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Analysis of Employees' Competencies in the Context of Industry 4.0

Barbara Kowal [1,*], Daria Włodarz [1], Edyta Brzychczy [2] and Andrzej Klepka [2]

[1] Faculty of Civil Engineering and Resource Management, AGH University of Science and Technology, 30-059 Cracow, Poland
[2] Faculty of Mechanical Engineering and Robotics, AGH University of Science and Technology, 30-059 Cracow, Poland
* Correspondence: bkowal@agh.edu.pl

Abstract: The implementation of Industry 4.0 technology and meeting the expectations of employers, the labour market, and, in fact, sustainable development are new challenges for industry employees, especially for their knowledge and skills. The changes introduced during industrial revolutions have always affected the job market and employees' required competencies. The same can be said for the latest industrial revolution, Industry 4.0, in which the human factor plays an important role, mainly because new challenges are posed by human beings' role in digitised reality. Our research aimed to identify the employee competencies that are required in the context of Industry 4.0. We investigated two groups of respondents (employees and students). These groups were subjected to a comparative analysis of their digital, technical, social and personal competencies. As a result of the analysis, we identified the highest-ranked competencies in defined groups. Our results show that technical and soft skills are equally important in this highly technically based industrial revolution.

Keywords: industry 4.0; competencies; employees; soft skills; technical skills; knowledge and skills of engineers

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1. Introduction

Currently, the world is undergoing many technological, economic, and social changes [1]. The fourth industrial revolution has initiated many changes in production companies concerning the technologies or solutions that directly affect an organisation, including the workforce [2–4]. The increasingly widespread use of technologies such as the Internet of Things [5–15], cyber-physical systems [16–23] or artificial intelligence [24–33] causes not only technological development but also social and personal changes [34]. In connection with the development of Industry 4.0, there is also a growing demand for unprecedented employee competencies, which are becoming necessary in the efficient management of companies. According to Fareri et al. [35], technical competencies will still be necessary. However, horizontal competencies (e.g., methodological, personal, social) will be the essential competencies in Industry 4.0. It is also emphasised that the combination of work organization and new digital technology will have a determining role in further competence and skills development [36,37]. The rapid development of the idea of the fourth industrial revolution creates both new opportunities and challenges for organisations and universities in the context of the human factor, especially in terms of employees' competencies. These challenges relate to leadership in organisations, markets, business ecosystems and value creation. For investors, attractiveness "is perceived by the creation of a favourable feedback loop between the development of competence and the inflow of capital" [38].

The term competence derives from the Latin word competentia. It is most commonly understood as the ability to perform an activity effectively, or a specific range of knowledge needed to perform a job, i.e., professional skills [39–42].

The market value of a company is the primary determinant of its position in the market. It consists of both basic and intellectual capital. Human resources and competencies are the most valuable capital in a company and sources of created value and permanent competitive advantage in dynamically changing environments. These additional benefits for the company are generated by intellectual property, which, as a new type of asset, fits into the concept of Industry 4.0 [43–46].

In recent years, a trend referred to as the competence revolution has developed. It is characterised by the appreciation of the role of competencies. As a key element of resources, the characteristic and distinguishing feature of competencies is their unique and difficult-to-replace character.

Despite the growing interest in the human factor and employees' competencies, in the context of Industry 4.0, the literature shows directions of research covering the external environment, e.g., production audits [47,48] or warehouse systems [49,50], but not the internal work environment [51] and the employees themselves. The research on the content of the available literature on Industry 4.0 presented in [52] showed that the issues related to the human factor discussed in the relevant publications relate to purely technical aspects. However, the literature on the subject also includes research and considerations of human beings' role in Industry 4.0. In [53], the authors show how work will change along with the evolution of the concept and increasing technological possibilities, and show the potential of human-centred design of systems to support production-planning and control. Some publications concern human well-being and the system's overall productivity [4,37,54,55] and integrate human factors and ergonomics (HF/E). The research presented in [4] concerned the effects on well-being before, during, and after implementing new digital technologies. The results showed the following before the implementation of new technologies, workers "are worried about working with new digital technologies", "question their skills and competencies", while during implementation, they "become reluctant to work with new digital technologies" and experience stress. It is evident that most companies are still not accustomed to using and working with new digital solutions [54].

Hence, the subject matter of this publication seems to complement the identified gap. The interactions between people and systems will be of crucial importance for the success of the effort related to systems' design and their functionalities [56]. This approach will allow the creation of sustainable social development in cyber-physical production systems [57].

It is worth noting that the effect of implementing Industry 4.0 in enterprises is the use of advanced digital solutions in the technological and process areas. The consequence is the ability to analyse large data sets at a speed previously unattainable by machines. However, some decisions regarding further actions must still be taken or controlled by humans. Therefore, competencies are the factor that distinguishes human work from the work of designed machines or information systems. The use of specific competencies allows success in the efficient building of enterprises within Industry 4.0. However, developing them in employees is possible only after accurate analysis and identification.

Moreover, the current revolution aims to increase human capabilities by applying new solutions. Contrary to popular opinion, the phenomenon of replacing people is not taking place; rather, some roles are undergoing redefinition, while others are being created. Therefore, the development of competencies in this context has a permanent character [58].

Our research aimed to answer the question: Which competencies should an employee working in Industry 4.0 conditions possess? Two groups were examined to answer this question—employees and students of technical studies. In the research, we used the diagnostic survey method. We collected data and analysed them using exploratory data analysis (EDA). During the EDA, we tested whether there were statistically significant differences between the importance assessment of digital, technical, social and personal competencies in the examined groups. We formulated the following hypotheses:

H0: The assessment of competencies in both groups of respondents corresponds to the same distribution;

H1: The assessment of competencies in both groups of respondents does not correspond to the same distribution.

As a result of the data analysis, employees' competencies in Industry 4.0 conditions were identified, and differences between the examined groups in the assessment were discussed.

This paper contains five sections. Section 2 introduces the main assumptions and definitions of HR management, competencies and our research methodology. In Section 3, we present the results of our survey and we discuss the obtained results. Conclusions and future work are highlighted in Section 4.

2. Materials and Methods

The methodological framework consisted of a literature analysis about human-resources management, demand for new competencies among employees and competencies analysis, survey analysis, discussion and conclusions.

2.1. Human Competencies and Management

The development of human-resource management dates back to the turn of the 20th century, when small enterprises began to be transformed into factories in which mass production took place, which led to changes in the organisation of work systems [59–61]. The precursor of human-resource management is R. Owen, who was the first to perceive the role and importance of people in companies [62]. According to Michael Armstrong, HRM is "a strategic, homogeneous and coherent method of managing the most valuable asset of any organisation-people" [63]. The Cambridge Business English Dictionary presents a different interpretation of the term. The term HRM is explained as: "the activity of managing a company's employees, for example, by employing new workers, training them, managing their employment records, and helping them with problems" [64].

The process of globalisation, which results in increased competition and the development of information and communication technologies, makes it necessary for companies to adapt to emerging changes quickly. As a result, companies are forced to compete for a strategic position in the market, which directly affects the creation of new requirements for their management. Human resources and their potential are the most challenging elements to develop and manage in an organisation [65–67].

The concept of competence is not explicitly presented in the literature. In behavioural [68–73], praxeological [74–76], and attribute–process [77–80] approaches, competencies are defined differently. The concept was first used by David McClelland in the late 1960s and early 1970s. He conducted a study of characteristics, which he called competencies, instead of a study of personality traits. Boyatzis defined competencies as "the potential that exists in a person, leading to the kind of behaviour that contributes to meeting the requirements of a job within the parameters of the organisation's environment, which in turn produces the desired results" [63]. Competence was described differently by Spencer, according to whom competencies are: "the basic qualities of a person that show a causal relationship with (measured against certain criteria) work effectiveness and above-average performance, achieved in the course of a specific task or a given situation" [81].

Moreover, it is worth emphasising the differences between the definition of competencies in the Scandinavian, British, and American models. The Scandinavian and British models indicate that competence should not be identified with personality or character traits. This results in separating the notions of competence and personality, thus emphasising the thesis that personality has no impact on professional effectiveness. Moreover, personality traits in this approach are not subject to development during training or acquired experience. On the other hand, the American trend is that competencies are defined as "a relatively fixed structure of character traits, psychological needs and value system[s]" [82]. This model includes a broader perspective on competence, considering the level of knowledge or skills, character traits and personality.

Despite the many differences between the definitions of competencies, a common feature is their variability over time. Thus, competencies may be understood as features that develop along with a person's acquired experience and professional or life development. Moreover, competencies enable the achievement of specific company objectives.

One of the most common classifications of competencies is their division into [83]: the soft skills necessary to engage in the work performed (behavioural competencies), hard skills, such as the use of IT systems or computers (technical skills), and leadership characteristics (leadership competencies).

On the other hand, a broader approach to the classification of competencies is presented in [84]:

- threshold competencies—these are common and do not affect work,
- differential competencies—these are typical, specific to a given person, and rare or unique,
- general competencies—required by everyone (e.g., ambition, professional aspirations, organisational skills, personal learning, self-development, creativity or time management),
- functional competencies—specific to a particular type of position,
- technical competencies—the knowledge and skills necessary to perform a specific task,
- business competencies—the knowledge and skills necessary to run a business and make decisions,
- interpersonal competencies—knowledge and skills in the field of effective communication,
- intellectual competencies—necessary for organisation leaders,
- workplace competencies, leadership competencies and firm-wide competencies—treated jointly and concern, among others, strategic planning, future orientation, building relationships, fostering partnerships and leadership,
- generic and specific competencies—generic competencies apply to most positions, while specific competencies apply only to a specific job in a given industry.

Competencies can be classified according to various criteria, taking into consideration [82]: the source of competence acquisition (division into formal and actual competencies), substantive scope (narrow and broad competencies), availability (the competencies of the organisation and those acquired through "borrowing"), purpose (general competencies common to all employees and specialist competencies), time horizon (current and anticipated competencies), the breadth of impact (narrow competencies, necessary for a specific job, and broad competencies, necessary in the wider social environment), measurability (easy or difficult to measure), ownership (individual and group competencies), content (professional, social, business and conceptual competencies) and accuracy of definition (generally or specifically defined).

Identifying the relevant competency profiles of employees is extremely important from the organisation's point of view. Therefore, it is possible to compare the existing state with the desired state in a given company. In order to correctly identify the required competencies, the so-called "competence matrix" is used. There are common competencies, called core competencies, for all the employees in this matrix. Other matrix elements are the function-specific competencies needed in a particular department, e.g., the purchasing department. Thanks to these competencies, comparing employees within one organisational unit is possible. These competencies also play a significant role in planning professional paths and vertical promotions. The last type of competence included in the matrix is role-specific competence, e.g., leadership. These competencies are also called hierarchical competencies, enabling the comparison of employees occupying positions at the same level in a company's hierarchy [85].

2.2. Industry 4.0. as Demand for New Competencies in Employees

Industry 4.0 is related to reorganising human-resource management in companies and, thus, changing the demand for specific skills or competencies. Of course, it is primarily associated with technological progress and economic and social changes.

Technological progress increases the demand for skills, and investment in skills allows this increased demand to be met. Business digitisation means that employees work in a new environment. The workforce is very sensitive to changes, resulting in the need to acquire new competencies or qualifications. Companies try to meet these challenges through appropriate training or additional education [86–88].

Deloitte's report [89] presents the changes that will take place by 2030 in competencies related to the progress of digitisation and automation. As competencies of the future, they identified those that give employees an advantage over machines in the context of low automation capacity. These competencies are in high demand, creating a need for new jobs. The report summarises three categories of competencies [89]:

1. Knowledge in:
    - areas in which knowledge will be essential, and many new jobs involving these areas will be created by 2030. The areas with the most significant number of anticipated new jobs include Customer and Personal Service, English Language, Education and Training, Computers and Electronics and Mathematics. Around 600,000 new jobs will be created in each of the first two areas;
    - niche knowledge areas, resulting in an increase in new jobs of 30% by 2030. These include psychology, sociology and anthropology, which show less capacity for automation. Areas such as manufacturing, mechanics and the food-related sector are likely to decline in employment.
2. Skills:
    - creative skills (e.g., complex problem solving, social skills);
    - niche skills (e.g., systems skills, such as data analysis).
3. Abilities:
    - basic abilities (the basis for the development of other abilities);
    - logical and creative abilities. These abilities have low automation potential and will be needed in almost 50% of jobs.

Dr Ulrich Schmid of the MMB Institute for Media and Competence Research conducted a study within the "Factory of the Future" project on the impact of the fourth industrial revolution on employee competencies and key skills requirements [90]. According to 30% of the companies surveyed, inadequate competencies are one of the key problems for Industry 4.0 companies. The research also identified various types of competencies based on a literature review (Table 1).

Table 1. Competencies types.

Competencies	Description
Technical	Knowledge of the discipline (basic and specific)
Digital	Data control, evaluation and analysis, data security and protection, data utilisation
Social	Interdisciplinary collaboration, teamwork skills, communication skills, decision-making, organisational and leadership competencies, project management
Personal	Analytical thinking, problem solving, flexibility, abstract thinking, continuous learning ability

Source: based on [90].

Technical competence requires the necessary knowledge of both processes and systems. It makes it possible to control and monitor production processes, enabling the early detection of emerging disturbances directly affecting the quality of services or products.

Digital competence, on the other hand, focuses mainly on data evaluation and analysis, i.e., its emphasis is on the development and application of systems at the user level. Currently, security and the protection of sensitive data are becoming essential.

Social competencies include fundamental communication skills and teamwork, which are increasingly interdisciplinary.

Personal competencies are mentioned as a group requiring special attention because the skills included in this group are very difficult to acquire through educational or further training.

The grouping of competencies into four main categories (technical, methodological, social and personal) was also presented by S. Leinweber. In his study, experts found these competencies important for the assessment of engineering education [91].

Based on available reports, we chose the most important representatives of a specific group of competencies, also taking into consideration our recognition of market needs, and we formulated the questions for the questionnaire. A list of selected competencies and the research methodology are presented in Section 2.3.

2.3. Research Methodology

In this research, we used the diagnostic survey method. Two questionnaires were created, each with different questions concerning the characteristics of the respondents. One of the questionnaires was addressed to the employees of enterprises, while the other was to students of technical faculties [92]. The main objective of the research was to determine the set of digital, technical, social and personal competencies necessary for the employees of Industry 4.0 enterprises.

The employee questionnaire was posted on LinkedIn and sent directly to enterprises' employees. For the survey addressed to the students, the questionnaire was made available on a Facebook group and sent out directly to the students.

The survey was divided into five parts. The first part included questions concerning the characteristics of the respondents:

- the questionnaire addressed to the employees contained questions about their education, an assessment of their level of knowledge about Industry 4.0 (with a scale from 1—low to 5—very good), the size of their company, position, employment period, and the industry in which the company operated.
- the questionnaire addressed to students included questions about their education, their assessment of the level of knowledge about Industry 4.0 (with scale, as mentioned above), their field, and their year of study.

The second part included questions concerning the assessment of digital competencies in Industry 4.0 conditions. The digital competencies included: data analysis and modelling, IT systems operation, programming skills, cloud computing processing and work with artificial intelligence (AI).

The third part included questions concerning the assessment of technical competencies. The technical competencies included: knowledge of a process system and procedures, quality management, machines and network system communication, network-system monitoring, business-model understanding and data-protection understanding.

In the fourth part, there were questions concerning the assessment of personal competencies in Industry 4.0 conditions. Within personal competencies, we included: conscientiousness/reliability, willingness to engage in constant learning, innovation, flexibility and the ability to work under pressure, entrepreneurship and creativity.

The fifth part included questions concerning the assessment of social competencies. Within the framework of social competencies, we included: communication and teamwork skills, conflict resolution ability, presentation skills, knowledge and experience sharing in an organisation, language skills and intercultural communication, leadership and project management.

The survey questions regarding competencies were formulated as follows: "Please indicate which of the following competencies [the name of the group] should be pos-

sessed by an employee employed in a company implementing the Industry 4.0 concept. When answering, please use the scale from 1 to 5, where 1—not important, 5 are very important." [92].

The survey participants rated individual competencies on a Likert scale from 1 to 5, where 1 means that the skill is not important in Industry 4.0 conditions, while 5 means that it is a crucial skill.

The survey was conducted between March and April 2020. We received 60 completed questionnaires, 30 from the employees of enterprises and 30 from the students. Due to the low response rate, we treated this survey as initial; however, the statistical significance of the obtained results was proven.

The results of the conducted survey are presented in the next section.

3. Results and Discussion

3.1. Characteristics of Trials

The research was carried out on two respondent groups. The first group consisted of industry employees, while the second included students of first and second degrees.

The vast majority of the respondents in this sample (77%) had higher education. Only 23% of the respondents had secondary education (Figure 1).

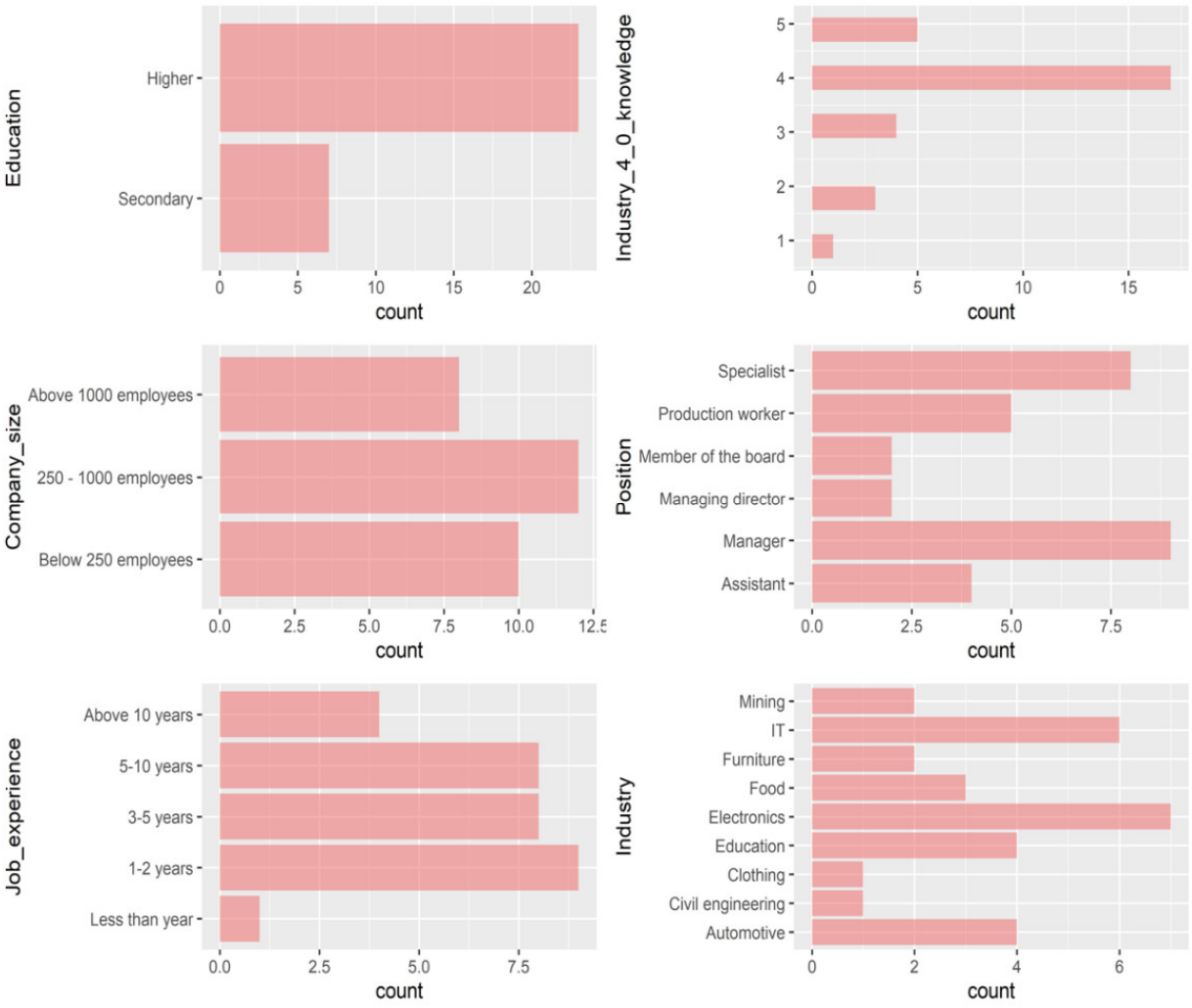

Figure 1. Characteristics of employees in the trial. Source: own elaboration.

The next question on the questionnaire concerned the declared level of knowledge about Industry 4.0. Over 50% of the respondents—24—declared a good or very good level (4 and 5) of knowledge.

The respondents primarily worked in companies employing between 250 and 1000 employees in the following positions: assistant, board member, managing director, manager, production worker and specialist. Among the respondents, the most significant percentage were managers, 33%, and specialists, 27%.

The smallest number of respondents—only 3%—had worked in their enterprise for less than a year. The largest number of responses indicated one to two years of service with an employer—30%. Responses indicating 3–5 years and 5–10 years of service with an employer received the same number of votes, 8, which represented 27% of the total responses. The industries in which the respondents worked were diverse. Most worked in the electrical, IT, automotive and education sectors.

More than half of the respondents in the student trial, i.e., 67%, had higher education, which meant they were studying for their second degree. The remaining students had secondary education (Figure 2).

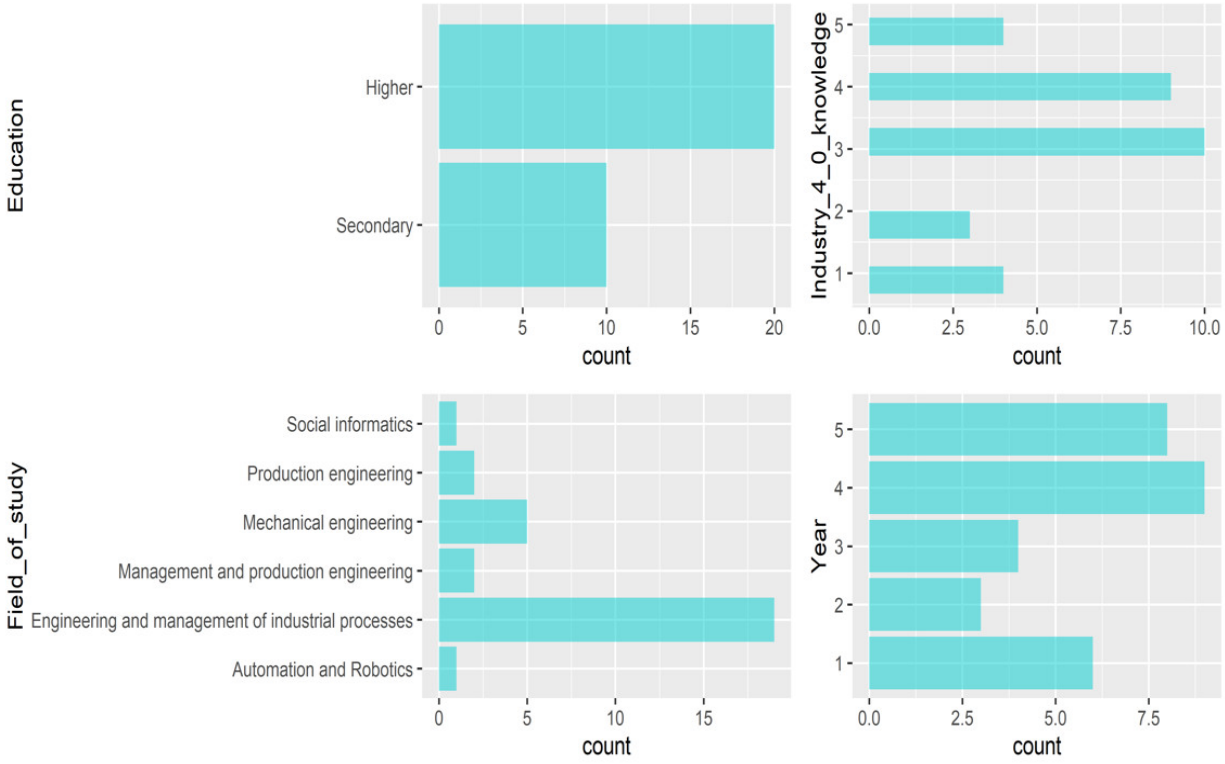

Figure 2. Characteristics of student trial. Source: own elaboration.

For Industry 4.0 knowledge, most of the respondents declared their level of knowledge t be medium (33%) or good (30%).

The most common field of study for the respondents was Engineering and Management of Industrial Processes (63%). The answers also included Automation and Robotics, Social Informatics, Production Engineering, Mechanical Engineering, Management and Production Engineering. The students were mainly in their fourth and fifth year of study.

3.2. Digital Competencies

The operation of IT systems and data analysis and modelling received the highest grades from the employees in terms of digital competencies. The mean value of the responses was 4.16. The ability to work with AI, for which the median of scores was 3, was considered the least necessary competency in the set (Figure 3).

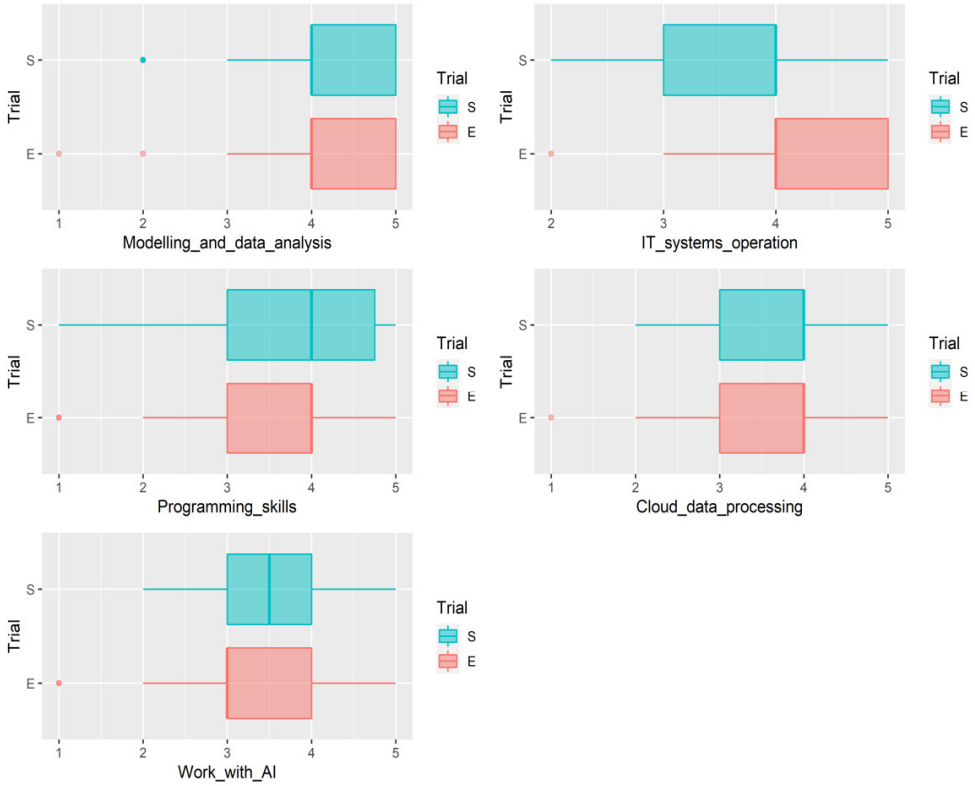

Figure 3. Assessments of digital competencies in the trials (1—not important, 5—very important). Note: student trial is marked as S, employee trial is marked as E. Source: own elaboration.

The group of students considered that the most necessary digital competencies in the context of industry 4.0 were the ability to analyse and model data, with a mean value of 3.96, followed by the ability to operate IT systems (3.76). However, as with the group of employees, they considered the ability to work with AI to be the least necessary.

3.3. Technical Competencies

According to the mean values, the knowledge of processes, systems and procedures, communication with machines and network systems, as well as network-monitoring systems were considered the most necessary competencies among the employees.

All the technical competencies received a median response of 4 (as shown in Figure 4), although the lowest mean values of the responses were for understanding of business models and quality management (3.63).

Among the students, the highest scores were for competencies such as the knowledge of systems, processes and procedures, with an average grade of 4.13, and the monitoring of network systems, with an average grade of 3.93. Understanding data protection had the lowest rate, with an average of 3.63. The employees made a similar choice regarding their knowledge of systems, processes and procedures. All the technical competencies had a median score of 4.

3.4. Personal Competencies

In the employees' trial, from the personal competencies, the highest mean scores were obtained for willingness to engage in constant learning, with 4.53, followed by conscientiousness and reliability (4.33). Entrepreneurship was considered to be the least necessary among the personal competencies. The median score for willingness to engage in constant learning was 5, while for conscientiousness and reliability, it was 4.5; therefore, both of these competencies were assessed as the most important in the conditions of Industry 4.0 (Figure 5).

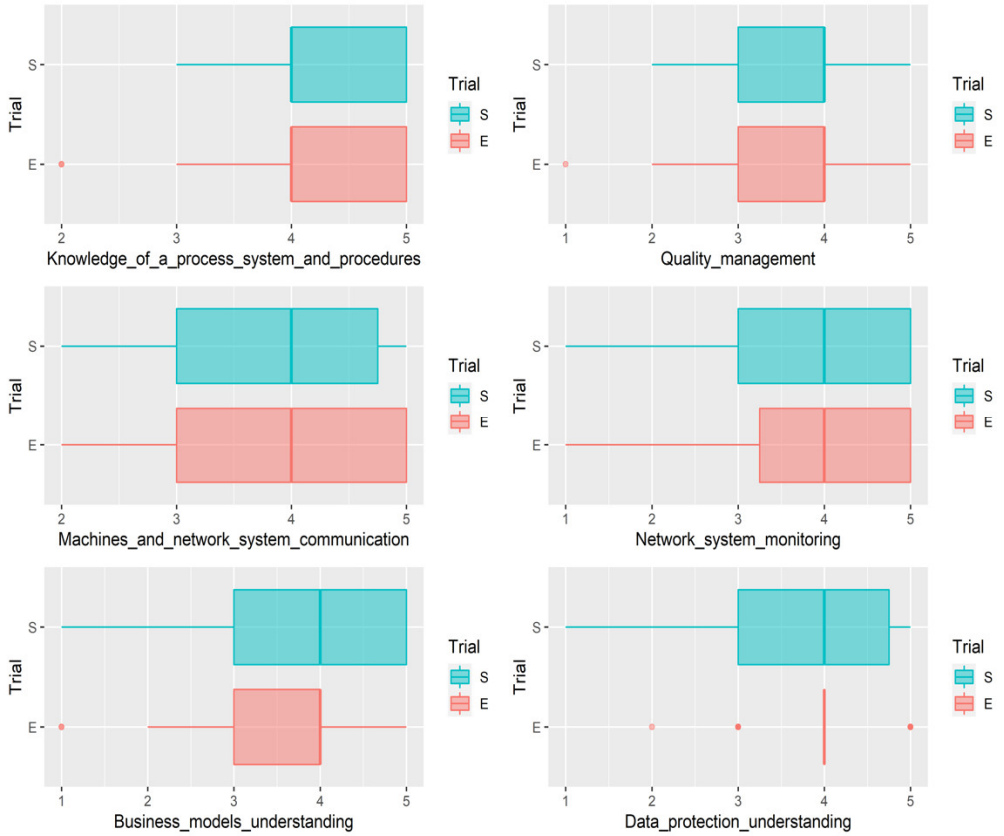

Figure 4. Assessments of technical competencies in the trials (1—not important, 5—very important). Source: own elaboration.

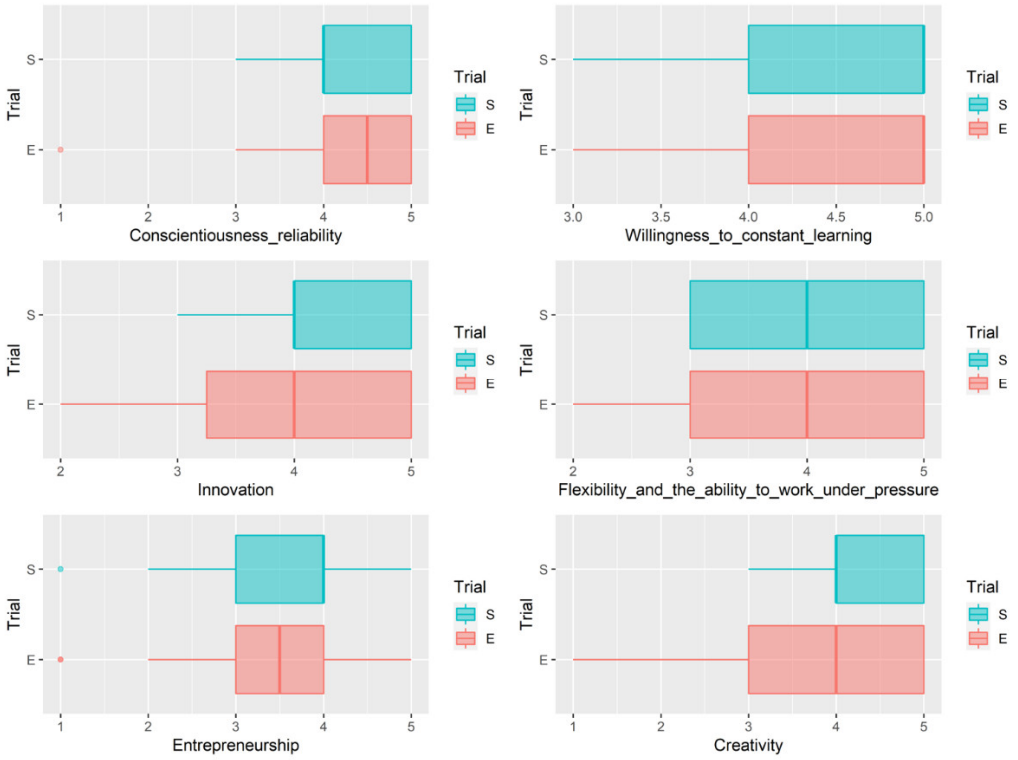

Figure 5. Assessments of personal competencies in the trials (1—not important, 5—very important). Source: own elaboration.

Among the students, skills such as conscientiousness and reliability, willingness to engage in constant learning and innovation were rated the highest, with mean values of 4.23, 4.5 and 4.23, respectively. Among the personal competencies, entrepreneurship was deemed the least necessary by the students (as with the employees). The highest median (5) was for the willingness to engage in constant learning; for the remaining competencies, the median value was 4.

3.5. Social Competencies

In the group of employees, among social competencies, the highest mean values (4.5) were obtained for such competencies as communication and teamwork and the sharing of knowledge and experience within the organisation.

Conflict resolution was considered the least necessary skill in Industry 4.0 conditions, with a mean value of 3.6. Moreover, the competencies with the highest mean values had a median of 5. The remaining skills from the set of social competencies received a median value of 4 (Figure 6).

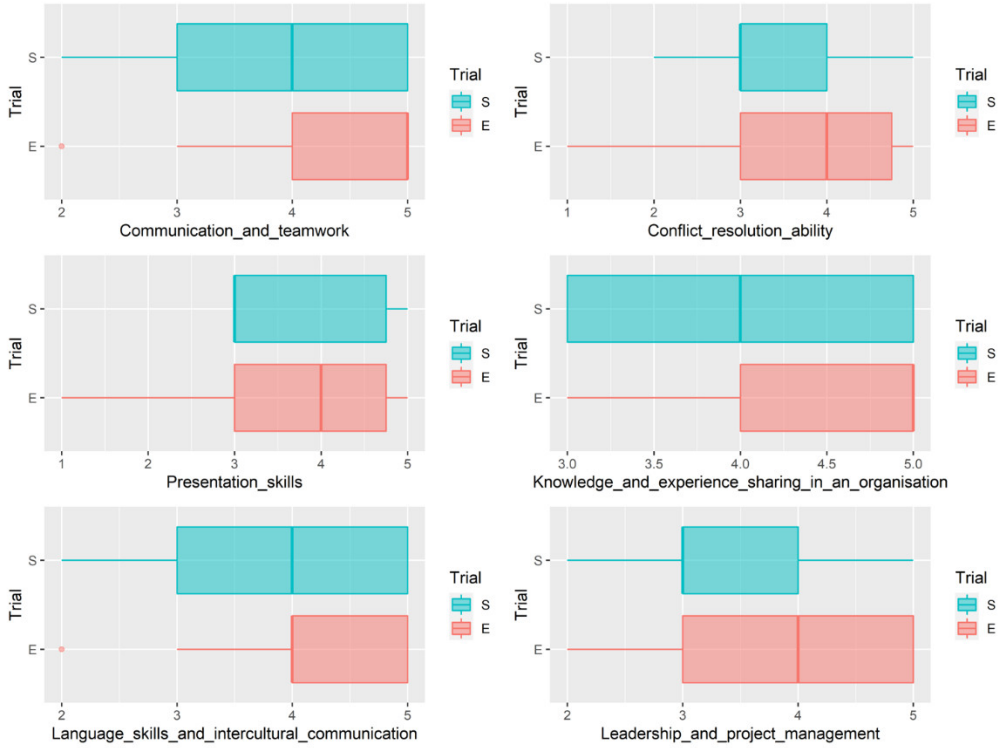

Figure 6. Assessments of social competencies in the trials (1—not important, 5—very important). Source: own elaboration.

Among the students, the highest marks were given to knowledge of foreign languages and the ability to engage in intercultural communication, with a mean value of 3.96, followed by communication and teamwork skills, with a mean value of 3.9. Leadership skills were considered the least necessary.

Compared to the employees' answers, the knowledge of foreign languages was considered more necessary by the students, which is consistent with the analyses carried out, among others, in [89]. On the other hand, both groups included communication and group work among the essential competencies.

Most of the highest-rated competencies in the group of employees and the group of students overlapped, but there were several differences. Hence, we checked whether the differences in the studied groups were statistically significant.

The relationship between the groups was tested using the Wilcoxon rank-sum test. This is a nonparametric test used to check whether two independent samples containing *n*

and m elements correspond to the same distribution. Unlike the t-test, it does not require the assumption of a normal distribution of variables. The Wilcoxon rank-sum statistic W is computed as follows: the $n + m$ observations of the two independent samples are combined in a single dataset. The elements of this dataset are sorted from smallest to largest. If the null hypothesis of an identical population distribution is true, the n ranks from the first population are random samples from the $n + m$ integers $1, \ldots, n + m$ [93].

When examining the relationships between the groups of respondents, we formulated the following hypotheses:

H0: The assessment of competencies in both groups of respondents corresponds to the same distribution;

H1: The assessment of competencies in both groups of respondents does not correspond to the same distribution.

For the purposes of the study, we assumed a significance level of $\alpha = 0.05$. If the p-value was lower than α, we rejected the null hypothesis. Table 2 shows the results of the testing of the hypothesis for individual assessments.

Table 2. The comparison of competency assessments between trials.

	Variables	Wilcoxon Rank-Sum Test
Digital	Data analysis and modelling	W = 514, p-value = 0.314
	IT systems operation	W = 567.5, p-value = 0.066
	Programming skills	W = 443.5, p-value = 0.926
	Cloud computing processing	W = 432.5, p-value = 0.790
	Work with AI	W = 434, p-value = 0.810
Technical	Knowledge of processes, systems and procedures	W = 506, p-value = 0.376
	Quality management	W = 434, p-value = 0.808
	Machines and network system communication	W = 504, p-value = 0.406
	Network-system monitoring	W = 432, p-value = 0.785
	Business-model understanding	W = 432.5, p-value = 0.794
	Data-protection understanding	W = 502.5, p-value = 0.414
Personal	Conscientiousness/reliability	W = 496.5, p-value = 0.458
	Willingness to engage in constant learning	W = 456, p-value = 0.925
	Innovation	W = 451, p-value = 0.993
	Flexibility and the ability to work under pressure	W = 455, p-value = 0.943
	Entrepreneurship	W = 394.5, p-value = 0.394
	Creativity	W = 382.5, p-value = 0.293
Social	Communication and teamwork skills	**W = 618, p-value = 0.007**
	Conflict-resolution ability	W = 481.5, p-value = 0.634
	Presentation skills	W = 492, p-value = 0.517
	Knowledge and experience sharing in an organization	**W = 640, p-value = 0.002**
	Language skills and intercultural communication	W = 506.5, p-value = 0.379
	Leadership and project management	W = 538, p-value = 0.175

Source: own elaboration.

On the basis of these results, we can conclude that the null hypothesis applied to most of the competencies, which means that the group of employees assessed the competencies in the same way as the group of students. In the case of social competencies, such as communication and teamwork and knowledge and experience sharing within the organisation, the alternative hypothesis applied, suggesting statistically significant differences between the assessment distributions.

Based on the analysis of the responses, we decided to select the most necessary competencies in the context of Industry 4.0 conditions. From each group of competencies, digital, technical, personal and social, the two skills with the highest mean and median were selected. Three of the personal competencies were distinguished in the group of

students because they had the same mean and median values. A similar situation occurred in the group of employees regarding technical competencies.

The competencies with the highest statistics in the group of employees are presented in Table 3.

Table 3. The most popular competencies in employee trial.

Competencies	Selected	Mean Value/ Median of Scores
Digital	IT systems operation	4.16/4
	Data analysis and modelling	4.16/4
Technical	Knowledge of processes, systems and procedures	4.26/4
	Machines and network system communication	3.93/4
	Data-protection understanding	3.93/4
Personal	Willingness to engage in constant learning	4.53/5
	Conscientiousness/reliability	4.33/4.5
Social	Communication and teamwork skills	4.5/5
	Knowledge and experience sharing in an organisation	4.5/5

Source: own elaboration.

Table 4 presents the competencies selected by the group of students from technical universities.

Table 4. The most popular competencies in the student trial.

Competencies	Selected	Mean Value/Median of Scores
Digital	IT systems operation	3.76/4
	Data analysis and modelling	3.96/4
Technical	Knowledge of processes, systems and procedures	4.13/4
	Network system monitoring	3.93/4
Personal	Willingness to engage in constant learning	4.5/5
	Conscientiousness/reliability	4.23/4
	Innovation	4.23/4
Social	Communication and teamwork skills	3.9/4
	Language skills and intercultural communication	3.96/4

Source: own elaboration.

Under technical competencies, the employees rated the knowledge of processes, systems and procedures, the ability to communicate with machines and network systems, and data-protection understanding as the most important. At the same time, the students, apart from the first one, indicated network-systems monitoring. In the group of students, the ability to communicate with machines and network systems was ranked third according to the mean values obtained. On the other hand, the competence of network-system monitoring was ranked fourth by the employees, according to the mean values.

Under personal competencies, innovation was not considered in the employee trial, but it ranked third in terms of the grades obtained in the student trial.

Both groups of respondents considered communication and teamwork the most necessary social competencies. In the group of employees, the ability to share knowledge and experience within the organisation also ranked highly. For the students, knowledge of foreign languages and intercultural communication skills was ranked highly. In the group of employees, the knowledge of foreign languages was third in terms of the mean value; in the group of students, the ability to share knowledge and experience within an organisation was third place. The conducted statistical test showed that competencies such as communication and teamwork skills, as well as sharing knowledge and experience within the organisation, were assessed differently by the groups of respondents. Although

communication and teamwork skills were included in the highest-rated competencies, the assessments differed significantly between the groups. In the group of employees, the mean value for this skill was 4.5, while in the group of students, it was only 3.9. Evidently the employees' experience at work in terms of cooperation and communication was vital for them. It is worth mentioning that lack of communication is one of the most frequently quoted causes of conflict in teams. Good cooperation requires good communication, but also the sharing of knowledge and experience. This was clearly emphasised by the high ratings of these competencies among employees, with a mean value of 4.5. In the case of the student group, the mean value was 3.83.

Based on the conducted research, we distinguished the following set of competencies, which, according to the respondents, employees should possess in Industry 4.0 conditions (Figure 7): IT systems operation, data analysis and modelling (orange colour), knowledge of processes, systems and procedures, machines and network-system communication, network-system monitoring, data-protection understanding (azure colour), willingness to engage in constant learning, conscientiousness/reliability, innovation (blue colour), communication and teamwork, knowledge and experience sharing in an organisation, language skills and intercultural communication (red colour).

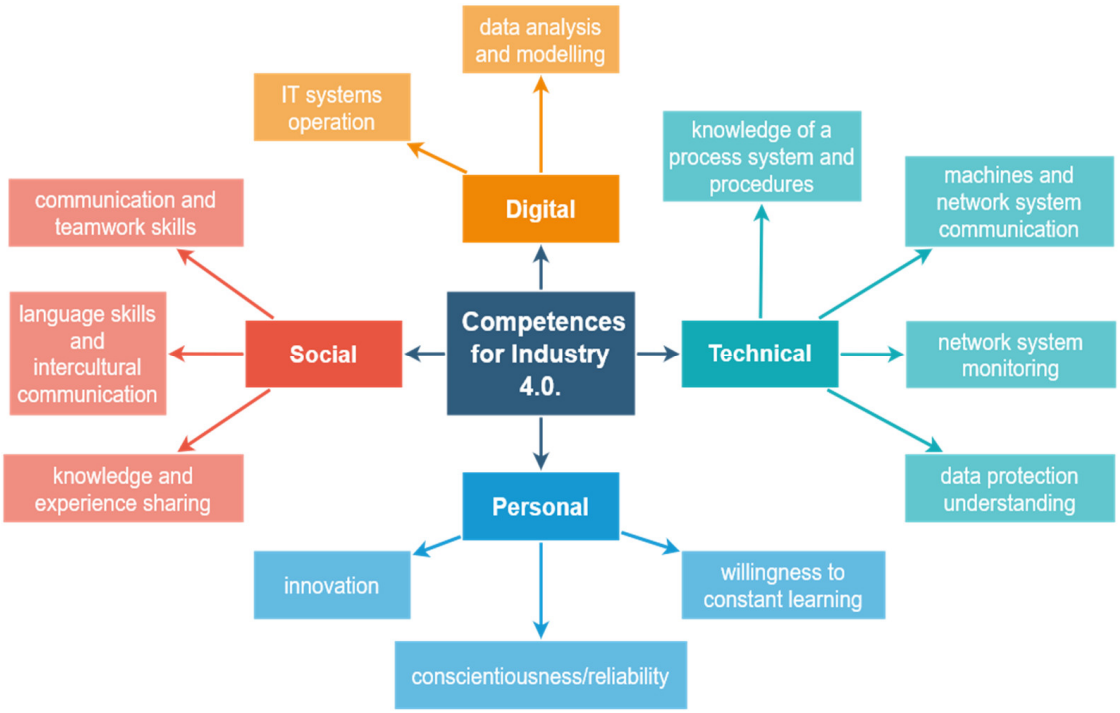

Figure 7. Competencies of employees in Industry 4.0 conditions. Source: own elaboration.

On the prepared list, it can be seen that each type of competency was considered necessary in the respondents' assessments. Both technical and soft skills are essential; thus, future education for Industry 4.0 conditions should consider these insights.

The results presented in our study coincide with other research showing that the most critical digital competencies are IT-system-operation skills, computational skills, analytical thinking, the ability to quickly analyse data and data modelling [94–96]. Among essential technical competencies, understanding Industry 4.0 principles, data-protection principles, systems, processes and procedures and knowledge of privacy and cybersecurity are listed [95,96]. Furthermore, the personal competencies, diligence, reliability and readiness to engage in continuous learning play a vital role [95]. Among social competencies, teamwork and communication skills, sharing knowledge and experience, and problem solving are the most important [94,95,97–99].

4. Conclusions

The human factor plays an essential role in industrial processes and will continue to do so in the near future, despite the new solutions and technologies aiming to replace human labour. Creating sustainable production systems is possible if employees' competencies are properly developed. Human "participation is necessary to implement crucial Industry 4.0 technologies and ensure an effective symbiosis between operators and cyber-physical systems" [100]. However, the primary barrier to implementing modern CPSs is the low level of employee qualifications [1]. Furthermore, other studies, conducted in Poland, identified problems related to a lack of qualified employees (77%), low levels of cybersecurity (68%) or insufficient levels of knowledge about the technologies involved in Industry 4.0 (41%) [101]. These low levels of relevant competencies and qualifications should certainly be addressed. Therefore, it is necessary to introduce changes to the higher-education system and vocational and employee training.

Industry 4.0 presents engineers with entirely new challenges. The effectiveness of engineering staff no longer depends only on technical skills. The simultaneous acquisition of technical and psychosocial competencies, consisting mainly of soft skills, such as teamwork or communication, is increasingly important.

This article presents the results of research confirming this argument and concerning the determination of the competencies that it is expected that employees will need to possess under the conditions of Industry 4.0. The study investigated two respondent groups, employees and students, to whom prepared questionnaires were addressed. The respondents assessed the importance of individual digital, technical, personal and social competencies for employees in Industry 4.0 conditions.

As a result of the research, it was found that the essential competencies are: IT systems operation, data analysis and modelling, knowledge of processes, systems and procedures, machines and network-system communication, network-system monitoring, data-protection understanding, willingness to engage in constant learning, conscientiousness/reliability, innovation, communication and teamwork skills, knowledge and experience sharing in an organisation, language skills and intercultural communication.

The presented research results show a particular trend in the changes caused by Industry 4.0. Widespread digitisation and the Internet of Things require the ability to fluently operate IT systems and deal with large amounts of data. Smart home solutions and remote work will accelerate the learning of new competencies in the digitised world.

These changes will not be possible without social or personal competencies. Therefore, new skills, such as adaptation to changes, mental resilience and self-organisation at work, will gain in significance [102–104].

The conducted analysis showed that both technical and soft competencies are essential for the functioning of employees in the conditions of Industry 4.0. Therefore, it is necessary to focus on educating interdisciplinary specialists, especially considering the pace of technology development. It is necessary to constantly develop competencies and build engineering-staff-development programs [105] as a result of the "extra pressure exerted on universities to develop complex equipment skills" [40].

In this context, it is worth investigating the ability of current course offerings at universities to develop, improve, supplement or disseminate the competencies required by students and future employees in Industry 4.0. This topic will be one of our future research directions.

Based on our research, the primary recommendations for universities and companies are to follow current technological and social trends and to cooperate closely with relevant entities. Companies should identify the competencies lacking in labour-market participants, and universities should adapt their study programs to the identified needs. Every entity from the science, business and public administration sectors should "jointly expand also the technological sphere of Industry 4.0 as well as the 'soft sphere' related to competences" [43]. Of course, such activities involve significant effort, especially for universities. They have to ensure the development of their own employees' competencies in order for them to

pass on knowledge about technological developments, using modern teaching techniques (which also require proficiency and digital competencies). It is important to update ageing competencies and encourage the continuous development of employees [1,106], as well as to supplement teachers' knowledge of the necessary topics (such as data analytics, the digitisation of processes and communication in CPS, AI and AR systems), which are widely used in modern companies [107].

The main limitation of our work is the small number of respondents. However, we treated this trial as a preliminary survey. Its results encouraged us to continue our research with a more extensive scope in terms of the competencies and factors influencing the proficiency of employees in the selected areas.

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