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1 Introduction

This report represents the second iteration on the market demands analysis as a result from task 2.5 “Realizing the business plan for the DigiFoF Design Competence Network” and summarizes the findings with respect to market demands for competences within the second year of the project. As an iterative action, this version of the deliverable represents the second release of results on competences and industry needs, building upon the information collected in work package 1 results, documented in deliverable 1.2 “Reports on needs and demands for FoF Design: Findings and recommendations” (Jurczuk, Dębkowska, & Gudanowska, 2019).

The objective of the work performed in this task is to correlate findings from the information collected in the first period of the project (see D1.2 for details, 87 participants in survey from different participating countries) with initiatives and approaches on national level of higher-education institutions and industrial partners/networks. The country-specific expertise of partners is deemed essential to continuously align the work stream and educational material developed with market needs and demands. The series of reports, that are prepared within this task (yearly iterations and refinements), are established to collect these demands, a) align with national initiatives and adapt in a responsive manner to upcoming challenges and b) verify the developments and results of the project continuously.

For this second version of the report, the common description approach has been from version 1 has been extended and applied to harmonize the research results and provide a framework for discussion. This approach is adapted during the upcoming iterations according to the findings on national and European level. This common structure is briefly introduced below.

1. **National insights on FoF-Design Competency Needs:** What are the design skills and trainings in the national market? In this part, refer to national studies and surveys as well as to the results of the DigiFoF survey and report D1.2.

2. **Conclusions on FoF-Design Competency Needs:** What conclusions can be derived from D1.2 for the national market and additional studies on skills and competency requirements for FoF?

3. **National measures to Influence FoF-Design Competencies:** Which national and regional measures and initiatives/actions address the FoF competency demands and needs as well as vision and deployment strategy.

The first section of each chapter provides insights on the results of D1.2 and derived design skills. Section 2 focuses on the conclusions derived from the DigiFoF study and their impact is assessed in section 3. An important aspect during the work performed in this task is the alignment of academic institutions with industrial expertise, combining the viewpoint of higher-education and industry needs within the discussion.

Section 4 and 5 of each country-specific analysis is regarded a placeholder for the third and last iteration of the report.

2 Market Report France

In this chapter, the initial market analysis and review performed for France is presented. National insights on FoF design competences are discussed, introducing national initiatives contributing to the needs and requirements identified in the DigiFoF project building on the expertise of the French partners in the project, their knowledge on the market situation and the results from the questionnaires in WP1 and its interpretation. The analysis has been provided by DigiFoF partners EMSE, CLEXTRAL, VIAMECA and CIRIDD under the coordination of EMSE (Prof. Xavier Boucher, Dr. Elaheh Maleki).

2.1 National Insights on FoF-Design Competency Needs

Industries are today very focusing on the technological dimension of factories of the future. However, the ever-increasing spread of digital tools also has an impact on the structure and nature of employment. Repetitive jobs are expected to disappear in favour of jobs that are more qualified. Deep changes in the work environment are likely to happen. That is why employee's skills and competencies need to adapt and evolve. More generally, there is a trend towards the hybridization of the jobs. Industrialists look for candidates who master multiple competences at the same time. In this context, the training system must be redesigned to respond to the need to permanently adapt, to follow, to accompany and drive change.

In the hurried context of a desire to reindustrialize the French economic system, France launched in 2013 a strategic reflection to identify the industrial priorities on which it is essential to invest and mobilize resources. This reflection is combined with an offensive policy of industrial reconquest aiming at supporting companies in their process of transition and developing an offer of training much better adapted to the new stakes of the «New Industrial France»[2].

Indeed, the industrial metamorphosis operated by mundialization issues and environmental stakes and the opportunities provided by digital technologies comes with fundamental and deep transformations for skills and qualifications[3]. To answer it, the national initiative «Osons l'industrie»(Alliance Industrie du Futur, 2016) (i.e. Let's deal with Industry) was launched in March 2016, coordinated and implemented by the Alliance Industrie du Futur (i.e. Alliance for the Industry of the Future)[4]. The work done by this structure puts the man as a worker and his know-how in the core of the discussions and the answers to bring. In collaboration with several important stakeholders fully involved in trainings such as UIMM (Union des industries et métiers de la métallurgie – Union for Metal industry and jobs), IMT (Institut Mines Télécom), Arts et Métiers ParisTech, ONISEP, and under the aegis of CNI (Conseil National de l'Industrie – National Council for Industry), the initiative «Osons l'industrie» aims at helping the industrial workers in

[2] Name given to the French government strategy aiming at identifying the primary industrial stakes and sectors (Ministère du Redressement productif, 2017)

[3] ONISEP (Office national d'information sur les enseignements et les professions) is a public establishment in charge of elaborating and disseminating information about jobs and trainings to students, parents and staffs (ONISEP, 2019)

[4] Alliance Industrie du futur aims at helping companies, and more specifically SMEs, in their process of modernisation of the industrial tools and transformation of their economic models with digital and non-digital new technologies (Alliance Industrie du Futur, 2019b)

the digital transformation of their jobs and, more generally, to improve the image of industry on the job market.

In operational terms, the initiative is built around five main axes linked to the families of professions in the heart of the French industry of the future:

1. Maintenance,
2. Big Data,
3. Management,
4. Production, and
5. Supply Chain.

Each of these axes hinges on three steps:

1. The development and publication of job sheets linked to the industrial digital stakes and their consequences,
2. The provision of skills kits in order to elaborate new offers of training,
3. The creation of a web portal that is the entrance door to new jobs, new training offers, and job offers (IMT, 2018).

Each of them needs to be seen as a powerful didactical source made up of diverse contents (video presentation, educational sheets, interviews, definitions of technical terms…) that are easily affordable, freely downloadable and largely used by schools beforehand. All these elements – narrowly created with the companies that expressed their real needs for the digital transformation – can help the teaching and training communities to define a new speech on industry and more especially on the industry of the future.

In France, three types of skills are required: hard skill (technical *competencies*), soft skills and skills linked to the industry sector (Auvergne Rhone-Alpes Enterprise, 2019).

According to Association Pour l'Emploi des Cadres (APEC) (APEC, 2017) Industry 4.0 requires the following hard skills:

- Cobotics and exoskeleton;
- Artificial Intelligence (machine-to-machine communication, cloud and big data, reliability of high-power mechatronic system, maintenance optimization and predictive maintenance);
- Cybersecurity;
- Augmented Reality and Virtual Reality;
- Numerical simulation.

Industry 4.0 cannot be driven without soft skills. APEC mentions the following soft skills as the most crucial to develop industry 4.0:

- rigour,
- coordinating with others,

- autonomy,
- team spirit,
- customer service-oriented creativity,
- leadership, and
- flexibility.

Critical thinking skills will be valued within the industry 4.0 to master the challenges of the industry sector.

2.1.1 On Political Level

The political support given to industrial innovation in France is a rather recent action resulting from an awareness that the gradual withdrawal of public action was one of the important factors of the deindustrialisation process that began in the 1980s. This situational analysis provoked in the course of the 2000s a strong response from the public authorities and led to the return of, what some commentators call, a strategic State. This was characterized in particular by the multiplication of financial support mechanisms for investment and innovation as well as by the consolidation of national strategies. Public interventions in favor of industry have also been marked by consideration of issues at the territorial level. The regions have seen their competence in economic matters asserted and have taken many initiatives, even if the total resources they commit remain much lower than that of state interventions. The importance of interactions between local actors has been recognized and has led to the establishment of a series of instruments aimed at mobilizing them and getting them to cooperate on projects, such as “competitiveness clusters” and “territories”. of industry”.

Thus, the State is seeking to regain a leadership role, particularly with the "Industry of the future" plan. Via the National Industry Conference since 2010 and then the National Industry Council (CNI) since 2013, France has sought to establish an industrial policy built collectively, through dialogue between industrialists, employee representatives and public authorities, which resulted in sector contracts. The work carried out in this context has also contributed to the design of certain measures, including the tax credit for competitiveness and employment (CICE) and the “New Industrial France” program launched in September 2013. It was narrowed down to from spring 2015, with nine “industrial solutions” structured around the theme of “Industry of the future” presented as a matrix of industrial strategy and vector of the digital transformation of companies.

The government is also seeking to lead various technological foresight work which sometimes leads to strategic roadmaps developed jointly with various experts, particularly from industry. As in the case of the recurring "Key Technologies" exercise, it can also involve identifying development prospects, to guide public and private decision-makers in their choice of medium-term priorities. Since 2019, a technological forecast has also aimed to guide the choices of the Innovation Council installed in July 2018. The role of this council is to set the strategic priorities of the French innovation policy and in particular to steer the investments to be launched as part

of the Innovation and Industry Fund (FII) launched in January 2018 and endowed with 10 billion euros with an annual commitment capacity of 250 million euros[5].

While the uncertainty from COVID-19 persists throughout the globe, the French government is fully mobilized to face and protect the country from the economic and social consequences of the Covid-19 crisis[6]. At the end of July 2020, 40 billion euros have been mobilized, through the support plan. On October 27, 2020, as part of recovery plan, the Ministers of the Economy, Public Accounts and Industry signed a decree allowing industrial SMEs and ETIs (intermediate-sized companies) to benefit from financial support from the State to invest in the technologies of "industry of the future". 40 million euros have been budgeted to support these investments in sectors such as:

- robotic equipment;
- augmented reality and virtual reality software and equipment used for design, manufacturing, transformation or maintenance operations;
- integrated machines for high-performance computing, physical sensors collecting data on the company's production site, production lines or on transit system, etc.

2.1.2 On Academic Level

The industry has been constantly evolving and changing. Businesses have evolved to become more and more technological, the borderline between services and products is becoming increasingly blurred, etc. Nevertheless, its transformation is not yet complete. Changing business models, modernizing industrial sites, transitioning to the industry of the future, reducing environmental impacts, the place of mankind: these are just some of the challenges that manufacturers will have to face in the months and years ahead, in addition to the challenges posed by the current crisis. And this will require educational initiatives

French Educational initiative 1: Alliance for the Industry of the Future (Education and territorial anchoring)

Created in 2015, the role of the “Alliance Industrie du Futur” is to support French companies, particularly small and medium-sized businesses, in the modernization of their industrial tools and the transformation of their business model through new digital and non-digital technologies. The three missions of the Industry of the Future Alliance are:

- Transform SMEs, ETIs and sectors in the territories,
- Develop and integrate future technologies by participating in their standardization,
- Supporting the development of tomorrow's skills.

[5]https://www.strategie.gouv.fr/publications/politiques-industrielles-france-evolutions-comparaisons-internationales

[6] https://www.gouvernement.fr/france-relance-soutient-l-industrie-du-futur

5,200 companies are committed to an Industry of the Future initiative and the objective is to reach 10,000 by 2022. More than 100 companies have been labelled “Vitrines Industrie du Futur”.

The training cycle “RENAISSANCE INDUSTRIELLE” wants to be resolutely positive and turned towards the future, without hiding the difficulties posed by the crisis of Covid-19 and the impact on the collective competences of the past years of desindustrialization. The ambition of this training is to make emerging tracks of reflection on the rebirth of the national industry and to contribute to draw its role in the society. Rethinking industry in France and in the territories also means questioning the model of society we wish to defend.

In 2020, it will take place over three days, with the following agenda:

- Industrial sovereignty, governance and the territorial anchoring of industry.
- Industrial dynamism of territories and decentralization in the Ile-de-France region.
- Crossed views on Artificial Intelligence, in the context of the Industry of the Future.

A website for the “Vitrines Industrie du Futur”: http://www.industrie-dufutur.org/

French Educational Initiative 2: German-French Academy for the Industry of the Future

In October 2015, then Minister of Economy, Industry and Digital Technology, Emmanuel Macron announced the creation of the Franco-German Academy by the French Institute Mines-Telecom and the German Technische Universität München (TUM). This Academy has a triple objective in the field of research and training for the industry of the future:

- To form a research platform in the fields of digital technology for the industry of the future, industrial organization and logistics and human interfaces.

- By combining the strengths of the partners, develop new training courses, create content (MOOC) and intensify student exchanges.

- Set up innovative R&D projects within the framework of industrial partnerships around key themes such as automation, flexibility, big data, the Internet of Things, security, but also logistics and transport, organization and management, as well as human-robot cooperation and intelligent agents.

The Academy's mission is to carry out prospective reflection and research on the place of man in the digital and industrial transitions, and to bring out and mature the new paradigms of the industry of the future. News of **German-French Academy for the Industry of the Future** can be find with this link**: https://www.future-industry.org/news/**

The Industry of the Future Alliance and the "Dare to be Industry of the Future" project aim to define changes in the major operational (production, maintenance, etc.) and managerial professions. Indeed, the development of new skills, the capitalization of knowledge and the transfer of skills are at the heart of the digital transformation of companies. However, the question of critical skills will remain essential to the success of the transformation of companies (e.g. boilermaker, planter, etc.). Discover here the professions and skills in the industry of the future: http://www.industrie-dufutur.org/osons-lindustrie/

French Educational Initiative 3: ANR research policy « Industry of the Future »

The National Agency for Research, the French ANR launched a research program both for more fundamental and more applied research on Industry of the Future. Three main innovation axes are impulse:

- Technologies : support, understand and amplify the development of new digital, manufacturing or production technologies in order to meet the demand for innovative, customized and optimized products,

- Organisation : Promote a vision and a systemic organization of the plant, for a development process that integrates the life cycle dimensions of products and value networks,

- Human: focus the plant on people, who remain at the heart of operations, while work organization becomes more flexible. It will also be necessary to respond to production challenges while reducing the cognitive and physical work of operators.

These breakthrough areas are divided into seven themes:

- Human in new productive organizations,
- Intelligent, connected, controlled factory,
- Virtual factory,
- Flexible and agile factory,
- Green and socially responsible factory,
- Robotics for industrial performance, human-robot collaboration in production systems (technological, organizational and regulatory aspects)
- New production and control technologies.

The projects can come from different scientific communities: Engineering Sciences, Social Sciences, ergonomics...).

The Covid-19 Flash call, launched on 6 March, aims to mobilise the scientific community in efforts to tackle the four priorities identified by the World Health Organization (WHO), under the scientific guidance of the REsearch and ACTion targeting emerging infectious diseases (REACTing) consortium and coordinated by Inserm and the French Ministry for Research. In light of the exceptional circumstances, ANR has introduced an accelerated and streamlined process to address urgent research needs, while maintaining the principles of peer review. The French

National Research Agency (ANR) funds 86 projects totalling €14.5 million and opens a new call for Research-Action projects among which industrial research on agile business models and production systems is well represented.

2.2 Conclusions on FoF-Design Competency Needs

The focus group for the project are French SMEs in manufacturing and machinery. Managers who answered the questionnaire have been in their position for 5 years and less. They mentioned that they evaluate the design skills of candidates during the employment process. They also facilitate access to related training for employees during the work and consider promotions for employees who have improved their skills. The results of the survey are discussed in (Jurczuk et al., 2019)

The training subjects in which the French companies are interested are mostly managerial and technical (strategy level and technical level). There is direct relation between the level of competency of employees and the training they attend. Even though the business process and middle managers have medium competency level in the scope of Factory of the Future, they are the most important groups to attend the training (see Figure 1).

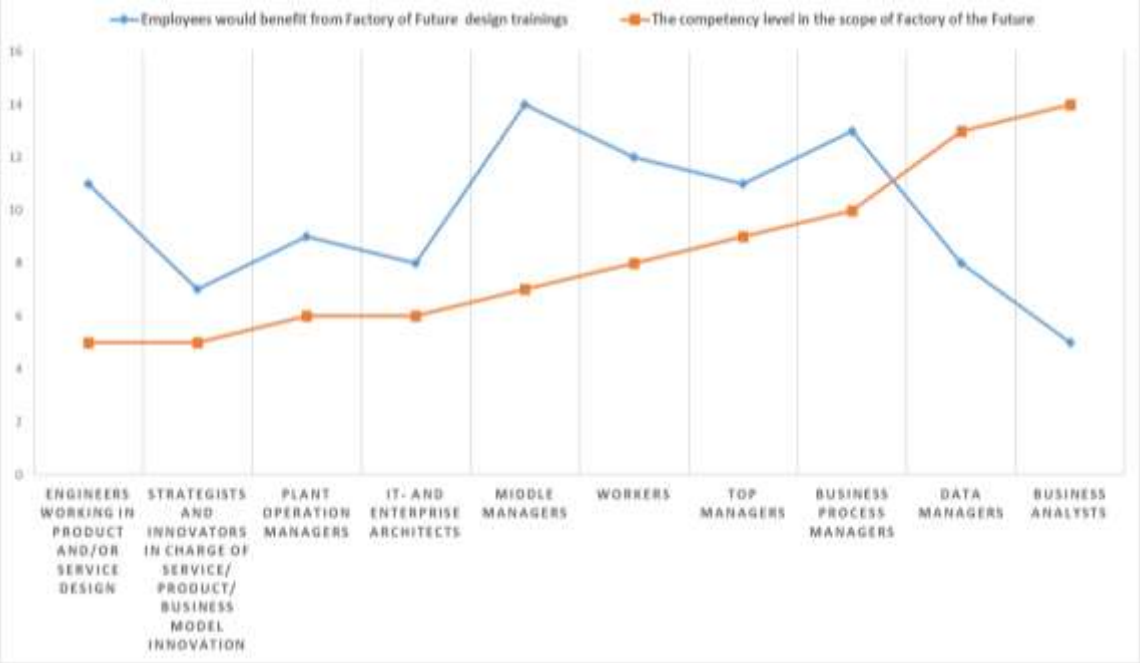

Figure 1 Competency and Training in French Companies (France)
Source: Own representation based on T1.3 results in DigiFoF

Innovation in different subjects (product, service, Business model and process) and Value proposition is well known and used in French companies. However, many tools are not well known for them (see Table 1)

Table 1 Focus on Innovation Techniques (France)

If you use innovation techniques on what do focus now or plan to do in the future	
Business model innovation	Actual state
Future Service innovation	Actual state
Product innovation	Actual state

Business process innovation	Actual state
Value proposition canvas	Known and used
Technology innovation	Not known
Business Model Canvas	Not known
Stakeholder Analysis	Not known
Customer Journey	Not known
Persona	Not known
Brainstorming	Not known
Minimum Viable Product	Not known
Scenario Technique	Not known
Thinking Hats	Not known
After Action Review	Not known
Systematic Inventive Thinking	Not known
Weighted Selection	Not known
Osborn Checklist	Not known
Customer-oriented innovation	Plan
Product-service-innovation	Plan

Source: Own representation based on T1.3 results in DigiFoF

The data collection from the production system is mostly automated. As a result, the design tools are mostly related to the production and design in manufacturing (Computer-aided design, Computer-aided manufacturing, Product data management and Data modelling) as well as some strategic level subject such as Enterprise architecture management (ERP) (see Table 2)

Table 2 Design Tools (France)

What design tools do you use within your company	
Computer-aided design (CAO)	Known and used
Computer-aided manufacturing (FAO)	Known and used
Product data management	Known and used
Enterprise architecture management (ERP)	Known and used
Data modelling	Known and used
Digital Mock-up	Not known
Computer-aided engineering	Not known
Business process modelling (BPM)	Not known
Business modelling	Not known

Source: Own representation based on T1.3 results in DigiFoF

The most interesting result is about programming languages for the automation of cyber-physical systems. All respondents answered that they do not use any programming language. This is to say, they do not develop tools inside the company. They either buy prepared solutions or outsource it to external partners.

2.3 National Measures to Influence FoF-Design Competencies

The French initiative for the industry of the future is part of a national project entitled “New Industrial France”. This project is the result of the collaboration between various partners. Since 2015, the “New Industrial France” has entered into its second phase aiming at bringing it into line with the major challenges of the future. This resulted in a transversal program called the “Industry of the Future”. Its ambition has been broadened from the modernization of the productive tools to supporting the digital transformation of companies. The steering of the

program has been entrusted to different representatives of the economic world, who will be responsible for defining the roadmap. We find today representatives of public authorities, industries and representatives of the alliance for the industry of the future. It brings together numerous players from the industrial and digital worlds, the world of research and training and is open to all trade unions and professional federations wishing to get involved in the project.

National Policy

At the very beginning of the 2010s, France has started up working on a strategic reflection about the industrial policy and the strategic sectors (Nouvelle France Industrielle). In April 2015, a large plan dedicated to Industry of the Future was launched and financed by PIA (Programme d'investissements d'avenir – Investment Program for the Future). Alliance Industrie du Futur (Alliance for the Industry of the Future - AIF) is created in July 2015 with the mission to «support and coordinate, at the national level, the initiatives, projects and works aiming at modernizing and transforming the industry in France» (Alliance Industrie du Futur, 2019c). AIF is the meeting point of the professional federations and unions, engineering schools, applied research centres, pôles de compétitivité and public entities involved in helping companies to innovate and invest. Its action is built around three main strategic axes, each of them composed of different working groups:

1) SMEs, intermediary companies and sectors transformation
   - Promoting the existing technological offer
   - Industry of the Future showcases (« Vitrines »)
   - Deployment within the territories
2) Development and implementation of the technologies of the future and standardization
   - Development of the technological offer of the future (Innovation)
   - Standardization
3) Development of the competencies for tomorrow - human and Industry of the Future

Three examples of the main public and visible outputs from AIF are mentioned below that are relevant for the project:

- The technological catalogue for FoF (list of levers from technologies to business models or organizational mutation) in (Alliance Industrie du Futur, 2019a);
- The National Catalogue of Solutions Suppliers in (Alliance Industrie du Futur, 2019d);
- The initiative « Osons l'industrie » (Let's deal with industry) aiming at promoting industrial jobs and contributing to modifying training for these jobs in (Alliance Industrie du Futur, 2019e).

Deployed at Regional Level

The actions led by AIF are spread and rolled out at the regional level with the help of its members' network as CCI (Trade and Industry Chambers), professional technical centres, federations and unions and *pôles de compétitivité*. In 2019, an ambitious program aiming at supporting 10 000 French SMEs by the end of 2022 is launched.

Each region is then called to adapt this program by taking into account their specificities and more especially their own Smart Specialization Strategy. In Auvergne-Rhône-Alpes, the economic development policy is built around 8 main excellence fields (DOMEX) that elaborate specific sectoral strategies in order to gather the different regional scientific, economic and academic stakeholders. For example, one of these fields is dedicated to Industry of the Future, a second one to Digital Technologies. *Pôles de compétitivité* plays a key role to animate relate and mediate the national and regional initiatives. In Auvergne-Rhône-Alpes, there are 12 *pôles de compétitivité* and 20 clusters. CIMES (formerly ViaMéca) is in charge of the animation of the working group for Industry of the Future gathering almost all the *pôles de compétitivité*.

Auvergne-Rhône-Alpes is also well involved at the European level thanks to the *pôles* and clusters, notably in the S3 platforms. For example, CIMES is one of the members of EFFRA and I4MS. Consequently, the transnational perspective roadmaps are also important and valuable assets for the regional strategies. Finally, CIMES holds the initiative of a DIH focused on manufacturing playing a major role in this regional strategy linked to the national level and Europe in order to share and capitalize on all these sharing practices and to build a transnational network of competencies centres.

Other Initiatives and Good Practices

Other initiatives relevant for the Project, that take into account local specificities other initiatives are introduced below:

- Local call for projects led by CIMES dedicated to traditional SMEs and devoted to innovation in manufacturing fields. Almost 390 k€ founding for 41 SMEs since 2015.
- RELIEF Program devoted to servitization in SMEs lead by CIRIDD. This program aims to train 20 firms from Auvergne-Rhône-Alpes region to develop a functional economy within their business model (Pédron, 2019).
- Hall 32, Industrial Jobs and careers promotion centre. Lead by Private companies (Michelin, Limagrain, Banque de France), rectorate and pôle CIMES, founded by companies, AURA Région and French government (Hall 32, 2019).
- COEF Program aims to help the local authorities to develop public tendering including the functional economy.

Market Report Finland

This chapter provides the key facts on the market for FoF-Design in Finland. It focuses on the industry sector relevant to the project and provides insights into the effects of digital transformation on national level. The analysis has been provided by DigiFoF partner University of Oulu (Prof. Juha Röning, Timo Mäenpää and team).

2.4 National Insights on FoF-Design Competency Needs

Industry is driving force for Finland's economy contributing 28,2 % of GDP. The largest industries in Finland are in order metal industry, chemical industry and forest industry. Metal industry can be further divided to metal products, machinery, electronics and vehicles (Suomen virallinen tilasto (SVT), 2018). Growth of industry has been increasing since 2016 from 1.3 % to 4 % per year in 2018. Growth is expected to slow down in the following years (Berg-Andersson, Kaitila, & Kaseva, 2019). Finland's industry is centralised: ten largest companies represent 52 % of industry's contribution to GDP.

Several export dependent industries have had difficulties in the last years. Interest in forestry product has decreased and manufacturing of IT-devices is smaller compared to previous years. Despite of difficulties in earlier years, Finland has been successful in globalisation. Several companies (for example Kone , Cargotec, Wärtsilä, Outotec) have become leaders in their sector. Specialisation and switching to higher refinement level products have been one way for success in the markets (Elinkeinoelämän Keskusliitto EK.FI, 2016).

Strengths of Finland include high education level. Investments to education, skills, research and innovation have been substantial. Companies innovation is focused on incremental improvements rather than to breakthrough innovations. Historically, enterprise have succeeded in invention, but not so well in commercialisation (Työ- ja elinkeinoministeriö, 2014).

Finland is one of the leading countries in digitalisation of business. Every company employing 10 or more people uses computers and has a broadband connection and over 90 % have a webpage. ERP- and CRM systems are used in around 40 % of enterprises (Pohjola, 2014). According to the Finnish Innovation Survey the importance of digitalisation for enterprises' business activity is less strongly acknowledged in manufacturing enterprises than in service enterprises. 25.34 % of manufacturing enterprises consider one form or another of digitalisation key to the firm's operation compared to 41 of service enterprises.

2.4.1 On Political Level

In recent years Finland has implemented reforms of vocational education and training system to increase digital and workplace learning. In addition, new curriculum for primary and lower secondary education includes coding as mandatory theme starting from the first grade. As of mid-2018 more than 100 enterprises, education providers and NGO have pledged to reduce digital skills gaps by taking actions such as training courses, matching for digital jobs, certification and awareness raising (European Commission, 2019b).

Finland launched national artificial intelligence programme in May 2017. The programme and its networks have taken Finland towards the age of artificial intelligence. According of results from the project challenges in adopting artificial intelligence is not in technology or in access to technology. Instead, challenges are in understanding the business potential of artificial intelligence and the shortage of AI specialists. The programme found also that pilots and agile test environments play an important role in finding new areas of application in particular. To facilitate agile test environment Business Finland launched AI Business programme (AI and platform economy) at the beginning of 2018. The programme activities have included disseminating AI knowledge regionally in Finland in collaboration with the Federation of Finnish Enterprises and supporting the establishment of local AI Hubs even outside big growth centres. To further continue developing AI the Ministry of Finance launched the AuroraAI programme[7] on February 2020. The task in AuroraAI is to develop an operating model for arranging public administration activities to support people in different life situations and events so that services provided by organisations function seamlessly between service providers in different sectors. AurororaAI project will continue until the end of 2022.

2.4.2 On Academic Level

Only university in Finland providing education under Factory of Future name is Aalto university. Factory of Future is broad term, and it is not surprising that research and education about subjects included in the Factory of the Future concepts happens under more general labels such as robotics, intelligent systems. Courses about design thinking are provided as part of curriculum in several universities level of permeability of Factory of the Future topics can be found from RAAS-ecosystem for autonomous solutions and services development. Member of RAAS include 19 Finnish universities that have research and education about autonomous systems.[8]

Five Finish universities are part of National DEFA (Digital Education for All) project providing first year courses in Computer science freely to everyone interested. Teaching happens mainly with MOOC (massive open online course). One example of popular MOOC is the Elements of AI course created by the University of Helsinki and the technology company Reaktor. The course was very popular, and a continuation course and various language versions of the course were created later.[9]

2.5 Conclusions on FoF-Design competency needs

Importance of digitalisation has increased in companies of all size. In small companies (<50 employees) 44 % feel that digitalisation is at less moderately important. Interest in using cloud computing and robotics in production has increased in last years. In addition, digital design, distribution and marketing have gained importance in industry. In contrast, interest in IoT has stayed low. Computing and data collecting have become relatively easy so interest in big data analytics will continue to increase. Currently around 20 % of companies employing 10 or more

[7] Ministry of Economic Affairs and Employment, Leading the way into the era of artificial intelligence: Final report of Finland's Artificial Intelligence Programme 2019 https://julkaisut.valtioneuvosto.fi/handle/10024/161688?show=full
[8] Source: https://autonomous.fi/members/
[9] Source: https://www.helsinki.fi/fi/projektit/digital-education-for-all

people uses big data analytics compared to 15 % few year ago (Ali-Yrkkö, Mattila, Pajarinen, & Seppälä, 2019). In addition of technical skills importance of soft skills will increase in the future as requirements of industries change rapidly.

Despite Finland's high ranking in digital skills, almost 60 % of Finnish companies reported hard-to-fill vacancies for jobs requiring information and communications technology specialist skills.

2.6 National measures to influence FoF-Design competencies

Finland does not have an e-skills strategy or a national digital skills and jobs coalition. The main policy strategy for information society in Finland is the Digital Agenda for 2011-2020 'Productive and inventive Finland' It identifies e-skills and ICT-related education as a cornerstone for the future of the country and contains a range policy measures to support ICT-development.

One project to provide solutions for factories of future is Reboot Finland IoT Factory (Reboot IoT). It is a new corporate and research ecosystem project funded by Business Finland, aiming to covert factories to innovation platforms, enhancing the competitiveness and efficiency in the manufacturing industry. Challenges that Reboot IoT Factory tries to solve are:

1. Cognitive supply network
2. Robotics fusion
3. Labour at digital work environment
4. Digital production

The operative model is based on agile co-creation and experience sharing within real-world production environments. Each forerunner factory commits as a research and development platform for proof-of-concept experiments. Research organizations produce new scientific knowledge, which IoT solution provider can package as proof of concepts in order to test and validate against needs of the factories. Universities can also utilize project in teaching with concrete research problems (Reboot IOT Factory, 2019).

3 Market Report Italy

This chapter introduces the initial market report for Italy, discussing insights on a national level and the relation to the project's objectives. The market size is assessed and relevant programs and directions on national level are discussed. The analysis leading to this chapter has been performed by DigiFoF partner UNIBG and AFIL under the coordination of UNIBG (Dr. Fabiana Pirola).

3.1 National Insights on FoF-Design Competency Needs

Manufacturing is a fundamental pillar for Italy as it generates employment and wealth based on solid industrial skills, encouraging research and innovation activities of huge added value, with effects at all levels of society. The sector represents 15% of the GDP generated in Italy, with a turnover of ~ 900 billion euro (2014) and an added value of 224 billion (2014), created thanks to almost 3 million employees employed in over 387,000 companies. The observation presented in the reports analysed is valid for the project today.

In 2012, Italian manufacturing exports represented EUR 306 billion and, in terms of destination, Italian exports mainly ended up outside Europe. Capital goods in particular are the leading Italian export, putting Italy in a very strong position within the international panorama. Furthermore, it is estimated that, for each job in industry, two supplementary jobs are created in the services associated with it. According to World Bank data (World Bank, 2016), Italy was among the top seven countries in the world for added value generated by manufacturing, with the top ten countries representing 70% of the global added value.

In 2016, Italy continues to play a leading role in the European Manufacturing industry, ranking at the second place after Germany in terms of added value and number of employees. According to a study carried out by Fondazione Edison (Fortis, 2018), in the years 2015 – 2017 the added value of the Italian manufacturing industry has increased regularly in comparison to the main European countries. Figures for 2017 are: Italy + 3.8%, Germany + 2.7%, United Kingdom + 2.3% and France +1.7%. Further, in the 2014-2017 period the added value of the Italian Manufacturing industry has increased cumulatively by 10% that is over two and half times more than the GDP (+ 3.8%).

The "Research and Innovation Roadmap" (Fabbrica Intelligente, 2018) developed by the National Intelligent Factories Cluster (CFI) in 2012 defined the main research priorities of the Italian manufacturing sector.

These research priorities indicate that Italy could stand out by focussing on innovative technologies, machine tools, customised solutions and products with high added value, through the integrated innovation of products, processes and systems in order to provide a competitive edge in the variable market conditions. This can be made possible by the existence of particular environmental conditions in the Italian system, determined by a series of factors including:

- the strong industrial tradition and manufacturing culture rooted in the economy;

- the widespread presence of industrial districts where territorial excellence enhances the uniqueness of each region;
- the presence of universities, research organisations and technological transfer centres that work in conjunction with the industrial sector;
- the international reputation of “Made in Italy” as a concept of quality, design and tradition;
- the contribution of the manufacturing sector, more than any other, to the production of new scientific and technological knowledge;
- the industrial, economic and social conditions that can attract qualified resources.

The CFI roadmap defined the following 7 strategic action lines and the related research priorities:

1. Systems for Personalised Production:
   - Advanced tools for the configuration and design of personalised solutions;
   - Solutions for the efficient manufacture of functional customised products with high added-value;
   - Models and tools for the creation of dynamic networks for personalised production;
   - Advanced solutions for the management of customer-driven production;
   - Mini factories: a model for reorganising the production and distribution chain;
   - Production systems for smart materials (sensor-based, bio, etc.) for the customisation of the product/service.
2. Strategies, Methods and Tools for Industrial Sustainability:
   - Integration of design and development processes with a view to life cycle management;
   - Monitoring of the energy footprint of the products;
   - Integrated product-process-system modelling for the optimisation of eco-efficiency (energy and resources);
   - Technologies and processes for the reuse, remanufacturing and recycling of products, components and materials;
   - Technologies and tools for intelligent re- and demanufacturing systems;
   - Modelling and simulation for the sustainable supply chain;
   - Business models for the “Circular Economy”.
3. Factories for Humans:
   - ICT solutions for knowledge management and sharing;
   - New materials and new technologies for safety in the workplace;
   - Technologies and applications of virtual reality/ augmented for product-process-system management;
   - Technologies and methods for trainings.
4. High-efficiency Production Systems:
   - Advanced control for optimization of hybrid systems;
   - “Zero-Defect" production based on solutions for maintenance, quality and logistics integration;
   - Systems for supervision and control of industrial processes;

- Cyber Physical Systems (CPS) for the intelligent factory;
- Advanced motion planning for industrial robots;
- Accurate modelling of industrial robots.

5. Innovative Production Processes:
   - Processes technologies for innovative materials;
   - Advanced solutions for the micro-scale manufacture of products;
   - Hybrid processing;
   - New technologies for additive manufacturing;
   - New materials for additive manufacturing;
   - Technologies for the high-volume production of components in composite materials;
   - Innovative laser-based production processes.
6. Evolutive and Adaptive Production Systems:
   - Intelligent man-machine interaction;
   - Human-robot co-working;
   - Integrated simulation tools for the virtual commissioning of production systems;
   - Smart machines;
   - ICT for model-based machinery development;
   - Integrated digital platforms for the configuration of production systems;
   - Mechatronic modular systems for high flexibility.
7. Strategies and Management for Next-Generation Production Systems:
   - Methods and tools for the strategic product/process assessment in the life cycle engineering perspective;
   - Innovative business models for integrated product-service solutions;
   - Tools for the management of collaborative businesses and dynamic supply chains;
   - Robust planning for risk management in MTO and ETO production;
   - Development of semantic-based operational environments for users;
   - Tools to support decisions in complex environments.

The main skills required at the Italian level are those ones needed to implement the above-mentioned research priorities. These are both technical and soft skills needed to design and manage these new manufacturing systems.

The survey of needs and demands for FoF-design carried out in WP1 and reported in D1.2 (Jurczuk et al., 2019), highlighted these findings, valid also for the Italian context:

1. Knowledge gap exists in the scope of advanced methods and tools supporting the development of innovative products and services;
2. Respondents recognize the need to improve them mainly through organization and participation in additional internal trainings;
3. A lack of skills or a lack of access to necessary infrastructure supporting process modelling and model-based designing for cyber-physical systems;
4. Formal notations of process modelling (BPMN, EPC) are not common in use;

5. Programming languages (Java, C/C++) are widely used for automation of cyber-physical systems;
6. A lack of practical experience within an enterprise architecture management, business modelling and digital mock-up;
7. Process automation and controlling represents mostly low or moderate level.

3.1.1 On Political Level

In 2016 the Chamber of Deputies carried out a cognitive survey on "Industry 4.0": which model to apply to the Italian industrial fabric. Tools to promote the digitization of national industrial supply chains" to address the recommendation of the Council to the Eurozone related to the need to increase productivity through structural reforms in the areas of research and innovation. The survey was conducted by the X Commission on Production Activities and the related concluding document[10] was unanimously approved on June 30, 2016. The objective of the survey, which was substantially shared by all political forces and the Government, was to contribute with operational proposals to an Italian Industry 4.0 strategy through a better definition of the regulatory framework necessary to promote its implementation.

After an analysis of the strengths and weaknesses of the Italian industrial system in relation to its digitization, as well as the opportunities and risks, arising from the European and international context, that could favour the Industry 4.0 model or hinder its development, the document elaborates some operational proposals for an Italian digital strategy.

In particular, the survey illustrates the five pillars on which to build an Industry 4.0 strategy.

- Creation of a governance for the national system, with the identification of the objectives to be achieved and the proposal for the establishment of a “Cabina di regia governativa”;
- Implementation of enabling infrastructures through the ultra-wideband plan, the development and deployment of fifth generation wireless connection networks, smart electricity grids, DIH (Digital Innovation Hubs) and a digital public administration;
- design of digital skills training, with school and post-school training aimed at developing digital skills in all areas, including humanities;
- strengthening research both within university and in international research centres;
- open innovation, based on open standards and interoperability and on a system that promotes the Made in Italy, exploiting all the opportunities provided by the Internet of things.

After the conclusion of the survey, on September 21st, 2016, the Government presented the National Industry Plan 4.0 (Piano Nazionale Industria 4.0), for the period 2017-2020. The Plan foreseen a control room at government level (“cabina di regia governativa”) characterized by

[10] Source: http://documenti.camera.it/apps/nuovosito/Documenti/DocumentiParlamentari/parser.asp?idLegislatura=17&categoria=017&tipologiaDoc=documento&numero=016&doc=pdfel (in italian only)

the presence of public operators (Politecnici di Bari, Milan, Turin, Scuola Superiore S. Anna di Pisa, ITT, CREA, public long term investor companies such as Cassa Depositi e Prestiti) and private (economic and business world), as well as trade unions, as well as competent institutions (PCM, MEF, MISE, MIUR, Ministry of Labour, MIPAAF and Ministry of Environment).

Given the characteristics of the Italian industrial system (few large private industrial and ICT - Information and communication technology able to guide the transformation of Italian manufacturing; limited number of supply chain leaders able to coordinate the evolutionary process; industrial system characterized by SMEs, key role of prestigious universities and research and development centres; strong cultural connotation of finished products), the Plan, outlines some strategic guidelines for intervention, also indicated in the Update Note to DEF 2016. Of these guidelines, divided into key and accompanying guidelines, the Plan has also identified the corresponding financial commitment.

Table 3 National Industry Plan 4.0 Guidelines (Italy)

<table>
<tr><th colspan="2">KEY GUIDELINE</th><th colspan="2">ACCOMPANYING GUIDELINE</th></tr>
<tr><th>Investments in innovation</th><th>Competence</th><th>Enabling infrastructures</th><th>Measures of public support</th></tr>
<tr><td>- Encourage private investments on technologies and products I4.0
- Increase private spending in Research, Development and Innovation
- Strengthen finance in support of I4.0, VC and start-up</td><td>- Spreading I4.0 culture through School
- Digital and Alternance School-Work
- Develop the skills I4.0 through Universities courses and Institutes Superior Technicians dedicated
- Funding I4.0 research by enhancing Clusters and PhD program
- Create Competence Centre and Digital Innovation Hub</td><td>- Ensure adequate network infrastructure (Ultra Band Piano Wide)
- Collaborate at the definition of standards and criteria of IoT interoperability</td><td>- Ensure private investments
- Supporting large innovative investments
- Strengthen and innovate the presence in international markets
- Support the exchange salary-productivity through the corporate decentralized bargaining</td></tr>
<tr><th colspan="4">Governance e awareness</th></tr>
<tr><td colspan="4">Raise awareness of the importance of I4.0 and create public-private governance</td></tr>
</table>

The Government then disseminated, in September 2017, the first results of the measures introduced with the Industry Plan 4.0[11], starting the so-called "phase 2" of the Plan, which took

[11] https://www.camera.it/temiap/2017/10/20/OCD177-3150.pdf (in italian only)

the name "Piano Nazionale Impresa 4.0" (with a view to include not only the manufacturing sector, but also the other sectors of the economy - services first and foremost - in order to allow small and medium-sized enterprises to equip themselves with the tools to support the transformation into a digital key). The Government, in the same place, also illustrated the guidelines of the Plan for 2018. Finally, the budget law for 2018 (Law no. 205/2017) has further strengthened the tools to support the Enterprise 4.0 strategy.

3.1.2 On Academic Level

In Italy, a database of Higher Education Institutions (HEI) courses is missing. For this reason, to investigate the coverage of the Factory of the Future and digitalization topics at academic level, we started identifying the 10 first universities in Italy. To do so we relied on the Italian university ranking provided by Censis[12], Centro Studi Investimenti Sociali, that is one of the main Italian socio-economic research institute. This is an articulated analysis of the Italian university system (state and non-state universities, divided into homogeneous categories by size) based on the evaluation of available structures, services provided, level of internationalization, communication capacity and employability. Given the topic under analysis, we consider the group of industrial and information engineering, that includes aerospace engineering, biomedical engineering, chemical engineering, security engineering, automation engineering, telecommunications engineering, electrical engineering, electronic engineering, energy and nuclear engineering, management engineering, computer engineering, mechanical engineering, naval engineering, mathematical-physical modelling for engineering, science and materials engineering. The figure below reports the 10 main Italian universities.

Figure 2 University Ranking (Italy)

[12] Source: https://www.censis.it/formazione/la-classifica-censis-delle-universit%C3%A0-italiane-edizione-20202021/la-didattica-lauree

Then, we searched for all 10 HEIs the extent to which they cover the topics “Design Thinking”, “Cyber-physical Systems”, and “Factories of the Future”. The table below reports the main results.

Table 4 FoF Course (Italy)

	Cyber Physical system	**Design thinking**	**Factory of the future/ intelligent manufacturing**
Politecnico di Milano	Master	Master	Master, executive master and PhD programmes
Genova	Master	Pills in few courses	Master focused on operator 4.0
L'Aquila	Only at PhD leve	Master	Only at PhD level
Padova	Master	Pills in few courses	Master
Trento	Master	Master	Only at PhD level
Bologna	Pills in few courses	Master	Master and executive master programmes
Pavia	Pills in few courses	Pills in few courses	Dedicated school
Bergamo	Pills in few courses	Pills in few courses	Executive master and PhD
Brescia			Pills in few courses
Palermo	Dedicated school		Dedicated school

As it is possible to notice from the table, all the universities cover the topics of Cyber Physical System, mainly in master courses or at least as pills in other courses. Design Thinking is the less covered topic and there are few courses specifically offered on it. Factory of the future/intelligent manufacturing is covered by all the universities, at master, PhD and executive level.

As a conclusion, we can state that the Factory of the Future topics are well covered by all the Italian universities, providing evidence on the perceived importance of the topic at academic level and on the attempt to train students (also executive students) with the digital and technological competences required to guide Italian companies in their digitalization journey.

3.2 Conclusions on FoF-Design Competency Needs

Taking into consideration the research priorities identified by the National Intelligent Factories Cluster and the results of the survey carried out at the beginning of the DigiFOF project, the main skills for the future of Italian manufacturing are the same reported in the World Manufacturing Forum report (WMF, 2019):

1. Digital literacy as a holistic skill to interact with, understand, enable, and even develop new digital manufacturing systems, technologies, applications, and tools;
2. Ability to use and design new AI and data analytics solutions while critically interpreting results;
3. Creative problem solving in times of abundant data and technological opportunities in smart manufacturing systems;
4. A strong entrepreneurial mindset including proactiveness and the ability to think outside the box;
5. Ability to work physically and psychologically safely and effectively with new technologies;
6. Inter-cultural and -disciplinary, inclusive, and diversity-oriented mindset to address new challenges arising from a more diverse manufacturing workforce;
7. Cybersecurity, privacy, and data/information mindfulness to reflect the rapidly increasing digital footprint of the manufacturing value chain;
8. Ability to handle increasing complexity of multiple requirements and simultaneous tasks
9. Effective communication skills with humans, IT, and AI systems through different platforms and technologies;
10. Open-mindedness towards constant change, and transformation skills that constantly question the status quo and initiate knowledge transfer from other domains

3.3 National Measures to Influence FoF-Design Competencies

At regional and national level there are several initiatives related to Factory of the Future (FOF).

At national level, in 2016 the Ministry of Economic Development (MISE) launched the Piano Nazionale Industria 4.0, then followed in 2018 by the “piano Nazionale Impresa 4.0. In order to boost productivity and accelerate technological upgrading the National plans “Industria 4.0” and “Impresa 4.0” of the Italian Government are focusing on strategic measures to support innovative investments and empower skills, such as: Super and Hyper amortisation schemes, tax credits on R&D and on profits from intangible and patented assets, strengthening of vocational training, creation of I4.0 Technological Clusters and Industrial PhDs. Moreover, complementary measures being implemented are the establishment of Competence Centres and of a network of Digital Innovation Hubs, Ultra Broadband with fibre to the factory approach, cooperation on IoT open standards and interoperability, easier access to financing and productivity salary taxation exchange.

In particular, regarding DIH, the national industrial associations has created a network of DIH, which objective is to strengthen the level of knowledge and awareness of companies regarding the opportunities offered by digital transformation, also within the framework of the National Industry Plan 4.0 and the European Strategy for the Digitization of Industry (DEI Digitising European Industry). In more detail, DIHs aim is to stimulate and promote the demand for innovation in the production systems and are the "gateway" of enterprises to the world of Industry 4.0. More in detail, directly or through the innovation ecosystem (University, Competence Centre, Cluster, ICT Services, Research Centres; Science Parks and Technology

Poles, Start-up Incubators) they offer: support to SMEs in the analysis of needs, opportunities and technological options 4.0; mentoring and factory training; support for the construction of industry projects 4.0; access to the network of national and European Competence Centres and collaborations with technology clusters; consultancy on Industry 4.0 (intellectual property, tax, business modelling, assessment of investment projects); self-assessment of digital maturity; access to public and private, national and European projects and funding.

Considering Lombardy, in 2016, the Region approved "Manifattura Diffusa Creativa E Tecnologica 4.0," which is an instrument with allocated funding in the amount to €600m coming through the ERDF fund that is aimed at the promotion and development of innovative manufacturing.

A leading role in the advanced manufacturing belongs to AFIL (Associazione Fabbrica Intelligente Lombardia), which is the Technological Cluster for advanced manufacturing of Lombardy. The main goals of the cluster are: i) to set up a stable community by connecting companies, universities, research institutions and associations, thus favouring cooperation by promoting research and innovation projects and initiatives; ii) to be a reference counterpart for the Region for the definition of R&I innovation policies in the manufacturing industry and iii) to support the development of R&I inter-regional networks through the participation to national intelligent factory (CFI) and the connection with different European Regions within the Smart Specialisation Strategy.

AFIL aims at foster research and innovation in the advanced manufacturing sector, promote best practices and enabling technologies to support and develop the leadership and competitiveness of the Lombard production system.

A recent project launched by AFIL is Cento4.0, which aims to reward and recognize the most innovative manufacturing companies in the area. After the first year, Cento4.0 will develop a map of high innovative manufacturing companies, which will provide an indebt overview of the level of competitiveness at national, European and global level and position Lombardy Region in that regard.

4 Market Report Poland

In this chapter, the insights on FoF competencies derived on national level for Poland are presented. Based on the questionnaire information gathered, an alignment to national initiatives is performed, validating the objectives of the DigiFoF project. The results presented in this chapter have been prepared by DigiFoF partner UNIBIAL, IDPC, BOC under the coordination of UNIBIAL (Prof. Arkadiusz Jurczuk and the team).

4.1 National Insights on FoF-Design Competency Needs

4.1.1 On Political Level

The processes of digital transformation permeate the entire economy, gradually transforming it into a digital economy, conditioned by the acceleration and intensification of digitization processes lasting for over two decades, i.e. the growing use of digital technologies by enterprises, public institutions and non-governmental organizations, employees, consumers and citizens. As a result, the functioning of the market of production factors and the market of goods and services, the financial system and enterprises are being transformed. The methods of production and consumption, the organization of the market are changing under the influence of new business models, the nature of work and employment relations, the basic functions of the state and the manner of their implementation (Śledziewska & Włoch, 2020).

Poland has the most dynamically developing economy among European Union countries, although it is still one of the last places in terms of its digitization, despite the general awareness of the important role played by innovative technologies in this matter. This situation results rather from the structure of the Polish economy and the fact that it is dominated by very small enterprises for which investing in technologies is a huge challenge and which build a competitive advantage by keeping labour costs low, rather than implementing modern technologies and developing the ability to use them. Therefore, compared to other countries, the use of digital technologies in Polish enterprises is low. The degree of digitization of Polish enterprises is on average 34% lower than in Western Europe (the average for France, the Netherlands, Germany, Sweden, Great Britain and Italy) (Gudanowska et al., 2020).

Despite the fact that Poland ranks among the last places in the European Union in terms of the digitization of the economy and workforce, it is also one of the fastest digitizing economies in Europe (Gudanowska et al, 2020). Research conducted by McKinsey shows that by 2025, thanks to digitization, the added value of the entire economy in Poland could increase by 13-22%. Digitization would reduce the productivity gap by 12-21% compared to the most advanced economies of Western Europe and by 27-47% compared to the EU-15 countries (McKinsey, 2016).

Poland was placed 23rd (advanced by two places in comparison to 2019) in the EU DESI ranking, published by the European Commission for 2020. DESI is the index of the digital economy and digital society (European Commission, 2020). For Poland, the potential economic and developmental benefits of digitization can reach up to €64 billion in additional gross domestic

product (GDP) by 2025. This would allow Poland to join the most digitally advanced economies in Europe.

Actions taken at the national level for the digital transformation of the economy and society may contribute to increasing the level of digital competences in Poland. Directives and challenges have been formulated among others in:

- European Cloud Federation (European Alliance on Industrial Data and Cloud) (access on November 2020);
- Operational Programme Digital Poland;
- Recommendations of the Council for Digital Affairs on programming financing for digital development in Poland in the budget perspective of the European Union for 2021-2027;
- Polish Artificial Intelligence Development Policy;

The development of digital competences has been recognised by the Council for Digital Affairs at the Prime Minister's Chancellery of Poland as one of the priority and strategic projects for the next seven years that should be implemented as part of Poland's digital transformation (Council for Digital Affairs, 2019). This program envisages a digital transformation of the education system focusing on development program of high education institutions dealing with teaching methodology and programs, including:

- development of scientific research on the creation of standards for the methodically correct use of competences and digital devices to improve the quality of education,
- development of didactics integrating digital achievements into the teaching process by school and university teachers,
- cooperation of universities and schools in this area.

Moreover, Council for Digital Affairs recommended to launch innovative study programs of related to new generation technologies (Big Data, Artificial Intelligence, IoT, Blockchain). These initiatives should be undertaken in cooperation with enterprises and science and research institutes (Council for Digital Affairs, 2019).

Committee of the Council of Ministers for Digital Affairs adopted in the November 2020 the “Polish Artificial Intelligence Development Policy”. This document outlines and defines the activities and objectives for Poland along with the requirements and conditions for the use of Artificial Intelligence. The key challenges and assumptions of the program include:

- activities aimed at preparing a team of experts in the field of AI (AI and science),

- organizing and conducting training, from the level of primary education to the level of higher education, for people at risk of losing their jobs due to the development of new technologies (AI and education).

Apart from the already mentioned elements it should be noted that on a political level there is an ambition to increase adoption of robots and other elements of FoF in Poland. Even though Poland significantly increases number of robots in 2019 (which is shown by placement in top 15 countries in IFR report[13]), the saturation is still low. That is one of the reasons for planned for 2021 tax incentives for companies buying or leasing robots as well as for the trainings[14]. This initiative is expected to increase industry competiveness as well as counter expected drop of available workforce.

Despite of the existing gap of digital competences McKinsey considers Poland to be one of ten Digital Challengers markets based in Central and Eastern Europe. These countries exhibit lower digitization rates than the so-called Digital Frontrunners (Belgium, Denmark, Estonia, Finland, Ireland, Luxembourg, the Netherlands, Norway and Sweden) or EU Big 5 markets (France, Germany, Italy, Spain, and United Kingdom). However, Poland has strong foundations on which to accelerate its digitization. The most essential is the fact, that Poland has a large future need for workforce reskilling: up to 49 percent of workplace activities could potentially be automated by 2030, using technology that already exists. Key enablers for further digitization in Poland are:

- increase the provision of training to develop/upgrade digital skills of employees by Polish enterprises;
- increase the adoption of digital tools by Poland's SMEs;
- improve Poland's ICT regulatory environment to ensure investment attractiveness and increase the adoption of digital skills (McKinsey, 2019).

By virtue of the digital competence deficits diagnosed in numerous studies and the lack of methodological competences in this field, it is necessary to consistently introduce study programmes at all universities (High Education Institutions, HEI), thus filling the existing gaps in this area.

4.1.2 On Academic Level

The importance of the quality of academic education in the context of shaping the competences of the future (understood as social, cognitive and technical competences including basic and advanced digital competences) in Poland is particularly high: every fifth Polish person aged 25-64 has higher education. Polish universities should create qualified human capital - a key element of the digital transformation - to a large extent. Unfortunately, numerous studies prove

[13] See https://www.isbtech.pl/2020/11/polska-w-czolowej-15-rynkow-kupujacych-roboty-przemyslowe/

[14] See https://www.gov.pl/web/rozwoj-praca-technologia/ulga-na-robotyzacje--nowe-ulatwienie-od-1-stycznia-2021-roku

that Polish people do not have an appropriate profile of competences and skills (Włoch & Śledziewska, 2019).

The results of the diagnosis of the universities' offers in Poland in the field of digital competence development indicate significant deficits in this respect. The evaluation of the academic offer was concentrated on four areas of competence (Righi et al., 2020):

- Artificial Intelligence (AI),
- High Performance Computing (HPC),
- Cybersecurity (CS),
- Data Science (DS).

The content of the above-mentioned areas of digital competences is presented synthetically in Fig. 5.1.

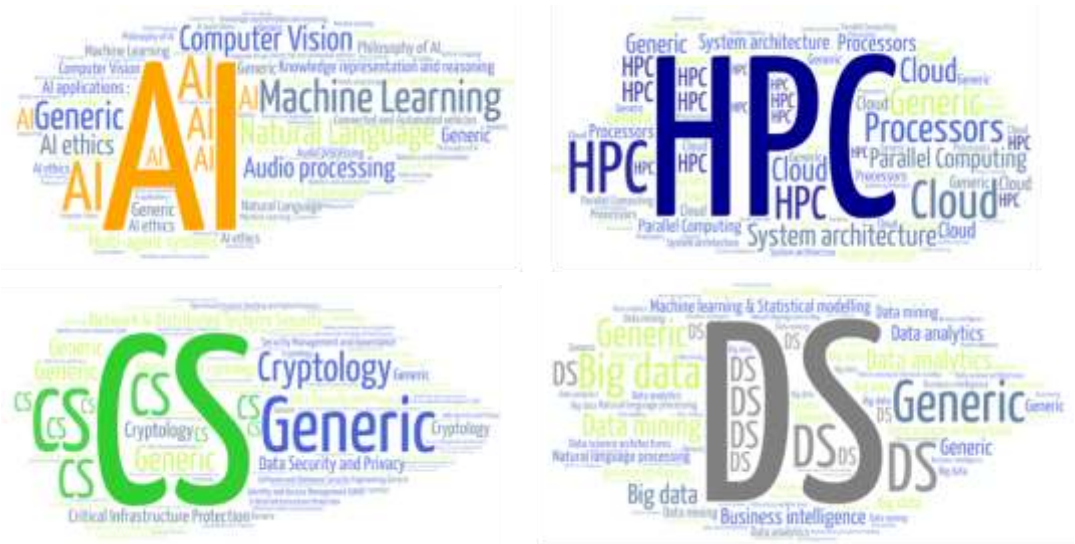

Figure 4.1. The content of digital competences areas (by the list of domain specific keywords) (Poland)

Source: Righi, R., López-Cobo, M., Alaveras, G., Samoili, S., Cardona, M.., Vázquez-Prada Baillet, M., Ziemba, L.W., and De Prato, G., *Academic offer of advanced digital skills in 2019-20. International comparison. Focus on Artificial Intelligence, High Performance Computing, Cybersecurity and Data Science*, EUR 30351 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21451-9, doi:10.2760/225355, JRC121680.

The analysis of the academic offer of Polish universities was carried out on the basis of defined keywords (Fig. 5.1). However, the diagnosis covered only the fields of study conducted in English (not a native language). Therefore, the research results presented in the report of European Commission (Righi et al., 2020) cannot be related to the full academic offer in Poland.[15]

[15] Offers submitted on https://studyportals.com/. Survey conducted

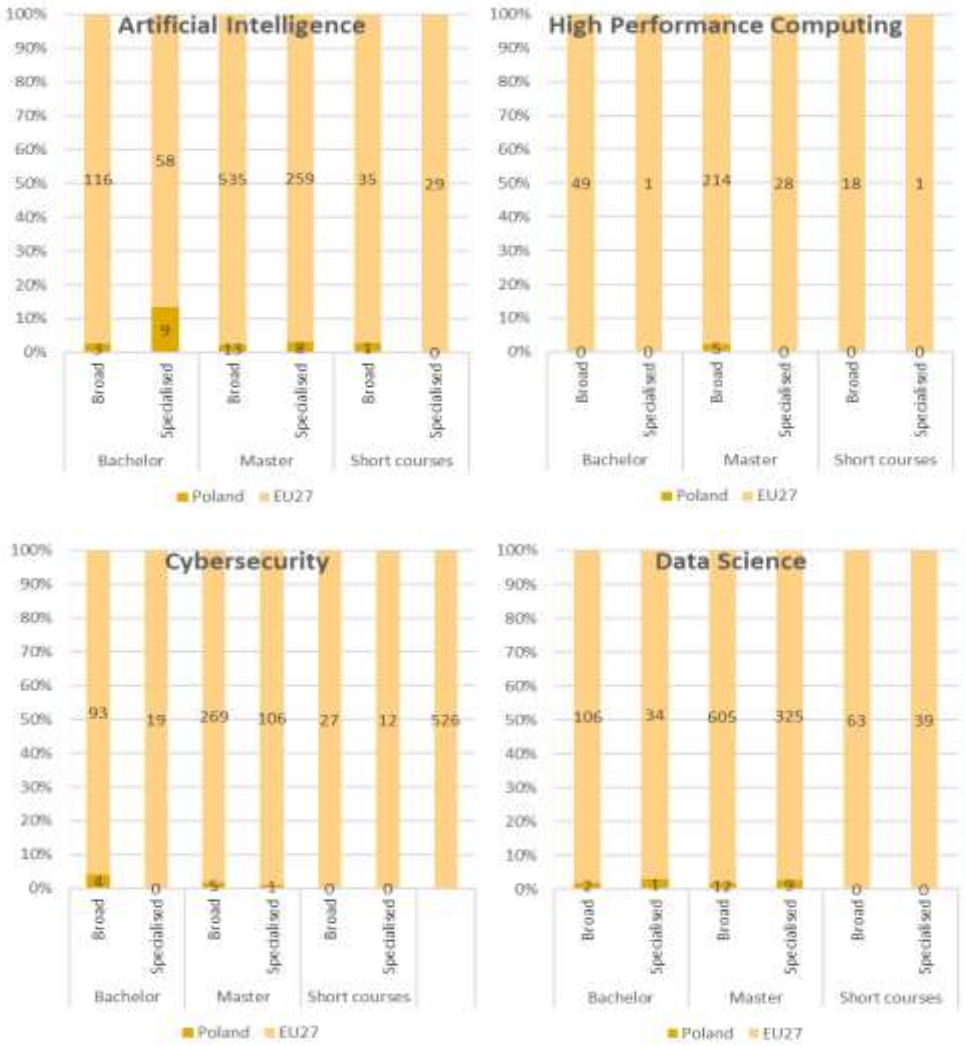

Figure 4.2. Number of academic offer in EU27 countries and Poland in the chosen digital domains (Poland)
Source: Righi et al., 2020.

Taking into account the offer of studies on a bachelor and master level conducted in English, there is a strong deficit in this area in Poland compared to other European countries (EU27). Poland is in the group of countries whose share of the academic offer related to digital competency development does not exceed 5% (Fig. 5.2). Referring to the results of the above-mentioned four areas it can be seen that the widest range of Polish universities is related to the area of AI. However, this is a negligible share in the total EU27 academic offer (about only 3% of the total number of programmes). Poland has also a marginal role in the entire EU27 offer of High Performance Computing bachelor and master's degrees (less than 2%). The similar situation is observed in the following two technology domains: Cybersecurity and Data Science. Poland plays not a significant role in the EU27 landscape in these fields with a share not larger than 2% (Righi et al., 2020). Due to the indicated limitations of the research methodology (limited data sources, including study programs only in English), the presented results should be considered as a starting point for a discussion on the competitiveness of universities in the European arena.

A certain shortage in the offer of studies developing IT competences is reflected in the opinions of graduates and students of Polish universities. According to research conducted by Digital Economy Lab of Warsaw University (DELab UW) at the breakthrough of 2018 and 2019 in Poland, education on academic level allows to learn new activities, facilitate networking and develop intellectually, but to a small extent it prepares well for professional work and does not teach the competences of the future, which is particularly emphasized by graduates and students of technical humanities. Almost half of the respondents stated that the on academic level is it possible to learn the ability to use digital programs and tools only at a basic level, and every third person indicated that they do not teach it at all. At the same time, most of the respondents assessed these skills as very important for their professional careers. According to them, there are not enough hours of programming classes at the university, and they expect more data visualization classes and data search and analysis classes. Moreover, the research report notes that Poland also belongs to the group of five countries with the highest percentage of the adult population with low digital problem solving skills (Włoch & Śledziewska, 2019).

4.2 Conclusions on FoF-Design Competency Needs

Currently, it is indicated that in Poland, within the next ten years, the demand for work on routine tasks will decrease, which will result in the necessity to increase investments in improving mainly digital competence of employees, among others. It is their level that will guarantee competitiveness on the labour market, employment security and the highest salaries (Gudanowska et. al., 2020).

There is also a noticeable deficit of specialists in the IT professions and the mismatch between their competences and market needs. However, at the same time it is noted that Poland is the fastest in Europe to make up for the shortage of IT staff. The available studies also indicate large deficits in both soft competences (e.g. communication, project management, teams, cooperation skills, etc.) and digital competences. According to the strategies developed in the country, the demand for digital competences in the perspective of 2030 will be horizontal, permeating many sectors and spheres of economic and social life (Gudanowska et. al., 2020).

The Polish economy can be considered a developed, but it is necessary to make optimal use of the upcoming changes brought about by the so-called Fourth Industrial Revolution. This is possible due to the fact that this revolution is just beginning, both in Europe and all over the world. The foundation of the ongoing transformation is the digitization of the entire value chain of companies and all owners in them the place of trials. It is to be hoped that the changes brought about by the digital revolution, in particular the skill using the potential of digital technologies and digital competences of enterprises and people, will be used by organizations in Poland and will be treated as an opportunity to increase their competitiveness, as well as allow for further strengthening the condition of the Polish economy (Gudanowska et al., 2020).

It is worth noting that students and graduates in Poland generally accept the fact that nowadays continuous further education is necessary. Among the desired skills they mention higher cognitive competences, such as: the ability to think critically and solve complex problems and

creativity, as well as entrepreneurship and the use of new digital programs and tools (Włoch, Śledziewska, 2019).

In the context of the development of digital competences, it is worth emphasizing that, according to the representatives of the The Polish Information Processing Society, 60% of children starting education today will be in jobs that do not exist yet, and almost 90% of jobs created require a minimum of basic digital skills.

It is also worth emphasizing that the ongoing COVID-19 pandemic will accelerate the achievement of economic growth in Poland. In the first months of the pandemic-related restrictions, the digital economy in Poland grew by 18.4 percent, i.e. 2.5 times faster than the average growth in 2017-2019 (McKinsey, 2020). The coronavirus will bring also forward the digital transformation of enterprises and the adaptation of Industry 4.0 technologies of them. This will be possible thanks to the comprehensive use of the digital potential, as well as fitting employees with the necessary digital competences.

4.3 National Measures to Influence FoF-Design Competencies

At present a number of activities are undertaken in Poland to develop the competences of the Polish economy in line with the challenges of the fourth industrial revolution. Over the past few years, the Future Industry Platform Foundation (Foundation) has grown to become a leader in promoting solutions in the field of Industry 4.0.

The foundation was established to strengthen the competences and competitiveness of enterprises operating in Poland by supporting their transformation towards Industry 4.0. The Foundation's activity is aimed at entrepreneurs operating in Poland, entities managing innovative clusters, entities operating for the benefit of an innovative economy, social and economic partners.[16]

In 2020, the process of establishing Regional Councils of the Industry of the Future was started in each voivodeship (region) in order define more precisely the regional potentials in the field of the industry of the future and tools for reinvigorating the processes to strengthen the competences of the regional economies of the above-mentioned range.

Actions taken by the Ministry of Labour, Development and Technology (formerly the Ministry of Development / Ministry of Entrepreneurship and Technology) are important activities aimed at raising the competences of the Polish economy to the challenges of the industry of the future.

In particular, activities aimed at recognizing and supporting the development of the Digital Innovation Hubs (DIH) network should be indicated. Mentioning about the competition "Standardization of the services of Digital Innovation Hubs to support the digital transformation of enterprises" under the Minister's Program for 2019-2021, entitled "Industry 4.0". The aim of the program was to select, expand and supplement the potential of centres that have the ability

[16] See: https://przemyslprzyszlosci.gov.pl/

to act as Digital Innovation Hubs, develop good practices and standardize the services they provide to support entrepreneurs in the field of product, service and organizational transformation, using the latest technological solutions, including: 5G connectivity; learning algorithms (Artificial Intelligence), including autonomous systems; Internet of Things (IoT); BIM (Building Information Modelling); computing cloud; quantum technologies (Quantum Computing); augmented and virtual reality (AR and VR); automation and robotics (Computer Integrated Manufacturing); cybersecurity; additive technologies (3D printing). The program is addressed to entrepreneurs who need to implement solutions in the Industry 4.0 area. Digital Innovation Hubs, i.e. unions/consortia between entities such as enterprises, research units, innovative clusters and non-governmental organizations, are eligible for financial aid under the Minister's Program.[17] In 2021 another edition of the competition will be announced and it is expected to emerge about ten more regional and interregional DIHs in Poland.

Moreover, increasing digital competences and digital transformation are carried out by other government units, including Industrial Development Agency, which implements the Open Innovation Network (SOI) project[18]. It is focused on building a culture of open innovation. Technology transfer transactions to small and medium-sized enterprises in Poland are created and supported as well.

Furthermore, the Industrial Development Agency runs the Technology Transfer Platform (PTT), which connects the owners of innovative solutions, those who want to purchase them and experts willing to share knowledge. All this with one goal in mind: to commercialize technologies for the benefit of Polish industry. PTT is also a website where registered users can inform about their innovative resources, about their needs in the field of innovation, as well as search relevant database.[19]

Additionally, under the Polish Development Fund (PFR) operating in Poland since 2016, a number of programs and projects devoted to building the competences of the future are implemented. PFR has also initiated a number of pro-development programs responding to the growing need for education in the area of future competences, including the international educational program PFR School of Pioneers, or PFR Innovation Designers - design thinking workshops organized by Google in a strategic partnership with PFR.[20]

The new PFR strategy "The Strategy of the Polish Development Fund for 2019-2021 assumes, among others, 5 strategic goals "Pro-development activities" and in it, along with other activities: digitization of the Polish economy and development of innovation.

[17] See: https://www.gov.pl/web/rozwoj/przemysl-4-0
[18] See: https://siecotwartychinnowacji.pl/czym-jest-soi/
[19] See: https://ptt.arp.pl/o-nas
[20] Development strategy of the Polish Development Fund. Summary of the activities and strategy of the Polish Development Fund capital group for 2019-2021, PFR, Warsaw 2019, p. 15.https://prowly-uploads.s3.eu-west-1.amazonaws.com/uploads/landing_page_image/image/180636/7ef2f4394ca54a555e02b77230fe48c3.pdf

The Polish Agency for Enterprise Development (PARP) is a specific implementer of activities for the development of industry 4.0. For a long time, it has been promoting and supporting entrepreneurs in implementing innovative solutions, especially in the small and medium-sized enterprises sector. One of the examples of PARP's activities are various types of project financing programs in the field of digitization of the economy. One of the activities is the competition planned for the turn of 2020 and 2021, dedicated to supporting the development services of clusters in Poland. The purpose of the competition is to support activities aimed at expanding the offer of the coordinators of the Key National Clusters by at least one new service in strategic areas provided for under the cluster policy, in particular activities in the field of digitization and digital transformation, transformation towards the industry of the future (Industry 4.0), circular economy (circular economy), low-emission economy.

The activities above should be supplemented with measures on a smaller scale, undertaken at the regional level by regional authorities, business environment institutions or clusters to develop economic potential for the industry of the future.

4.4 National key players relevant to FoF-Design

The confrontation of the conditions for implementing the assumptions of the industry of the future, the development of innovation in the SME sector and large enterprises in Poland, the development of centres supporting them in the process with the activities undertaken in Poland in the period 2017-2020 by public authorities allows us to state the following. The key players in the process of shaping the conditions for the development of Industry 4.0 in Poland are:

1) Future Industry Platform Foundation;

2) Key National Clusters;

3) Parks and technology incubators;

4) National level funders and regional authorities supporting regional cross sector projects.

Future Industry Platform Foundation

The aim of the Future Industry Platform Foundation is to increase the competitiveness of entrepreneurs by supporting their digital transformation in the field of processes, products and business models, using the latest achievements in the field of automation, artificial intelligence (AI), ICT technologies and communication between machines and humans and machines, taking into account the appropriate level of the security of these solutions.

According to the statutory assumptions of Future Industry Platform Foundation, its basic tasks include: building the awareness of entrepreneurs and promoting the benefits of digitization of industry and the use of modern ICT technologies; supporting the improvement of the technical, technological and organizational level of entrepreneurs, taking into account processing, logistics and energy processes, as well as digital integration of these processes;

promoting and supporting the use by entrepreneurs of intelligent management, production and distribution systems based on the acquisition, collection, transmission and analysis of data; initiating, in cooperation with entrepreneurs, research projects aimed at the development of material engineering, manufacturing techniques and new products; conducting information and training activities for entrepreneurs in the field of industry digitization; creating mechanisms of cooperation, sharing knowledge and building trust in relations between entities involved in the digital transformation process; cooperation with entities providing technical education to promote the adaptation of employees' competences to the needs of the industry of the future.

In 2020, Future Industry Platform Foundation started the process of creating Regional Industry Councils of the Future, which purpose is to activate actions in 16 regions of Poland (voivodships) for activities for the Industry of the Future. At the same time, regional councils are intended to be a bridge between activities undertaken at the national level by Future Industry Platform Foundations and activities undertaken by various entities at the regional level. Councils are composed of a representative of the world of business, science and administration from a given region, including representatives of centres supporting the development of innovation in a given region. This year, the Regional Industry Councils of the Future were established in the podlaskie and wielkopolskie voivodship.[21]

Parks and technology incubators

Technology parks and technology incubators are important in the process of generating solutions at the Industry 4.0 level due to the level of innovation, as well as the inflow of new ideas and technological ideas to the economy.

The task of parks and technology incubators is to facilitate the start-up of young companies and to create conditions for technology transfer through contacts with scientific units, verification of business concepts, implementation of various types of consulting and training for enterprises. Innovativeness of companies located in Polish parks and technology incubators is higher than the national average in Poland.[22]

The innovative development of modern enterprises is largely conditioned by the ability to adapt them to the industrial revolution 4.0 taking place on a global scale (Industry 4.0). Although 45% of technology parks do not have the technical resources and engineering tools to create Industry 4.0 solutions, nearly half of the survey participants declared that their business profile fits in with the latest trends related to the Industry 4.0 concept. These companies most often prefer using the Internet of Things, use software that reduces the costs of prototyping products and

[21] See: https://przemyslprzyszlosci.gov.pl [28.11.2020]

[22] M. Borowy, M. Mażewska, J. Rudawska, *Innowacyjność i internacjonalizacja przedsiębiorstw działających w polskich parkach i inkubatorach technologicznych w kontekście wyzwań Przemysłu 4.0*, Stowarzyszenia Organizatorów Ośrodków Innowacji i Przedsiębiorczości w Polsce, Wydawnictwo SGGW Warszawa 2020, s. 113-114

introducing new products to the market using cloud computing. Almost half of the surveyed entities undertake activities consistent with the directions of the industrial revolution 4.0.[23]

Based on the above, it is necessary to point out that the enormous potential of parks and technology incubators supporting to dynamise Industry 4.0 solutions in the entire economy. This can take place thanks to the inclusion of representatives of park management boards in the Regional Industry Councils of the Future. In this way, they will be connected to the national ecosystem supporting the construction of Industry 4.0.

Population of Key National Clusters (KNC)

At present, there are 13 KNC in Poland. A significant number of KNC coordinators are physically located in parks and technology incubators. Thanks to this, the coordinators have close contact with the novelties that are generated in the parks and incubators.

The most developed clusters in the world are treated as natural innovation ecosystems and contribute to the generation of technological solutions at the highest world level.

KNC in Poland, due to the huge technological potential accumulated thanks to the entities operating among them and based on intra-cluster cooperation as an ecosystem of open innovations - constitute a natural platform for building technological solutions, that are very often cross-sectoral and meet the requirements of Industry 4.0. It is enough to guarantee an appropriate financial impulse for the use of KNC as tools for the relationship of the economy digitization process and preparation of the economy to the challenges of Industry 4.0 in accordance with the assumptions of the Cluster Development Policy in Poland for 2020+.[24]

Funders at the national level and regional authorities supporting regional cross sector projects

One of the most important links in the Ecosystem of the Future Industry are the holders of support funds. These are most often public entities (very rarely private), which allocate funds for the creation of financial programs, providing the market with dedicated instruments and tools supporting the digital transformation process. The disposers of support funds can be divided into central and regional area.

The largest central administrator of support funds in Poland is currently the National Center for Research and Development (NCBiR). The NCBiR portfolio includes instruments based on European and domestic funds. At the central level, institutions that create dedicated programs are, among others: PARP, ARP or PFR.

The key regional administrators of the funds are Voivodship Self-governments, and in larger agglomerations - city authorities. However, it is in the Marshal's Offices that significant financial

[23] Op. Cit.

[24] J. Choińska-Jackiewicz, B. Lubos, M. Łata, M. Mackiewicz, A. Wancio, Directions of cluster policy development after 2020, Ministry of Development, Warsaw 2020, p. 44.

resources dedicated to digital transformation are located, including from the Cohesion Fund. It should be remembered that the subsequent success of implementations and economic innovations depends on the quality and effectiveness of the programs, competitions or grants developed by the funds administrators. The aim of these entities is therefore the development of instruments and support tools that would correspond to the real needs of the market and stimulate the emergence of real innovations. [25]

It is important to effectively and efficiently include the largest possible number of actively operating entities and groups of entities that are operational and technologically ready to bear the burden of developing regional and national economies to generate solutions that meet the requirements of Industry 4.0 in the funding stream from programs. The current development process in Poland indicates the possibility of meeting the above criteria by the KNC, technology parks and incubators. Around these entities, it is reasonable to build a network of additional cooperation links with other research and development units, universities and business support institutions.

4.5 Global insights on FoF-Design

Current situation in 2020 caused many companies to increase emphasis on FoF. It is expected that following periods will see more companies investing in FoF tools and services (including FoF design).

[25] Assumptions of the Future Industry Program, Fundacja Platforma Przemysłu Przyszłości, Warsaw 2020. Prezentacja prezentowana w dniu inauguracji Podlaskiej Regionalnej Rady Przemysłu Przyszłości, 14.10.2020.

5 Market Report Romania

This chapter provides the market report for Factory of the Future (FoF) Design in Romania. The analysis was provided by ULBS DigiFoF partner. The information provided in this section are acquired from public sources from local and government institutions of Romanian.

The report focuses on national measures to influence FoF-Design competencies. The report investigates national measures from the point of view of higher education institutions and policy. In July 2020, Romanian Government publish the new National Investment and Economic Recovery Plan[26] where a main objective is Digitalization and bureaucratization measures in administration and economics and in 26.10.2020 Education Ministry from Romania provide the idea for a new strategy for the learning digitalization (SMART-Edu) and will continue in 2021 to propose the new strategies for implementation until 2027. The new strategy is based on flexible, digitalized, adaptable education quality system. This was the main source used in this part.

5.1 National Insights on FoF-Design Competency Needs

The strength of the Romania industry is based on an innovation and economic system characterized by heterogeneity, diversity, and specialization. In order to maintain and even restore its strength, Romania is actively steering the digital transformation, especially in the production domain. Unfortunately, Romania ranks 26th out of 28 EU member states based on the Digital Economy and Society Index (DESI)[27] for 2020 [DESI 2020], published by the European Commission, an index that monitors global digital performance in Europe and tracks EU progress regarding digital competitiveness. Romania records the best results in the Connectivity dimension, due to the high use of very high-speed broadband and the wide availability of very high-capacity fixed networks. However, the digitalization of the economy has lagged behind, given that almost a fifth of Romanians have never used the Internet and less than a third has at least basic digital skills.

5.1.1 On Political level

These aforementioned initiatives focus on several aspects of Factories of the Future. Some focus on the new skills required by the workforce and the requirements for changing the Higher Education Initiatives landscape, others focus on regulatory aspects.

In Romania, in 2020, the Authority for the Digitalization of Romania[28] (ADR) was founded as an institution able to achieve the ambitious objectives of the Romanian Government in the sphere of digital transformation of Romanian society. The ADR is a structure with legal personality within the working apparatus of the Government and under the coordination of the Prime Minister. The role of ADR is to achieve and coordinate the implementation of public strategies and policies in the field of digital transformation and the information society. Members of the

[26] Source: https://www.adr.gov.ro/wp-content/uploads/2020/07/Planul-Nat%CC%A6ional-de-Investit%CC%A6ii-s%CC%A6i-Relansare-Economica%CC%86.pdf
[27] Source: https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi
[28] Source: https://www.adr.gov.ro/

DigiFoF project from ULBS partner was selected as members of the National Council for Digital Transformation (CNTD)[29] which is the advisory body of ADR, without legal personality, in order to start and consolidate the collaboration between the private sector and civil society. Some of the main objectives of government for digitalization are:

- Empowerment of the industry by providing supporting infrastructure, dedicated trainings, and funding for innovation and research & development initiatives;
- Empowerment of the workforce primarily by continuous education programs and trainings;
- Empowerment of Higher Education Institutions primarily by establishing research and funding schemes.

Digital transformation differs from automation and computerization: it requires systemic changes in business processes, business models and economic relationships within and around the enterprise. Creating an environment for the digital transformation[30] of SMEs operating in traditional sectors of the economy should have a range of technological and specialized business consultations, which can be provided by centers of expertise, through the collaboration of the public and private sectors in initiatives at (like skills development standards and common standards), as well as a comprehensive financial framework to support SMEs in this complex effort.

According to the EU report from 2020, 3% of Romanian companies exchange information electronically, while only 8% use social communication platforms (EU average: 25%). There has been a slight improvement in the share of SMEs making online sales, from 8% in 2017 to 11% in 2019, but this remains well below the EU average of 18% because until 2019 Romania does not have a clear national strategy for digital transformation for enterprises. According with this in 2020 Romanian Government publish the new National Investment and Economic Recovery Plan[31] where a main objective is Digitalization and bureaucratization measures in the administration and the economics. In this plan the digital transformation component represents a new vision in the public sector, which the Romanian Digitalization Authority wants to transpose from the business environment.

As directions of action, it aims to:

- ✓ **Digital transformation of public institutions**

  The digital transformation component represents a new vision in the public sector, which the Romanian Digitalization Authority wants to use the good ideas and experiences from the business environment. The benefits of digital transformation, such as efficiency, transparency, and simplicity, lead to much higher process productivity. Awareness of the

[29] https://www.adr.gov.ro/cntd/

[30] https://eufordigital.eu/ro/digitising-industry-best-practices-to-promote-the-digital-transformation-of-smes-in-traditional-sectors-of-the-economy/

[31] https://www.adr.gov.ro/wp-content/uploads/2020/07/Planul-Nat%CC%A6ional-de-Investit%CC%A6ii-s%CC%A6i-Relansare-Economica%CC%86.pdf

need for new technologies by leaders of public institutions, continuous adaptation to the requirements of citizens, quality, safe and fast online public services are just some of the vision elements that ADR will develop in its work.

- ✓ **Interoperability**

Interoperability between the IT systems of public institutions is one of the most important digitalization projects. Romania is still a country without "digital highways", which are responsible for the exchange of data between institutions. Interoperability has the ability to significantly reduce the time for managing a public service and the stress to which a citizen is subjected, while ensuring transparency.

- ✓ **Electronic identity**

One of the essential pillars of Romania's digitalization is electronic identity. Simplifying access to electronic public services requires a unique element of identification, which should be recognized by all institutions and authorities, so that access to more electronic public services does not require the repetition of authentication procedures. Electronic identification will provide citizens with a valid, verified identity. In relations with public institutions, the documents signed with the digital certificate in the virtual space will have the same value as the documents signed in handwriting, on paper.

- ✓ **Cloud computing technology**

Cloud computing technology will generate many benefits for public institutions: scalability, resilience, high performance, strength and security, cost efficiency, but also profitability. The government cloud will provide the necessary infrastructure for all institutions that have the obligation to take over and store the information of the beneficiaries of public services, as well as to protect their data. Also, the government cloud has the capacity to optimize the operation of all electronic public services in Romania. In this direction the Romanian Government start a platform for Integration of al eGovernment services called Point of unique contact (PCUe)[32] where a lot of electronics services for citizens and industry are putted together in order to be easy to be accessed.

Lucian Blaga University of Sibiu together with EOS (Education for Open Society) NGO from Timisoara, Romania, collaborated and implemented the program “Career accelerator in cloud” for graduates and students from Engineering Faculty. The career accelerator in the cloud meets the needs of students with at least two current topics: the first - the virtualization of resources (cloud technology) and the way of teaching / learning or doing jobs and the need to adapt to a new way of working, and the second being represented by Artificial Intelligence (AI) which is found everywhere in our life and activity. AI is gaining an increasingly important role in the digital manufacturing sector

[32] Source: https://edirect.e-guvernare.ro/SitePages/landingpage.aspx

in solving complex problems by providing a new path to economic growth. AI-specific skills have dominated the list of fastest growing jobs in 2018, and the trend is for growth in the future. Machine learning and AI algorithms are expected to create 133 million new jobs until 2022, as companies commit to adopting technologies that promise to revolutionize the way how they do business. The impact of artificial intelligence in everyday life is ubiquitous, from the comfort of smart homes to self-adaptive marketing, to "*business intelligence*" applications that extract knowledge from massive data, classification, or prediction tools, etc. The impact of AI becomes crucial in the manufacturing process in the automotive industry focused on automation, image processing, the use of evolutionary algorithms in optimizing the multi-objective design space of components under different constraints (time, cost, space, etc.), the predictive maintenance used to predict the next failure of a part, machine or system. As the COVID-19 pandemic spread globally, the overall cloud services market reached a record high of $31 billion. The growth was also driven by the migration of education into the virtual space with distance learning and by homework for many of the company's employees around the world. In addition, the rules imposed by the university autonomy to record and store each course and exam determined an increase in the need for storage space per teacher and implicitly per institution. Progress in Artificial Intelligence, IoT, Robotics, Automation, Biotechnology and 3D printing will bring significant transformations to all European industries. The economy will be more heterogeneous and decentralized than at present and will therefore help markets function more efficiently and sustainably.

The EU 2030 strategy[33] also aims to rethink natural resource management and reorganize industrial chains towards a circular economy that will "do more with less.

5.1.2 On Academic level

In October 2020, the Education Ministry from Romania provide the idea for a new strategy for the learning digitalization (SMART-Edu)[34]. They launched the idea and in 2021 will propose the new strategy. Through this strategy to digitalization of Education, the Ministry of Education and Research proposes a call to action for closer cooperation of all stakeholders, starting from the following priorities: Accessibility, Connectivity, Community, Digital Educational Ecosystem, Innovation and Sustainability.

Industry 4.0, Smart Manufacturing, Factories of the Future all describe aspects of the heralding era of digitalization of manufacturing aiming to interconnect every step of the manufacturing process and seamlessly integrate the physical and digital world.

The main challenge is represented by educational system, how prepared is to provide students, future employees, the digital competences necessary for the Factories of the Future. What are the structural and curricular measures Higher Education Institutions need to take in order to

[33] Source: https://factory40.ro/2020/01/28/strategia-ue-2030/
[34] Source: https://www.edu.ro/smartedu-strategia-privind-digitalizarea-educa%C8%9Biei-din-rom%C3%A2nia-2021-2027

align engineering education, especially in the design of all constituents of Factories of the Future, with the need of competences in new manufacturing era? In this sense the educational system should include in its undergraduate (BSc) and master's (MSc) study programs that prepare students for the following jobs: Virtual Reality/Augmented Reality System Specialist, Digital Manufacturing Engineer, Digital Factory Automation Engineer, Chief Digital Officer [Florea, A. (2019)].

At European level exists the European Qualifications Framework (EQF) which is a translation tool helping in communication and comparison between qualifications systems from European countries. EQF is structured on eight reference levels described in terms of learning outcomes: knowledge, skills and competences. EQF ensure a unique reference level for any national qualifications frameworks (NQFs) and qualifications in Europe. This European framework helps also the learners, graduates, providers and employers who may compare qualifications awarded in different countries and by different education and training systems [Fiore, U (2019)].

In Romania, the National Register of Qualifications in Higher Education (RNCIS) is aligned to European Qualifications Framework. Actually, each country owns its national qualifications framework (NQF) and relates it to EQF. Each specialization (study program) accredited and enrolled in RNCIS represents practically a qualification that has six professional and three transversal competences, but which specifies the possible occupations the graduate can have. Competencies are clarified by level descriptors related to thematic content areas, taught topics, and related credit points. These are written on the diploma's supplement of each graduate of bachelor or master programs. In Romania, under Ministerial Order (OMECS) no. 5204/2014, all accredited study programs must register their competencies in RNCIS. Two examples of Master degree programs related to Industry 4.0 are "Automotive engineering-design, manufacture and development" implemented at University of Craiova and "Embedded Systems" implemented at Lucian Blaga University of Sibiu [Florea, A. (2019)].

Also, at Lucian Blaga University of Sibiu in 2020 a postgraduate specialization program was also accredited at Engineering Faculty called Cyber-security[35] based on strategy of Romanian ministry regarding cybersecurity that propose to prepare specialists in the management and security of information systems.

Unfortunately, at least at national level, the rapid transition to Industry 4.0 is not accompanied by an evolution of the Romanian educational system with the same rhythm. Education slowly advances from understanding the necessity of new study programs which offer qualifications specific to the digital factory of the future, up to the proposal of these qualifications, validation and enrolment in the National Register of Qualifications in Higher Education (RNCIS), the development of an accreditation file for a new study program.

[35] Source https://www.ulbsibiu.ro/wp-content/uploads/news/2019_Pliant_CYBERSECURITY_web.pdf

Although the scientific literature contains enough examples aiming the need for new skills in the era of enterprise digitalization, are not many examples that address the issue at the stages level of realizing the curriculum of a new study program.

Through the Hasso Plattner Knowledge Transfer Center from the Lucian Blaga University of Sibiu (https://centers.ulbsibiu.ro/itchpiulbs/en/), in 2020, a workspace has been implemented where trainings and workshops on the concept of the Design Thinking take place. Analysing the universities, one can see, that especially Design Thinking is represented by almost all of them with dedicated courses for continuous education programs for employees and/or university courses for students, and/or workshops offered also to external parties.

Starting with 2020 ULBS become member of a Global Design Thinking Alliance (GDTA)[36] that is a network of institutions that teach, research and further develop the methods and mindsets of Design Thinking.

Thus, Design Thinking is very well reflected amongst technical and non-technical universities whereas Cyber-physical Systems and Factories of the Future are more considered at technical universities. Additionally, one needs to consider the different abstraction levels of the surveyed topics. Design Thinking is taught at courses that naturally often comprise the term Design Thinking itself. On the other hand, Cyber-physical Systems and Factories of the Future are highly complex and heterogeneous topics which naturally need to be decomposed into more specific courses which then form part of curricular programs at HEIs.

A solution for awareness the necessity for digitalization applied at Lucian Blaga University but also in other cities of Romania is to organize virtual events like Sibiu Innovation Days 2020 (26-27 of November) - https://events.ulbsibiu.ro/innovationdays/. Details you can find also on https://ec.europa.eu/research/index.cfm?pg=events&eventcode=845723D2-CA08-C194-036E18AE84064248 and https://www.linkedin.com/events/sibiuinnovationdays202067303951188236328896/).

Sibiu Innovation Days has emerged from the desire to bring closer academia, businesses and decision makers. The event closely follows the successful model of Cluj Innovation Days, which has proven over the years to be a platform among all the main stakeholders in the Cluj wider region interested in bringing innovation in many aspects of their activities. This year's edition of Sibiu Innovation Days is hopefully the first episode of an equally successful series of events that will consolidate the position of Sibiu City as an emerging innovation centre, with impact in shaping the economic and social vitality of the entire region.

During the two days of the conference we will be exploring, with the guidance and expertise of our invited speakers, the process of digital transformation and how this can help our community of students, researchers, and business and decision makers to add value to everything we are doing. The event is looking to strengthen the collaboration among all these stakeholders while

[36] Source: https://gdta.org/about-us/member-institutions/#1600250243638-b971147b-bfb5

also improving the way in which we understand and use the innovative services available in Transylvania and the Sibiu region. The conference will also highlight current research and development concerns of companies in the area, will bring increased visibility for Hasso-Plattner Knowledge Transfer Institute at the “Lucian Blaga” University of Sibiu, and will create new opportunities for collaboration among those participating.

The participation to conference is free and could be following on YouTube stream. The main topic is DIGITAL TRANSFORMATION - A ROADMAP TOWARDS A SMARTER SOCIETY and includes 9 topics: Autonomous driving / challenges in automotive, Digitalization / industry 4.0, Applied Artificial Intelligence, Innovative partnerships, Smart health applications, European challenges from RDI, The Future of Work, Smart city and Cybersecurity. There are at least two sessions related to DigiFoF - Panel 4 The Future of Work and Panel 8 Digitalization.

5.2 Conclusions on FoF-Design competency needs

An effort needs to be made to raise awareness in society, especially of organizations and leaders in education, but also in today's workforce, about the need to adapt their skills to the demands of society and the global economy, based on digitalization. The popularity of digitalization concepts is currently characterized by an upward trend, but the education system is not yet prepared with programs to support the new jobs created by digitalization. Thus, it is imposed as a need to generate programs for specific qualifications and skills for factories of the future.

From the perspective of study programs that offer classical engineering skills, Romania is positioned quite well, but has not yet bothered to include in the curriculum relevant topics for digitalization compared to the difference from other European countries. So, we need adapted programs (at the engineering level, but not only), with the inclusion of new disciplines. Europe should continue to invest in training programs for workers at risk of losing their jobs. It should also invest in digital skills to remain competitive, prioritizing machine learning, information security, design thinking, problem-based learning, systems design in a holistic way that integrates business and technology issues into the final product.

An analysis regarding the matching of the educational curriculum with the research trends was performed based on (1) the National Register of Qualifications in Higher Education, which provides national competency profiles on engineering programs in Romanian universities and (2) a search on master's degree at international level.

The aim was to identify - at master's level - (a) whether the subjects in research trends match the subjects provided in the educational programs, (b) what educational point of view the curricula approached in terms of discipline, and (c) how to compare Romanian educational programs with international programs when searching for similar search criteria, ie keywords. It is worth mentioning, due to the lack of a formalized database of master's programs at international level, the comparison in (3) is only partial.

The following tasks were performed to carry out the research:

a. Search in the National Register of Higher Education Qualifications for those disciplines that address engineering as a competency addressed

b. Of those study programs selected in point (a) were excluded from the analysis, which were not industry specific. This means that study programs for chemical, naval, mining, aerospace, nuclear and physical engineering have been excluded. The reason for the exclusion was twofold: (1) there were insufficient data available in the analysis of the research papers to clearly distinguish industry-specific and non-industry-specific topics and skills; and (2) the number of study programs that could be found at national level. and internationally was very low and the comparison would have been partially at the individual program level.

c. The search in (a) and (b) gave a number of 23 study programs in Romania, which were further analysed according to the topics they address.

d. The web search was performed on the same keywords as the search in the Scopus database, namely digital design, factories of the future, intelligent production / industry 4.0, digital transformation and robotics. The results were 60 master's degree programs that address one or more of the above keywords.

The FoF Design competence network adds to an international knowledge sharing community on digitalization. Moreover, the OMiLAB4FoF network as the innovation and prototyping environment fits very well to the digitalization context. Eventually, the training concept and materials developed within the DigiFoF project can be used directly for empowering the industry as well as the workforce in digital innovation and innovative prototyping with Cyber-physical Systems.

5.3 National measures to influence FoF-Design competencies

Analysing the 23 study programs in Romania, it is observed that there is a gap between research and the Romanian curriculum [Florea 2019]. Of the 23 programs, all had at least two courses that addressed conceptual engineering activities, such as design, modelling, and simulation / optimization (either at the theoretical level or at the applied level). Depending on the field he approaches, he focuses either on product or process engineering, or on management and optimization of the organization. While the topics do not focus on the term "controller" - in fact only in one of the master's programs, one of the Design of the embedded systems controller was addressed - conceptual engineering was present in educational programs. However, what could be observed at the current level was that no interdisciplinary design topics were addressed (product service design or product data modelling, etc.). Similarly, each of the study programs contained at least three courses addressing field-specific topics, but less than 5% of the general topics were specifically interdisciplinary. However, this is different at program level, where of the 23 programs, 12 address one area, 6 are interdisciplinary and 5 focus on cross-cutting engineering topics without a specific area.

No specific course topic could be identified that directly links a technology to the subject of digitalization. There are several topics that address technologies (circuits, power plants, computer-aided design), although the syllabi for these courses do not indicate that they are specifically aimed at digitization.

What appeared in the analysis of the research works, but which are still completely missing in the analysed programs, are topics such as user experience design, community development and planning (either from a business or engineering perspective), virtual and augmented reality, cooperation mechanisms based on innovation management teams, technologies or innovation concepts (such as open innovation, etc.). No such courses could be found in any of the 23 selected master programs.

The OMiLAB created through DigiFoF project in ULBS, comprising both, the expertise and materials for conducting Design Thinking workshops as well as providing CPS entities for realizing and evaluating first experimental prototypes, and might benefit from and respond to the existing demand in Romanian industry and HEIs. These activities are promoted at the national level using Digital HUBs[37] and Hasso Plattner Knowledge Transfer Center[38].

[37] https://dih4society.ro/
[38] https://centers.ulbsibiu.ro/itchpiulbs/en/studies.php#course-fer

6 Market Report Germany

This chapter provides the market report for FoF Design in Germany. As for Germany, no survey has been conducted in WP1. The report therefore focusses on National measures to influence FoF-Design competencies. The report investigates the national measures from the standpoint of Higher Education Institutions and Politics. The analysis has been provided by DigiFoF partner OMiLAB.

6.1 National Insights on FoF-Design Competency Needs

The strength of the German industry is based on an innovation and economic system characterized by heterogeneity, diversity, and specialization[39]. In order to maintain and even restore its strength, Germany is actively steering the digital transformation, especially in the production domain. Several initiatives on national level like the "Leitbild Industrie 4.0", "Leitbild 2030 für Industrie 4.0", "Die Hightech-Strategie 2025[40]", and the "Digital Made in DE" have been initiated in recent past.

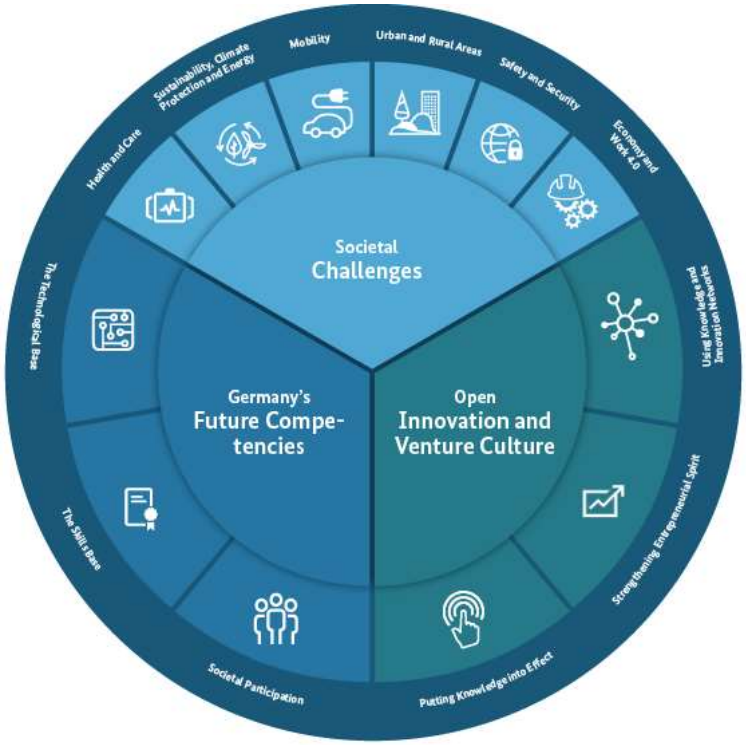

Figure 3 High-Tech Strategy (Germany)

6.1.1 On Political level

These aforementioned initiatives focus on several aspects of Factories of the Future. Some focus on the new skills required by the workforce and the requirements for changing the Higher Education Initiatives landscape, others focus on regulatory aspects. Consequently, several

[39] Source: Bundesministerium für Wirtschaft und Energie (BMWi), Leitbild 2030 für Industrie 4.0 - Digitale Ökosysteme global gestalten
[40] Source: Germany Hightech Startegy 2025, https://www.hightech-strategie.de/en/index.html

Federal Ministries are involved in these initiatives, the Federal Ministry of Education and Research, the Federal Ministry for Economic Affairs and Energy, the Federal Ministry for Family Affairs, Senior Citizens, Women, and Youth, and the Federal Ministry of Labour and Social Affairs. Exemplarily to showcase not only selected and isolated but also comprehensive initiatives of several German Federal Ministries the strategy paper "Nationale Weiterbildungsstrategie" (national continuing education strategy) shall be noted. This initiative is a cooperative effort of the Federal Ministries of Education and Research, Labour and Social Affairs, and Economic Affairs and Energy.

From surveying the political situation in Germany, it is crystallized, that the German strategy builds on several pillars:

- Empowerment of the industry by providing supporting infrastructure, dedicated trainings, and funding for innovation and research & development initiatives,
- Empowerment of the workforce primarily by continuous education programs and trainings;
- Empowerment of Higher Education Institutions primarily by establishing research and funding schemes.

A recent major ambition of Germany is the establishment of so called **Regulatory Sandboxes**[41]. These sandboxes shall provide an environment for innovative prototyping. The strategy paper states, that "Digital innovations are now conquering all fields of everyday life and business – and this is taking place faster than ever before. If companies and research establishments are to research and develop new technologies and business models and to bring them to market, they need to try them out in practice."[42]. The strategy for Regulatory Sandboxes entails three aspects: more scope for innovation, networking and getting information out, and launching and supporting regulatory sandboxes.

The community aspect is much focused in the strategy paper. The German Federal Government aims to establish knowledge exchange within a network of Regulatory Sandboxes by supporting their establishment and by enforcing communication amongst them. "Boosting the transfer of knowledge and technology plays a central role in ensuring the future of the German economy.[42]" To that end, the Labs Network Industrie 40 was founded, "by companies related to the Plattform Industrie 4.0 in cooperation with the federations Bitkom, VDMA, and ZVEI. It aims at supporting the German mid-sized sector in taking a leading role in the global digitalization.[43]"

6.1.2 On Academic level

For investigating to which extend Higher Education Institutions (HEI) in Germany cover the topics of digitalization and Factories of the Future, we followed a step-wise approach. First, we were

[41] Source: Regulatory Sandboxes: https://www.bmwi.de/Redaktion/EN/Dossier/regulatory-test-beds-testing-environments-for-innovation-and-regulation.html
[42] Source: Federal Ministry of Economics and Energy: Making space for innovation: The handbook for regulatory sandboxes), https://www.bmwi.de/Redaktion/EN/Publikationen/Digitale-Welt/handbook-regulatory-sandboxes.html
[43] Source: Labs Network Industrie 4.0, https://lni40.de/?lang=en

interested to identify a representative set of HEIs as there is a lack of a comprehensive database of HEI study programs and courses in Germany. We thus decided to use the latest list of selected universities of the German "Exzellenz-Initiative" – a highly competitive selection amongst HEIs to attract huge amounts of Federal Funding for several years. This resulted in a list of 13 German HEIs. In a second step we then searched for all 13 HEIs, regarding the extent to which they cover the topics "Design Thinking", "Cyber-physical Systems", and "Factories of the Future" both, in research and education.

Analysing the universities, one can see, that especially Design Thinking is represented by almost all of them with dedicated courses for continuous education programs for employees and/or university courses for students, and/or workshops offered also to external parties. 61.5 % of the universities have dedicated Design Thinking courses in their curriculum. Almost 40 % of the universities provide workshops for founders and courses for continuous education on Design Thinking. Six out of the 13 universities provide dedicated courses on Cyber-physical Systems. At some universities, like the Technical University of Munich[44] (TU Munich) and the Rheinisch-Westfälische Technische Hochschule Aachen[45] (RWTH Aachen) even exist dedicated research chairs for Cyber-physical Systems.

Three of the 13 surveyed universities have a visible focus on Factories of the Future. Furthermore, RWTH Aachen has even a dedicated research centre for Factories of the Future[46] while the Karlsruhe Institute for Technology (KIT) operates a French -German Joint Research Institute for Industry of the Future[47].

From the survey it can be considered, that FoF is, as of 2020, primarily considered at those universities that have a strong engineering and technical background. To conclude the survey findings at HEIs, it becomes clear, that Design Thinking is very well reflected amongst technical and non-technical universities whereas Cyber-physical Systems and Factories of the Future are more considered at technical universities. Additionally, one needs to consider the different abstraction levels of the surveyed topics. Design Thinking is taught at courses that naturally often comprise the term Design Thinking itself. On the other hand, Cyber-physical Systems and Factories of the Future are highly complex and heterogeneous topics which naturally need to be decomposed into more specific courses which then form part of curricular programs at HEIs. The comparison of the search result only on a quantitative basis is therefore not possible. However, albeit the small number of surveyed universities the survey already shows a very strong penetration of the DigiFoF topics at German HEIs.

[44] Source: Cyber-physical Systems chair at TU Munich, https://www.mw.tum.de/cps/startseite/
[45] Source: Cyber-physical Systems research group at RWTH Aachen, https://www.comsys.rwth-aachen.de/research/cyber-physical-system
[46] Source: FoF at the RWTH Aachen, https://www.rwth-campus.com/center-factory-planning/
[47] Source: KIT Research Institute for Industry oft he Future, http://institute-industry-of-the-future.eu/

6.2 Conclusions on FoF-Design competency needs

A survey amongst 132 Bavarian companies showed, that the importance of digitalization and Factories of the Future (FoF) is very high. 10% of the companies even considered digitalization/FoF as the most important topic for the future[48]. The field which participants consider the most significant for digitalization/FoF is 'Service'. Moreover, the topic considered most important for the enterprises is the differentiation from competitors.

The political measures sketched previously combined with the survey amongst industry companies produces a clear picture of where Germany sees the most relevant and important action fields. Considering FoF Design, this project directly contributes to several German endeavours. For example, the FoF Design competence network adds to an international knowledge sharing community on digitalization/FoF. Moreover, the OMiLAB as the innovation and prototyping environment fits very well to the Regulatory Sandboxes. Eventually, the training concept and materials developed within the DigiFoF project can be used directly for empowering the industry as well as the workforce in digital innovation and innovative prototyping with Cyber-physical Systems.

6.3 National measures to influence FoF-Design competencies

Germany installed several national measures that will positively influence the FoF Design competences. Innovation, prototypical experimentation, and community building are central to most recent political strategies like "Leitbild Industrie 4.0", "Leitbild 2030 für Industrie 4.0", "Die Hightech-Strategie 2025", and "Digital Made in DE".

From the survey of HEI it can be derived, that aside from the political strategies one can observe also an increase of knowledge transfer between HEIs and industry. In particular, two means of collaboration have been found regularly: Design Thinking workshops organized and operated by HEIs with the aim of involving industry partners to benefit from their real-world problems and trying to help them finding an innovative solution.

A further collaboration was found by means of collaborative research consortia especially for Cyber-physical Systems and Factories of the Future. An explanation of this might be that the first collaboration is very knowledge intensive, thus the industry benefits from the existing expertise at HEIs, whereas the latter collaboration is very cost-intensive and often needs a lot of space. For conducting research in FoF huge investments in robotics and CPS entities are required upfront. Here is where the industry can help the HEIs by providing access to such environments.

The OMiLAB, comprising both, the expertise and materials for conducting Design Thinking workshops as well as providing CPS entities for realizing and evaluating first experimental

[48] Soure: VDMA survey results on demands for Industrue 4.0, https://bayern.vdma.org/documents/106096/0/Auswertung_Bedarfsanalyse/3b3747ca-3b00-4bc2-b7f8-713d375dcb80

prototypes, might benefit from and respond to the existing demand in German industry and HEIs.

7 Conclusion

This deliverable represents the second result from T2.4 “Realizing the business plan for the DigiFoF Design Competence Network” with the objective to reflect the outcomes of WP1 results as “D1.2 Report on needs and demands for FoF-design: Findings and recommendations” and align them with a broader market perspective. As such, initiatives and developments on national level have been reviewed and discussed as a starting point for the uptake and business planning.

In this revision of the document, the aspect of FoF market analysis has been approached from a political as well as academic perspective, identifying key initiatives per country. As an additional view, the German perspective has been added to the report to reflect the challenges from the production industry in Germany.

Overall, the analysis of different national initiatives shows that there is a general need for training and expertise exchange with respect to designing the factory of the future. Country-specific focus points are the result of political and industrial frameworks in place and can be understood as a domain-specific distinction. This implies for DigiFoF, that the approach followed to have country/culture specific expert knowledge and a tight collaboration between academic (HEIs) and industrial partners is required to enable the future generation with adequate skills and expertise.

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