Basic Technologies and Models for Implementation of Industry 4.0

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Representation of Industry 4.0 Technologies in the Economy and Education of the Sarajevo Canton

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Abstract: *Since the introduction of the concept of Industry 4.0 until today, the world is facing a series of changes resulting from intensive scientific, technical and technological innovations. Research, innovation and development changes are aimed at improving production, business and everyday life through the application of basic technologies of Industry 4.0. In order for individuals, organizations, communities and states to be able to use the benefits of these improvements, it is necessary to rapidly adapt to all innovative trends: developing the necessary skills of individuals and groups for the adoption and use of these technologies, the implementation of technologies in companies, organizations and institutions, and the development of appropriate strategies that these processes would be managed and directed. In the developed world, these I 4.0 implementation processes are already reaching their maturity: educational programs are adapted to the needs of monitoring technical-technological changes, companies deal with solving challenges related to these processes after the implementation of Industry 4.0 technologies, and states and communities are working on devising further directions of development and a strategy that will further accelerate changes. In Bosnia and Herzegovina, the processes are somewhat slower: educational programs partially follow the needs of education for Industry 4.0, companies struggle with the challenges of adopting and implementing Industry 4.0 without adequate institutional support, and strategies related to exploiting the opportunities of Industry 4.0 have not been developed, both due to the lack of initiative, as well as due to administrative restrictions related to the complex political system of Bosnia and Herzegovina. Considering that, this paper presents the results of research on the representation of Industry 4.0 technologies in the economy and education of Sarajevo Canton. The sample on which the research was conducted included 105 companies and 239 respondents from the general population. The results show that the highest level of application of Industry 4.0 technologies exists in the part related to the advanced management of company resources using planning and management support systems, and in communications. These findings, as well as the results related to the established level of knowledge of Industry 4.0 technologies in the general population, speak in favor of the need for the urgent development of various educational programs that will accelerate the learning of Industry 4.0 among all members of the community, as well as the establishment of state programs to support the implementation of technologies in companies, so that the economy of the Canton and the country as a whole would not fall behind in relation to the world driven by the fourth industrial revolution.*

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1. Introduction

From the first appearance of the term Industry 4.0 at the fair in Hannover in 2011, until today, we are witnessing numerous changes related to Industry 4.0, which are present at all levels: from new skills and knowledge of individuals, through the way of doing business and production in companies, to strategic thinking at the level of wider communities.
Industry 4.0, as a phase in production-business and social development, is based on automation (specific to the previous one, Industry 3.0), and numerous disruptive novelties based on information and communication technologies (ICT), cyber-physical systems (CPS), and their high connection with operational technologies (OT) when performing production and business activities.
In 2015, the Boston Consulting Group [1] identified 9 technologies as the fundamental technologies of Industry 4.0, and these technologies were named ''the nine pillars of technological advancement'' [1]. In the meantime, the list was expanded [2], so that today the authors list a significantly larger number of fundamental technologies that support the functioning of Industry 4.0 [3].
Bearing in mind the number of new technologies included in Industry 4.0 and their complexity, it is clear that the successful application of Industry 4.0 technologies and the implementation of Industry 4.0 in business and production require both the acquisition of missing software, hardware and other necessary material resources, but also imply adequate training of employees for acceptance, implementation and application of the mentioned technologies. Although it is usually about user-friendly technologies that are used by a large number of people in everyday life to a certain extent, full utilization of the opportunities and benefits offered by the application of these technologies in production and business requires adequate training of employees, which can only be achieved with appropriate education programs in systems of formal and informal education and training at the workplace.
Considering the above, this paper will present the characteristics of Industry 4.0, its fundamental technologies and ways of using them in business and production as well as the key effects produced by Industry 4.0 in companies that use it. Data on the representation of Industry 4.0 technologies in the Sarajevo Canton in the economy will also be presented, as well as the understanding of Industry 4.0 and its technologies among the general population, as a reflection of the representation of Industry4.0 technologies program in educational programs of secondary and higher education in the Sarajevo Canton.

2. Fundamental technologies of Industry 4.0: application and implementation in business

Industry 4.0 and its fundamental technologies are the result of scientific-technical-technological development of the last 30 years in the domain of mechatronics, robotics, electrical engineering, computer science, artificial intelligence, sensors, chips, but also business administration, and business and information systems engineering. Thanks to the constant improvements of existing technologies, but also the ''emergence'' of new ones, from the ''initial'' five basic technologies (Cloud Computing, Big Data, Additive Manufacturing, BlockChain, Sensors), today we have reached the number of several dozen technologies that support the functioning of Industry 4.0 [3]. Nevertheless, among practitioners and theoreticians of Industry 4.0, 9 to 11 fundamental technologies are most often discussed in accordance with the identification offered by the Boston Consulting Group in 2015 (which include: additive manufacturing - 3D printing, autonomous and collaborative robots, Big Data, cloud computing, horizontal and vertical connection of systems, industrial Internet of Things, cyber security, simulations and augmented reality) [1]. In their operation, these technologies enable completely new ways of functioning of economic and everyday life, as described in Table 1 and Figure 1 [2].

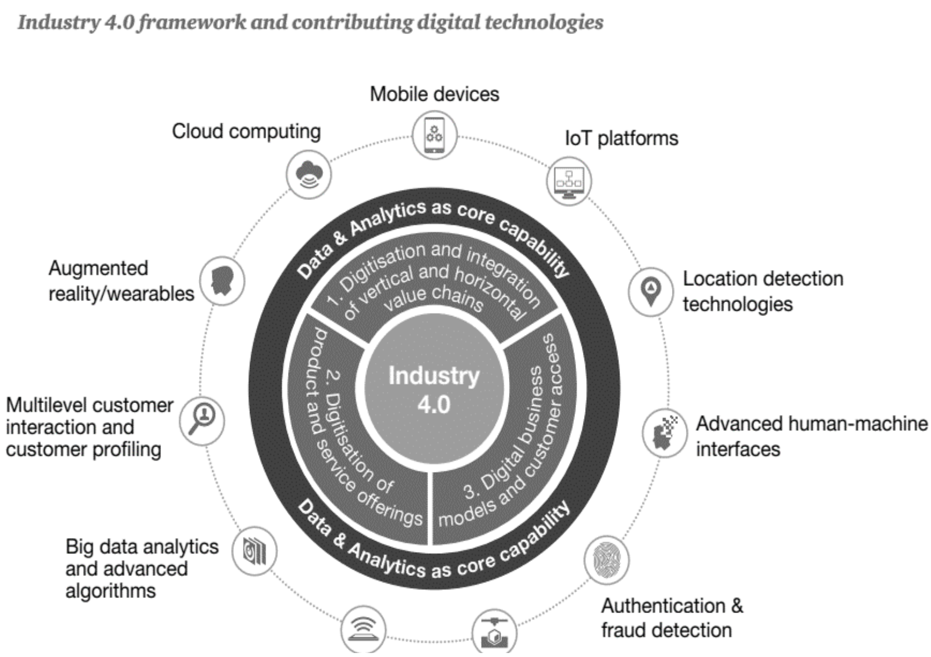

Figure 1. Industry 4.0 framework and contributing digital technologies [2]

Table 1.a. Industry 4.0 technologies and their application in business and industry (source: authors as cited)

Technology	Examples of application of Industry 4.0 Technologies
Additive manufacturing - 3D printing	Additive manufacturinginvolves the production of objects by applying thin layers of particles that bind together and thus build the desired shape. Construction of objects is done on the basis of a three-dimensional model (previously prepared using a CAD program or by three-dimensional scanning of an existing object that is to be ‘’copied’’). Additive manufacturing - 3D printing is applicable in all industrial branches for rapid production of prototypes, spare parts, new products, and even highly precise tools, while reducing costs related to testing. 3D printing has also found enormous use in the medical industry for the production of prostheses, implants, and even organs.[4]
Autonomous and collaborative robots	Autonomous robots are designed and built so that they can perform assigned tasks in a certain time, independently and without any human intervention to guide them. They are equipped with sensors and other elements that allow autonomous robots to monitor the environment and adjust according to possible changes in conditions. Collaborative robots work in physical interaction with humans in a shared workspace. Collaborative robots are also teleoperation robots that can be controlled ‘’remotely’’ via a wireless network, which is suitable for extreme situations and conditions.[4, 5]
Big Data	Big Data technology, based on Hadoop systems, enables the processing of large amounts of data in real time from various sources (instead of sample analysis). They are used by large trading and marketing companies to monitor and analyze consumer behavior and identify patterns of behavior to create optimized individual offers. In the banking industry, Big Data technology enables risk management, detecting fraud patterns, increasing customer satisfaction, etc. [6]
Cloud Computing	Cloud Computing enables computer data processing to be performed and billed as a service with the adaptability of IT system capacity to changing needs and the minimization of costs and expenses related to those adaptations. [7] Examples of commercial applications of Cloud Computing are: Amazon Elastic Compute Cloud, which provides users with access to a multitude of virtual devices, instance types, operating systems, and software packages through a network interface; Amazon Simple Storage Service (Amazon S3) that allows storing any amount of data downloaded from the Internet, regardless of location or time [8, 9]; Similar services are offered by Google, one of the leading providers of cloud computing services that provide end users with the possibility of secure data storage. [10]

Table 1.b. Industry 4.0 technologies and their application in business and industry (source: authors as cited)

Technology	Examples of application of Industry 4.0 Technologies
Horizontal and vertical connection of the system	Horizontal and vertical system integration is enabled and facilitated by the application of advanced and intelligent MRP and ERP systems based on machine learning and advanced analytics [4]. Namely, horizontal integration represents a business expansion strategy, in which the company creates a business line at the same level of the value chain, whereby the company uses its available resources. Example: Apple transferred its knowledge and experience in the production of mobile phones to the production of iPad tablets. Vertical integration is the expansion of activities into the previous or subsequent ''links'' of the supply chain (expansion in the activities of suppliers or customers) [11], where as an example we can again take Apple, which in the production of smart phones, notebook computers, etc. controls the entire flow of production and distribution, from beginning to end. Both vertical and horizontal integration make the organizational structure so complex that monitoring and management require the support of systems such as intelligent MRP and ERP.
The Industrial Internet of Things (IIoT)	The Internet of Things (IoT)represents the connection of objects (devices or things) via the Internet (most often wireless) in which physical and virtual ''things'' of all kinds exchange data and are invisibly integrated. Such integration creates new possibilities of control, monitoring and provision of advanced services [12]; The Industrial Internet of Things (IIoT) implies the monitoring of complete production in all aspects, with the possibility of application in all industries. Supervision is performed by a central workstation that monitors products, product parts, production techniques and environmental conditions via radio frequency, which it recognizes using assigned identification codes (for material elements in the system) and various sensors (for monitoring environmental conditions).[4]
Extended Reality: aR, AR, MR, VR	Extended Reality (XR) includes the four technologies Assisted (aR), Augmented (AR), Mixed (MR) and Virtual Reality (VR). XR combines the physical world with the ''world of digital twins'' allowing their proper ''interaction'' [13], Assisted Reality provides support in performing daily tasks by using appropriate devices (lenses, glasses, helmets, etc.) and providing relevant information in the immediate field of vision of the support user. Augmented reality is a version of the tangible real world supplemented and improved with digital information: visual elements, sound or other sensory stimuli based on modern technologies. Mixed Reality represents a combination of the real and virtual worlds, Virtual Reality - enables a digital experience, completely isolated from physical reality.[14]

Table 1.c. Industry 4.0 technologies and their application in business and industry (source: authors as cited)

Technology	Examples of application of Industry 4.0 Technologies
Extended Reality: aR, AR, MR, VR (cont.)	For example, AR supports the sale of consumer goods and services so that customers can get an idea of the product's features; in the regular work of the company in the maintenance of complex systems and for other purposes, up to medical interventions where it provides support to doctors through data necessary for the successful performance of medical procedures.[15]
Cyber security	Cyber security is a complex system of measures, activities, procedures and protocols to prevent malicious activities that can cause damage to one or more elements of the information system. [16, 17] The most common sources of malicious activity are: Ransomware (uses encryption to attack the target and force them to pay a ransom demand) [18], Mobile Malware (targets mobile devices and private content accessible via mobile devices) [19]; Infostealers (software that steals sensitive data from infected devices and sends it to the malware operator) [20], Banking Trojans: Malware that targets financial data and attempts to steal banking website logins and similar data [21]. It is clear that without appropriate cyber security measures, the functioning of I 4.0 technologies and smart factories based on cyber-physical systems is not possible.
Simulations	A digital twin is a virtual (digital) copy of a physical object. This technology is used to predict the behavior of products and systems at different stages of their life cycle (from design and planning, through construction, work and operations, to optimization and maintenance) as follows: predicting the behavior of complex systems; simulation of complex systems; interoperability - extracting data in complex systems, performing asset maintenance activities, both for carrying out repairs and for preventing breakdowns; visualization of complex systems during ''work''; product simulation during the ''design and manufacture'' phase. [22]

Based on Figure 1 and Table 1, it is evident that in a mutual combination of the listed technologies of Industry 4.0, they enable completely new ways of organization, implementation and management of industrial value chains, which are based on [23]:

''Data, computational power, and connectivity - based on blockchain, cloud computing, sensors and Internet of Things;

Analytics and intelligence - based on machine learning and artificial intelligence;

Human - machine interaction: collaborative robots - cobots, augmented reality, virtual reality, autonomous guided vehicles;

Advanced engineering: additive manufacturing and renewable energy'' [23, 24].

Bearing in mind the described specifics, the opportunities it provides and the key effects produced by Industry 4.0 and its technologies, Industry 4.0 can be defined as the complete digitization and automation of the business-production system, including the digitization of value chains that (all together) enable the communication of products, services, economic entities and the economic ecosystem as a whole.[2; 25: p. 240; 26; 27]

The successful implementation of Industry 4.0 in business and production implies the provision of missing software, hardware and other necessary material resources (which require significant financial expenditures), but also the ''equipment'' of employees with adequate knowledge and skills so that they can successfully meet the demands of jobs in the working environment characteristic of Industry 4.0. This means that companies and organizations should enable employees to improve and requalify (upskilling and reskilling), but also engage in finding candidates/future employees who possess the knowledge needed to use I 4.0 technologies[24]. For appropriate education and training of employees to master the technologies of Industry 4.0, appropriate programs for education on the technologies of Industry 4.0 are needed both within organizations and companies, as well as within public education systems.

Developing educational programs for Industry 4.0 implies appropriate curricula and programs within the formal education system, as well as strategies for successful implementation of goals, including sufficient financial resources and appropriate financial management, qualified personnel, partnership with business entities, advanced infrastructure, and effective workshops. Additionally, researchers emphasize the importance of developing practical expertise and implementing digital technologies to empower startups with the necessary skills and competitive advantage for Industry 4.0 [28]. Research conducted through a detailed review of the literature shows that augmented and virtual reality, simulations and the Internet of Things are present to a greater extent in current educational programs, as well as that these programs are more often related to university educational programs than to secondary school education programs [29].

3. Benefits of using I 4.0 technologies in companies

Despite the challenges related to the implementation of Industry 4.0 technologies, the benefits promised by the use of Industry 4.0 technologies in everyday business are a key argument for the accelerated introduction of these solutions in all business functions and activities. In general, the majority of authors state the following benefits: increased productivity (both labor productivity, due to increased production speed, and multifactorial productivity due to more rational use of resources), increased production flexibility due to the flexibility of machines, increased speed of product development due to the application of 3D printing, simulations and digital twins, and increased control due to the use of sensors and real-time monitoring, which ultimately results in reduced costs, increased profits and increased customer satisfaction.[4].

Taking into account the described characteristics of Industry 4.0 technologies, the consulting company McKinsey estimated that it is possible to expect significant improvements in various aspects of the performance of the business-production system, such as [30]:

‘’15 – 20% inventory holding cost reduction;
15 – 30%labor productivity increase;
30 – 50% machine downtime reduction;
10 – 30% throughput increase,
85% forecasting accuracy improvement,
10-20 % cost of quality improvement’’[24].

In addition, it is estimated that the application of Industry 4.0 technologies could generate values for manufacturers and suppliers of 3.7 trillion dollars in 2025 [30].

Although companies are aware of the numerous benefits that they can achieve by applying Industry 4.0 technologies, nevertheless, due to high costs, as well as other difficulties and challenges related to the implementation of Industry 4.0 technologies, companies usually implement individual technologies, which are available to them, taking into account the available financial and other resources. Even then, when only certain technologies are applied, the effects that are achieved are significant. Thus, research conducted in Brazil based on data from 2016 [31], showed that the implementation of certain Industry 4.0 technologies provides significant benefits in terms of individual company performance. The performed analyses determined that a positive and statistically significant influence ‘’on product characteristics, in terms of the level of customization, product quality and the speed of launching new products, has integrated engineering systems for product development and manufacturing, incorporation of digital services into products, additive manufacturing and Cloud Services, while Big Data analysis showed a negative impact on product-related elements. Furthermore, CAD/CAM, digital automation with sensors for process control and Big Data showed a positive impact in relation to the internal industrial activity of the factory: costs, productivity and process control, while additive manufacturing showed a negative impact on internal industrial activity. Finally, the positive impact of additive manufacturing on side effects, which include the improvement in sustainability (or reduction of externalities) and the reduction of labor claims'' [31]was determined. Analyses carried out in Italy [32], on over 900 companies monitored over a long period of time, showed a 7% increase in labor productivity based on the introduction of Industry 4.0 technologies, with better effects in the case of the introduction of two technologies (compared to the introduction of only one Industry 4.0 technology), greater positive effects in the case of the introduction of production technologies in high-tech companies and better effects from the introduction of customization technologies in low-tech companies, and a delayed positive impact of data-driven technologies on labor productivity in low-tech firms. This research also determined that the positive effects of the recorded increase in productivity decrease over time [32].

The implementation of Industry 4.0 in business is one of the key topics in the modern world, so, in order to make the most effective use of all the benefits promised by Industry 4.0 technologies, governments around the world are defining strategies for the accelerated implementation of I 4.0 in the economy and business [33, p. 54.]. Unfortunately, such organized activities to define a strategy for the adoption and implementation of Industry 4.0 technologies in the economy of Bosnia and Herzegovina are missing [34: p. 57, 80, 125], and the implementation activities of Industry 4.0 technologies are mostly based on the initiative of businessmen and managers through development strategies of individual companies. Considering all the above, it is important to identify the level of representation (and utilization) of Industry 4.0 technologies in companies in Sarajevo Canton, but also the understanding and knowledge of this phenomenon among managers, employees and the general population. In addition, it is necessary to determine the extent to which educational programs give importance to technologies and Industry 4.0, and to examine the understanding of this term and concept among pupils and students, participants in the education system in Sarajevo Canton.

4. Industry 4.0 in the Economy and Education of Canton Sarajevo

4.1. Ecosystem of the Sarajevo Canton economy

Sarajevo Canton is one of the ten cantons in the Federation of Bosnia and Herzegovina and the institutional center of the country. Sarajevo Canton is home to the capital city, the most important state and federal institutions as well as international institutions and organizations. Canton Sarajevo is one of the smallest cantons in the Federation of Bosnia and Herzegovina by area, with only 4.9% of the area it occupies in the Federation, but in terms of the number of inhabitants it leads in comparison to other parts of the country and cantons, with a total of 419,543 inhabitants [35, p. 23], i.e., 328.6 inhabitants/km^2 according to the data of the Federal Bureau of Statistics from 2022 [35, p. 14].

Table 2. The most important economic parameters for the Sarajevo Canton - 2020.[authors, according to: 36, p: 29, 36, 37, 43]

	Description of activity	Companies %	Employed %	Structure of investments %	Net Profit %
A	Agriculture, forestry	1%	0,7	0,2	0,2
B	Mining	0%	0	0	0,2
C	Processing industry	**8%**	**9,3**	6,5	**18,2**
D	Electricity production	1%	1,3	**16,4**	1,7
E	Water supply, sewerage, waste	0%	1,7	1,3	0,5
F	Construction	7%	4,8	**9,2**	5,3
G	Trade	**29%**	**18,9**	**12,9**	**29,7**
H	Transport and storage	4%	5,3	5,4	3,5
I	Provision of accommodation, preparation and food serving	5%	6,1	2,9	0,4
J	Information and communication	7%	6,6	8,9	**14,2**
K	Finance and insurance	1%	4,3	5,9	1,7
L	Real estate business	**8%**	1,4	4,9	3,2
M	Professional, scientific and technical activities	**17%**	5,7	1,4	**14,3**
N	Administrative and auxiliary service activities	7%	4,4	2,7	2,8
O	Public administration and defense	0%	**10,7**	**13,3**	0
P	Education	2%	7,3	2,2	0,7
Q	Health and social care	1%	6,6	2,8	2,9
R	Arts, entertainment, recreation	1%	2,0	1,1	0,1
S	Other service activities		3,1	1,5	0,2
	Households		-	0,6	-
	Total:	100%	100%	100%	100 %

A large part of the employees in the Federation of Bosnia and Herzegovina is concentrated in Sarajevo Canton. With 152,576 employees in 2021 [36, p. 27], the Sarajevo Canton ''gathers'' as much as 28.5% of the total number of employees in the Federation of Bosnia and Herzegovina, and the economy of the Sarajevo Canton generates about 32% of the gross domestic product of the Federation of Bosnia and Herzegovina, which in 2022 amounted to over 25.2 billion KM.
More than 40,000 economic entities operate in the area of Sarajevo Canton *[34, p. 37]*, of which 7,720 entities manage accounting in accordance with the accounting framework for economic companies (of the 25,270 that operated in the Federation of Bosnia and Herzegovina in 2022)*[37, p. 7]*.

Among economic entities, the most numerous are those from the tertiary sector of service activities with 4190 entities, i.e., 54.3%.Observed by activity, the largest number of economic entities is in trade, with more than 29.3% of enterprises, and in M activities - professional, scientific and technical activities, with a share of 16.9% [36, p. 37]. Most of the employees in Sarajevo Canton engage in the following activities: G - wholesale and retail trade, O - public administration and defense; C – processing industry; J - information and communications, P - education and Q - health and social care [36, p. 29].

The largest investments are related to the production and supply of electricity - 16.4%, construction - 9.2%, trade - 12.9% and public administration and defense, 13.3%. [36, p. 36]. The value of investments in 2020 amounted to 1 billion and 29 million KM, of which most investments were directed to construction works and transfer of ownership, (in both cases with growing investments of 18.9% and 197.4% more than the previous year, respectively). Investments in machinery, equipment, means of transport 40%, and other assets (intangible fixed assets and other tangible assets)make 9% of the value of total investments [36, p. 35-36].

The net profit achieved in 2020 in Sarajevo Canton was 974 million KM. The largest participation in the generation of net profit is held by trade with 29.7% of the realized net profit, followed by the processing industry with 18.2%, professional, scientific and technical activities with 14.3%, and information and communication activities with 14.2%.

All these data tell us about the impact of certain activities on the economy of the Sarajevo Canton, but also which activities could first invest in Industry 4.0 technologies. It is reasonable to expect that the last four listed activities (trade, processing, ICT and professional, scientific and technical), with the conditions they possess (which are linked to higher levels of generated net profit) and the possibility of benefiting from the application of Industry 4.0 technologies, will be the initiators for adoption and implementation of Industry 4.0 technologies.

4.2. Education system in Sarajevo Canton

Adequate education is the basis for the successful development of a certain community and a prerequisite for adequate training of the populationfor appropriate inclusion in the business world. Bearing this in mind, it is necessary to look at the effects of the teaching and educational programs implemented in the education system of the Sarajevo Canton, which are in the function of education about modern technologies and ways of their application.

Table 3. Educational institutions in Sarajevo Canton and technical equipment with computers [authors according to: 36, p. 53-57]

	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022
Elementary school	97	97	100	100	100
Computers/pupils	17	20,5	20,3	19	17,4
Secondary schools	39	39	40	40	41
Computers/pupils	9,6	9,3	9,7	8,5	7,8
Higher education institutions	37	32	32	31	31

There are 92 elementary schools, 41 secondary schools, and 31 higher education institutions in Sarajevo Canton (according to data from the Institute for Development Planning of Sarajevo Canton for the school and academic year 2021/2022). All educational institutions are equipped with a certain number of computers and other information technology, which meets the needs of successful teaching, *[36, p. 53-57]*, and educational programs necessarily include IT education and training (Table 3).

Secondary schools and faculties of technical orientation carry out teaching and training related to the technologies of Industry 4.0. Additionally, as of 2018, in about 5% of primary and secondary schools in Sarajevo Canton, through inclusion in appropriate development projects, STEM classrooms were established, suitably equipped (robots, 3D printers, scientific kits, etc.) [38] In *addition, the teaching staff was also trained for teaching and training within the STEM program in elementary and secondary schools.*

Considering the above, Sarajevo Canton demonstrates that it provides conditions for adequate education of pupils and students about the technologies of Industry 4.0, but the question arises as to what it is like in reality, and how much the pupils and students in the Sarajevo Canton, as well as the general population, really know about the technologies Industries 4.0.

4.3. Learning and knowledge about Industry 4.0 in Sarajevo Canton

Research on the understanding, knowledge and perception of the impact of Industry 4.0 among young people, employees and the general population in Sarajevo Canton and the representation of Industry 4.0 technologies in companies in Sarajevo Canton was carried out (for both parts of the research) in the second half of 2022. The research, in accordance with the objectives, was divided into two parts: one, which was focused on identifying knowledge and understanding related to Industry 4.0 and I 4.0 technologies, and the second part, which was aimed at identifying the use of Industry 4.0 technologies in the economy.

Table 4a: Demographic characteristics of the respondents

Demographic variables	**N**	**%**
Total respondents:	**239**	**100%**
Gender:		
Male	88	36,8
Female	151	63,2
Achieved educational level:		
Schoolar	84	35,1
Secondary school	42	17,6
College - II years	13	5,4
University degree	42	17,6
Masters	36	15,1
Doctorate	22	9,2
Occupation:		

Data collection was done online and to a lesser extent through printed questionnaires distributed using the snowball method. The questionnaires used for data collection were developed for the purposes of this research, and according to the questionnaires used in similar, previously conducted research[39].

The research included 239 individuals (general population) and 105 companies for which data was provided by company managers.

Demographic characteristics of

Pupils /students	125	52,3
Workers/employees	67	28,0
Senior level manager	19	7,9
Lower and middle lever manager	13	5,4
Employer/owner	12	5,0
Pensioner	2	0,8
Unemployed	1	0,4

respondents from the general population sample are presented in Table 4. As can be seen from Table 4a, the sample included: men and women of different levels of education, with different occupations, from all administrative units (municipalities) from Sarajevo Canton.

Table 4b: Demographic characteristics of the respondents

Demographic variables	**N**	**%**
Age group		
16-20 years	115	48,1
21-30 years	34	14,2
31-40 years	36	15,1
41-50 years	24	10,0
51-60 years	22	9,2
61 +	8	3,3

The respondents belonged to different age groups, aged 16 to 66 years, with younger respondents dominating the sample, in order to get answers related to the knowledge of young people regarding Industry 4.0 technologies (Table 4b).

The questionnaire used to examine the representation of knowledge about technologies and Industry 4.0 contained a total of 17 questions. In addition to 7 questions related to the demographic characteristics of the respondents, ten more questions were offered that related to the understanding of the concept of Industry 4.0, the ways of acquiring knowledge about Industry 4.0, the representation of topics related to I 4.0 in formal educational programs, and the understanding of the potential impact of implementing Industry technologies 4.0 in the economy to jobs and future employment opportunities. The most interesting findings determined by the research are presented below.

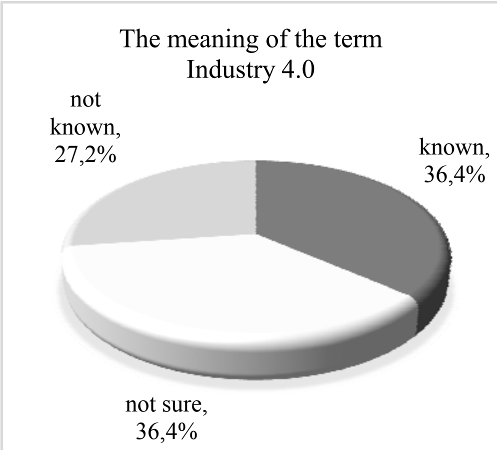

Figure 1. Understanding the meaning of the term I 4.0

The initial questions in the questionnaire oncerned knowledge and understanding of the term I 4.0. When asked about the meaning of the term I4.0, 36.4% respondents, i.e., 87 cases, answered that they know the meaning of the term Industry 4.0; 36.4% of respondents report that they do not know the meaning of the term, while 27.2%, or 65 respondents, are not completely sure of the meaning of the term Industry 4.0. (Figure 1)

Therefore, only a little more than a third of the total number of respondents included in the research know the content of the term Industry 4.0. Looking at the structure in the subgroups of respondents, this means: 34% of students, 13% of secondary school students, 40% of people in employment, and 68% of managers (from the number of respondents of the observed subgroup).

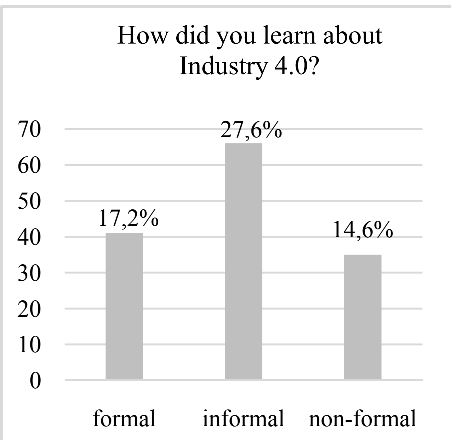

Figure 2. Learning about Industry 4.0

When asked about the method of acquiring knowledge about Industry 4.0, 66 respondents answered that they acquired knowledge through informal learning, that is, 27.6% of respondents in this group. In 17.2% of cases, i.e., 41 respondents, reported formal acquisition of knowledge about Industry 4.0, and 35 respondents, i.e., 14.6%, answered that they acquired knowledge about Industry 4.0 through non-formal education - through seminars, workshops, courses, etc. (Figure 2)

The next question in the questionnaire referred to the extent to which education about Industry 4.0 technologies is represented in formal education. To the question ‘’To what extent have you acquired knowledge about Industry 4.0 and the technologies it is based on during your education so far?’’, a large number of respondents answered in the negative. As much as 50% of respondents did not learn about these technologies through formal education, and only slightly more than 7% (17 respondents in total) answered that they learned about Industry 4.0 and Industry 4.0 technologies to a sufficient extent or a lot, as can be seen in Figure 3.

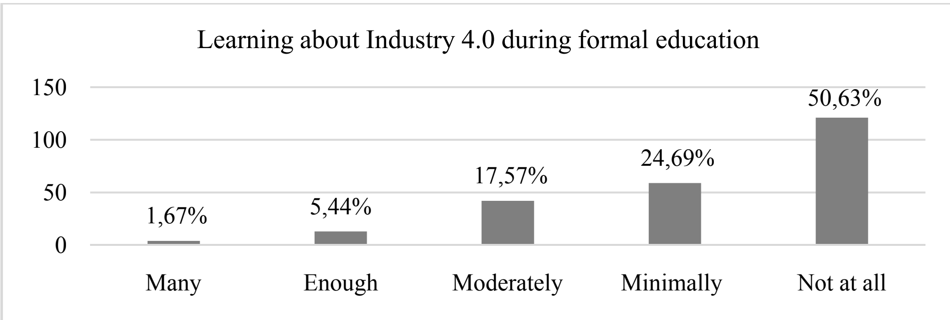

Figure 3. The scope of formal education about Industry 4.0

In the continuation of the questionnaire, the questions were aimed at examining the respondents’ perception of the impact that Industry 4.0 and its underlying technologies can have on the labor market. For the sake of a precise understanding of the term, a short interpretation of Industry 4.0 was stated in the questionnaire, and then questions were asked about the effect of Industry 4.0 on the generation of new jobs, but also the possible negative impact on the existing ones.

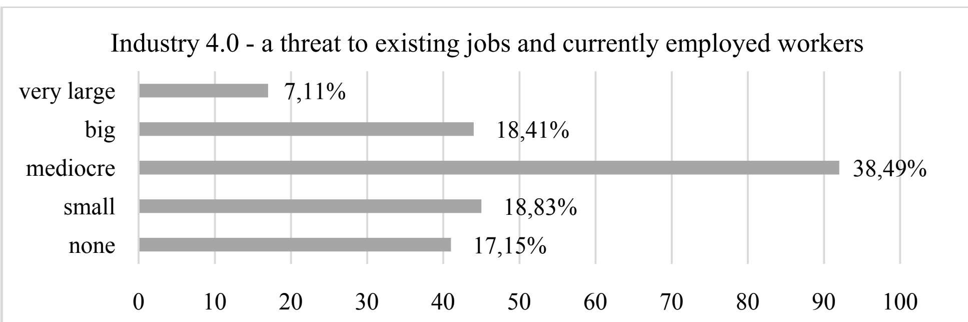

Figure 4. Perception of Industry 4.0 as a threat to existing jobs

More than 25% of respondents believe that Industry 4.0 is a big or very big threat to existing jobs, 38.5% of respondents think that this negative impact is moderate, while the remaining 36% of respondents think that Industry 4.0 does not represent a significant threat to existing jobs (i.e., that Industry 4.0 technologies pose little or no threat). At the same time, the vast majority of respondents recognize the potential positive impact of Industry 4.0 on the generation of new job positions and jobs. As can be seen in Figure 5, 87.87% of respondents believe that Industry 4.0 will have a positive impact on the creation of new job positions, while only 12% of respondents expect little or no impact of new technologies on the creation of new job positions.

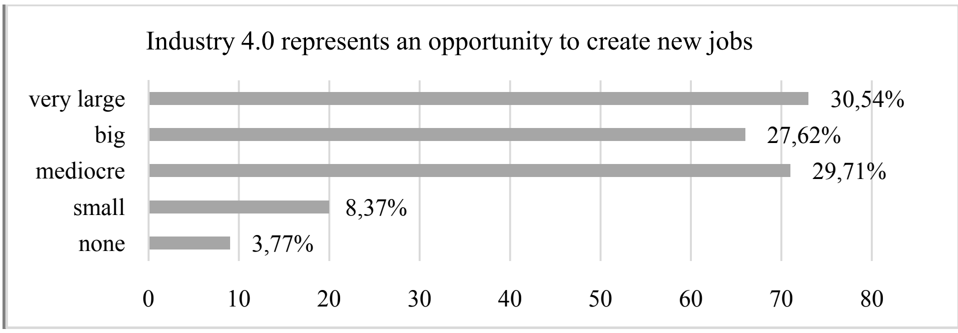

Figure 5: Perception of Industry 4.0 as an opportunity for new jobs

The described answers of the respondents speak of the insufficient knowledge of the general population when it comes to Industry 4.0 and its basic technologies, but also of the positive perception of the respondents in Sarajevo Canton about the impact of new technologies on the labor market. According to the answers given by the respondents, it can be concluded that the respondents expect the positive impact of new technologies to a much greater extent, compared to the potential negative impact in terms of endangering jobs. Furthermore, findings related to answers to questions about knowledge of Industry 4.0 technologies and the extent of formal education, can suggest two recommendations: the need to increase formal teaching content related to Industry 4.0 technologies, but also the need to develop adequate programs of informal education. Although formal education is the most effective way of disseminating knowledge, the fact that in the case of Industry 4.0 it is about new technologies, speaks in favor of the need to develop as many informal education programs as possible in order to spread knowledge about these technologies and the possibilities of their use in different branches and activities in order to be more distributed to the general population in Sarajevo Canton.

4.4. Representation of Industry 4.0 technologies in the economy of Sarajevo Canton

In order to complete the picture of the representation of Industry 4.0 technologies in Sarajevo Canton, the second part of the conducted research was focused on the application of Industry 4.0 technologies in companies in Sarajevo Canton. In this case, the interviewees were managers from the companies in the sample, and the sample included 105 companies.

Table 3a: Structure of the sample of companies

Demographic variables	**N**	**%**
Total respondents:	**105**	**100%**
Occupation:		
Senior level manager	27	25,7
Lower, middle level manager	57	54,3
Artisan	4	3,4
Employer/owner	17	17

As stated, the data in the research was provided by decision makers in companies: managers of different levels, entrepreneurs and business owners.As can be seen from Table 3b, the sample included companies of various sizes, from most economic branches and activities operating in Sarajevo Canton (excluding mining, water supply, health and administration - public).

Table 3b: Structure of the sample of companies

Demographic variables	**N**	**%**
Total respondents:	**105**	**100%**
Company size		
Micro (1-9 employees)	24	22,9
Small company (10 - 49)	20	19,0
Middle-large companies	29	27,6
Large companies (250+)	32	30,5
Type of production	**N**	**%**
Individual and small batch	36	34,3
Serial and large-batch	36	34,3
Modular production	22	21,0
Web product configuration	11	10,4

In the companies taken from the sample, the production of products and services takes place most often as individual and small-batch and serial and large-batch (in 34.3% of cases for both).

In 21% of cases, modular production is applied, and in 10% of cases, web configuration of the product is possible.

The next question in the questionnaire referred to the company's readiness for ''Industry 4.0''. Respondents' answers to this question were distributed almost normally (Figure 6). 30.5% of respondents believe that the company they work in is moderately prepared for Industry 4.0; 42% of respondents believe that the company is sufficiently or significantly prepared for Industry 4.0, while 29.5% of respondents consider the company they work in to be insufficiently prepared for I 4.0, of which 3.8% of respondents rated this preparedness as completely insufficient.

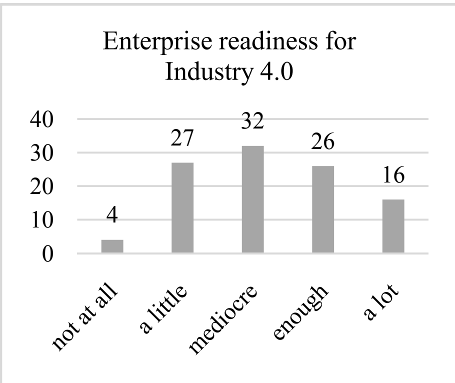

Figure 6: Company readiness for Industry 4.0.

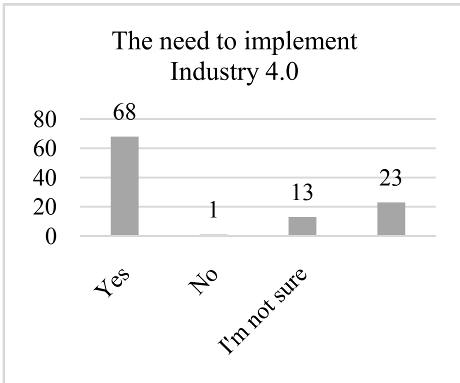

Figure 7: The need to introduce Industry 4.0 technologies

The respondents' perception of the need to implement Industry 4.0 technologies in companies in Sarajevo Canton is in accordance with the assessment of the readiness for the introduction of Industry 4.0 technologies. 64.8% of respondents believe that there is a need for the introduction and application of Industry 4.0 technologies in business and production processes, and 34.3% of respondents are not sure or believe that the implementation of Industry 4.0 technologies depends on and should be adapted to the trends in the environment. Only one participant in the research believes that there is no need to implement Industry 4.0 technologies (Figure 7).

The following questions examined the current situation with the representation of certain Industry 4.0 technologies in the business and production processes of companies in Sarajevo Canton- The questions concerned the technologies used for the development of products/services, the way of communication in companies, the use of industrial robots, the use of composite materials, the use of additive manufacturing and the application of software programs for decision support.

As can be seen in Figure 8 (below), Industry 4.0 technologies are used in as many as 66.7% of cases in companies from the sample for product development, namely: most often CAD systems for product development - in 45.7% of cases, 3D technology in 18.1% of cases, and simulations in 2.9% of cases. Nevertheless, 1/3 of the companies still do not use modern technologies for product development, which creates room for improvements in their business.

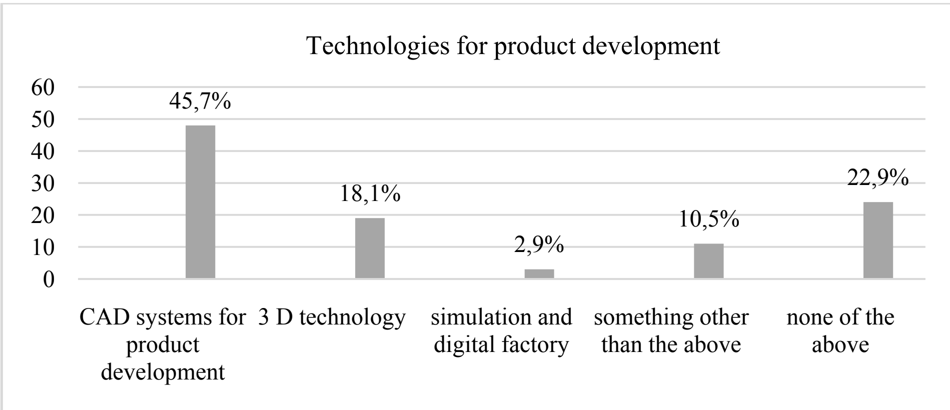

Figure 8: Overview of technologies used for product development

When it comes to the way of communication in the production and business process of the companies from the sample, as shown in Figure 9, human-to-human communication, written and oral, is used to the greatest extent (53.3% and 48.6% respectively). The Internet connection is used for communication in internal processes in 43.8% of cases, while in 55.2% of companies from the sample, human-machine and machine-machine communication is used. In most companies, combinations of the above methods of communication are used, and in only 15 cases (i.e., 14.3%) only person-to-person communication, written or oral, was reported.

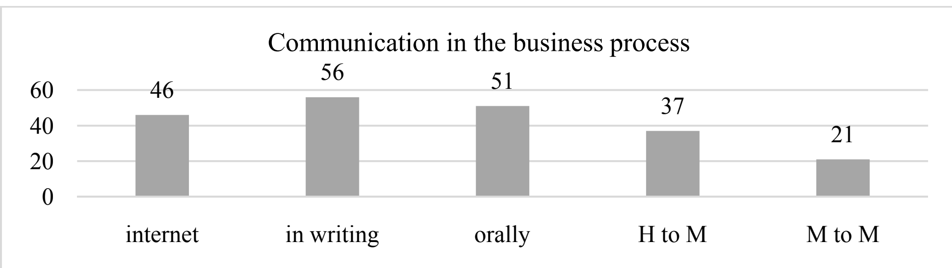

Figure 9: Overview of technologies used for communication in the company

The use of industrial robots in the companies in the sample is the least represented of all Industry 4.0 technologies. Namely, as seen in Figure 10, only 16% of the companies in the sample have industrial robots, while more than 75% of the companies in the sample do not use industrial robots to perform parts of the work and production process. 8.6% of respondents gave a neutral answer to the question about the use of robots in business and production processes (they do not know or believe that the question is not applicable to the case of a specific company). In companies that have industrial robots, in most cases these machines are well used, as can be seen from the analysis shown in Figure 11. Only one respondent reported low utilization of the industrial robots at the company's disposal.

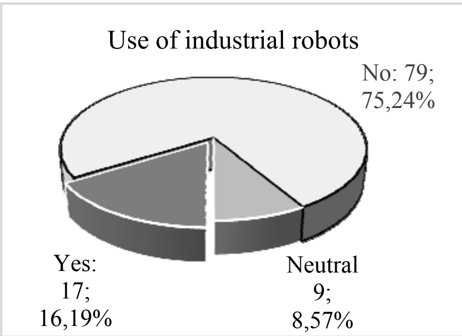

Figure 10: Use of industrial robots

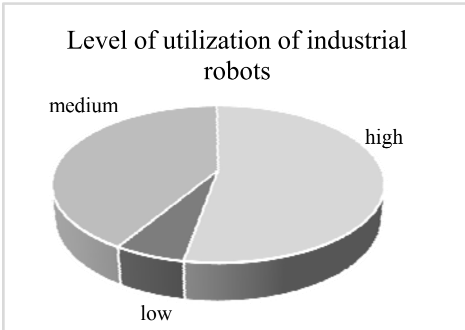

Figure 11: Utilization of industrial robots

When it comes to the use of composite materials, the situation is similar to the use of industrial robots. Namely, as seen in Figure 12, 18% of the companies in the sample use composite materials, 39% of the companies in the sample do not use composite materials in the production process, and in the case of 43% of the companies in the sample, the question is not applicable. If we take into account the structure of the sample in terms of the participation of manufacturing companies, then we can conclude that the use of composite materials is represented in approximately 2/3 of the manufacturing companies included in the research.

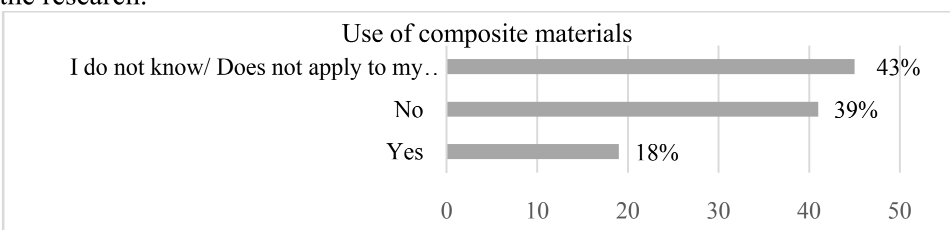

Figure 12: Use of composite materials

The use of additive manufacturing for the purpose of rapid production of prototypes and other objects is a frequent practice in modern business. The extent to which this practice is present in companies in Sarajevo Canton is shown in Figure 13. According to the respondents' answers, 20 companies, or 19% of the sample, use additive technology (3D) for prototyping and other needs. 34.3% of respondents report that this question is not applicable to their company, while 46.7% of respondents declare that they do not use 3D technology in their company.

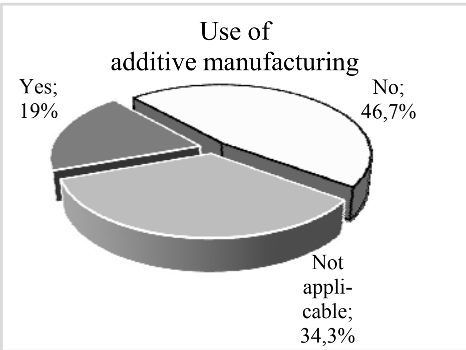

Figure 13: Use of additive manufacturing

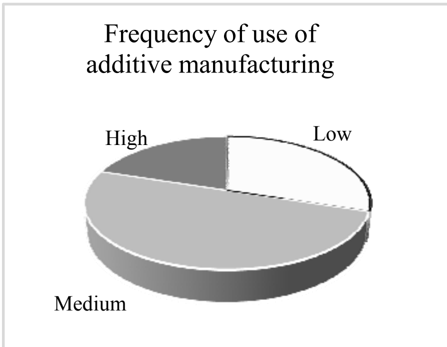

Figure 14: Frequency of use of additive manufacturing

In the companies that stated that they use additive manufacturing, this technology is mostly used moderately (in 10 companies), while in 4 companies the use of additive manufacturing for prototype development and other needs is frequent. For the sake of precision, this number makes up 20% of the total number of companies that use additive manufacturing, and 3.8% of the total number of companies in the sample. Six respondents reported infrequent use ofthis technology, that is, a low level of use, which is visible in the Figure 14.

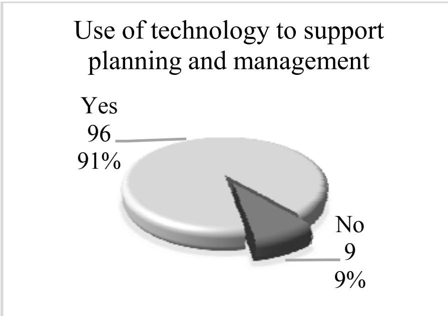

Figure 15: Use of computer technology to support planning and management

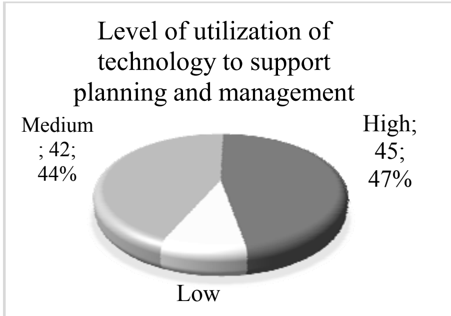

Figure 16: Utilization of computer technology to support planning and management

The last question in the questionnaire referred to the use of software for decision support, that is, support for planning and management of business and production. As expected, it turned out that this is the technology that is used to the greatest extent, i.e., in the largest number of companies from the sample. As many as 91.4% of respondents reported that their company uses software to support planning and manage materials and resources. According to the respondents' answers, 9 companies (which is 8.3% of the entire sample) do not use these programs. (Figure 15).

The use of computer programs to support planning and management of business and production in companies that rely on this technology is, as can be seen in Figure 16, high in 47%, moderate in 44%, and low in only 9% of companies that use it. It is certain that such a high frequency of application of this technology can be explained by its affordability (higher compared to other technologies) and the ratio between the costs of use and the possibilities and benefits it offers. In addition, the high level of utilization in more than 90% of the companies that have this technology speaks in favor of the fact that in the sample companies there is a willingness to adopt technologies and their mastery and use, but that the costs of acquiring certain technologies and the possibility of full use is not under favorable conditions.

4.5. Discussion

Research on the representation of knowledge about Industry 4.0 among young people and employees and the representation of Industry 4.0 technologies in companies in Sarajevo Canton was conducted on a sample of 239 respondents and 105 companies. The results of the research obtained after the conducted survey showed that among pupils and students and employees of companies in Sarajevo Canton, there is a certain level of understanding and knowledge about Industry 4.0 technologies. Slightly more than one-third of respondents arefamiliar with the term Industry 4.0, but that in most cases this knowledge was not acquired through the formal education system, i.e., that education on the topic of Industry 4.0 and basic technologies is either absent or does not provide adequate effects. The most common way in which the respondents included in the research acquired knowledge about these emerging technologies was through informal learning. Bearing in mind the described part of the research results, it is necessary to work on improving formal education programs in schools and colleges, but also to provide appropriate informal education programs on Industry 4.0 technologies in order to enable up-to-date adoption of the latest knowledge related to Industry 4.0. Despite the insufficiently high level of knowledge related to Industry 4.0 technologies among young people and employees, there is a noticeable positive perception of respondents in Sarajevo Canton about the impact of new technologies on the labor market. According to the responses of respondents, the vast majority of them expect a positive impact of new technologies on the labor market and the creation of new jobs (in more than 87% of cases), compared to ¼ of the respondents who expect a potential negative impact in terms of endangering existing jobs.

Research on the representation of Industry 4.0 technologies in Sarajevo Canton companies, based on a sample of 105 companies, showed that companies in Sarajevo Canton use I 4.0 technologies in all phases of business and production. Nevertheless, some of the technologies are used in less than 20% of cases (industrial robots, composite materials and additive technologies in 16%, 18% and 19% of cases respectively), while for other needs the application of technologies is much more frequent (e.g., for communication in 85% of cases and for planning and management support in 91% of cases).

If we compare the results obtained from this research with the data from other researches (e.g. [40, p. 53]), we can see that our respondents reported the use of Industry 4.0 technologies in business and production (covered by this research, e.g., industrial robots) in a much higher percentage 18% vs 5% in [40], or 3D technologies: 19% vs 4% in [41]). These differences may be a consequence of the specificity of the sample we used in our research, the more restrictive way of defining certain technologies in the research on which the reports described in [40 and 41] are based, or the fact that the research was conducted in Sarajevo Canton, which compared to the rest of the country has the most different resources, especially referring to knowledge resources, but also material resources.

Respecting the results of the research, it would be desirable that further research in the future to focus on the use of a wider group of Industry 4.0 technologies (compared to those that we covered in our research), as well as to pay special attention to practices in certain industrial branches, especially those of importance for competitiveness of economy of the canton and the state.

5. Conclusion

Complex processes related to the creation, development and use of Industry 4.0 technologies are taking place around the world. On the one hand, these processes imply the development of new and constant improvement of existing Industry 4.0 technologies by innovators, scientists and practitioners. On the other hand, the processes include the creation of national development strategies that should further stimulate the acceleration of the previously described processes in the function of the development of societies as a whole. In parallel with these processes, companies strive to take advantage of these changes and all the benefits available through the characteristics and possibilities of certain technologies and their combined use. These processes regularly require high levels of knowledge and available resources, which is usually unattainable for most small and underdeveloped countries. Unfortunately, Bosnia and Herzegovina also belon to this last group. In order for the Bosnian economy to be involved as effectively as possible in the processes of implementation and exploitation of Industry 4.0 technologies, it is necessary to work permanently on improving the knowledge and skills of existing and potential employees, as well as on the accelerated implementation of all Industry 4.0 technologies in the production and business processes of domestic companies, in order to increase the efficiency, effectiveness and competitiveness of the economy as a whole, but also of individual companies. Bearing in mind the limitations of the available resources that are needed to make the relevant technologies available to companies, as well as the complexity of their full use, it is desirable at the beginning of the process of implementing Industry 4.0 technologies to focus on selected groups of technologies and selected groups of companies so that the implementation process of these technologies runs as quickly as possible, and the positive effects of their use are felt as soon as possible and further distributed. These processes would require the effort of all participants: companies in terms of organizational efforts, availability of resources and cultural changes, employees in terms of learning and flexibility, institutions in terms of the development of business support programs, and the development of a national strategy for the implementation of Industry 4.0, which would give effects through increasing the competitiveness of the economy as a whole and of all companies individually.

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