital integration of services is increasing in all three countries. The overall regional assessment below provides a more detailed view of the regions in terms of five levels of digital integration as defined in Europe's Digital Progress Report of 2017: The Digital Economy and Society Index (DESI). The DESI looks at connectivity, digital skills of the population, use of internet services by citizens, and integration of digital technologies by businesses. In this metric, Finland ranks number two in Europe, with Portugal being near the average, and Poland in the lower end (European Commission, 2017a). The sections below will go into greater detail into these metrics, plus the findings of the research on educational opportunities in the three countries.

Educational opportunities

In **Finland, Poland**, and **Portugal**, the offering for up-and re-skilling opportunities[2] is scarce. After joining the workforce, people rarely return to HEIs. There is expensive and heavy management education, and in Finland, there are open university courses that are often the same as offered to degree students. However, the offering between these two options is limited. HEIs do not in general offer opportunities for continuous learning, except for some programmes that

[2] Upskilling refers to developing skills and competencies of employees for a broader or a more complex role within the same or a related area of work i.e., teaching complementary knowledge or skills. Re-skilling refers to retraining of employees to perform new roles in a different area of work i.e., teaching skills.

can be done at the side of work. The type of education that would allow people to get faster to work after high school is missing. Students often work and study simultaneously, and especially ICT students are sought after in the labour market. This can be seen as a sign of the education being of good quality, but according to some interviewees, it is more a reflection of the high demand.

Digital skills and Internet use

In **Finland**, digital skills are being integrated into the curriculum, and effort is placed into developing the digital skills of teachers. The high levels of Science, Technology, Engineering and Mathematics (STEM) graduates and digital skills reflect Finland's economy, which is highly based on ICT services. However, there is still a great demand for STEM employees in the industry. It is projected that in the next four years, 53,000 positions in technology will need to be filled, with not enough people to fulfil them (Juvonen et al., 2018). This number does not account for the re-skilling that needs to be provided for workers currently in the workforce. More graduates from STEM subjects are needed, as are more re-skilling opportunities. There is a need to re-skill a million people in Finland, and the re-and up-skilling opportunities have become better than before but are not at a level that would help solve the issue at hand. Furthermore, the lack of basic digital skills for 27% of the population still needs to be addressed (European Commission, 2017b).

Although only 44% of **Poland's** population masters basic digital skills, their level of digital skills, particularly among the youth (16–24 years old), as well as the number of STEM graduates, are increasing. However, the number of STEM graduates remains too low, and STEM universities are accepting students without a STEM background and giving them a "crash course" (European Commission 2017a). There is an active push from the state to develop digitalization in Poland through various programmes intended to build infrastructure, promote digitization in business and public services, and IT skills in the more marginalized population. This shows Poland being one of the countries digitalising most rapidly in Europe. Efforts are being made also for primary school programs. People from higher age groups have more limited digital skills and might need more support for acquiring them. For the development of skills specifically for Industry 4.0, Poland is currently developing a network of Competence Centres for students and researchers to learn and apply Industry 4.0 concepts in the industry (European Commission 2017a). Poland also has other programmes to further Industry 4.0, like Air 4.0 and the Broad Alliance on Digital Skills. (Arak & Bobiński, 2016; European Commission 2017a, European Commission, 2017c, interviews with Ministry).

Warsaw University of Technology

In the interviews, the Polish process of transformation was highlighted, as it is constructing new, coherent and clear regulations concerning the entire system of science and higher education. The changes, which will be gradually implemented in collaboration with the academic community, aim to improve Polish science and higher education. These include:

- A new model of effective university management
- Extending the autonomy of universities
- Sustainable development of higher education throughout Poland
- New academic career paths
- A new model of doctoral education
- Guarantees of rights for workers and students
- An effective funding system for universities and greater flexibility in this respect
- Pooling the potential of scientific disciplines
- Guarantees of additional funding for education and higher education
- Support for the Responsible Development Strategy

There is a fear that these changes might not be enough. There is also a perceived lack of resources for companies and HEIs to work efficiently together. From an Industry 4.0 perspective, Poland is not there yet, as it is "one of the biggest assembly lines in Europe". This makes it hard to find relevant partners and to get universities to focus on training students suited for the kind of jobs that local industries offer, which are rarely Industry 4.0 leadership roles. A weakness in the Polish education system is a lack of quality interdisciplinary education. There are excellent educational programmes within specific fields, but the lack of interdisciplinarity can cause the graduates' careers to stop moving forward after an initial good start, for example, due to a lack of management skills within the IT graduates.

In **Portugal**, only 68% of the population uses the Internet, and about 48% has basic digital skills. Similarly, 26% of the adult population has never used the Internet, and 22% of the active labour force has no digital skills. However, this might be due to the country's type of economy, as only 32% of companies reported having problems filling ICT vacancies, compared to the EU average of 41%. This lack of digital skills is more common particularly for the elderly and in rural areas. However, overall, 2% of students graduate from a STEM field, which is higher than the EU average. In 2017, Portugal launched the National Initiative on Digital Skills, as part of its *Indústria 4.0* plan, to address these challenges and make digital technology more accessible to all members of the population. While Portugal has a high score for connectivity and online services, the high costs of Internet access and the lack of basic digital skills in a large part of the population make the Internet inaccessible for certain members of society. (European Commission 2017a, European Commission 2017d). However, the percentage of the population with secondary education has been steadily and consistently climbing over the last 15 years from 48% to 81% of the population in their 20s, and the number of people getting a tertiary education went from 15% to 33%. While this is a bit below the European average, it is in alignment with the increasingly larger economic impact of knowledge, technology, and innovation-based industries (Indicadores Inovacão).

Connectivity and digital technology

Finland has a high level of connectivity, as the majority of the population has a mobile broadband connection, most people have some access to fixed broadband, and the price as a percentage of income tends to be low. Most Finns use the Internet regularly to read the news, use it for music, videos and games, social networks, and especially for banking and shopping. While the use of video on demand is low (37%), it is still much higher than average. Only video calls are lower than average. Easy access to the Internet and high digital skills results in a 64% rate of use for government services, almost twice the European average, and in the top four rankings as to the amount of data available to citizens and researchers. (Arak & Bobiński, 2016).

The overall use of digital technology in Finnish companies is very high, especially in the use of social media, e-invoices, and the cloud. Electronic information sharing and use of RFID is slightly higher than average, with SME e-commerce rates being average. Recent Finnish initiatives focus on supporting digital service platforms and ecosystems, digital transport services, big data businesses, and fostering trust in the digital business environment. Furthermore, Finland has invested 100 million euros in the digitalization of public services. To organize this huge amount of digital information, a public initiative called the *Information Management Act* was launched to provide a unifying information services platform.

70% of the population in **Poland** regularly access the Internet. The use of the Internet, however, is increasing in general, and particularly for online banking and shopping (European Commission, 2017d). Poland's bottleneck in connectivity is fixed broadband, with higher costs being cited as the reason for lack of connectivity, as well as geographical conditions. In Poland, the industry is arranged in well-connected regional clusters (Alessandrini, Celotti, Gramillano, & Lilla, 2017). In contrast, there are high costs and low demand for broadband infrastructure in low demographic density areas, where mobile broadband is more common. The *Operational Programme Digital Poland* 2014 – 2020 is a plan for increasing connectivity in Poland, through incentives for infrastructure investments. The 2016 *Programme for the Integrated Digitisation of the Country*, and the *OpenPeppol Association programme* aim to increase digitized services in the public sector.

Polish companies are digitalizing, and consumers are slowly catching up. The highest use of the Internet is to read the news, and public services are digitalizing faster than consumers. (Arak & Bobiński, 2016.) Only 25% of the population use these e-Government services. Out of these services, 58% are used for pre-filled forms, 79% for online service completion, and 56% for open data. The lack of use of e-Government services could perhaps be addressed through better usability and higher visibility (European Commission, 2017d). Another thing that can be improved is for Poland to provide greater data transparency for research purposes (Arak & Bobiński, 2016).

There is a great area of opportunity for Polish businesses to integrate digital technologies into their business models and processes. Low-hanging fruit would be the digitalization of sales and marketing, as well as the use of e-invoicing, particularly among SMEs. This is already being addressed through business innovation investment and start-up support programs. According to The Digitalization of the Polish Economy Report (Arak & Bobiński, 2016), 60% of Polish enterprises have e-commerce capabilities.

In Portugal, the level of electronic information sharing and use of RFID in companies is much higher than average. This suggests companies' interest in active investment in technology. Lisbon is currently also aiming to become a digital hub, hosting a yearly Web Summit in Lisbon.

Portugal is in the top ten of digital public services but is limited by the lack of digital skills. In response, Portugal's government has been implementing a series of initiatives to promote the digitalization of public digital services, not only for easier access but for increasing transparency and interoperability[3]. This has resulted in the number of eGovernment users being higher than the EU average, but lack of digital skills may be limiting the growth of use. An initiative aimed to increase the use of digital government services is called *Citizen Spots*, where spaces with computers are made available to teach citizens how to use them, with help from an assistant.

Portugal has 99.8% of broadband coverage and 95% of 4G coverage. Fixed broadband take-up is 68% while broadband take-up is only 55%. Although it has a higher number of subscriptions to fast broadband than average, they are still only 63%, this might be due to the higher prices of Internet connection in the country.

Portugal's use of the Internet for news, listening to music, videos, and games, and making video calls is average, with the use of social networks being slightly higher than the EU average. Use for banking is 41 % and shopping 43 %, rating less than average. The use of the SMEs online sales activities is on par with the EU average, lagging in the use of social media, e-invoices, and the cloud. The fact that only 43% of the population regularly shops online would suggest that those who do, shop frequently enough to raise Portugal´s eCommerce turnover to be on par with the European average.

Figures 2–10 (below) show in greater detail the scores for internet use, digitalization, human capital, and connectivity in Finland, Poland, and Portugal.

[3] *Plano de Ação Justiça + Próxima,* hosting the *Sharing & Reuse Conference 2017*, and the *European Conference on Digital Government.*

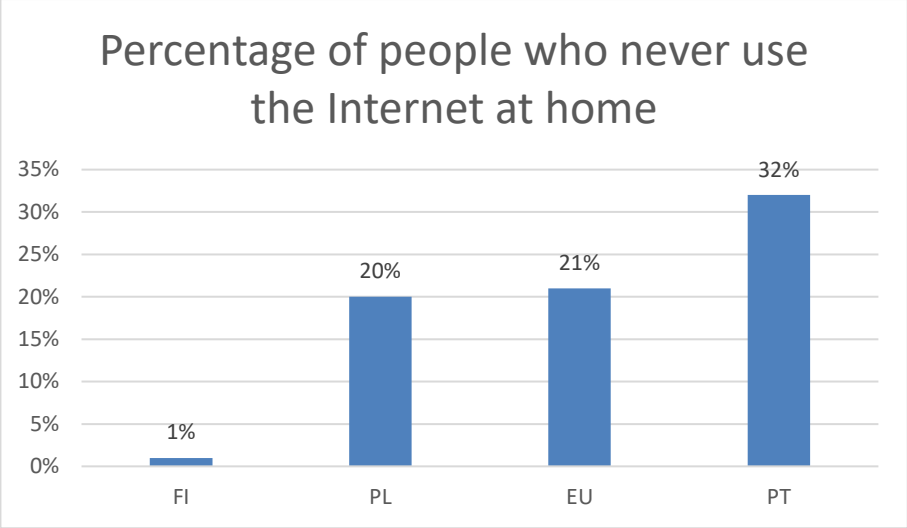


Figure 2. Percentage of people who never use the Internet at home. Scores for Portugal, Poland, and Finland, with the European average as a comparative baseline(EU Open data portal, 2014)

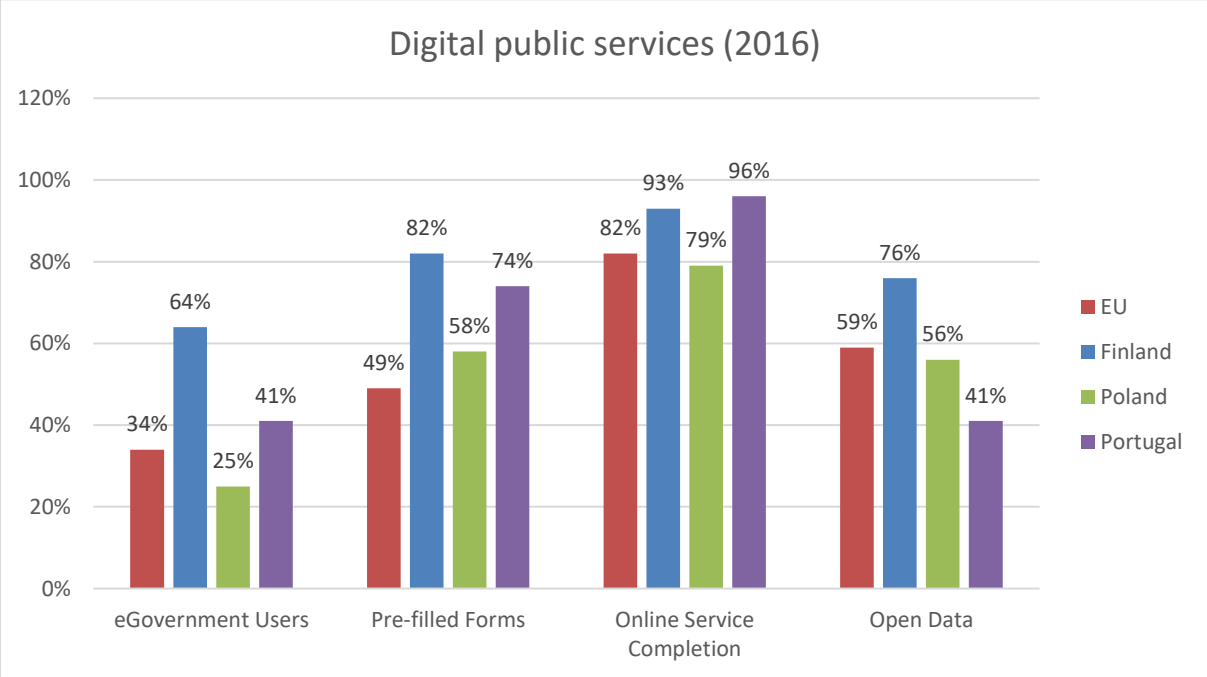
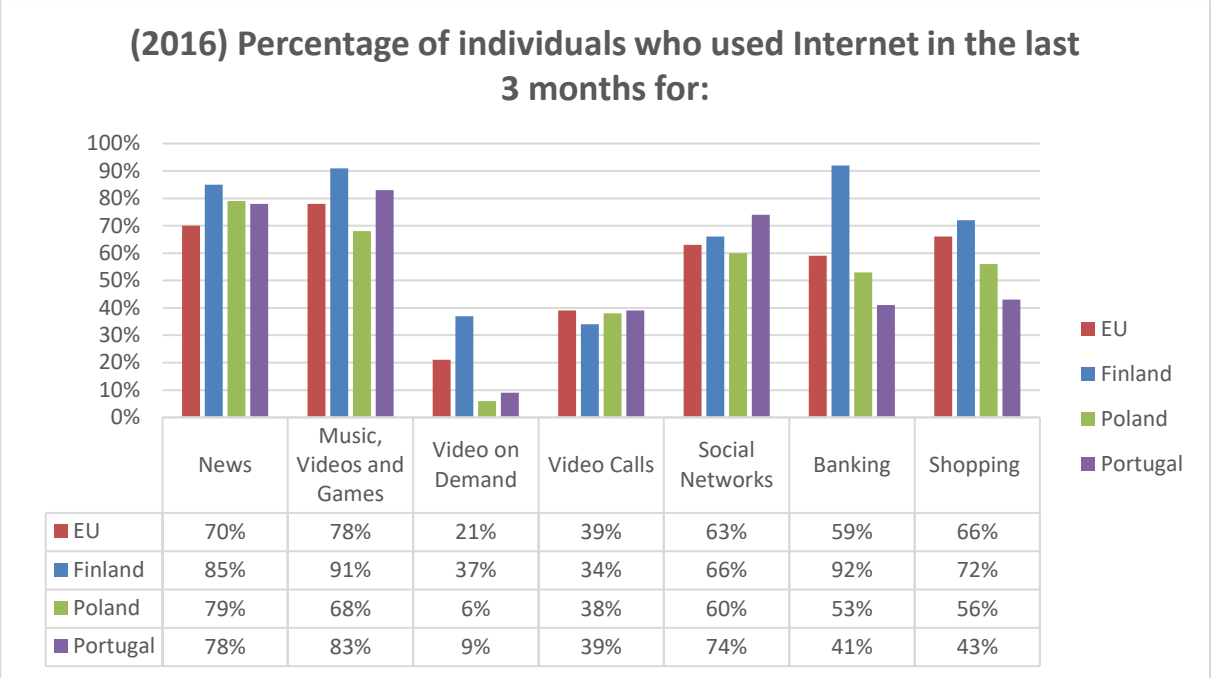


Figure 3. Digital public services. Scores for Portugal, Poland, and Finland, with the European average as a comparative baseline **(European Commission, 2017b, 2017c, 2017d)**



	News	Music, Videos and Games	Video on Demand	Video Calls	Social Networks	Banking	Shopping
EU	70%	78%	21%	39%	63%	59%	66%
Finland	85%	91%	37%	34%	66%	92%	72%
Poland	79%	68%	6%	38%	60%	53%	56%
Portugal	78%	83%	9%	39%	74%	41%	43%

Figure 4. Percentage of use of the Internet for different tasks. Scores for Portugal, Poland, and Finland, with the European average as a comparative baseline. (European Commission, 2017b, 2017c, 2017d)

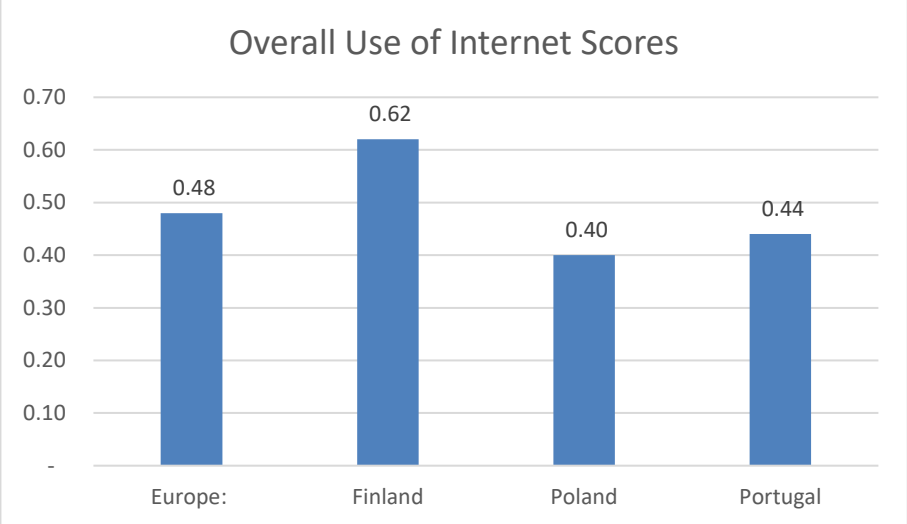


Figure 5. Overall use of Internet scores for Portugal, Poland, and Finland, with the European average as a comparative baseline. (European Commission, 2017b, 2017c, 2017d)

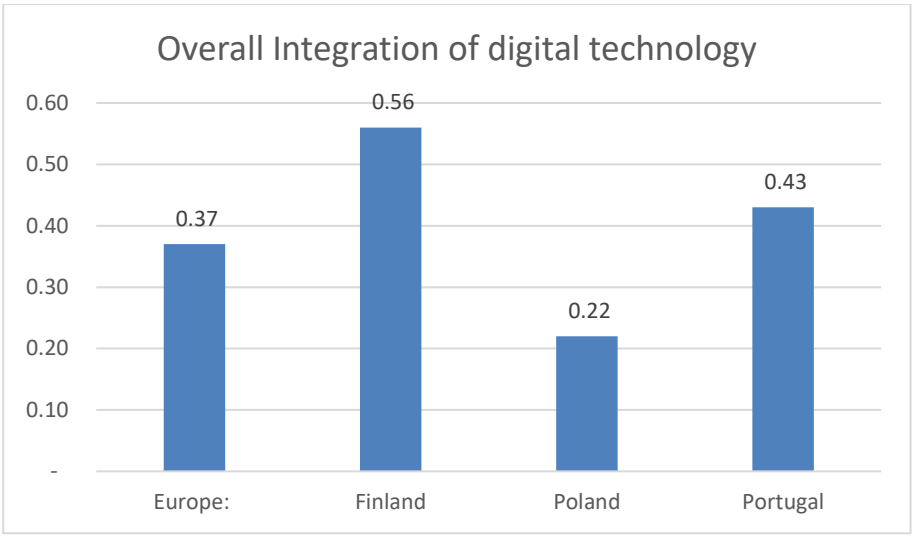


Figure 6. Overall integration of digital technology. Scores for Portugal, Poland, and Finland, with the European average as a comparative baseline (European Commission, 2017b, 2017c, 2017d).

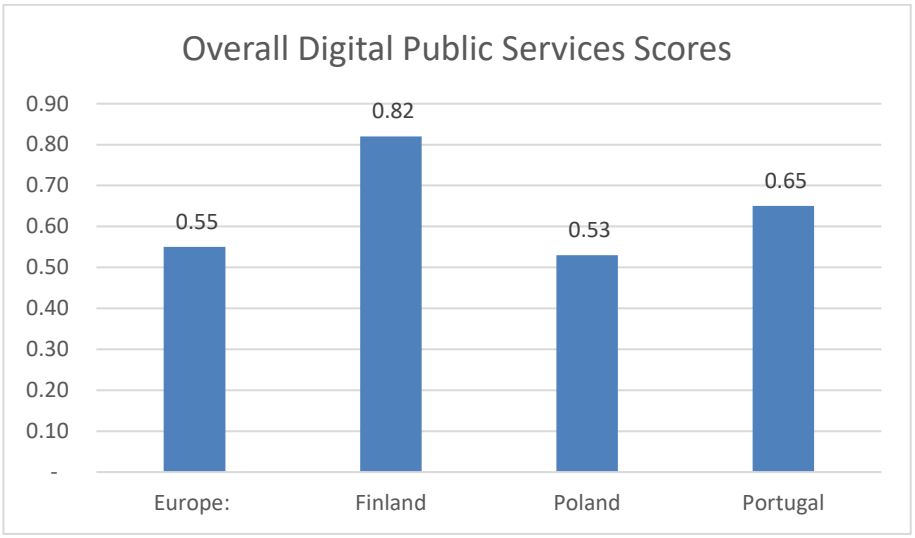


Figure 7. Overall digital public services. Scores for Portugal, Poland, and Finland, with the European average as a comparative baseline **(European Commission, 2017d, 2017c, 2017b)**

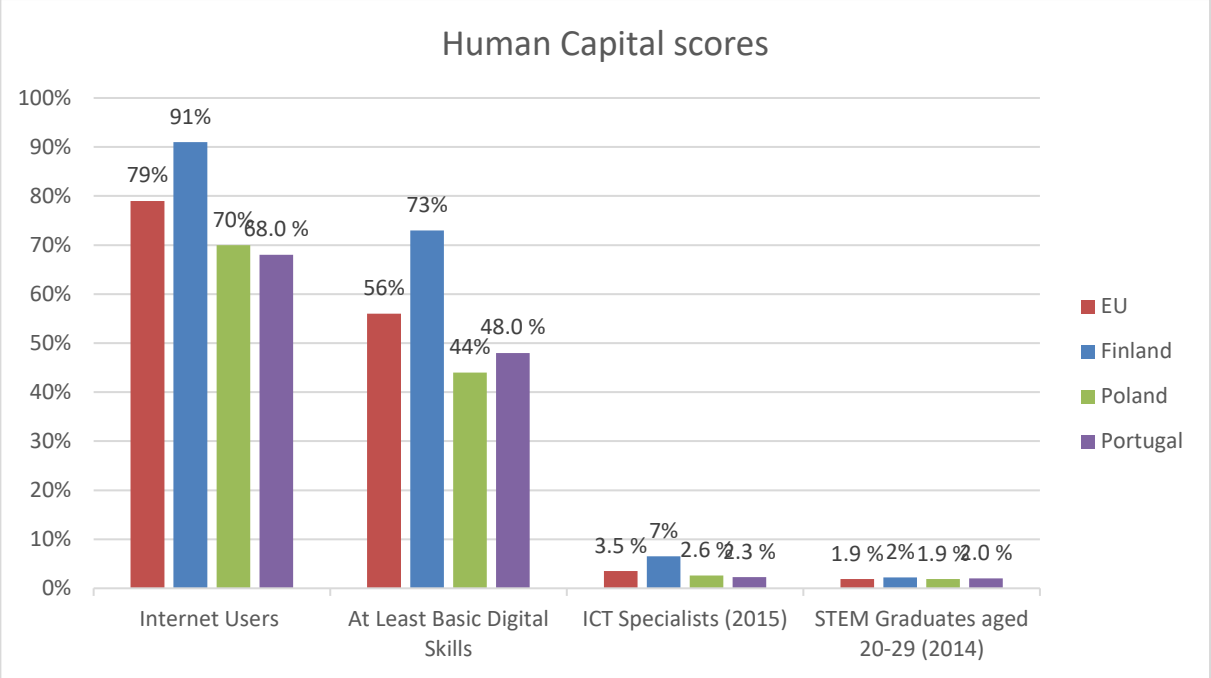
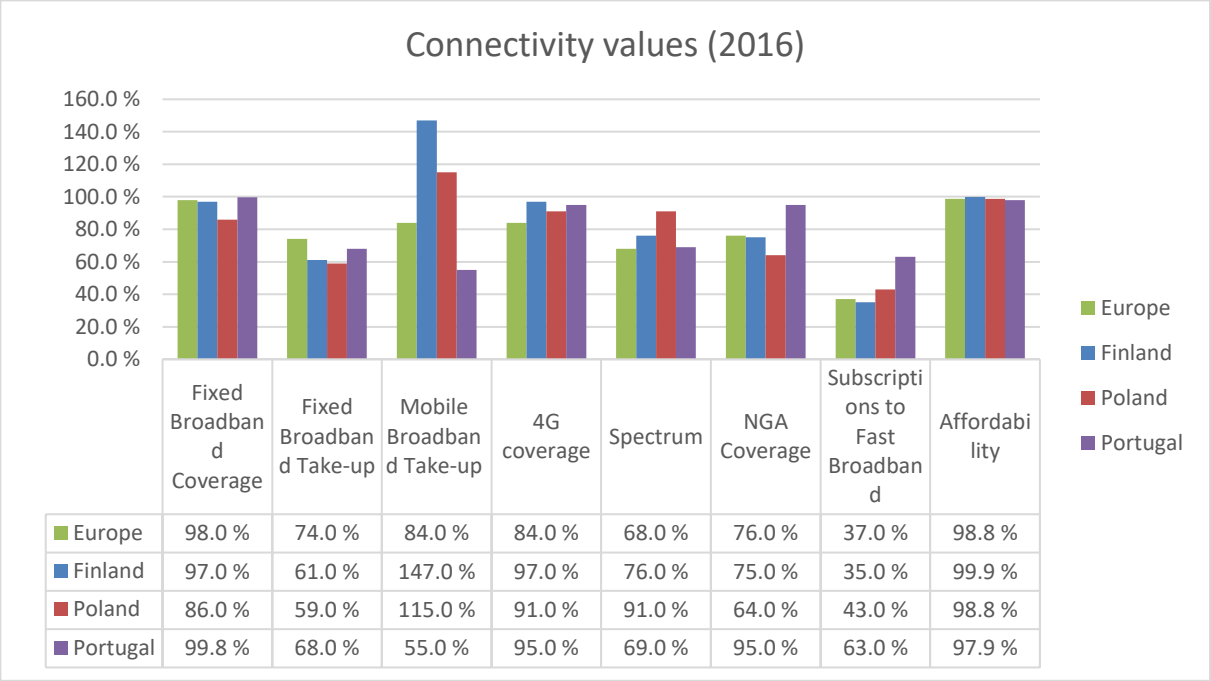


***Figure 8. Human Capital scores for Portugal, Poland, and Finland, with the European average as a comparative baseline* (European Commission, 2017d, 2017c, 2017b)**



	Fixed Broadband Coverage	Fixed Broadband Take-up	Mobile Broadband Take-up	4G coverage	Spectrum	NGA Coverage	Subscriptions to Fast Broadband	Affordability
Europe	98.0 %	74.0 %	84.0 %	84.0 %	68.0 %	76.0 %	37.0 %	98.8 %
Finland	97.0 %	61.0 %	147.0 %	97.0 %	76.0 %	75.0 %	35.0 %	99.9 %
Poland	86.0 %	59.0 %	115.0 %	91.0 %	91.0 %	64.0 %	43.0 %	98.8 %
Portugal	99.8 %	68.0 %	55.0 %	95.0 %	69.0 %	95.0 %	63.0 %	97.9 %

***Figure 9. Connectivity Values for Portugal, Poland, and Finland, with the European average as a comparative baseline* (European Commission, 2017d, 2017c, 2017b).**

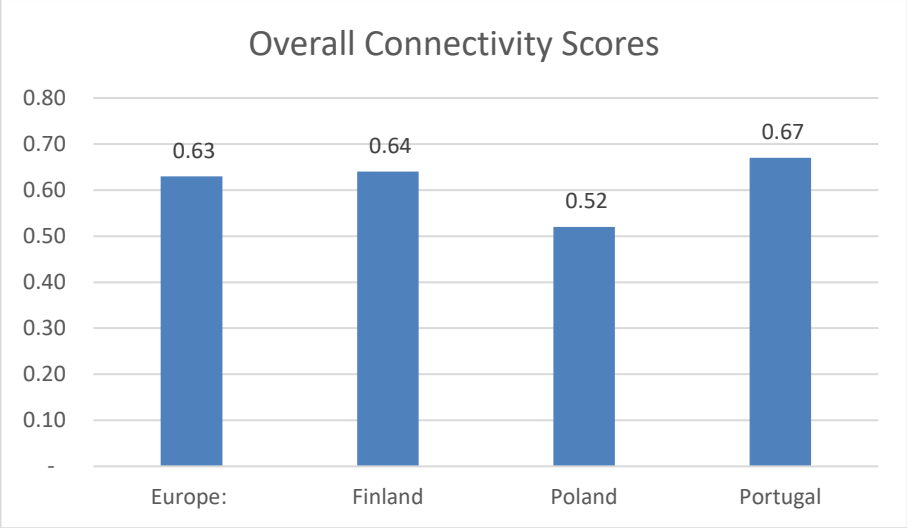


Figure 10. Overall connectivity scores for Portugal, Poland, and Finland, with the European average as a comparative baseline **(European Commission, 2017d, 2017c, 2017b)**

Challenges hindering the effective implementation and adoption of Industry 4.0

To identify the key challenges around the implementation of Industry 4.0, thirty interviews with researchers, industry representatives, and governance advisors were conducted. The interviewees were selected based on suggestions of the Universities of the Future consortium members. The interviews covered topics surrounding Industry 4.0 and the transformation of work, as well as the educational needs created by them. Three key challenges were identified: lack of vision on technology, lack of skilled workforce, and lack of understanding on how to prepare for future work. These challenges were common to Finland, Poland, and Portugal, suggesting that they may apply to other European contexts as well. **Figure 11. Challenges for Industry 4.0** presents these main challenges, along with their central causes and effects.

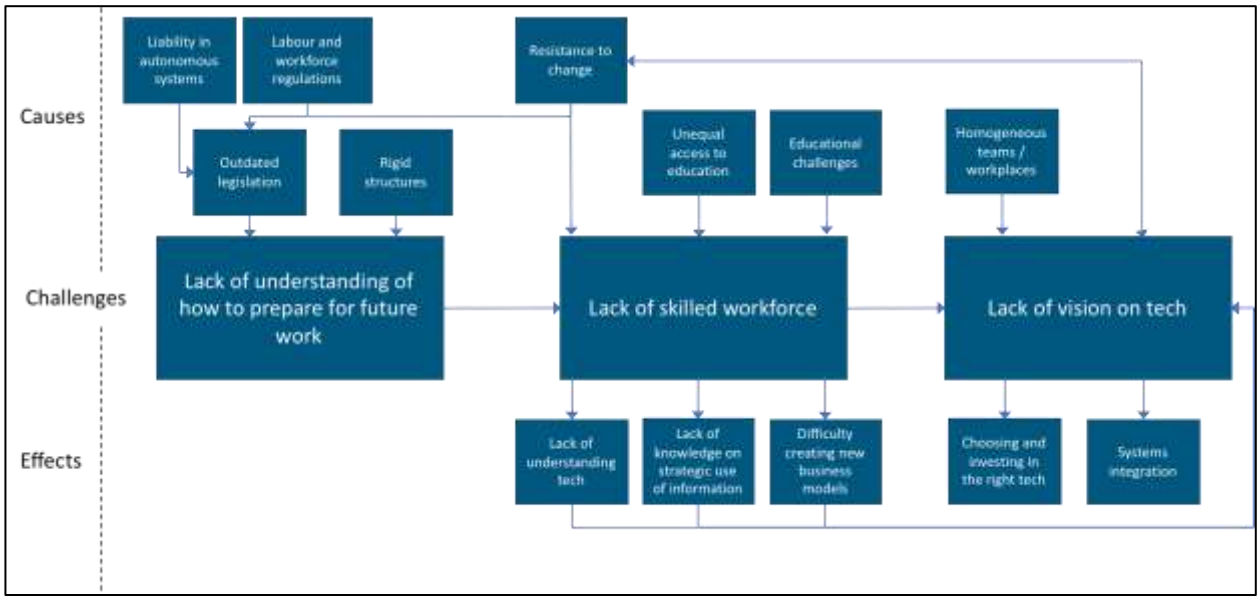


Figure 11. Challenges for Industry 4.0

Lack of a skilled workforce

New technologies create new ways to work. Work is becoming less tied to a place or time, and professionals are increasingly freelancing or working within platform economies. **Not knowing how to prepare for future work** slows down the emergence of Industry 4.0. It requires an understanding of what the future work could be like, the organisational structures that allow for it to emerge, and the legislation to support it. This lack of knowledge on how to prepare for the future of work makes it difficult to allocate resources for educating people to have the needed skills, making it one of the causes for a lack of a skilled workforce. This can slow down the innovations that could potentially improve human lives and the environmental situation.

"Other possible causes for a lack of skilled workforce include people studying fields that have high unemployment rates after graduation instead of seeking to study for the professions that are lacking workforce." - BEST focus group

The lack of a skilled workforce manifests in three different ways: **a lack of understanding technology, a lack of knowledge of strategic use of information, and a lack of abilities to create new business models**. These challenges contribute to the overall lack of vision on technology.

The lack of vision on technology

The lack of vision on technology refers to the inability to understand the **potential use cases** of technology and the **impact that technology can have on people's lives and the environment**. The lack of vision causes an *inability to choose and invest in the right technology* as well as an *inability to achieve systems integration*. In other words, the lack of vision on technology is one of the central issues hindering the implementation of Industry 4.0.

BEST/AYY, PKA and TEK

The participants of the focus groups run by BEST/AYY, PKA and TEK identified the following challenges:

- Outdated legislation is an extremely important challenge from the viewpoint of businesses. Regulations are hindering new models from being developed or tried out, and businesses don't often understand the regulation processes. Solving it requires more dialogue from both sides – those who work on legislation and those who understand technology.
- Merely updating the regulation is not enough, as people will need to also prepare to work in a new environment. The future workforce should be able to understand technological opportunities, as well as other disciplines that can help them create new business models.
- Unfamiliarity with Industry 4.0, and a lack of shared vision between industry and education on what it means is a challenge.

Unequal access to education

Unequal access to education is leaving a wide variety of potential future workforce outside of the educational system. Discrepancies in educational opportunities among different groups can contribute to the problem of **homogeneous cultures**, resulting in a system where tunnel vision makes change more difficult. A lack of technological vision is amplified by the cultures that tend to concentrate on a single point of view instead of a diversity of views that allow organizations to widen their perspective, thus being able to identify more opportunities for innovation or needed change.

Outdated Labour and workforce legislation

Labour and workforce legislation needs to be updated to protect the new types of workers and to allow a new type of agile work to bloom. As new technologies emerge, the legislation does not keep up to date. This can be seen for example in the uncertainty on **liability issues with autonomous systems**, like self-driving cars. Outdated legislation hinders the development of future work, both from the perspective of the adoption of new technologies and new types of work. **Rigid structures** within corporations prevent people from working flexibly, and on a state level, it slows down the pace and processes of updating legislation.

PKA and BEST/AYY

Insights from the PKA and BEST/AYY focus groups showed the participants worried about HEIs lagging in Industry 4.0 development due to *fear of the unknown* and *uncertainty* of how the new systems would work. They also highlighted "bureaucracy" as one of the main barriers for co-creating the educational change needed to co-create new curricula.

Resistance to change

The inevitable change in the way work is conducted requires education and governmental support systems to challenge their current approaches. Adding more flexibility to the educational offering and making it more student-focused are central approaches that the governmental, industry and higher education representatives interviewed generally agreed on. However, education is increasingly taking place outside the traditional systems, with more peer-to-peer initiatives, private companies focusing on education, and new types of educational models emerging. This reflects the perceived need to develop education beyond how it has been traditionally arranged and organized. Quality education can be provided through a wide array of different approaches that deviate from the traditional teacher-centred lecture-based approach, with the use of learner-centric approaches such as peer-to-peer learning increasing.

Resistance to change in HEIs hinders the creation of new study programmes and limits the number of people enrolling in them. Furthermore, current study programmes need to be updated more often in cooperation with other stakeholders.

Challenges for HEIs

Collaboration between and across disciplines, stakeholders, and national borders is regarded as an absolute necessity to improve education and create interdisciplinary educational offerings. However, collaboration is also highlighted as one of the key challenges. Different stakeholders and people in different fields have their assumptions and ways of working, so it can be difficult to understand the mutual value, organise the collaboration, and work together.

Once a new type of education initiative has been proven effective, **scaling up and replication can be difficult.** Collaboration with the surrounding ecosystem was seen as effective, but scaling those efforts is dependent on the size

of the ecosystem. Local job markets, laws, and the economy also dictate at least a part of how well the initiatives function, making it hard to implement a similar activity in a different geographical location. The combination of quality and scalability is yet to be discovered, even though some impressive efforts have been made (Universities of the Future Benchmarking report). Financing is a central issue. Teachers need resources to implement new interdisciplinary curricula, whether in the form of access to experts in different disciplines, or monetary resources to compensate them.

Assessing the impact of education remains a challenge. The effects of education are often seen only after extensive trials over longer periods. This makes it difficult to effectively test and assess new forms of education, and even to assess which traditional forms of education would need updating.

Reputation and familiarity of the education provider proved to be important issues, as the most talented students tend to gravitate towards institutions with a reputation of being excellent. Being able to attract motivated and smart students is regarded as a crucial indicator of the quality of education.

Skills needed for working within Industry 4.0

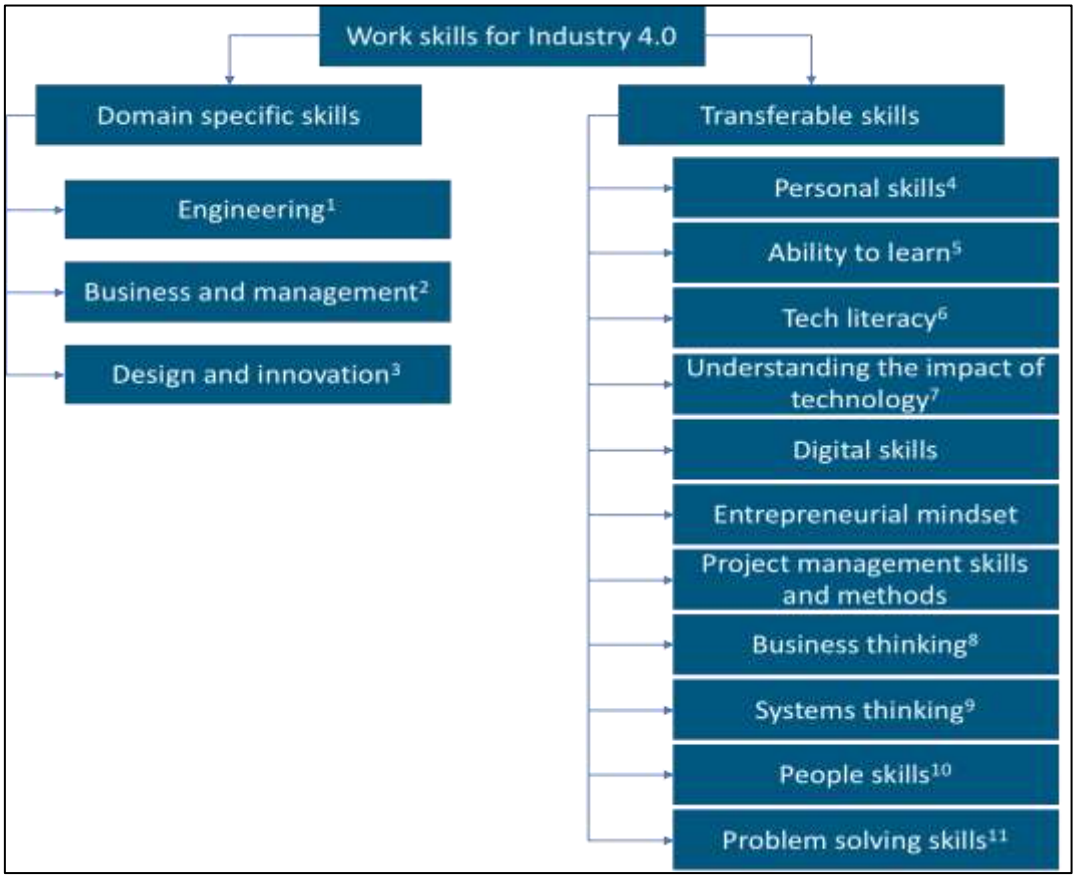


Figure 12. Skills for Industry 4.0

The State-of-Maturity on Education report outlined skills needed for Industry 4.0 through both desk research and interviews. In this Blueprint, those skills are divided into two categories. The first category is **domain-specific skills**, which refer to skills needed to perform a specific job. These skills are further divided into engineering, business and management, and design and innovation specific skills. The second category is **transferable skills**, which refer to skills that can be applied in different settings and contexts. The domain-specific skills apply only to a small part of the workforce, whereas transferable skills can be seen to be relevant across the borders of professions. The skills and their categorisation are presented in ***Figure 12. Skills for Industry 4.0***. For a more detailed presentation see Appendix 1.

Personal skills such as **s**elf-learning skills and promoting a flexible mindset is required to adapt to changing working conditions. It is also important to understand one's professional impact on society. **Systems thinking** – the ability to extrapolate content to understand and navigate in a complex world – should be encouraged.

People need to understand the basics of **business thinking** and keep up with new trends and business models, e.g. the circular economy.

Increasing the number of people with engineering skills is one of the most immediate goals, but not only as it pertains to the use of technology, but also the implications of technology. In general, graduates need to have **technological literacy,** that is, a general understanding of the technology needed for Industry 4.0 implementation. People from different study backgrounds will need to make decisions regarding technology and its potential uses; therefore, familiarity with the topic is highly beneficial. Teaching **people skills** are imperative**.** Communication and teamwork are crucial in technology development and **project implementation**.

Finally, digital competencies should also be emphasized. For that, digital education should start at an early stage. People are not always sufficiently aware of the implications and possibilities of using the Internet, its traps and threats. It is also necessary to develop a culture of maintaining **safety on the Internet**.

Finally, understanding the **problem-solving process**, as well as the importance of science and related skills (critical thinking and experimentation, for example) is something that every professional should have. There is currently a lack of knowledge on reading the research, read data and information, and verifying data sources. HEIs should teach methods to evaluate, interpret, understand, and analyze data and information.

3. Evolution scenario

The Universities of the Future project aims to create a paradigmatic change in the way HEIs, industry, and public bodies collaborate around education for Industry 4.0. This evolution scenario is developed to serve as an image of the desired future

What are evolution scenarios?

Evolution scenarios present alternative images of the future. A scenario is not a forecast, as it is impossible to predict a certain future. Scenario planning is a method used for discussing the possible effects of current decisions on the future. The goal of scenario planning is not to create a precise picture of the future, but rather to help make the right decisions concerning the future (Hiltunen, 2012; Schwartz, 1998).

Scenarios can be divided into three different categories: Dystopia, Utopia and Business as Usual (Hiltunen, 2012). For this Blueprint, only the utopian scenario for a prosperous Industry 4.0 was developed.

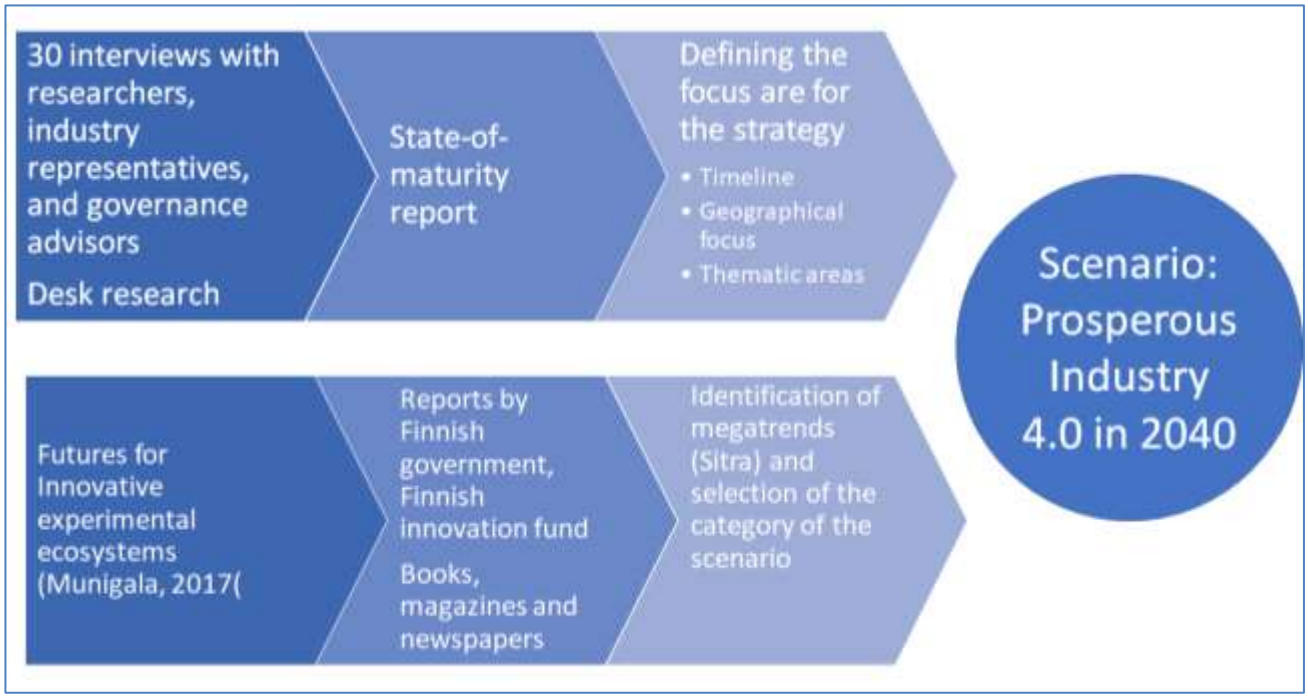


Figure 13. Scenario planning process

What is this evolution scenario based on?

The selected timeline for this evolution scenario is 2020–2040. The contexts of the scenario are Finland, Poland, and Portugal. However, these three countries are considered to be tightly connected to and affected by the rest of the globalized world.

The evolution path from the current state to the prosperous Industry 4.0 in 2040 is developed with back-casting. The method is based on giving recommendations for the steps required to reach the desired future and highlighting the intermediate goals to reach the desired future. The required actions to be taken today are drawn from the intermediate goals.

The evolution scenario presented in this Blueprint is based on the drivers, such as global megatrends and more local trends in Western, industrialised, and democratic nations. The megatrends include ageing societies, global population growth, local population decline in some geographic areas, urbanisation, a decrease of raw materials, climate change, technology advancement, and internationalisation. (Hiltunen, 2012). The evolution scenario also draws from the field research done for the *Best Practices* and *State-of-Maturity* reports as well as from the forecasting reports of Finnish governmental agencies (Kamppinen et al., 2003; Kaskinen et al., 2017; Prime minister's office, 2018; Prime Minister's office, 2017; Schuh et al., 2014; Sitra, 2018) [4]

Imagining the Future

It is the year 2040. After two decades of trial and error, research, and learning by doing, Europe has reached a point where Industry 4.0 is booming. The industry has taken the new technologies to use and the technological, economic, and social transformation are benefitting society as a whole. Education is scalable, effective, of high quality, and available to all. The governments have developed Industry 4.0 enabling legislation for new technologies, such as autonomous systems, and business models, including legal structures around new types of work, such as platform economies. This evolution scenario and the intermediate steps are presented in **Figure 14. Evolution scenarios**.

[4] The background study for the evolution scenario included the following references:
Kaskinen et.al. (2017), Futures School (2018), Sitra (2018), Prime Minister's office (2017), Finnish Government (2018), Kamppinen et. al (2013)

Figure 14. Evolution scenarios

New ways of working

The ways people work, and employee-employer relationships have changed. There is less hierarchy and more freedom from place and time. Work is more task-based and pay is performance-based. At the individual level, working life is more demanding and requires more self-management. There are fewer routine tasks and more higher-level tasks. For example, lawyers are focusing on advising clients, negotiating deals, and appearing in court as AI and machine learning are taking care of the time-consuming tasks of reviewing documents and conducting legal research. However, such changes are not equally wide nor happening simultaneously in all sectors (Prime minister's office, 2018).

Appreciation of many occupations conceived as traditional (e.g. handicrafts, human service providers) has increased (Prime minister's office, 2018). People work within platform economies through which work is being "crowdsourced", have project-based contracts, and often have more than one employer, all enabled by technology. As the amount of work to be done by humans has decreased and the tasks that remain are highly specialised or creative, there is universal basic income to enable people to have a good standard of life, even when they are not working. The universal basic income also evens out uncertainty caused by scattered work. It has become normal that people opt for having part-time work to enable them to pursue their other interests.

TEK perspective

For managers and supervisors, there has been a change from the role of an operational leader to a team leader, as mentoring and communication have become necessary for workers to evolve with the job. Automation project leaders have systemic understanding and team-working skills.

A better acknowledgement of one's own skills and the use of external resources and data to direct one's own learning have become increasingly important in the professional career path.

Educating a skilled workforce

The socio-cultural environment has changed to regard learning as an ongoing process throughout life and in all aspects of it. Up-skilling employees in collaboration with HEIs has become a basic practice in the industry and being able to offer good self-development opportunities for employees is considered as one of the key aspects of employer attractiveness. HEIs are doing their part by offering a wide range of up- and re-skilling options through a school-as-a-service model. Cities, NGOs, start-ups, and other businesses are actively supporting HEIs in providing relevant education and keeping education close to working life. However, HEIs also have a major role in educating ethically conscious people and doing science other than strictly business-related purposes.

> *"Blue collar jobs have become more specialised and certain service functions are automated, such as patients using chat bots to input their symptoms and robotic arms aiding in the care of moving immobile patients. However, robots haven't completely replaced care type of work performed by, for example, life coaches, social workers or psychologists."*
>
> *- Industry Representative*

AI-assisted virtual assistants support teachers in daily labour-intensive activities, such as administrative work and scheduling, as well as help to personalise learners' curricula based on their competence level and the needs of society. This way teachers have more time for interacting with learners. The use of technology in education has increased: VR and AR enable bringing high-quality education even to remote areas and enable learners to put their theoretical knowledge to practice in a virtual environment.

> *"Change leaders must have both managerial and design skills, as well as good interpersonal skills that enable cooperation, communication, and creativity. Project leaders should have good organizational skills, technology literacy, and ability to obtain information.*
> *Mentoring programs are helping both students to develop skills for a more successful career path, and industry to have a workforce which is better aligned to its needs."*
>
> *– Warsaw University of Technology igniting event*

Having a clear vision of technology

Almost all businesses have emerging technology experts working in their strategy teams to ensure seamless integration of new technology. Industry and HEIs work together to conceive new applications for the most recent technological advancements. Human resources is seen as a key function within businesses, not just to ensure the attractiveness of the employer, but also to ensure a level of diversity that is beneficial for innovation.

> *"New products and services are based on modern technologies, such as wearables, augmented reality, simulation, autonomous vehicles and robots, additive manufacturing, distributed ledger systems such as blockchain, big data analytics, mobile computing, and cloud computing. These technologies have enabled the creation of new business models, and more business opportunities are created through strategic use of information."*
>
> - TEK focus group

4. Strategic goals for HEIs, industry and public bodies

This chapter presents a development strategy for Industry 4.0. The insights are compiled from the interviews and workshops with Industry 4.0 experts and stakeholders during the project.

Creating a change and sharing a common vision

To leverage the development opportunities of Industry 4.0, all societies need to communicate a **sense of urgency** alongside a positive message of empowerment related to the inevitable transformation of work. Communicating the message requires finding a common language between various stakeholders of Industry 4.0. The needs of the different stakeholders must be aligned to reduce resistance to change, to create a shared vision, and to support a willingness to act. The transformation of Industry 4.0 needs to be people-driven. Consequently, it is crucial to recognise the **importance of people**, as collaboration is only as good as the people involved. When people understand what the inevitable changes entail and what they can do to be prepared, they are more likely to accept it and even become active participants in it.

Ensuring a skilled workforce

One of the main solutions to the challenges of Industry 4.0 is ensuring a skilled workforce. The world has changed from having one job after graduation to a world requiring continuous learning. As occupations change or disappear, employees are expected to have up-to-date skills, and up-and re-skilling will be required for large segments of the population. In this setting, flexibility and the ability to react fast are required to stay relevant in a fast-paced world. There has already been a change in the learning mindset, as even older generations see the importance of lifelong learning.

> ***What happens when our own profession gets outdated: how about with university degrees or taxi driver licenses? – TEK focus group participant***

Timely updates of degree programs are needed to ensure that education is proactive rather than reactive to the needs of industry and society. More collaboration is required across different types of borders to create frequent dialogue and feedback loops between higher education institutions, industry, and the public sector. Students and alumni should be more involved in educational development, as new grassroots initiatives often emerge as a response. A higher level of integration ensures a more relevant educational offering. It also supports employers' and students' awareness of relevant professional competencies for Industry 4.0.

> ***"The current academic structures are not seen as useful anymore. Useful information is mostly created in labs, within universities or companies. Universities have to be very careful at the moment; in a complex environment, they have to be close to the real world. The aim is to create a seamless university in which it is not possible to tell where the university stops, and the outside world starts. If universities become seamless and flexible enough, there is no risk of becoming irrelevant." - Polish Igniting Event***

> ***"Frontiers between institutions – HEIs, companies, public bodies – must be more liquid." - ANI focus group***

Lifelong learning strategies

The conception of a growth mindset embraces everyday life as an opportunity for learning. Such a mindset should be an integral part of education, making people more aware of their skill development and the continuous learning opportunities around them. These lifelong learning opportunities include peer-to-peer learning and intergenerational learning.

Peer-to-peer learning is a useful long-term learning strategy. People hardly ever know everything about their field, so there is always an opportunity for growth. Students are capable of learning from each other and solving a problem together. Furthermore, this way of learning also has hidden benefits such as better teamwork, mutual trust and respect for opposing views. These dimensions provide the basis for lifelong learning.

Intergenerational learning refers to mentoring between juniors and seniors. The mentors can be teachers, senior students, or professionals from the industry. Both juniors and seniors bring their expertise and experience to the learning process. HEIs should ensure that all students are exposed to the exchange of skills, knowledge, and experience through **mentoring** during their studies.

Strategies for inclusion and diversity

When it comes to equality, technology is a double-edged sword. Technological advancements can either increase or decrease inclusivity. Education should support inclusivity by reaching large segments of the population at an **affordable** price. For broader inclusion and increased diversity in technological fields, a **resource sharing** strategy between HEIs, industries, and the government must be derived. Sharing resources would allow much flexibility and wider reach since any one institution will not be subject to excessive burden. In the process, financial commitments should be drafted between stakeholders to ensure that the specific target of inclusivity is achieved.

Scalable solutions must be used to involve a larger amount of people in the education efforts. The increased availability would result in more equality of access to education. This is needed for reacting to the future workforce needs and for avoiding unemployment growth. One way to achieve scalability is through **the use of technology.** Using digital tools would allow all stakeholders to reach a larger population in an online learning environment than any on-campus arrangement can do.

It is necessary to communicate a **positive message** on the opportunities that technology brings. This can be especially impactful when targeting underrepresented groups in technology, such as females. A positive message motivates people to stay on board with Industry 4.0. At the same time, it is important to create awareness of the importance and the benefits that diversity can bring to the industry and working life. This requires opportunities for interaction with people from different backgrounds.

Strategies for developing Industry 4.0

National governments need to create strategies for developing technology and facilities for Industry 4.0. However, for successful strategy development, different governing stakeholders need to understand their roles better. Further integration between different players is needed to understand the technological and educational challenges and to develop novel ways of solving them efficiently. Direct funding is needed not only for research but also for education in industry 4.0 related areas. These could include specific targets, such as becoming a leader in AI, or specific key performance indicators. Funding should be allocated based on these targets.

The legislation does not always keep up with innovations, which often results in legal loopholes and incorrect interpretations of the law. Legislation must be updated to support and protect new models of work through labour and workforce regulations. Increased collaboration between public institutions and industry is needed to gain insights into

the societal needs resulting from technological advancement. Furthermore, citizens must engage in participatory democracy – encouraging regular participation of different stakeholder groups, citizens and experts in influencing policy and legislation.

HEIs are uniquely positioned as a neutral space for supporting participatory democracy and collaborative development. Therefore, HEIs should develop themselves as bridge-builders, hubs or **platforms,** bringing together students and professionals from different companies, public bodies, NGOs and start-ups. HEIs must foster open innovation and the establishment of co-creation ecosystems, support mobility of professionals between companies and HEIs, and develop flexible learning opportunities for all. The resulting **clusters of collaboration** are beneficial for attracting international talent, creating new career opportunities, developing new technological solutions, and enabling more efficient information sharing. These partnerships are also crucial for co-creating innovative solutions for a prosperous Industry 4.0.

"It is good for a country to have several feet to stand on" - TEK focus group

Recommendations for HEIs

- Include *working life skills* into the syllabus and support it with opportunities for *industry collaboration*, such as *mentorship programs and internships*.
- Raise awareness of opportunities for professional development during and after university studies.
- Use case studies and real-life projects to *combine theory with practice*.
- Use *project work* to provide safe opportunities for setbacks. Embrace failure as part of the learning process.
- Promote *interdisciplinary work* in the beginning of studies to foster broad-minded thinking and innovation.
- Establish *supportive physical and socio-cultural environments*, such as co-working spaces with modern tools, to students' motivate learning.
- Take part in *global university collaboration* to support the mobility of faculty and students.
- *Pool resources* with other universities to create common online courses, platforms, hubs, and innovation centres. Establish a *centralized online base* for shared educational materials.
- Develop Industry 4.0 related educational offering in *collaboration with companies*.
- Test novel forms of collaboration with *small-scale experiments*.
- *Seek partnerships* with organisations that are already in the online learning business.
- Create a *virtual university* to provide access to resources (laboratories and equipment) without the need for physical presence.

Recommendations for Industry

- Support employees' participation in educational activities, such as online courses.
- Establish facilities and tools for retraining, such as simulations and role-play workshops.
- Allow time for self-development and support on-the-job learning.
- Organise open educational events with a focus on a company's core area of expertise.
- Create online courses and share open-access course materials in co-operation with HEIs.
- Recognise the hard-to-measure benefits. Promote the idea that "this is a great place to learn"
- Hold a day to recognise employees' learning (e.g. "Solution Wednesdays" for sharing what has been learned during the week).
- Enable transfer of knowledge by organising in-house training between different units of operation.
- Participate in global open-source projects.
- Teach the potential clients about your company's offering. The more specialized and complex the offering, the more there is a need for the prospective customers to learn about it.

Recommendations for public bodies

- Increase citizen participation by creating shared public spaces that bring together different groups of people, break silos, and enable collaborative learning.
- Increase international collaboration to promote the exchange of good practices in Industry 4.0.
- Invest funds in the creation of collaboration clusters. Start the collaboration with larger companies, they will attract the smaller ones.
- Support local companies' transformation towards understanding and applying Industry 4.0 by financing HEI's initiatives targeted at educating businesses.

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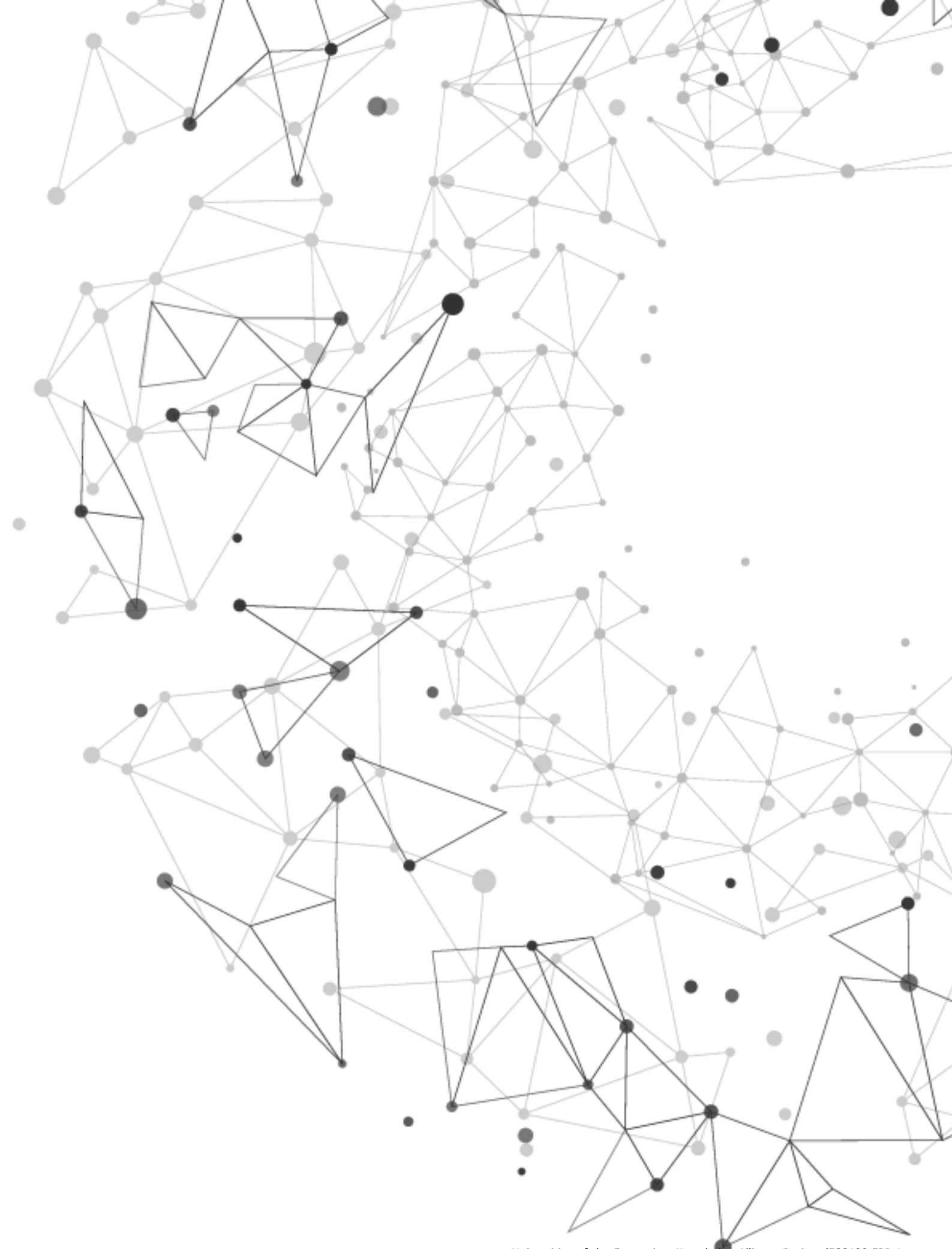
6. Appendix 1: Skills required for Industry 4.0

domain specific	
engineering	data science (advanced bid data analytics…) novel human-machine interfaces digital to physical transfer technologies advanced simulation (virtual plant modelling..) automated production management systems (for product and process quality control, inventory, and logistics) AI robotics automation programming information technologies (data communication, networks…) mechatronics cybersecurity AR and VR
management	change management and strategy talent management (strategies and tech tools) organisational structures the role of managers as facilitators business analysis (using forecasting data and planning metrics…)
design and innovation	human-robot interaction and user interfaces tech enabled product and service design
transferable skills	
digital skills	
understanding impact of tech (other than social and social)	
Entrepreneurial mindset	
personal skills (self-management, self-knowledge, self-motivation, self-confidence, work attiude, professional and ethical responsibility)	
ability to learn (lifelong learning /self-learning /learning how to learn)	
project management skills and methods	
tech literacy (basic science and tech, mathematics)	
business thinking (service orientation, LEAN, basic pricinples)	
systems thinking	understanding ethical issues futures literacy
people skills	empathy emotional intelligence communication (written, oral, and use of communication tech, persuasion, negotiation) team work (multidisciplinary, international) leadership
problem-solving skills	gather, analyse and manage infomation knowledge management creative thinking critical thinking analytical thinking experimentation judgement or decision making



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