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IN SEARCH OF A COMPETENCY GAP IN THE ERA OF INDUSTRY 4.0 – THE CASE OF MANAGER 4.0 IN POLAND

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Purpose: The main objective of the research is to identify a competence gap in "Industry4.0" – the difference between the competencies currently acquired by students at universities with a technical and economic profile, and the competencies desired by companies from the industrial processing sector.
Design/methodology/approach: Empirical material was obtained in two studies. The first survey was conducted among 120 companies in the industrial engineering sector, while the second was carried out among over a thousand students and graduates of economic and technical universities.
Findings: This work contributes to an in-depth understanding of companies' needs regarding "Manager 4.0" competencies, and enables the identification of existing educational gaps. Our research results show that there is a competence gap on the labour market in each of the analysed categories of competencies: social, personal, managerial, technical and professional. At the same time, some differences are visible between students of economic and technical universities. The findings of the study suggest the need to redesign student education programs at universities so as to provide interdisciplinary education taking into account key competencies for Industry 4.0.
Research limitations/implications: We identified three limitations of our research, resulting both from the size of the research sample of the analyzed comapanies, the possible ambiguity of the respondents' understanding of the examined competences (ambiguity of their interpretations) and their mutual interdependencies, as well as the subjective assessment of the students themselves.
Practical and social implications: The study indicated the need for specific employee competencies, the development of which requires interdisciplinary study programmes in areas including production engineering and management. Besieds, the results of our research are particularly important for adapting employee training systems. We assume that the development of new training programs best suited to the needs of the market (need for specific employee competencies) should be done through cooperation between companies in the industrial processing sector and the academic community.

Originality/value: The conclusions of the research shed new light on requirements regarding managerial positions in companies from the industrial processing sector, by indicating the need to modify curricula at universities in selected areas of competence.

Keywords: Industry 4.0, Manager 4.0, human resources, managerial competencies.

Category of the paper: Research paper.

1. Introduction

The Covid-19 pandemic accelerated digital transformation both in the world of education and work. In this fast-changing and turbulent environment, referred to as the Fourth Industrial Revolution, an updated set of competencies (including digital competencies) is needed for university graduates. They will become employees who will face paramount challenges, and who will participate fully in the economic and business life of the modern digital world (Poszytek et al., 2021).

In a knowledge-based economy, competencies are becoming a key non-material resource, with a significant influence on the development of companies (Graczyk-Kucharska et al., 2018), many of which perceive the development of competencies as the key to gaining a competitive advantage and developing transformation strategies for improving individual and company performance. Competencies can also leverage further knowledge at all levels of the organization. In addition, managers in manufacturing companies can more easily manage the risks that occur during the transformation process if they develop the necessary competencies (Jerman et al., 2019).

Technical competencies are one of the attributes of the engineers and managers of the future, however, they must be supplemented with other competencies (Gudanowska et al., 2018). Some researchers forecast that the economy may face a labour crisis such as simultaneous unemployment and the shortage of a skilled workforce. The collaboration of all stakeholders in employee competencies is crucial to preventing this crisis (Śledziewska, 2020). One of the many causes lies in the considerable difference between what is offered by the educational system and what the labour market needs (Kusmin et al., 2018). This conclusion inspired us to study the situation from both perspectives in Poland.

In the debate on implementation of the Industry 4.0 concept, scientists and practitioners have already partly answered the question of what knowledge, skills and attitudes are needed by employees in an Industry 4.0 environment. In this article, we go further and want to identify whether the competencies acquired by students of universities in Poland meet the requirements set by companies.

The main objective of the article is to identify a competence gap in "Industry 4.0 Manager" – the difference between the competencies currently acquired by students at universities with a technical and economic profile, and the competencies desired by companies from the manufacturing sector for managerial positions. The conclusions of the research shed new light on requirements regarding managerial positions in companies from the industrial processing sector, by indicating the need to modify curricula at universities in selected areas of competence. The results of this research are particularly important for adapting employee training systems, as well as the education process. This research area is all the more important as over the years individual competences undergo revaluation and it iis necessary to recognize the current requirements and conditions on the labor market.

The structure of the paper is as follows. First, we discuss the theoretical background, we point to the challenges of Industry 4.0 and the corresponding competencies that companies require when undertaking digital transformation. Then, we present the research methodology and data collection. The third part of the paper presents the results and discussion sections. The competency gap is summarized in Tables 5-8. The paper ends with conclusions as well as managerial implications, limitations and future research directions.

2. Theoretical Background and Literature Review

2.1. Meaning and typologies of competence

Effective implementation of goals in organizations and the projects implemented within them is ensured by competent managers. The word "competence" in the era of the knowledge-based economy takes on a special meaning and can be defined as a certain resource of knowledge, skills and motivation (attitudes) conditioning behaviours that enable the execution of professional tasks as expected (Filipowicz, 2016).

One very important issue when considering the parameters describing competencies is to place them in the context of the system (e.g. sector, company) or subsystems (e.g. specific department) within which they apply. On the one hand, the system of a specific organization defines the competencies expected of all employees (so-called company competencies) and for specific positions. On the other hand, the organizational system plays the role of a regulator in revealing certain undesirable behaviours among organization employees (Gwarda-Grusczyńska, Czapla, 2011, p. 6; Gracel, Makowiec, 2018).

Competency research is mostly based on one of three approaches that have been developed independently (Jerman et al., 2020). The functional approach focuses on competencies as requirements for the successful completion of a task by limiting the scope of competence to the necessary skills and knowledge. The behavioural approach focuses on attributes beyond cognitive abilities, including self-awareness, self-regulation and social skills. In turn, the integrated/ multidimensional approach describes competencies as a set of specific competencies that an individual needs, and the organizational skills required at the level of the entire organization in order for the desired results to be achieved (Straka, 2004).

The literature in the field of human resource management lacks clear conclusions as to the number of employee competencies (also managerial) that can be distinguished. Every concept and attempt at classification, if it is to have practical application, must take into account the evolution and deepening diversity of the business world. Some researchers also conduct factor analysis of various sets of competencies in an attempt to try and extract "key competencies" from these sets (see e.g. Levy-Leboyer, 1997, p. 36). In Poland, competence models have been created, among others, by T. Oleksyn (2006), Jurek (2012) and Padzik (2013). Each of these approaches reflects a certain model approach to competencies specific to a particular type of organization. In addition, it is worth noting that the scope and diversity of the described competencies often lead to attempts to systematize them into certain categories, but that in this case also there are significant differences between the authors' approaches. R.L. Katz (...) focuses on managerial competencies, taking into account three types of competencies: 1. Technical, 2. Social and 3. Conceptual. An interesting contribution by Katz was the assigning of separate competence categories to different levels of management. At the level of middle management, social competencies become increasingly important and technical skills become less important. One of the latest typologies was presented by Filipowicz (2016, p. 94), who divided competencies into personal, social, managerial and professional, which form the so-called "Universal Competence Model". Personal and social competencies seem to be more universal than other groups of competencies. It is therefore necessary to assume that they often form the basis for the development of more specialized skills.

2.2. Industry 4.0 challenges and the corresponding competencies

The Fourth Industrial Revolution (or the era of Industry 4.0), is inextricably linked with the integration of machines, systems and people. Its characteristic feature is great acceleration in the development of organizations based on the latest technologies. The Fourth Industrial Revolution not only has a huge impact on the changes to the entire industrial system, but also poses significant challenges for employees in the area of the competencies required, without which it will be difficult for them to adapt to the new reality. We are dealing with a revolutionary change in the area of employee competence rather than an evolutionary one, mainly due to the challenges associated with Industry 4.0 faced by companies. Industry 4.0 creates many new opportunities for companies, but at the same time causes certain challenges

to the whole economy to arise from the ongoing automation and digitization (Hecklau et al., 2016).

The challenges resulting from the Fourth Industrial Revolution affect, amongst others, several perspectives (Simic, Nedelko ,2019; Hecklau et al., 2016): economic, social, technical, political and legal. The new conditions force changes in the competency profiles of employees involved in the implementation of the Industry 4.0 concept. Some professions will be replaced, and only qualified and highly educated employees will be able to control new technologies. However, the biggest challenge for industrial leaders isn't technology – the focus is instead on people (Simic, Nedelko 2019).

Among the economic challenges it should be noted that with the ongoing globalization process, companies have to cope with reduced time-to-market, shorter product lifecycles and the need to cut costs to stay competitive. For this purpose, companies need to streamline their innovation processes and transform their business model to ensure a higher level of service orientation. Subsequently, the need for collaboration is more important than before. Companies now have to enter into strategic alliances with their suppliers or competitors to stay competitive (Hecklau et al., 2016). Ongoing globalization requires intercultural skills, language skills, time flexibility and networking skills. In addition, the increasing need for innovation requires entrepreneurial thinking and creativity as well as problem-solving. Consequently, workers experience increased complexity in their daily tasks and are required to be highly flexible and to demonstrate adaptive capabilities in very dynamic working conditions (Longo, 2017). Demand for higher service orientation requires employees to develop communication, conflict solving and networking skills, as well as the ability to compromise. Due to the characteristics of Industry 4.0, it is inevitable that the latest industrial revolution is reshaping industry boundaries, creating entirely new industries and exposing established manufacturing companies to new competitive challenges (Müller et al., 2018).

Among the challenges of a social nature, attention should be paid to demographic changes, employee training and changing social values. Fewer young people are entering the labour market to replace those retiring. Thus, strategies need to be developed to attract young people, whilst retaining the knowledge from older employees. Moreover, younger generations propound different social values, such as the growing importance of a good work-life balance (Hecklau et al., 2016). This goes hand in hand with growing employee flexibility due to changes in work organizations. The flattening of organizational structures, the self-organization of work, multitasking and empowerment make the ability to transfer knowledge, accept work-task rotation, as well as time and place flexibility even more important (Łapuńka, Marek-Kołodziej, 2017). Furthermore, the growth of strategic tasks with more responsibility requires new types of appropriate leadership competencies. Managers of future manufacturing systems will need to transform their management methods from power-driven to value-driven due to highly diverse teams in terms of culture, education and geographical location (Hecklau et al., 2017). Additionally, processes are becoming more complex, which is leading to an increase in jobs

requiring higher qualifications and a decrease in jobs requiring lower qualifications. Therefore, companies need to train their employees to carry out more strategic, coordinating and creative tasks with higher responsibilities (Hecklau et al., 2016).

The technical and technological challenges apply to both the exponential growth of technology and data usage, and also the growth in collaborative work on platforms. The understanding of information and data will have to increase amongst employees so that they are able to implement technical potential within companies. Employees must further acquire skills in virtual communication, media skills and the ability to be cooperative and work in teams. Digital connectivity implies the sharing of data and opening up to a competitive market environment, resulting in a transparent business that is largely facilitated by online platforms. A high level of transparency exposes companies to the risks of cyber-attacks and industrial espionage, and the challenge of securing data rights and access (Simic, Nedelko, 2019). To ensure the fluid exchange of data between partners within a network, it is further necessary to develop standardized interfaces and open architectures which enable collaborative work together on different platforms (Hecklau et al., 2016). Technical skills, as well as analytical and coding skills are essential to meet those challenges.

The political and legal challenges can be considered through the prism of standardization, data security and personal privacy. The most evident political challenge is the increasing need for funding for research programs. Governments need to support organizations in the development of new technologies, as well as the integration of those technologies into the existing environment. Growing work flexibility further requires the establishment of regulations for working times and safety in order to protect employees (Hecklau et al., 2016).

Taking into account the above challenges, it is important from a scientific and practical point of view to create a list of required competencies that will enable an adequate reaction to these challenges. Table 1 lists the competencies relevant to Industry 4.0 identified in the literature review[1]. Among the articles analysed, 10 articles were empirical and 9 articles included conceptual analysis.

Table 1.
Identification of Industry 4.0 competencies based on a literature review

Competence	Indication in the literature																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Ability to quickly analyse data and information	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Ability to use ERP / BI / CRM systems	X		X	X	X		X	X	X		X	X	X	X		X	X	X	X

[1] To identify the literature, we used the Google Scholar search engine by entering as key words: 'Industry 4.0 competencies', 'Fourth Industrial Revolution competencies', ‘Manager 4.0’ and ‘Industry 4.0 skills’. After filtering by time range (2016-2022), relevance and title screening, 117 studies were preselected. 24 references were chosen after abstract screening, and after a full text review 19 references were selected for inclusion in the analysis.

Cont. table 1.

Ability to work under pressure	X				X				X		X	X	X	X	X	X	X	X	X
Analytical thinking	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Basic programming skills		X	X		X	X	X	X	X		X	X	X	X		X	X	X	X
Building relationships	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Communicativeness	X	X		X	X	X		X		X	X	X	X	X	X	X	X	X	X
Comprehensive (systemic) approach to strategy implementation	X	X				X	X			X			X		X	X	X	X	X
Conflict resolution skills	X		X		X			X	X	X	X	X	X	X	X	X	X	X	X
Reliability						X	X	X		X		X			X	X	X	X	X
Cooperation skills within the whole organization		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Emotional intelligence						X	X	X			X	X	X	X	X	X	X	X	X
Employee evaluation and development	X			X			X				X	X	X		X	X	X		X
Entrepreneurial skills		X	X		X	X						X	X	X		X	X	X	X
Independence/decision making			X	X	X	X			X	X	X	X	X	X	X	X	X	X	X
Innovativeness and flexibility	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Intercultural communication	X		X	X	X				X	X	X	X	X	X		X	X	X	X
Interdisciplinary thinking	X	X	X			X	X		X	X	X		X			X	X	X	X
Knowledge of foreign languages	X		X	X	X		X		X		X	X	X	X	X				X
Leadership skills		X		X	X		X	X			X	X	X		X	X	X	X	X
Manufacturing procedures	X			X	X			X	X	X		X	X	X	X	X	X	X	X
Motivating	X			X	X		X	X		X	X	X	X	X	X	X	X	X	X
Negotiating				X				X						X	X				X
Presentation skills						X									X		X		X
Problem-solving	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Process management	X	X		X	X		X		X			X		X	X	X	X	X	X
Project management				X					X						X	X	X	X	X
Pursuit of results			X	X	X	X			X	X	X	X	X		X	X	X		X
Quality management							X								X	X	X	X	X
Self-management (including time management)	X			X	X	X			X			X		X	X	X	X	X	X
Sharing knowledge and experience	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X
Strategic thinking / long-term planning	X	X	X	X		X	X			X			X		X	X	X	X	X
Task delegation				X		X				X		X	X		X	X	X	X	X
Team building	X		X	X	X			X		X	X	X	X	X	X	X	X	X	X
Teamwork	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X
Understanding business models	X	X	X	X	X		X				X	X		X	X	X	X	X	X
Understanding the basic principles of data protection and cybersecurity		X			X						X			X		X	X	X	X
Understanding the principles of manufacturing processes	X		X				X	X		X	X	X		X	X	X	X	X	X
Understanding the principles of technologies, functioning and the goals of their implementation	X	X	X	X			X		X		X	X	X	X		X	X	X	X
Lifelong learning	X	X		X	X		X	X	X	X	X		X	X	X	X	X	X	X

Source: Own elaboration based on: 1 - Erol et al. (2016); 2 - Hecklau et al. (2017); 3 – Łupicka, Grzybowska (2018); 4 - Simic, Nedelko (2019); 5 - Hecklau et al. (2016); 6 - Prifti et al. (2017); 7 - Jerman et al. (2020); 8 - Jerman et al. (2019); 9 - Graczyk et al. (2018); 10 – Łapuńka, Marek-Kołodziej (2017); 11 - Kusmin et al. (2017); 12 – Mdluli, Makhupe (2017); 13 – Imran, Kantola (2018); 14 – Ismail, Hassan (2019); 15 – Dębkowska et al. (2017); 16 – Shet, Pereira (2021); 17 - Saniuk et al. (2021); 18 - Tommasi et al. (2022); 19 – Ribeiro et al. (2021).

In the context of the above list, we chose only those competencies that were indicated by at least four authors, realizing that the above list is not complete. In the case of some competencies, we have used simplified and synonymous treatment of some of the terms used in the articles. As a result of the above procedure, we identified a list of 40 competencies whose frequency of indication varied significantly, ranging from four articles to nineteen (all) articles.

2.3. The role and importance of Industry 4.0 Manager

There is no doubt that the modern technologies necessary in the process of implementing the concept of Industry 4.0 are a strong driver of changes in today's economic reality. Managers can either resist global trends or prepare for them properly, giving the companies they manage a chance to gain a competitive advantage by stimulating business processes using modern technologies. However, companies will not be able to use technology 4.0 without the appropriate competencies necessary to properly implement the idea of Industry 4.0. This is a huge challenge at every level of the economy, affecting almost every industry. In the literature, there have been attempts to build a catalogue of necessary competencies, for example, Gracel and Makowiec (2018) and Łupicka and Grzybowska (2018) distinguished the requirements set for managers and the desired competencies in the context of Industry 4.0, with lists of competencies indicating the differences.

What connects current theoretical approaches and the results of empirical research is a clear indication that despite the automation of many processes, the human factor will not be eliminated. People will continue to be essential, amongst others to intelligently control and evaluate reports generated by analytical systems, and to make key business decisions. At the same time, there is no doubt that Industry 4.0 will cause a significant change in employment profiles. It will be necessary to employ people who can handle various, often very complicated processes and elements of production systems, depending on current needs or emerging problems (Śledziewska, 2020). Key people in this respect are Industry 4.0 managers who are able to use their competencies to take a holistic look at the process of implementing modern solutions.

In this article, we understand competency as certain specific resources of knowledge and skills, as well as attitudes that enable managers to implement business goals. For the purposes of the research, we have created an original typology of Manager 4.0 competencies, inspired by the Universal Competence Model (Filipowicz, 2016), conclusions from interviews with practitioners who have successful implementation processes in the field of Industry 4.0 technology, and above all our catalogue of Industry 4.0 competencies based on the literature review (Table 1). On this basis, we have divided the competencies into 1) social - affecting the quality of performed tasks related to contact with other people, 2) personal - determining the speed, adequacy and reliability of activities undertaken, 3) managerial - regarding "soft" and strategic areas of management, and 4) technical and professional competencies – related to business models, procedures in the production environment and efficient use of new

technological solutions, inscribed in the concept of Industry 4.0. Each of the above groups includes 10 competencies (40 in total, Table 2). In addition, each of the indicated competencies has been defined so that there are no doubts how they should be understood (Appendix).

Table 2.
Competencies of the "Manager 4.0"

Social competencies	Personal competencies
1. Building relationships	1. Pursuit of results
2. Sharing knowledge and experience	2. Entrepreneurial skills
3. Communicativeness	3. Innovativeness and flexibility
4. Presentation skills	4. Analytical thinking
5. Negotiating	5. Independence/decision making
6. Teamwork	6. Problem-solving
7. Conflict resolution skills	7. Reliability
8. Intercultural communication	8. Lifelong learning
9. Cooperation skills within the whole organization	9. Self-management (including time management)
10. Knowledge of foreign languages	10. Ability to work under pressure
Managerial competencies	**Technical and professional competencies**
1. Team building	1. Understanding business models
2. Emotional intelligence	2. Understanding the principles of how 4.0 technologies function and the goals of their implementation
3. Employee evaluation and development	3. Understanding the principles of manufacturing processes
4. Task delegation	4. Manufacturing procedures
5. Motivating	5. Ability to use ERP / BI / CRM systems
6. Strategic thinking / long-term planning	6. Basic programming skills
7. Leadership skills	7. Ability to quickly analyse data and information
8. Interdisciplinary thinking	8. Understanding the basic principles of data protection and cybersecurity
9. Comprehensive (systemic) approach to strategy implementation	9. Quality management
10. Project management	10. Process management

Source: Own elaboration.

3. Research Method

Implementation of the basic research objective, i.e. determining the competence gap between the competencies currently acquired by students at universities and the competencies desired by companies from manufacturing industries, was possible thanks to quantitative research among two research groups. One included students of economic and technical universities in Poland (mainly state universities), while the other included companies from the industrial processing sector. The choice of this sector is due to the fact that it is characterized not only by an increasingly higher level of automation and robotization, but is also more likely to implement other modern solutions using artificial intelligence and BIG Data (Yasin et al., 2021; Deloitte, 2020). Thus, there are huge competence needs. Students of technical and economic universities

constitute potential middle and senior staff dealing with Industry 4.0 solutions in industrial processing companies.

3.1. Empirical setting and data collection

The adopted research procedure consisted of 8 stages presented in Figure 1. After creating the conceptual framework for the study, i.e. a complete list of Manager 4.0 competencies, a pilot study was carried out, followed by the main survey questionnaire among companies and students. In both cases, the same sets of competencies were used, which were assessed on a 5-point Likert scale (1 - very low, 2 - low, 3 - neither low nor high, 4 - high, 5 - very high), with students assessing the intensity of developmental activities at the university (compulsory classes, optional classes, training, etc.), while companies assessed the required level of a given competence for Manager 4.0 positions.

Companies had the opportunity to complete the questionnaire in electronic form. The EMIS Professional database was used as a sampling frame. From the database, access was obtained to a list of current companies (the studied population) along with contact details. Invitations to participate in the study were sent by e-mail. The study was conducted at the turn of 2019/2020. What is important, we took into consideration only those companies, which confirmed the knowledge about Industry 4.0 concept and have implemented at least some of the I4.0 solutions.

Two forms of the questionnaire were adopted for the students – paper and electronic. At the same time, various channels of reaching the research group was used, i.e. seminar groups and student organizations from across Poland. The part of the study involving students was carried out between March and October 2020.

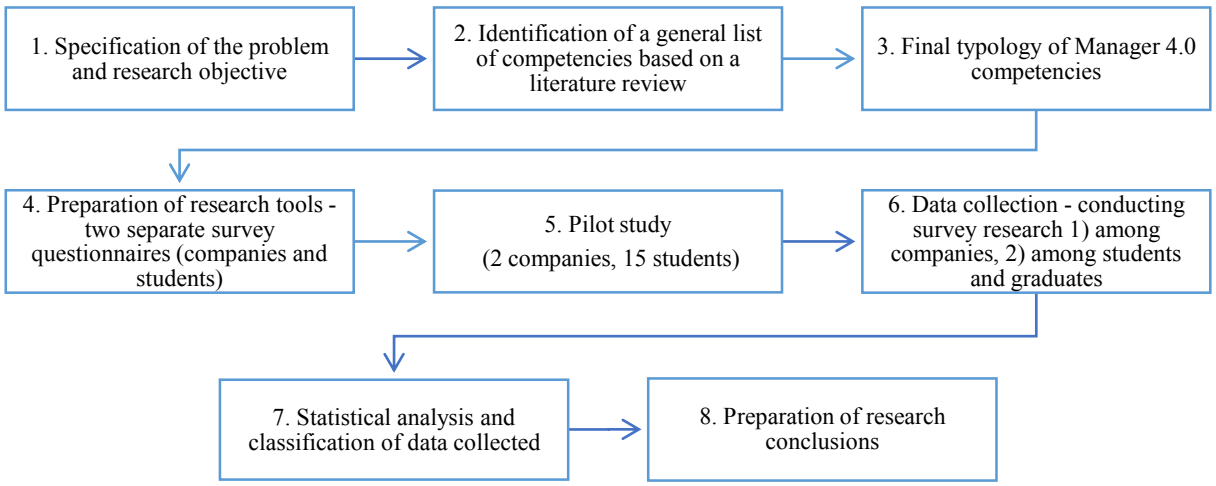


Figure 1. Research procedure.

Source: own elaboration.

The empirical data obtained was statistically analysed using the one-way ANOVA method. The distributions of the examined variables were presented in tabular and graphical form, and the structure, intensity and measurements of the descriptive statistics were defined. The results made it possible to identify competency gaps and verify whether they are statistically significant.

3.2. Research sample

The analysed empirical material was obtained as part of two studies. The survey of 120 companies included owners, board members, CEOs, executive directors, strategic directors and managing directors. The respondents represented manufacturing companies from the industrial processing sector that conduct business activity in Poland. Over 52% of the entities studied have already implemented some Industry 4.0 solutions or plan to start the process of digital transformation in the medium term, which – in our opinion, confirms the implementation of the adopted research goal. Detailed features of the companies studied are presented in Table 3.

Table 3.
Characteristics of the companies examined

Feature		Number	% of N in column
Age of companies	Created before 1989	41	34.1%
	Founded between 1989 and 2004	45	37.5%
	Established in the years 2004-2011	16	13.4%
	Established after 2011	18	15.0%
	Total	120	100%
Employment	F**ewer** than 50 employees	48	40.0%
	50 to 249 **employees**	46	38.3%
	More than 249 employees	26	21.7%
	Total	120	100%
Source of capital	Polish capital	90	75.0%
	Foreign capital	16	13.3%
	Mixed capital	14	11.7%
	Total	120	100%
Industry / Economic Classification (PKD)	Electrical appliances	27	22.5%
	Groceries	22	18.3%
	Machinery and equipment	12	10.**0**%
	Chemical products	7	5.8%
	Computers & Accessories	6	5.0%
	Furniture	7	5.8%
	Clothing	5	4.2%
	Drinks	4	3.3%
	Other	30	25.0%
	Total	120	100%

Source: own elaboration.

The research sample was dominated by small and medium-sized companies founded before the popularization of the concept of Industry 4.0. The vast majority are entities with Polish capital representing various branches of the industrial processing sector, with more than half from the electrical appliances, foodstuffs, machinery and equipment industries.

The second research sample included students and graduates (up to 1 year after graduation) of economics (718 respondents) and technical (421 respondents) universities. State universities dominate – in particular in the case of students of technical faculties (Table 4). At the same time, it is worth noting that the sample is represented by students of all years of study, which allows for a holistic look at the educational program concerning the competencies required for Manager 4.0 positions.

Table 4.
Characteristics of the student survey participants

Students		Number	% of N in column
1. University profile:	Technical	421	37.0%
	Economic	718	63.0%
	Total	1139	100.0%
2. Type of university:	State	962	84.5%
	Private	177	15.5%
	Total	1139	100.0%
4. Current year of study:	1	166	14.6%
	2	96	8.4%
	3	195	17.1%
	4	330	29.0%
	5	259	22.7%
	Graduate	93	8.2%
	Total	1139	100.0%

Source: own elaboration.

4. Research results

The results of the study confirm that education at every level as well as the personal development of today's and future managers should be focused on strengthening the key resources of knowledge, skills and attitudes necessary for acting as a manager in the process of implementing 4.0 technologies.

The results allowed us to identify statistically significant differences in the importance of the social, personal, managerial and technical-professional competencies of the survey respondents. The results indicate a lower perceived intensity of development activities for all the examined competencies in the group of students compared to the assessment of their importance (competence needs) made by companies.

The perceived intensity of development activities in the field of social competencies shows slight differences in the case of students of both types of universities (Table 5). Differences in this area are visible in the case of sharing knowledge and experience (2), presentation skills (4) and teamwork (6), where the average perception of the intensity of the conducted development activities of these competencies is statistically higher in the group of economics students. In addition, the highest importance for all respondents (including companies) was for teamwork, the average importance of which (3.77) was much higher than in the case of the other competencies studied. In turn, the lowest average importance for students (both economics and technical) was attributed to negotiation – this is interesting because companies considered this competence to be important (3.98) and desirable among employees responsible for implementing Industry 4.0 solutions. The biggest competence gap between students (in general) and companies is visible in building relationships and conflict resolution skills. In the case of the latter competence, there is a noticeable lack of preparation of future managerial staff to deal with conflicts and disputes among cooperation partners, as well as in relations with external stakeholders. The development of conflict resolution skills is gaining importance, especially in the context of the high assessment by companies of teamwork, which is a commonly used form of work in today's business environment. It is worth paying attention to the relatively small competence gap in the case of presentation skills and teamwork, which indicates a strong inclusion of these competencies in university teaching programmes.

Table 5.

Comparison of the importance of social competencies between groups of students of technical universities (T), students of economics universities (E) and companies (F)

Social competencies	Average overall	Groups T | E | F	ANOVA	T E F
1. Building relationships	3.05	$2.76^1 \approx 2.95^1 < 4.07^2$	84.505***	2,76 2,95 4,07
2. Sharing knowledge and experience	3.35	$2.99^1 < 3.32^2 < 4.09^3$	55.688***	2,99 3,32 4,09
3. Communicativeness	3.41	$3.19^1 \approx 3.32^1 < 4.23^2$	58.732***	3,19 3,32 4,23
4. Presentation skills	3.44	$3.16^1 < 3.44^2 < 3.79^3$	16.066***	3,16 3,44 3,79
5. Negotiating	2.93	$2.68^1 \approx 2.81^1 < 3.98^2$	80.663***	2,68 2,81 3,98
6. Teamwork	3.77	$3.41^1 < 3.77^2 < 4.24^3$	32.776***	3,41 3,77 4,24
7. Conflict resolution skills	3.03	$2.76^1 \approx 2.89^1 < 4.18^2$	99.659***	2,76 2,89 4,18
8. Intercultural communication	3.00	$2.78^1 \approx 2.94^1 < 3.68^2$	29.978***	2,78 2,94 3,68
9. Cooperation skills within the whole organization	3.26	$3.14^1 \approx 3.16^1 < 4.04^2$	46.352***	3,14 3,16 4,04
10. Knowledge of foreign languages	3.31	$3.24^1 \approx 3.23^1 < 3.90^2$	23.765***	3,23 3,24 3,90

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups $^{1, 2, 3}$ - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Source: Own elaboration.

In the case of the personal competencies assessed by both groups of students studied, the results indicate even smaller differences than in the case of social competencies (Table 6). A slight discrepancy is noticeable only in the case of entrepreneurial skills and the ability to work under pressure. These differences are understandable, taking into account the different fields of study and teaching programmes. The biggest competence gap in the area of personal competence can be seen in the case of problem-solving (6) and reliability (7). Expectations in the labour market regarding attention to quality, commitment to the tasks carried out, as well as identification of problems and the ability to effectively solve them, are much higher than the preparation of students in this area. This is an unquestionable conclusion because reliability is also a competence that companies considered to be the most important (4.43) of the analysed personal competencies. Interestingly, the smallest competence gap is visible in the case of the ability to work under pressure, which is an optimistic result in the context of the need to work in an unpredictable and changing business environment in the era of Industry 4.0.

Table 6.

Comparison of the importance of personal competencies between groups of students of technical universities (T), students of economics universities (E), and companies (F)

Personal competencies	Average overall	Groups T | E | F	ANOVA	T E F
1. Pursuit of results	3.41	$3.33^1 \approx 3.30^1 < 4.17^2$	50.608***	3,30 3,33 4,17
2. Entrepreneurial skills	3.40	$3.07^1 < 3.37^2 < 4.08$	42.522***	3,07 3,37 4,08
3. Innovativeness and flexibility	3.27	$3.13^1 \approx 3.16^1 < 4.12^2$	53.448***	3,13 3,16 4,12
4. Analytical thinking	3.44	$3.44^1 \approx 3.30^1 < 4.18^2$	46.741***	3,30 3,44 4,18
5. Independence/decision making	3.48	$3.34^1 \approx 3.38^1 < 4.21^2$	44.767***	3,34 3,38 4,21
6. Problem-solving	3.44	$3.28^1 \approx 3.33^1 < 4.29^2$	62.922***	3,28 3,33 4,29
7. Reliability	3.42	$3.30^1 \approx 3.27^1 < 4.43^2$	79.667***	3,27 3,30 4,43
8. Lifelong learning	3.38	$3.32^1 \approx 3.27^1 < 4.13^2$	44.036***	3,27 3,32 4,13
9. Self-management (time management)	3.41	$3.25^1 \approx 3.32^1 < 4.09^2$	33.840***	3,25 3,32 4,09
10. Ability to work under pressure	3.41	$3.54^2 > 3.27^1 < 4.02^3$	28.509***	3,27 3,54 4,02

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups $^{1, 2, 3}$ - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Source: Own elaboration.

Slightly more differences are visible in the case of the intensity of development activities perceived by students in the context of managerial competency (Table 7). Students of economics universities rated the level of development of competencies such as team building (1), emotional intelligence (2), employee evaluation and development (3), task delegation (4) and motivating (5) higher than students of technical faculties. It is worth noting that emotional intelligence obtained the lowest average importance (2.91) among all the studied managerial competencies in the opinion of both students and companies. This conclusion indicates a low level of the use of this competence for the implementation of Industry 4.0 processes, which is partly confirmed by the lack of full agreement among researchers regarding the importance of this competence. In the literature review, only 12 out of 19 publications indicated its key importance for the effectiveness of Manager 4.0 activities (see Table 1). Some authors, in turn, believe that emotional intelligence is the basic competence for other competencies (Filipowicz, 2016, p. 78). The impact of emotional intelligence is wide - it affects almost all aspects of functioning in a managerial position. In the case of this competence, the largest competence gap between companies' expectations and the declared development activities in economics and technical studies in Poland is also noticeable. Emotional intelligence is a competence that is difficult to develop during the classic didactic forms adopted at universities (lectures), as it requires interaction with another person, knowledge of their needs and high self-awareness. The other two competency gaps and competencies in this category concern motivation and delegation of tasks. Both of these competencies support teamwork, a high level of which is required by companies. What is surprising, however, is the large gap in the area of motivating others, as it is an issue that is very often addressed within the framework of various subjects in study programmes, especially economics. Nevertheless, the problem may lie in the transmission of only theoretical knowledge and students' awareness of their lack of ability to put it into practice. The smallest competence gap was noted in the case of project management competency, which indicates that students are well prepared in planning and organizing project work, and know the principles of project management and building project teams.

Table 7.
Comparison of the importance of managerial competencies between groups of students of technical universities (T), students of economics universities (E), and companies (F)

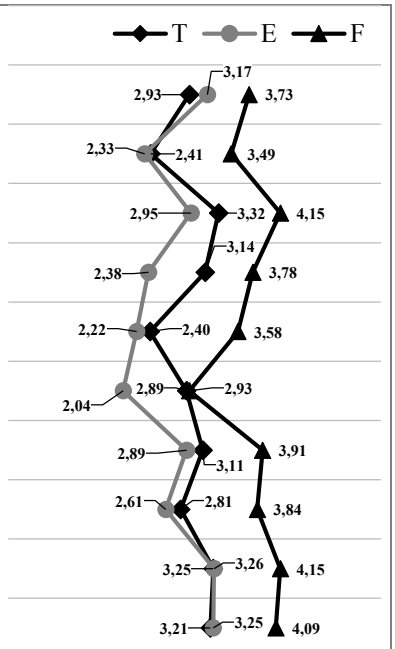
Managerial competencies	Average overall	Groups T | E | F	ANOVA	T E F
1. Team building	3.36	$2.96^1 < 3.37^2 < 3.93^3$	37.550***	2,96 3,37 3,93
2. Emotional intelligence	2.91	$2.51^1 < 2.85^2 < 3.81^3$	66.170***	2,51 2,85 3,81
3. Employee evaluation and development	3.10	$2.74^1 < 3.05^2 < 3.88^3$	54.060***	2,74 3,05 3,88
4. Task delegation	3.17	$2.86^1 < 3.09^2 < 4.08^3$	64.912***	2,86 3,09 4,08
5. Motivating	3.09	$2.69^1 < 3.03^2 < 4.01^3$	66.524***	2,69 3,03 4,01
6. Strategic thinking / long-term planning	3.36	$3.09^1 < 3.31^2 < 4.03^3$	36.371***	3,09 3,31 4,03
7. Leadership skills	3.19	$2.90^1 < 3.13^2 < 3.95^3$	46.702***	2,90 3,13 3,95
8. Interdisciplinary thinking	3.19	$3.02^1 \approx 3.11^1 < 3.90^2$	41.763***	3,02 3,11 3,90
9. Comprehensive (systemic) approach to strategy implementation	3.32	$3.18^1 \approx 3.22^1 < 4.02^2$	41.181***	3,18 3,22 4,02
10. Project management	3.55	$3.29^1 < 3.53^2 < 4.03^3$	24.055***	3,29 3,53 4,03

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups $^{1, 2, 3}$ - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Source: Own elaboration.

In the case of technical competencies, there are many more differences in the intensity of development activities perceived by both groups of students (Table 8). These differences are particularly evident in the case of the competencies: understanding principles of manufacturing processes (3), manufacturing procedure (4) and basic programming skills (6), which may result from differences in curricula. An interesting result of the study, however, is that basic programming skills obtained the lowest average rating (2.30) in the opinion of all respondents. On the one hand, universities do not emphasize the development of these competencies (perhaps they also do not have adequate resources to teach them). On the other hand, the companies studied do not have high expectations in this area, although IT skills are the basis of technological progress – also in the manufacturing environment. Perhaps for companies, of greater value and more needed are specialists whose skills far exceed the basic level, and whose competencies allow them to implement advanced data programming activities. The most significant gaps in the area of technical competence can be seen within three competencies: understanding principles of manufacturing processes (3), manufacturing procedures (4) and the ability to use IT systems such as ERP, BI, and CRM (5). This shows that the education programme on the principles and procedures of production processes are not adapted to real market needs. The cost and variability of software solutions can be a financial problem and a competence challenge for university staff. The smallest competence gap was recorded in the case of understanding business models (1), which indicates a satisfying preparation of students to face the challenges of building and maintaining a competitive advantage in the market.

Table 8.
Comparison of the importance of technical and professional competencies between groups of students of technical universities (T), students of economics universities (E), and companies (F)

Technical and professional competencies	Average overall	Groups T | E | F	ANOVA	
1. Understanding business models	3.19	$2.93^1 < 3.17^2 < 3.73^3$	25.275***	
2. Understanding the principles of technologies 4.0 functioning and the goals of their implementation	2.49	$2.41^1 \approx 2.33^1 < 3.49^2$	65.426***	
3. Understanding the principles of manufacturing processes	3.17	$3.32^2 > 2.95^1 < 4.15^3$	79.040***	
4. Manufacturing procedures	2.69	$3.14^2 > 2.38^1 < 3.78^3$	108.325***	
5. Ability to use ERP / BI / CRM systems	2.43	$2.40^1 \approx 2.22^1 < 3.58^2$	77.255***	
6. Basic programming skills	2.30	$2.89^2 > 2.04^1 < 2.93^2$	56.384***	
7. Ability to quickly analyse data and information	3.06	$3.11^2 > 2.89^1 < 3.91^3$	48.894***	
8. Understanding the basic principles of data protection and cybersecurity	2.80	$2.81^1 \approx 2.61^1 < 3.84^2$	65.088***	
9. Quality management	3.37	$3.25^1 \approx 3.26^1 < 4.15^2$	42.368***	
10. Process management	3.34	$3.21^1 \approx 3.25^1 < 4.09^2$	42.273***	

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups [1, 2, 3] - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** p≤0.001, ** p≤0.01, * p≤0.05

Source: Own elaboration.

5. Conclusions

It can be assumed that as a result of progressive automation and robotization, the scope of necessary work for low-skilled line workers will decrease. At the same time, managers will have to face greater complexity and abstractness in their environment, as well as increasing demands on problem-solving as interaction and connecting systems increase. The competencies assessed as part of the study form the basis for shaping an effective Manager 4.0, characterized by the appropriate knowledge, skills and attitudes desired for this position. At the same time, it is worth mentioning that the discussion on the results of the research is limited due to the small number of literature sources that directly refer to the competence gap in Industry 4.0.

Regarding the survey among companies in the industrial processing sector, it is worth noting that respondents do not expect from managerial candidates the ability to use IT systems, understand the principles of I4.0 or programming skills (which belong to the category of technical and professional competencies), which is also confirmed by the results of a study by Łupicka and Grzybowska (2018). On the other hand, the research results may seem quite surprising in the current era of progressive digitization (Rof et al., 2022). Most companies

expect employees in a managerial position to be able to solve problems as part of teamwork, to be reliable, and to have the willingness to participate in continuous learning. The high importance of long-life learning is also highlighted by Saniuk at al. (2021), according to whom such an approach requires the promotion of a climate of innovation, a change in learning culture and a new approach to talent development (Sivathanu, Pillai, 2018). Looking at the four competency categories analysed in general, the greatest needs are reported in the field of personal competencies, however, the differences between the competency categories are relatively small.

Looking at the four competence categories from the point of view of student evaluations, there are clear differences in the case of social, managerial, technical and professional competencies. A higher perceived level of shaping social and managerial competencies is declared by students of economics universities, in contrast to technical and professional competencies, which are developed to a greater extent at technical universities. It is interesting that in the case of personal competencies there is a visible convergence in the respondents' assessment, which may be due to the fact that the real impact of curricula on the formation of these competencies is limited.

Referring directly to the aim of the article, it should be noted that there is a competence gap in the labour market in each of the forty competencies analysed, although with some differences between technical and economics students. It is worth noting that analysis of the gap within individual competencies may be of greater cognitive value than the assessment of gaps within entire categories of competencies. The study proved that there are competencies within which the gap is small, e.g. teamwork and project management. This may be due to the nature of university learning experiences – frequent tasks carried out as part of project work. At the same time, some competencies indicate deep deficiencies in the knowledge, skills and attitudes of students with regard to the expectations of companies in the industrial processing sector, e.g. building relationships, conscientiousness and conflict resolution skills. From our point of view, these are competencies whose development often requires many years of experience in environments with joint responsibility for the implementation of common goals.

The results of the study confirm that the position of Manager 4.0 requires interdisciplinary employees who have competencies in many areas. Their education requires the adaptation of staff training systems and the process of educating students. We believe that both economics and technical universities do not sufficiently prepare future managers to take responsibility for the implementation of Industry 4.0 solutions and technologies. Universities, courses and training often artificially separate technical competencies from social or managerial ones (Saniuk, 2021), while in business practice they are interdependent.

5.1. Managerial implications

The conclusions of the research suggest the need to restructure student education programmes at universities with both an economics and technical profile. The study indicated the need for specific employee competencies, the development of which requires interdisciplinary study programmes in areas including production engineering and management. This, in turn, requires closer cooperation between companies in the industrial processing sector and the academic community. Such cooperation may naturally include practical classes and the implementation of team projects and activities in the field of R&D. The basis for such joint activities is the appropriate level of competence needed for cooperation, communication and the ability to build relationships. Increasingly, the literature mentions the legitimacy of introducing personalized and customized learning, which takes into account individual differences and needs (Shemshack, Spector, 2020, p. 6). Personalized learning aims to tailor the learning experience to the needs of different groups by adapting the content, structure and presentation to each individual person (Treiblmaier et al., 2004).

5.2. Limitations and further research areas

Firstly, the size of the research sample of companies does not allow the results to be generalised for the entire manufacturing sector in Poland due to the lack of entities representing all parts of this sector. Secondly, despite the glossary of definitions of competencies used during the survey, it is possible that individual competencies – in particular, the level of their development – may have been ambiguously understood by respondents. Thirdly, the degree of acquisition of some competencies may depend on the development of others, not necessarily from the same category (e.g. emotional intelligence as the basis for building relationships). Fourthly, the students' answers were declarative – the perspective of academic teachers could be a good supplement. Fifthly, we are aware of the debatability of the qualification of certain competencies to particular categories, which results from possible differences in interpretation. Finally, we should be aware that not every graduates from technical or economic universities expects to work on the managerial position.

The results of the study show potential directions for further research. First of all, future research could focus on the search for an optimal set of teaching tools that will allow the academics and companies to comprehensively build managerial competencies. Secondly, it would be worth repeating the research, in particular to assess the effects of the Covid-19 pandemic on the development or regression of certain competencies. Thirdly, there is also the idea of comparing the results of the research in Poland to the results obtained in other countries.

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Appendix

Table
Definitions of "Manager 4.0" competencies

Social competencies	Definition
1. Building relationships	Establishing and building good relationships. Care for contacts and effective cooperation.
2. Sharing knowledge and experience	Providing practical knowledge and advice in a useful way that makes it easier for others to achieve their goals.
3. Communicativeness	Proper understanding of other people's statements, the ability to listen to and display information.
4. Presentation skills	Ability to use techniques and principles of presentation in the process of effective communication.
5. Negotiating	Developing mutually beneficial solutions for negotiations and maintaining positive contacts.
6. Teamwork	Active participation in the work of the team is based on commitment and striving to achieve a common goal.
7. Conflict resolution skills	Resolving disputes among colleagues, in the team and in relations with clients.
8. Intercultural communication	The ability to effectively conduct interactions with members of different cultures, aimed at establishing relationships.
9. Cooperation skills within the whole organization	Cooperation with other organizational units based on trust and willingness to pursue common strategic goals.
10. Knowledge of foreign languages	Communication in speech and writing in a language other than the mother tongue in a way that is understandable to the recipients.
Personal competencies	**Definition**
1. Pursuit of results	Striving to achieve set goals, facing difficulties, and looking for new opportunities.
2. Entrepreneurial skills	Undertaking new, unconventional projects, and showing initiative in their research and implementation.
3. Innovativeness and flexibility	Taking new initiatives and looking for innovative solutions in the case of deviation from standard situations.
4. Analytical thinking	The ability to analyse information, think insightfully and to solve problems.
5. Independence/decision making	Making the right decisions on time, based on the data and premises we have.
6. Problem-solving	Identify the sources of problems and find optimal solutions for given situations.
7. Reliability	Attention to quality and commitment to tasks. Readiness for a long-term effort.
8. Lifelong learning	Willingness to constantly renew, develop and improve knowledge and skills.
9. Self-management (including time management)	Effective self-implementation of tasks without detailed guidelines, and with efficient use of time resources.
10. Ability to work under pressure	Dealing with time or other resource constraints, the difficulty of the task or having insufficient knowledge required to complete the task, or unforeseen changes or problems.

Cont table

Managerial competencies	Definition
1. Team building	Create, integrate and organize team activities.
2. Emotional intelligence	Recognizing your own and others' emotional states.
3. Employee evaluation and development	Setting goals and expectations, monitoring performance, task inspection, coaching, consulting, mentoring and coordination of development activities.
4. Task delegation	Delegate tasks to employees. Providing adequate information and powers and the support necessary for their implementation.
5. Motivating	Building commitment and a positive attitude among employees in the implementation of tasks.
6. Strategic thinking/long-term planning	Shaping the strategy of action based on data, analysis of the situation and trends.
7. Leadership skills	Implementation of inspiring concepts, building the involvement of teams and individuals in the process of achieving goals.
8. Interdisciplinary thinking	The ability to draw insights from many disciplines and apply them to one's area of interest in a way that challenges traditional views and enriches the conversation about it.
9. Comprehensive (systemic) approach to strategy implementation	The ability to look at a complex system (and subsystems) from a global point of view without focusing on details, and to make effective strategic decisions based on this.
10. Project management	Determination, coordination and control of project activities under the adopted methodological assumptions.
Technical and professional competencies	**Definition**
1. Understanding and introducing business models	Ability to acquire and analyse the knowledge necessary to achieve a competitive advantage for the company and provide better insight into the functioning of the organization based on the planned business model.
2. Understanding the principles of technology 4.0 implementation	Knowledge of the scope of technology 4.0, opportunities and threats related to their implementation in manufacturing companies.
3. Understanding the principles of manufacturing processes	Understanding the principles and elements common to all manufacturing industries, e.g. making operational decisions at all levels of production in the context of series production, where speed, quality, cost and flexibility are key indicators.
4. Manufacturing procedures	Practical knowledge and adherence to operating procedures and regulations for working at production w**ork**stations.
5. Ability to use ERP / BI / CRM systems	Practical skills in using advanced, organization-wide computer software for enterprise resource management.
6. Basic programming skills	Skills needed to write a computer-enabled program.
7. Ability to quickly analyse data and information	Data analysis and drawing conclusions - understanding complex situations and relationships.
8. Understanding the basic principles of data protection and cybersecurity	Understand the need to conduct business safely in the current cyber threat environment using the available range of supporting technologies.
9. Quality management	Overseeing the activities and tasks that need to be performed to maintain the desired level of excellence in the organization.
10. Process management	Define, control, coordinate and improve processes in your organization.

Source: own elaboration.