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COMPETENCES AND SKILLS OF SMES FOR INDUSTRY 4.0 – CASE STUDIES OF SELECTED EUROPEAN INITIATIVES[1]

Summary

Purpose – SMEs tend to have an intuitive approach when it comes to management, which means that, contrary to bigger companies, they frequently lack sufficient competences and expertise needed to implement the Industry 4.0 concept. The article identifies and analyses case studies of selected state-funded European initiatives (from Poland, Italy, Spain, Slovenia, the United Kingdom, and Finland), which help SMEs prepare for the implementation of Industry 4.0 through the acquisition of adequate competences and skills.

Research method – With the use of the case study method, the author has performed the analysis of selected national public initiatives focused on the development of competences and skills of enterprises needed to implement the Industry 4.0 concept. The initiatives were deeply analysed during the implementation of the Interreg Europe SMARTY project (Smart SMEs for Industry 4.0).

Results – Based on the results of the case study analysis performed, the author identifies competences and skills SMEs need to successfully implement Industry 4.0.

Originality/value/implications/recommendations – The competences and skills identified as part of the case study analysis seem to be required for effective implementation of the Industry 4.0 concept in SMEs and they could also serve as recommendations for policy makers as regards the development and organisation of Industry 4.0-related training courses for SMEs.

Keywords: competences, skills, Industry 4.0, development of SMEs.

JEL classification: O33, O35, O39

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1. Introduction

The rising dependency of businesses on the internet and the growing digitalisation of all spheres of business operations observed in the recent years focused on increasing the productivity, efficiency, and cost-effectiveness of business operations is creating more opportunities for the industry 4.0 market, the value of which in 2020 amounted to USD 101.69 billion – up by 14.5% year-on-year compared to the 2017–2019 period – and is projected to grow to USD 337.10 billion in 2028 [www1]. The main focus of Industry 4.0 is on the digitalisation of the manufacturing process to produce higher-quality products at reduced costs. Industry 4.0 is a major part of companies' digital transformation and it gives them better control over all their processes and operations, and, therefore, helps them make more informed decisions to boost profitability and competitiveness [www2]. As Industry 4.0 is all about digitalisation and automation, to implement the Industry 4.0 concept, enterprises need to apply advanced digital technologies and use data sets to ensure that all their systems are well-networked and enable smooth digital communication as well as real time exchange and use of the data stored in them. To do so, they need to identify the technologies that are best fit to their actual requirements and, most importantly, be ready to implement them in their operations. This means that the Industry 4.0 transformation requires from companies certain capabilities and qualifications and from their employees – certain skills and competences, without which the implementation of the Industry 4.0 technologies and processes will prove futile.

The core scientific objective of this research is to identify and analyse the competences and skills which are needed in the companies in order to meet Industry 4.0 requirements.

The author explores the initiatives which enable the employees to navigate their transition between traditional and Industry 4.0 areas in relation to the engagement in the business activities in the companies.

The research involves comparative analyses of competences and skills from Poland, Spain, Italy, Finland, the United Kingdom and Slovenia.

The main research question is: which types of competences and skills are crucial in order to ensure effective work in the modern organisation? How can competences and skills in the area of Industry 4.0 be achieved?

2. Competences and skills for Industry 4.0

The topic of competences and skills required for Industry 4.0 is discussed in articles spanning various academic disciplines and professional domains, including,

among others, business, management, education, human resources, engineering or manufacturing. Some authors focus on hard skills only [e.g.: Motyl et al., 2017, pp. 1501–1509; Nordin, Norman, 2018, pp. 1–7; Ahmad et al., 2018, pp. 221–235], some entirely on soft skills [e.g.: Kivunja, 2015, pp. 224–239; Afrianto, 2018, pp. 1–13; Hariharasudan, Kot, 2018, pp. 1–13; or Shet, Pereira, 2021, pp. 15–26], and some (as discussed below) include a mix of hard and soft skills. Given that the last approach is far more comprehensive, in their analyses the author reviewed articles that present both hard and soft skills required for Industry 4.0.

The literature reviewed offers different classifications of competences and skills needed for Industry 4.0. Frequently, they are assigned to four groups, but the author also came across classifications into two and three groups.

The classification of competences required for Industry 4.0 into four categories may be found, among others, in the articles by Hecklau et al. [2016, pp. 1–6]; Bermúdez, Juárez [2017, pp. 25–26]; or Hernandez-de-Mendez et al. [2020, pp. 1511–1524] (Table 1).

TABLE 1

**A four-group classification of competences for Industry 4.0
identified in literature reviewed**

Authors	Competence categories
Hecklau et al. [2016, pp. 1–6]	• technical competences • methodological competences • social competences • personal competences
Bermúdez, Juárez [2017, pp. 25–26]	• competences concerning information and communication technologies • competences concerning innovation management • competences concerning organisational learning • competences concerning business environment
Hernandez-de-Mendez et al. [2020, pp. 1511–1524]	• engineering competences • design competences • business competences • transversal competences

Source: author's own elaboration.

Hecklau et al. [2016, pp. 1–6] discuss strategic competences the workforce will need to adopt the Industry 4.0 concept, i.e.: (1) technical competences (e.g.

media skills, coding skills, and understanding of processes); (2) methodological competences (e.g. creativity, problem solving, decision making and analytical skills); (3) social competences (e.g. intercultural skills, communication skills, networking skills, teamwork skills, and leadership skills); and (4) personal competences (e.g. ambiguity tolerance, flexibility, motivation to learn, and ability to work under pressure).

Bermúdez and Juárez [2017, pp. 25–26] discuss skills and competences to be adopted for Industry 4.0 by operations managers, analysing them from the perspective of the four dimensions of Industry 4.0, i.e.: (1) information and communication technologies, which require such hard skills as, among others, knowledge of big data and data analytics or knowledge and management of software and interfaces intended to support operations management; (2) innovation management, which requires a mixture of hard and soft skills (e.g. virtual collaboration, knowledge and management of simulation systems, and the ability to adopt new models); (3) organisational learning, which requires soft skills like the ability to motivate and encourage employees' professional development or knowledge of lean manufacturing techniques; and (4) environment, which requires a number of soft skills, out of which creativity in designing strategies to introduce new practices is listed as the most important.

Hernandez-de-Mendez et al. [2020, pp. 1511–1524] group the new skills and competences the companies will need to have ready for Industry 4.0 into (1) engineering, (2) design, (3) business and (4) transversal competences, which are all interrelated and coupled. The first two types of competences are hard skills mainly related to the ability to use and interact with Industry 4.0 technologies, and they include, among others, knowledge and understanding of and familiarity with data science and advanced analytics; novel human-machine interactions and interfaces; robotics; mechatronics; automation; cybersecurity; advanced simulations; communication protocols; cloud solutions; and lean manufacturing. On the other hand, business and transversal competences include soft skills. Business competences are mainly related to technology awareness, change management, talent management, forecasting, scheduling, planning, and analysis, while transversal competences include problem-solving, teamwork, language, communication, as well as analytical and logical thinking skills.

Skills and competences needed for Industry 4.0 are assigned to three groups by, among others, Grzybowska, Łupicka [2017, pp. 250–253] and Fitsilis et al. [2018, pp. 130–133] (Table 2).

Grzybowska, Łupicka [2017, pp. 250–253] identify three categories of core managerial competences, i.e. (1) technical competences acquired through practice and learning, and comprising all job-related knowledge and skills (e.g. media or coding skills); (2) managerial competences facilitating the business decisionmaking

processes and helping run the company effectively (e.g. analytical and research skills, conflict and problem solving, and creativity); and (3) social competences (e.g. values, motivations, leadership skills, or the ability to work in a team).

TABLE 2

A three-group classification of competences for Industry 4.0 identified in literature reviewed

Authors	Competence categories
K. Grzybowska and A. Łupicka [2017, pp. 250–253]	• technical competences • managerial competences • social competences
P. Fitsilis et al. [2018, pp. 130–133]	• technical competences • behavioural competences • contextual competences

Source: author's own elaboration.

Fitsilis et al. [2018, pp. 130–133] propose a model of core skills and competences needed for Industry 4.0 that can be used for the purpose of Industry 4.0-related training courses. In the model, the skills and competences are grouped into: (1) technical skills (e.g. knowledge of robotics and automation, knowledge of data integration or human-robot interface design skills); (2) behavioural (or transversal) skills that are not specifically related to a particular job, but can be used in a wide variety of situations and work settings (e.g. organisational skills); and (3) contextual skills related to specific production processes, standards, guidelines or organisational structures.

Skills and competences the companies need to successfully implement the Industry 4.0 concept are assigned to two groups by, among others, Vrchota et al. [2019, pp. 1–20] (Table 3).

TABLE 3

A two-group classification of competences for Industry 4.0 identified in literature reviewed

Authors	Competence categories
Vrchota et al. [2019, pp. 1–20]	• technical competences • personal competences

Source: author's own elaboration.

The authors classify these skills and competences into (1) technical and (2) personal skills and competences, dividing them further into obligatory skills and competences (i.e. skills/competences that workers must have) and additional skills and competences (i.e. skills/competences that workers should or can have). As regards the obligatory technical competences, the authors name the following: IT skills, the ability to process and analyse data, knowledge of statistics, organisational and procedural awareness, and the ability to use the latest devices. These skills can be additionally supported by knowledge management skills, awareness of data protection and IT security, knowledge of production processes, general knowledge of technologies, as well as knowledge of applicable laws governing technology use. Among the obligatory personal competences, Vrchota et al. list organisational and time management skills, ability to change, teamwork, as well as social and communication skills, adding extra skills like willingness to learn and develop, and belief in new technologies.

The competences and skills related to Industry 4.0 requirements can be easily achieved through the participation of SMEs in different state-funded programmes supporting SMEs. There are hundreds of programmes dedicated to this topic among which it is worth highlighting for example Industrial Internet Consortium in the United States [www3], or Industrial Value Chain Initiative in Japan [www4]. Moreover, the European Commission gives more and more funds for the inclusion of Industry 4.0 requirements in companies. The example can be the activities under Cluster 4: Digital, Industry and Space [www5]. It can therefore be seen that the entrepreneurs have a wide range of possibilities of achieving new competences and skills in this area.

3. Methodology

In order to help enterprises prepare for the implementation of Industry 4.0, several national and regional initiatives were launched. The author analyses them employing the following criteria:

– Initiative type – initiatives dedicated to the acquisition of Industry 4.0-related competences/skills;
– Sources of initiative funding – state-funded initiatives;
– Initiative location – the European Union (particularly Poland, Spain, Italy, Finland, the United Kingdom and Slovenia, as organisations from these countries participated in the Interreg Europe programme "Smart SMEs in Industry 4.0" and they indicated these case studies as key initiatives related to competences and skills for Industry 4.0 [www6]).

The author performed an in-depth analysis of the following initiatives (Table 4):
1. Skills for the digital transition in the textile sector: PRISMA's training programme (Italy).
2. Skills for 4.0 (United Kingdom).
3. Future Industry Platform (Poland).
4. Acelera PYME (Spain).
5. Future key skills and competences for I4.0 (SRIPs as a foundation for the digital transition) (Slovenia).
6. FrostBit Software Lab (Finland).

TABLE 4

Selected initiatives analysed in the paper

Initiative	Aim of the initiative
Skills for the digital transition in the textile sector: PRISMA's training programme (Italy)	PRISMA has the general objective of making the Italian textile and fashion industry more competitive and efficient, increasing its added value through a better use of resources, increasing the wealth produced by generating new businesses and jobs, and increasing the number of qualified workers through technology transfer. Therefore, the new competences and skills in the area of Industry 4.0 are of great interest to the programme.
Skills for 4.0 (United Kingdom)	The aim of this initiative is to identify the core skills related to a high performing economy, driven by high performing individuals who and businesses which are able to create and exploit new technologies and opportunities, rather than standing back and being swept along by the change.
Future Industry Platform (Poland)	One of the main goals of the initiative is to strengthen the competences of human resources for the industry of the future. This is done through the organisation of e-learning courses focused on the areas related to Industry 4.0.
Acelera PYME (Spain)	The Acelera Pyme is the initiative of the Ministry of Economic Affairs and Digital Transformation aimed at: • promoting the digital transformation of Spanish SMEs, with tools such as advice and training; • providing a platform to generate a digital ecosystem and a national community around digital transformation, this being the neuralgic point that connects all interest groups by unifying capacities; and • offering high-value services to promote the digital transformation of the greatest number of SMEs.

Initiative	Aim of the initiative
Future key skills and competences for I4.0 (Slovenia)	The initiative has several objectives, i.e.: • checking the relevance of competence needs with companies; • preparing forecasts of competence needs and descriptions of competence development levels; and • assessing the importance of predicted competence needs.
FrostBit Software Lab (Finland)	The FrostBit lab is the first Finnish virtual reality programming laboratory (state-owned funded initiative) aiming at: • real-life learning environment enabling quadruple helix stakeholders' participation; • systematic and strategic approach to operate as a frontrunner in digitalisation; and • TRL evaluation to support customers' technological maturity development.

Source: author's own elaboration.

4. Results of the comparative analysis of selected initiatives

The initiative analysis results suggest that technical skills or competences are the most important for enterprises as regards the Industry 4.0 transformation (Table 5).

TABLE 5

Technical competences and skills in the selected case studies

Technical competences and skills	IT	UK	PL	ES	SL	FI
Digital transformation	×	×		×	×	×
5 G for the industry	×					×
Wireless communication	×		×		×	×
Artificial Intelligence	×	×		×	×	×
Quantum communication	×					×
Blockchain technology	×	×		×	×	×
Cybersecurity in industry 4.0	×		×			×
Virtual and Augmented Reality	×					×

Technical competences and skills	IT	UK	PL	ES	SL	FI
Internet of Things	×				×	×
Communication in Factory of the Future			×	×		×
Management and optimisation of production		×	×		×	×
Digitalisation of administrative and business processes		×	×		×	×
Digitalisation of engineering processes		×	×	×	×	×
Renewable energy sources			×			
Circular economy and sustainable production			×			
Data analytics			×	×	×	×
Companies' automation				×		×
Simulation						×

Source: author's own elaboration.

From the comparative analysis it further follows that the initiatives consider mainly technical competences and skills which are listed in much detail. Crucial technical competences and skills are as follows: wireless communication, artificial intelligence, the Internet of Things, digitalisation of engineering processes, and data analytics. As it can be seen, the largest number of technical competences and skills is included in Italian and Polish initiatives, while in the UK initiative – the lowest. It does not mean that the UK initiative overlooks technical competences and skills in the Industry 4.0 transformation, but it is rather mainly concentrated on managerial (so called meta-skills) and universal competences and skills.

Apart from the technical competences and skills, the initiatives also indicate personal competences and skills required for the implementation of the Industry 4.0 concept (Table 6).

As depicted in Table 6, personal competences and skills mainly include networking between science and business, problem solving, leadership, and autonomy, followed by creativity, cognitive flexibility, entrepreneurship, commercialisation orientation, emotional intelligence, and interpersonal relationships and empathy, as well as critical thinking and accountability.

TABLE 6

Personal competences and skills in the selected case studies

Personal competences and skills	IT	UK	PL	ES	SL	FI
Leadership	×	×	×	×		
Networking between science and business	×		×	×	×	
Critical thinking		×	×			
Creativity		×	×			×
Problem solving		×	×	×	×	
Cognitive flexibility (i.e., updating of knowledge)		×	×			×
Emotional intelligence		×	×		×	
Entrepreneurship	×	×	×			
Commercialisation orientation	×			×		×
Autonomy		×		×	×	×
Accountability				×	×	
Interpersonal relationships and empathy	×	×			×	

Source: author's own elaboration.

By personal competences we mean complex skills conditioning the effectiveness of coping with certain types of situations, which are acquired by an individual in the course of social training. These competences are personality-related and they have a direct impact on, among others, the quality and manner of task performance, or relationship building. Personal competences and skills help people utilise their qualifications, expertise, and professional experience in the best way. That is why, even though Industry 4.0 is mainly centred around technologies, personal competences are still a key to success. This is particularly true in the case of commercialisation orientation, which, nowadays, is a very important competence. In the past, there were a lot of factors hampering commercialisation of state-funded research results, and they were mainly of structural, cultural, competence-related and legal nature [Kilian-Kowerko, 2013, pp. 27–32]. The aspect of commercialisation was not stressed so much and that is why many products were never

successfully brought to the market and made no profit for the company. Between 2014 and 2016 low demand for innovative goods or services was most often indicated in Portuguese and Cypriot companies (63% each), and least often in Danish (30%) and Swedish (31%) ones. The lack of marketing expertise most commonly hampered the commercialisation of innovations in Ireland (63%), Portugal, and Latvia (57% each). The best situation in this respect was in Germany (25%) and Sweden (28%) [Baruk, 2018, pp. 71–89]. That is why commercialisation-related competences and skills are also necessary for the Industry 4.0 transformation and have been included in the initiatives analysed.

All but Finnish initiatives also indicate management competences and skills as a separate group of competences and skills required for Industry 4.0 (Table 7).

TABLE 7

Management competences and skills in the selected case studies

Management competences and skills	IT	UK	PL	ES	SL	FI
Self-management	×	×			×	–
Optimisation and planning		×				–
Human resource management			×			–
Relation with clients		×	×	×	×	
Negotiation		×	×	×		–
Project management	×					–
Innovation management	×		×	×		–

Source: author's own elaboration.

Table 7 shows that management competences and skills mainly include self-management, relations with clients, negotiation and innovation management. Many initiatives do not consider managerial competences and skills, as they are somewhat included in technical or personal competences and skills.

As mentioned above, in the UK initiative the nomenclature is completely different: the terms of meta-skills and universal skills are used. Meta-skills include: 1) Self-management: manage the now; 2) Social intelligence: connect with the world; and 3) Innovation: create our own change. These skills are very general, but as the name denotes, they are wide and apply to different areas of the activity, not

only to Industry 4.0. Universal skills are more closely related to Industry 4.0: (i) Technical skills; and (ii) Digital skills: confidence in using and exploiting technologies, and the ability to create new technologies.

5. Conclusions

Industry 4.0 revolution is a must in the countries which think about the development of technologies that are pushing new production techniques, business models and value chains, and want to take global production to a completely new level [www7].

Unfortunately, not all countries are equally prepared to implement new technologies or equipped with the required competences and skills, but in all the countries analysed, there are initiatives that stress what competences and skills should be acquired in order to be well prepared for Industry 4.0.

These initiatives have a double role for potential beneficiaries. First of all, they strictly indicate which competences and skills should be taken into account in order to come closer to Industry 4.0. On the other hand, they help enterprises focus on those competences and skills which should be acquired or developed to boost the company's competitiveness and innovativeness.

The core scientific objective of this research was to identify and analyse the competences and skills which are needed in the companies in order to be coherent with Industry 4.0 requirements. The author identified competences and skills in Poland, Spain, Italy, Finland, the United Kingdom and Slovenia, and then, the competences and skills were analysed through the use of comparative analysis method. It turned out that technical competences are still the most important, but what is beneficial, the personal and managerial skills and competences are also taken into account when the companies intend to go towards Industry 4.0. That means that employees acquire not only the competences and skills that help them do technological activities in the professional way, but also the competences and skills that help them think in a more creative way.

The analysis shows only a small pool of knowledge on the Industry 4.0-related competences and skills, as it was limited to selected state-funded initiatives implemented as part of the SMARTY project, and concerned case studies it took into account. However, they can provide the reader with basic information which competences and skills to consider when transforming the company in line with the Industry 4.0 concept.

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