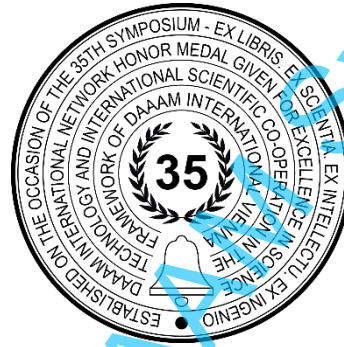


INSIGHTS INTO INDUSTRY 4.0 COMPONENTS AND ACCEPTANCE OF NEW TECHNOLOGIES IN INDUSTRIAL ENTERPRISES

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Abstract

Industry 4.0 is a revolution associated with digitization and automation of processes that are implemented in the company on a daily basis. All types of companies are affected by the mentioned revolution, but industrial enterprises are currently facing it to the highest extent. Among the most important components associated with Industry 4.0 are autonomous robots, big data, cloud solutions, simulations and virtual reality, internet of things, system integration, cybersecurity and cyberphysical systems. These components are developed and implemented gradually, while the very prioritization of individual components in industrial enterprises is influenced by the current situation in the enterprise, the focus of the enterprise, the need for digitization of selected processes, and the pandemic situation, which accelerated the implementation of selected components, was no less important. The main aim of the paper is to present the results of research focused on the components of Industry 4.0, their introduction in industrial enterprises and the presentation of results taking into account the perception of employees regarding the introduction of new technologies in industrial enterprises. The research was carried out through a questionnaire, which contains answers from 337 representatives of industrial enterprises in Slovakia.

Keywords: automation; components of Industry 4.0; digitization; Industry 4.0; industrial enterprises.

1. Introduction and theoretical framework

The fourth industrial revolution (Industry 4.0) is a forced and inevitable transformation process that is gradually reaching industries and global supply chains. One of its missions is the efficiency of operation management without disruptive effects on manufacturing companies and supply chains [1]. Choosing the right strategy is an important part of the plan that will help ensure digital transformation. However, choosing the right and appropriate strategy is a complex and laborious process, as it is necessary to evaluate all the factors and ambiguities that arise from Industry 4.0 [2].

The digital transformation itself helps to increase productivity, reduce costs, increase efficiency and competitive advantage. Due to the mentioned huge advantages, digitalization is adopted by companies as a strategic tool to gain a competitive advantage. Among other things, the outbreak of the pandemic accelerated digitization itself, as restrictions forced organizations to continue to operate without problems [3]. In addition to the potential benefits, the transition

from people to technology can also present risks for the company and for employees. Simple tasks can be replaced by machines, which can mean the loss of jobs for certain groups of employees and for personnel without qualifications [4]. Another concern of employees is that Industry 4.0 technologies may increase the degree of supervision over their work [5], eventually, it will be necessary for them to increase their qualifications, and thus there is an assumption that says that Industry 4.0 requires employees with specific qualifications [6].

Industry 4.0 is not only an industrial revolution, but also a challenge in terms of the integration of people, data, services and objects. It requires the interaction of many components, with key aspects including devices, connectivity, properly managed services and appropriate data [7]. Technologies such as cyber-physical systems, the Internet of Things, big data [8], and cloud solutions are considered to be the next generation of the industrial revolution [9]. Autonomous robots are also important [10], virtual reality and simulations [11]. With the right combination and involvement of the right components of Industry 4.0, depending on the type of company and current conditions, it is possible to ensure increased production, production per capita and productivity [8].

2. Materials and methods

The main aim of the paper is to present the results of research focused on the components of Industry 4.0, their implementation in industrial enterprises and the presentation of results taking into account the perception of employees regarding the introduction of new technologies in industrial enterprises. In order to fulfil the main aim of the paper, three research questions were determined. Based on the above-mentioned framework, we decided to focus on the employees' point of view, while it is necessary to differentiate their point of view on the perception of the introduction of new technologies and, on the other hand, their point of view on the importance of Industry 4.0 itself. Therefore, the following research questions were set:

Research question 1: How do employees of industrial enterprises perceive the introduction of new technologies?

Research question 2: How do employees of industrial enterprises perceive the importance of Industry 4.0?

Research question 3: What components of Industry 4.0 are introduced in industrial enterprises?

For the purposes of data collection, a questionnaire was constructed and distributed online. A total of 337 responses were received from representatives of industrial enterprises in Slovakia. For the purpose of a clearer presentation of the results, the companies were divided according to the industry sector in which they operate into the following categories: automotive sector; engineering, metalworking and metallurgy and other production; electrical engineering and energy; chemical industry and plastics; construction industry; food industry, agriculture and forestry; projecting and engineering; transport and logistics; information technology, communication. A basic overview of the research sample can be seen in Table 1.

Sector of industry	Number of employees in company			Respondent's gender		Sum
	1 to 49	50 to 249	249 and more	male	female	
Automotive sector	1	22	111	76	58	134
Engineering, metalworking and metallurgy and other production	16	11	61	67	21	88
Electrical engineering and energy	1	9	23	28	5	33
Chemical industry and plastics	2	10	16	17	11	28
Construction industry	8	2	6	6	10	16
Food industry, agriculture and forestry	2	7	6	7	8	15
Projecting and engineering	4	1	5	5	5	10
Transport and logistics	2	2	4	7	1	8
Information technology, telecommunications	4	0	1	5	0	5
Sum	40	64	233	218	119	337

Table 1. Overview of research sample (own elaboration, 2024)

In Table 1, it can be seen that the automotive sector has the largest representation with the number of employees 249 and more. As for the gender of the respondents, almost 65% (218) are men.

The collected data were evaluated using descriptive statistics, in the form of tables and figures with relative frequencies.

3. Results

In the third part of the article, the research questions established in the first chapter of the article will be evaluated; specific results will be presented.

3.1. Perception of the introduction of new technologies by employees of industrial enterprises

The aim of the first research question is to evaluate how employees perceive the introduction of new technologies in the company. The respondents had the opportunity to mark one answer, while they had the following options to choose from: as a necessity, as work facilitation, I do not observe it in our company, as a burden. The evaluation in relative frequencies can be seen in the following Table 2.

Sector of industry	as a necessity [%]	as a burden [%]	as work facilitation [%]	I do not observe this in our company [%]	Sum [%]
Automotive sector	38.06	5.22	51.49	5.22	100
Engineering, metalworking and metallurgy and other production	39.77	5.68	42.05	12.50	100
Electrical engineering and energy	60.61	9.09	24.24	6.06	100
Chemical industry and plastics	46.43	3.57	46.43	3.57	100
Construction industry	18.75	6.25	68.75	6.25	100
Food industry, agriculture and forestry	40.00	6.67	46.67	6.67	100
Projecting and engineering	40.00	0.00	40.00	20.00	100
Transport and logistics	25.00	12.50	37.50	25.00	100
Information technology, telecommunications	0.00	0.00	100.00	0.00	100

Table 2. Perception of the introduction of new technologies by employees of industrial enterprises based on the sector (own elaboration, 2024)

Based on the data in Table 2, it can be seen that within the automotive sector, more than half of the respondents consider new technologies to facilitate work and almost 70% in the construction industry sector. Technologies are perceived as a necessity to the highest extent in the electrical engineering and energy sector. A total of 12.5% of respondents from the transport and logistics sector consider technology as a burden. Overall, it is possible to positively assess the fact that respondents in almost all sectors perceive new technologies positively (as making work easier). The following Figure 1 contains an overall assessment of the first research question.

Research question 1: How do employees of industrial enterprises perceive the introduction of new technologies?

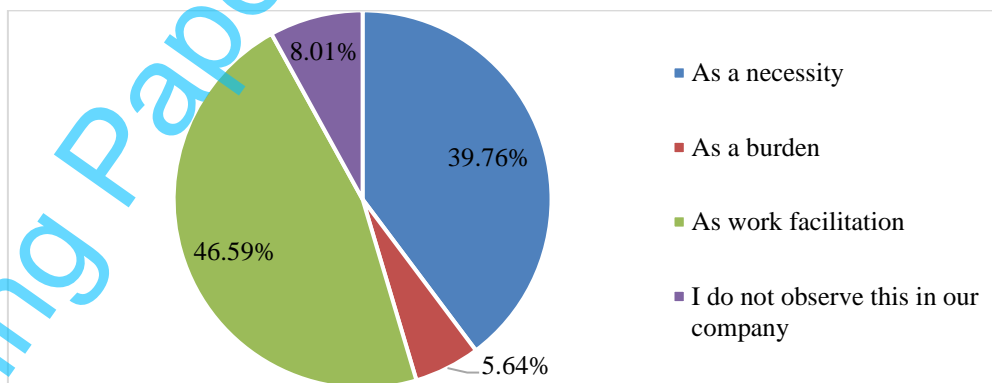


Fig. 1. Evaluation how do employees of industrial enterprises perceive the introduction of new technologies (own elaboration, 2024)

According to the data from Figure 1, it can be argued that, regardless of the sector, almost half of the respondents consider technology to facilitate work, followed by respondents who consider technology to be a necessity. On the other hand, more than 5% of respondents consider technology as a burden and 8% of respondents do not observe the introduction of new technologies in the company.

3.2. Perception of the importance of Industry 4.0 by employees in industrial enterprises

The second research question deals with employees' opinion on Industry 4.0. Based on the theoretical starting points, the advantages and risks resulting from the industrial revolution are obvious, but this research question aims to identify the opinion of the employees. Similar to the previous case, employees had the opportunity to choose one of four answers, while the actual evaluation in relative frequencies by sector can be seen in the following Table 3.

Sector of industry	very important for the future of the company [%]	increasing importance due to the pandemic [%]	I do not know [%]	currently low priority [%]	Sum [%]
Automotive sector	55.97	7.46	20.15	16.42	100
Engineering, metalworking and metallurgy and other production	53.41	9.09	20.45	17.05	100
Electrical engineering and energy	39.39	3.03	30.30	27.27	100
Chemical industry and plastics	46.43	3.57	35.71	14.29	100
Construction industry	43.75	6.25	43.75	6.25	100
Food industry, agriculture and forestry	66.67	0.00	20.00	13.33	100
Projecting and engineering	40.00	10.00	50.00	0.00	100
Transport and logistics	75.00	0.00	12.50	12.50	100
Information technology, telecommunications	20.00	20.00	40.00	20.00	100

Table 3. Perceptions of the importance of Industry 4.0 by employees of industrial enterprises based on the sector (own elaboration, 2024)

The data in Table 3 show that, to the greatest extent, employees consider Industry 4.0 necessary for the successful future of the company. Within the electrical engineering and energy sector, almost 28% of employees indicated that Industry 4.0 currently has a low priority. Respondents also reflected on the recent pandemic situation, for example in the information technology and telecommunications sector, a total of 20% of respondents indicated increasing importance since the pandemic itself. Similar to the previous case, the aggregated results for all sectors can be seen in Figure 2.

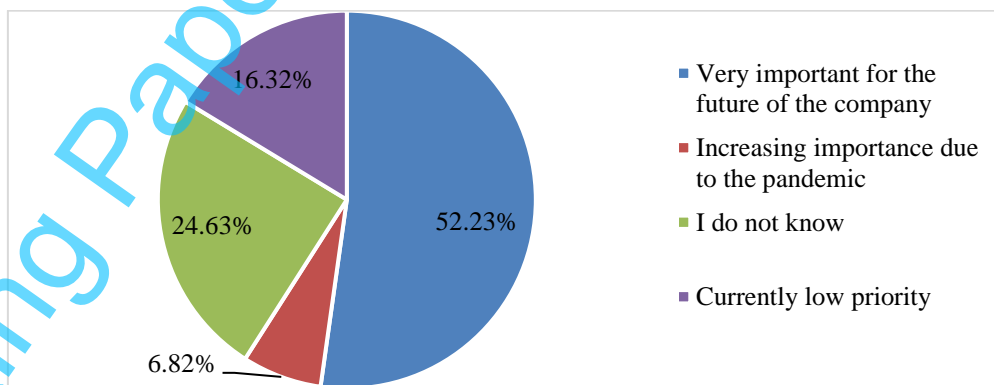


Fig. 2. Evaluation how do employees of industrial enterprises perceive the importance of Industry 4.0 (own elaboration, 2024)

Figure 2 shows that more than half of the respondents perceive Industry 4.0 as important for the future of the company, which can be considered a positive finding and it can be concluded that the employees themselves are aware that if the company is to prosper, the path of digitization and automation is necessary. Almost a quarter of respondents could not comment on the given area, and more than 16% of respondents think that Industry 4.0 is currently of low importance in the company.

3.3. Components of Industry 4.0 introduced in industrial enterprises in Slovakia

Based on the established third research question, it is possible to evaluate the current implementation of the components of Industry 4.0 in industrial enterprises. In the theoretical framework, specific components of the industrial revolution were defined, while the aim is to identify which of them are used to the highest or lowest extent. Respondents had the opportunity to select multiple answers and their relative frequencies can be seen in the Table 4.

Sector of industry	autonomous robots [%]	big data [%]	cloud based solutions [%]	simulation and virtual reality [%]	internet of things (IoT) [%]	system integration [%]	cybersecurity [%]	cyber-physical systems [%]	I do not know [%]
Automotive sector	21.02	9.94	14.20	7.39	4.26	9.66	11.93	13.35	8.24
Engineering, metalworking and metallurgy and other production	13.00	7.50	16.00	10.50	7.00	8.50	12.50	7.00	18.00
Electrical engineering and energy	15.66	18.07	20.48	4.82	3.61	9.64	13.25	9.64	4.82
Chemical industry and plastics	7.79	16.88	19.48	6.49	3.90	11.69	18.18	6.49	9.09
Construction industry	3.23	6.45	25.81	3.23	6.45	12.90	16.13	6.45	19.35
Food industry, agriculture and forestry	5.88	5.88	20.59	2.94	5.88	8.82	20.59	11.76	17.65
Projecting and engineering	4.76	9.52	19.05	4.76	19.05	9.52	9.52	4.76	19.05
Transport and logistics	25.00	12.50	12.50	6.25	6.25	18.75	6.25	0.00	12.50
Information technology, telecommunications	0.00	20.00	40.00	0.00	0.00	0.00	0.00	0.00	40.00

Table 4. Components of Industry 4.0 introduced in industrial enterprises in Slovakia based on the sector (own elaboration, 2024)

The relative frequencies in Table 4 show that autonomous robots are the most used element within the automotive and transport and logistics sectors. Within other sectors of the industry, cloud solutions are the most used element. Cloud solutions are generally considered to be an efficient and less expensive element. Internet of things, simulations and virtual reality are among the least used elements. For the construction industry, autonomous robots are the least used element. Aggregate results for all industry sectors are shown in Figure 3 below.

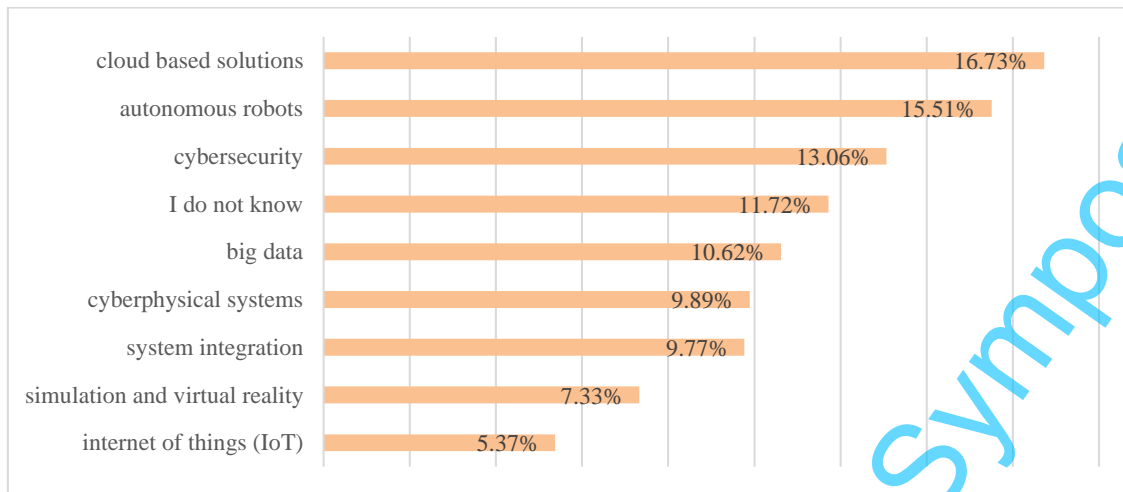


Fig. 3. Evaluation how do employees of industrial enterprises perceive the implementation of components of Industry 4.0 in industrial enterprises in Slovakia (own elaboration, 2024)

In summary, according to Figure 3, it can be concluded that Cloud solutions, Autonomous robots and Cybersecurity are the most used elements of Industry 4.0 by industrial enterprises. Among the least used are Internet of things, Simulations and virtual reality, Cyberphysical systems and System integration. Almost 12% of respondents could not answer the question.

4. Discussion

Digitization in the Industry 4.0 environment has become essential for improving the production process and related services. The increasing demand for sustainability due to external pressures such as strict government regulations and due to internal factors such as the need to reduce costs or the limited availability of resources is forcing manufacturing industries to adopt new approaches and implement new initiatives [12].

The challenge is the universal transformation and support of Industry 4.0 culture in small, medium and large enterprises. Although significant progress has been made in various industries such as the automotive sector, there will be a need to increase the pressure to raise awareness of the long-term benefits through consultancy, training, audit assessments and possibly competence development programmes. Industry-relevant transformation and learning need special attention to build long-term skills and capabilities [13]. Rapid technology modernization, adoption of new technologies was common during the pandemic, when remote work created operational uncertainty, often caused by a lack of employee skills [14]. For this reason, further research will also be directed to the education of employees in the conditions of Industry 4.0. However, since education is an important personnel process, further research will also focus on other personnel processes (such as employee evaluation, employee motivation, recruitment and selection of employees, etc.) and the need for their adaptation to the new conditions resulting from ongoing digitization and automation.

As part of Industry 4.0 technologies, an increase in productivity, better and more customized products and a better working environment are expected. However, one of the problems is employment, as it is assumed that the rate of automation will increase exponentially until it reaches its peak. One reason is that robots are becoming cheaper and more flexible. Overall, the impact of Industry 4.0 on employees is still a relatively unexplored topic and there are countries and industries where such research has not been conducted. The available publications do not provide a clear assessment of the impact of Industry 4.0 on employees and therefore further in-depth research is needed [15]. Our research has shown that employees have a relatively positive perception of the benefits of Industry 4.0 technologies, but their opinion and a deeper view of the barriers associated with digitalization need to be further explored.

Industry 4.0 contains various components that are gradually being developed and implemented. Individual sectors of the industry are characterized by the fact that they use certain elements to a greater extent [16]. Therefore, the right combination of Industry 4.0 elements can be crucial for industrial enterprises in order to increase productivity and profitability.

Among the limitations of the research, it is possible to include the fact that the research was carried out exclusively within enterprises in Slovakia. Employees of different job categories took part in the research, and therefore it would be useful to compare the results also within different job positions and thus to identify differences in the perception of importance between employees at different levels of management. On the basis of theoretical premises, Industry 4.0 affected all sectors and industries, and therefore it would be appropriate to expand the sample of respondents to include companies providing services, or public or state institutions.

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