*People in organization.*
*Selected challenges for management*
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CHAPTER 7

# Knowledge and Perception of Industry 4.0 Among Students of Computer Science

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**Summary**: Industry 4.0 is now a new area that should be included in the education system of future engineers. There is little research on this phenomenon, especially in the aspect of its knowledge and understanding among people who will have to work in its conditions. Are future engineers ready for operations in the Industry 4.0 environment, do they deserve the title of 4.0 engineers, do they have the necessary knowledge and skills? The chapter attempts to deepen the concept of Industry 4.0 awareness in the group of respondent professionals in the field of IT. The chapter presents the results of research conducted in a group of students of the Lublin University of Technology in 2019. The study was conducted to find out the level of knowledge and perception of Industry 4.0 among IT students. The idea was to learn about the attitudes and opinions on Industry 4.0, the readiness to function in its conditions and the awareness of the importance and potential benefits of the solutions it offers. The obtained research results indicate the need to improve educational programmes aimed at preparing future engineers to operate in the

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conditions of Industry 4.0. This will allow the acquisition and development of skills and qualifications required by Industry 4.0.

**Keywords**: Industry 4.0, knowledge, perception, students, awareness.

## 1. Introduction

Industry 4.0 is the digital transformation of production and related value creation processes. This concept is often used interchangeably with the concept of the fourth industrial revolution (Latinović et al., 2019, p. 4). It is a current trend of automation and data exchange in production technologies, which includes cyber-physical systems (CPS), industrial Internet of Things, cloud computing and artificial intelligence in the creation of intelligent enterprises.

Industry 4.0 is a vision that has evolved from an initiative to increase the competitiveness of the German manufacturing industry ("Industrie 4.0") to the globally accepted term referring to the industrial transformation in discrete and process production related to the concept and evolution of a smart factory. The creator of this concept is H. Kagermann (Kagermann, 2015, p. 32). From defining the development strategy of German industry, it has evolved to identify changes that are taking place in the production sector during the so-called Fourth Industrial Revolution. The concept of Industry 4.0 in the United States is known as "Connected Enterprise" (Morrar, Arman, Mousa, 2017, p. 13).

The European Member States and regions are required to adapt their innovation systems to Industry 4.0 trends, and Europe as a whole faces the challenge of finding a balance between promoting research and innovation excellence and enabling less advanced regions to benefit from the ongoing industrial revolution. However, relatively little is yet known about the scale of this economic phenomenon, the comparative advantages of countries and regions, and their technological specialization.

Industry 4.0 (Davies, 2015) is a development of concepts such as: industrial Internet of Things (Velandia et al., 2016), smart industry, smart factories (Chen et al., 2017), resilient factories (Rashid et al., 2018) or advanced manufacturing (Kopp, Howaldt, Schultze, 2016). Its characteristics include: 1) even more automation than occurred during the third industrial revolution; 2) connecting the physical and digital world using cyber-physical systems and the industrial Internet of Things; 3) a change from a central industrial control system to a system in which intelligent products define production stages; 4) data models and closed-loop control systems, and 5) product personalization (Bendel, 2015, p. 740). The goal of all these solutions is to enable autonomous decision-making processes, monitor resources and processes in real-time, and enable real-time value creation networks connected by early stakeholder involvement as well as vertical and horizontal integration.

Industry 4.0 heralds a profound transformation of business models, allowing a combination of virtual and real worlds and the use of digitization, automation and robotics in production. It digitizes and integrates processes vertically throughout the organisation, from product development and purchasing to production, logistics and service. All data on operational processes, process efficiency and quality management as well as operation planning are available in real-time, supported by augmented reality and optimized in an integrated network. Horizontal integration goes beyond the internal operations of suppliers for customers and all key partners in the value chain.

Industry 4.0 uses intelligent network systems and the Internet of Things on a massive scale. It creates intelligent products using intelligent procedures and processes. The intelligent factory operates on new principles. Employees, machines and resources communicate with each other along with the principles of social networks. Therefore, solutions in the scope of Industry 4.0 should be implemented in an interdisciplinary manner. The basic technologies and areas used in Industry 4.0 are: Big Data, autonomous robots, simulation, horizontal and vertical integration systems, industrial Internet of Things, cybersecurity, cloud computing, additive (incremental – 3D printing) manufacturing and augmented reality (Rüßmann et al., 2015, p. 2).

The term "industry 4.0" symbolizes new forms of technology and artificial intelligence within production technology. Intelligent robots will be widely found in factories of the future and will work with people in the necessary teams in many processes. Thanks to the fourth industrial revolution, classic production lines are undergoing comprehensive modernization, e.g., into module sets, which are independently assembled in such a way as to realise orders coming from customers as soon as possible.

Industry 4.0 is based on the use of cyber-physical systems (CPS). They are identified with the manifestation of the fourth industrial revolution that is currently taking place (Lee, Bagheri, Kao, 2015, p. 18). Their components are objects, devices, machines, and logistic elements that are equipped with integrated systems and have communication skills, can communicate via the Internet and use Internet services, can work autonomously or create networks and make decisions in a decentralized way or in cooperation with people.

We deal with the cyber-physical system whenever there is a combination of information and programming components with mechanical and electronic parts that communicate via a data infrastructure such as the Internet. Cyber-physical systems are characterized by a high degree of complexity. They are created by connecting integrated systems in a network using wired or wireless communication. Cyber-physical systems modify the way people interact with engineering systems, just as the Internet has changed the relationship between people and information.

Their use is supported by the rapid development of the Internet of Things (especially in the industrial edition) and its connection with artificial intelligence (AI), machine learning and cloud technology. They can be used in virtually every area of human activity. They form the basis of production infrastructure and "intelligent" services, and their ultimate goal is to improve the quality of life in various areas of the economy such as energy, environment, transport and healthcare. Examples of their practical applications include industrial process control and automation systems, communication logistics systems, systems for long-term environmental impact and observation, systems improving the quality of life of the elderly.

## 2. Engineering Skills and Competencies as Elements of Social Capital in Era of Industry 4.0

Industry 4.0 has consequences for employees, it will have a huge impact on both the content of the work and the organisation of work. All this will change the way human capital is used as an organisation's development resource. It is social capital that is the catalyst for the emergence and spread of Industry 4.0 (Ahmad, Shamsuddin, Aslinda, 2018, p. 221). The holistic method of human resource management for Industry 4.0 lists four required employee competencies: technical, methodological, social and personal (Hecklau et al., 2016, p. 4).

At the same time, Industry 4.0 changes the professional profiles and skills of employees, requires other skills adequate to the technologies used. Therefore, education systems must be prepared for this. Therefore, questions arise regarding the preparation of future engineers for the newly defined engineering competencies needed in the era of Industry 4.0, their assessment and teaching and training, e.g., in future engineering education, it should be considered that the era 4.0 working teams will be human-robot teams.

Unlike previous concepts, such as CIM (Computer Integrated Manufacturing) (Yu et al., 2015, p. 8), Industry 4.0 is not intended to create factories in which people are replaced by robots. Industry 4.0 makes factories a better place to work. People are invariably the most important, and thanks to new solutions they will receive much more support than before.

In practice, Industry 4.0 strongly integrates three components: people, machines, and processes.

Undoubtedly, this approach to the future development of production companies will make the role of engineers, in particular automation specialists, in the process of implementing the above ideas proves to be key. The integration of many advanced technologies: robotics, control, automation, and IT technologies will require companies to constantly develop their engineers.

Industry 4.0 will create a new global automated, virtualized, and networked work environment. It will require a new employee profile – a 4.0 engineer with specific competencies and skills that work in the new reality.

In the era of Industry 4.0, the emphasis is on the skills of an interdisciplinary approach to technology, which efficiently combine technical skills with broad knowledge of production management. Due to the technological complexity, future complex production sites of the smart factory type will require much greater professional skills from their employees. In-depth knowledge and technological skills, as well as effective competence in cooperation, will be required (Madsen et al., 2016).

The emergence of new digital industrial technologies and the dissemination of the Industry 4.0 framework presents future engineers with new challenges in terms of education and skills, which also results in the need to take these issues into account in academic teaching, especially at technical universities (Richert et al., 2016, p. 148).

This applies to the so-called hard and soft skills and competencies. Hard skills and competencies are technical in nature and are related to specific education. These include specialist/expert knowledge, command of foreign languages, support for specific computer programs, knowledge of a specific engineering speciality and industry standards, problem-solving skills, design skills; research and experimental skills, information processing, computer programming, etc. They can be confirmed with diplomas or certificates. At the same time, along with such concrete formation, it turns out that soft skills are becoming increasingly important in modern engineering education. These include analytical thinking, communication, creativity, teamwork and leadership skills.

Currently, another category of skills has emerged – digital skills. These include the ability to use information and data, communication and collaboration, media literacy, creating digital content (including programming), security (including digital comfort and competencies related to cybersecurity), intellectual property issues, problem-solving and critical thinking (EU Council Recommendations, 2018). They are relevant to all participants in the digital world, i.e. average Internet users, but also include special digital skills for ICT specialists and employees supporting modern technologies.

Considering future fields of employment, technical students should be prepared to meet the requirements of Society 4.0 and Industry 4.0 arising from the fourth industrial revolution. The technological concept of cyber-physical systems and the industrial Internet of Things lead to a model of an intelligent factory. The "Industry 4.0" vision is characterized by highly individualized and at the same time cross-linked production processes. Physical reality and virtuality are increasingly melting, and international teams collaborate around the world in virtual environments. Future engineers must be prepared to work in such conditions. Educational systems should use tools (virtual learning environments [VLEs]) to help them acquire the necessary new skills (Schuster et al., 2015, p. 5; Schuster et al., 2016).

The fourth industrial revolution promises to increase efficiency, flexibility, and automation of internal business processes, integrating value chains and supporting companies in designing and offering innovative services based on the availability of data provided by various technologies. As a result, companies are doing their best to understand how Industry 4.0 technologies can be implemented to increase their current operations and provide a more competitive offer to existing and new customers.

Due to the constantly changing and evolving industrial environment shaped by new technologies, students who are to supply the labour market must meet the needs and expectations of the industry. This can be ensured by improving education systems and, above all, by harmonizing academic education with new technologies. In this context, it is becoming increasingly important to determine the level of knowledge and interest of technical students in new technologies related to Industry 4.0. The literature already provides examples of this type of research (Motyl et al., 2017; Sertel et al., 2020; Omar, Hasbolah, 2018). Their results reveal students' opinions on Industry 4.0 and their priorities and expectations from engineering education. They show that students' knowledge of Industry 4.0 is very superficial. Industry 4.0 has enormous potential, but to make good use of it, curricula need to be adapted to integrate technological issues with the new skills required in the industry 4.0 environment.

## 3. Methodology

The concept of Industry 4.0 is still relatively new in Poland, which is why the level of awareness and knowledge about it is important for its effective implementation. This chapter is an attempt to explore the concept of awareness of Industry 4.0 in the group of respondent professionals in the area of computer science.

The research was aimed at finding out the level of knowledge and perception of students of Computer Science on Industry 4.0. The idea was to know the attitudes and opinions regarding Industry 4.0, willingness to act in its conditions and the awareness of the importance and potential benefits of such solutions.

The group of respondents was selected because in the future they will work in a digital work environment and it will be on them, among others, that the efficient implementation of various types of applications and technologies from the Industry 4.0 area will depend. Because Industry 4.0 is the future foundation of economic development, business entities, employees, but also consumers will be doomed to function in a virtual environment. Therefore, it seems interesting to examine how IT students, for one group, perceive Industry 4.0, what is their knowledge of the subject and their awareness of how this phenomenon works.

The study was conducted in a group of students of the Lublin University of Technology in December 2019. The group of respondents was a group of 205 students of Computer Science major full-time first-cycle studies, representing all years (I, II, III and IV years of study). The study was dominated by a group of 3rd and 4th-year students, constituting 74.6% of the respondents. The research tool was a structured questionnaire containing closed and open questions (14 main questionnaire questions and 5 metric questions).

## 4. Results and Discussion

The socio-demographic characteristics of the respondents are presented in Table 1. The dominant group in the study were men (84.9%). A little over 30% of respondents worked while studying, of which 76.6% in the industry as a programmer, Java Developer, Software Engineer, designer, or website moderator. The most numerous group of respondents (33.2%) were residents of Lublin.

Table 2 contains information on the use of computers and the Internet by the respondents. All the respondents had a computer. They were also users of smartphones (96.6%), smartwatches (18.5%), tablets (31.7%), e-book readers (18.5%), mp3 players (19.5%) and video game consoles (27.3%). 37.6% of the respondents claimed that they had been using the computer for as long as they could remember, and over half of them had been doing it for over 10 years, while for about 9% the use of computers stretched over 5–10 years. No one admitted to using a computer for less than five years. They were also experienced Internet users – 57.1% had over 10 years of internet experience, approx. 30% had used the Internet for over 5 years, 14.1% had been Internet users for as long as they could remember. The respondents were also active in social media – over 60% of them used them for 5–10 years, every 10th student had been using social media for over 10 years, only 12.7% of respondents did not use them. The respondents were active Internet users. Over 40% of them used it for over 6 hours a day. As many as 96% of the respondents spent over 3 hours online. Nobody spent less than 1 hour during the day on network activity. At least once a day, respondents searched for information on the Internet (94.1%), used social networks (85.8%), applications that allowed collaboration and data sharing, such as Google, Dropbox, or Skype (75.6%), they checked e-mail (72.7%), read and downloaded documents from the Internet (66.3%), used Office applications (21.9%) and performed activities related to running a website or blog (6.3%).

**Table 1.** Socio-demographic characteristics of respondents

| **Variable** | **Number** | % |
|---|---|---|
| Age | | |
| 18–25 | 205 | 97.6 |
| 26–40 | 5 | 2.4 |
| Sex | | |
| Woman | 31 | 15.1 |
| Man | 174 | 84.9 |
| Professional status | | |
| Non-working person | 141 | 68.8 |
| A working person | 64 | 31.2 |
| Place of residence | | |
| Village | 61 | 29.8 |
| City up to 20,000 inhabitants | 21 | 10.2 |
| The city of 20–50 thousand inhabitants | 15 | 7.3 |
| The city of 50–100 thousand inhabitants | 15 | 7.3 |
| The city of 100–200 thousand inhabitants | 15 | 7.3 |
| The city of 200–500 thousand inhabitants | 68 | 33.2 |
| A city of over 500,000 inhabitants | 10 | 4.9 |

**Source:** own study

**Table 2.** Information about computers and the Internet

| **Variable** | **Number** | % |
|---|---|---|
| Possession of equipment | | |
| Desktop computer or laptop | 100 | 100 |
| Smartphone | 198 | 96.6 |
| Smartwatch | 38 | 18.5 |

| Variable | Number | % |
|---|---|---|
| Tablet | 65 | 31.7 |
| Electronic book readers | 38 | 18.5 |
| Mp3 player | 40 | 19.5 |
| Video game console | 56 | 27.3 |
| Duration of computer use | | |
| A month or less | 0 | 0 |
| Several months (up to 1 year) | 0 | 0 |
| 1–2 years | 0 | 0 |
| 2–5 years | 0 | 0 |
| 5–10 years | 18 | 8.8 |
| More than 10 years | 110 | 53.6 |
| For as long as I can remember | 77 | 37.6 |
| Duration of Internet use | | |
| A month or less | 0 | 0 |
| Several months (up to 1 year) | 0 | 0 |
| 1–2 years | 0 | 0 |
| 2–5 years | 0 | 0 |
| 5–10 years | 59 | 28.8 |
| More than 10 years | 117 | 57.1 |
| For as long as I can remember | 29 | 14.1 |
| Activity on social media | | |
| I do not engage in such activity | 26 | 12.7 |
| A month or less | 0 | 0 |
| Several months (up to 1 year) | 0 | 0 |
| 1–2 years | 0 | 0 |
| 2–5 years | 31 | 15.1 |
| 5–10 years | 125 | 61 |
| More than 10 years | 23 | 11.2 |
| Daily Internet activity | | |
| 0.5–1 hours | 0 | 0 |
| 1–2 hours | 8 | 3.9 |
| 3–4 hours | 61 | 29.7 |
| 5–6 hours | 49 | 23.9 |
| Over 6 hours | 87 | 42.4 |

| Variable | Number | % |
|---|---|---|
| Regular activities (performed at least once a day) | | |
| Use of email | 149 | 72.7 |
| Using Office applications (e.g., Word, Excel, PowerPoint) | 45 | 21.9 |
| Searching for information on the Internet | 193 | 94.1 |
| Reading and downloading documents from the Internet | 136 | 66.3 |
| Running a website, blog | 13 | 6.3 |
| Using applications allowing collaboration and data sharing, such as Google, Dropbox, Skype | 155 | 75.6 |
| Using social networks (e.g., Facebook, Twitter) | 176 | 85.8 |

**Source:** own study

**Table 3.** Defining the concept of Industry 4.0

| What does the term Industry 4.0 include? | Frequency | % |
|---|---|---|
| artificial intelligence (including machine learning) | 115 | 56.1 |
| virtualization of production processes | 85 | 41.5 |
| intelligent sensors (including those reacting to human presence nearby) | 78 | 38 |
| the use of advanced materials and processing technologies | 73 | 35.6 |
| the use of large data sets, the ability to collect and analyse data in real-time, reducing the cost of data storage | 72 | 35.1 |
| networks of advanced production equipment controlled by computers connecting them into a physical and digital environment | 69 | 33.6 |
| industrial Internet of Things | 63 | 30.7 |
| a new quality of communication, universal access to the Internet | 62 | 30.2 |
| technologies or innovations that introduce digitization of manufacturing or business processes | 61 | 29.7 |
| cooperation in the field of advanced production networks | 57 | 27.8 |
| renewable energy sources | 49 | 23.9 |
| knowledge discovery technologies to support process automation (e.g. applications for advanced data analysis, image, sound and text analysis tools) | 47 | 22.9 |

| What does the term Industry 4.0 include? | Frequency | % |
|---|---|---|
| applying changes in the concept of organisation of the enterprise value chain | 45 | 21.9 |
| actions conducive to energy efficiency and decentralization of decision making | 45 | 21.9 |
| device mobility | 43 | 21 |
| solutions for the protection of industrial systems | 40 | 19.5 |
| business systems integration solutions | 33 | 16.1 |
| mature solutions and technologies supporting production processes, such as ERP or SCADA software | 25 | 12.2 |
| RPA systems or predictive maintenance solutions (predictive maintenance of e.g. machines or production lines) | 22 | 10.7 |
| increasing service orientation | 16 | 7.8 |

**Source:** own study

The respondents' knowledge about what the term "Industry 4.0" covers is presented in Table 3. The basic source of knowledge about this concept is the Internet, which was the answer of every fourth respondent. 65% of respondents admitted that they had never met with this concept (which is surprising in the face of the assumed selection of the research sample), at the same time unflatteringly indicating the mismatching of curricula to actual economic and technological conditions in this respect (Table 4).

Respondents were asked to comment on the skills they require from employees of Industry 4.0. The areas of skills that were identified in the study are presented in Table 5.

**Table 4.** Source of knowledge about Industry 4.0

| In what circumstances did you meet the term Industry 4.0? | Frequency | % |
|---|---|---|
| article in a specialized scientific journal | 14 | 6.8 |
| article in the daily press | 4 | 1.9 |
| information contained on the Internet | 50 | 24.4 |
| information from friends | 23 | 11.2 |

| In what circumstances did you meet the term Industry 4.0? | Frequency | % |
|---|---|---|
| I have never met this date | 134 | 65.4 |
| information obtained at school/university | 9 | 4.4 |

**Source:** own study

**Table 5.** Skills useful in industry 4.0

| What skills does Industry 4.0 require from employees? | Frequency | % |
|---|---|---|
| programming machines, robots, integrated systems | 126 | 61.5 |
| data management (information architecture, storage) | 112 | 54.6 |
| data analytics, data science | 92 | 44.9 |
| machine interfaces, machine control, machine communication | 90 | 43.9 |
| software development (enterprise application development, customization) | 74 | 36.1 |
| production management | 69 | 33.6 |
| data security (security architecture, defence mechanisms) | 67 | 32.7 |
| planning of engineering processes | 66 | 32.2 |
| interdisciplinary approach to technology | 62 | 30.2 |
| communication network management | 54 | 26.3 |
| organisation of human work (manual processes) in automated production | 52 | 25.4 |
| soft skills (openness to changes, ability to work in a team, building relationships, (intercultural) communication using virtual tools) | 46 | 22.4 |
| customer experience management (the sum of customer experiences that are associated with a given product brand or company) | 35 | 17.1 |

**Source:** own study

Respondents identify the positive effects of applying Industry 4.0 solutions (tab. 6). They point out that they are conducive to increased efficiency and productivity (74.6%), reduced production costs (52.2%), increased revenues (50.7%) and improved quality of products and services (50.7%). Next, the respondents indicate that Industry 4.0

solutions shorten the period from design to sale (43.9%), make the production process more flexible (38.5%) and promote the introduction of improvements and innovations (38.5%). Over 1/3 of respondents (34.6%) see the positive impact of Industry 4.0 on the emergence of new business opportunities and areas. In their opinion, Industry 4.0 also has a positive impact on reducing labour costs (25.8%) and improving the quality of customer service (24.4%). For these reasons, 54.1% of respondents claim that Industry 4.0 is the future of industrial development also in Poland. Only every tenth respondent does not see development opportunities in the application of Industry 4.0 solutions.

**Table 6.** Benefits of implementing Industry 4.0 solutions

| What benefits do you see from implementing Industry 4.0 solutions? | Frequency | % |
|---|---|---|
| increase in efficiency or productivity | 153 | 74.6 |
| cost reduction | 107 | 52.2 |
| revenue increase | 104 | 50.7 |
| improving the quality of products and services | 104 | 50.7 |
| shortening the period from design to sale | 90 | 43.9 |
| greater production flexibility | 79 | 38.5 |
| rapid implementation of improvements and innovations | 79 | 38.5 |
| creation of new business opportunities and areas | 71 | 34.6 |
| employment reduction | 53 | 25.8 |
| improving customer service | 50 | 24.4 |

**Source:** own study

## 5. Conclusions and Recommendations for Practical Application

The present research has shown that knowledge about Industry 4.0 among IT students is quite superficial. The problematic areas are the sources from which students derive knowledge on the subject. The basic source mentioned in the research is the Internet, which raises further questions about the quality of information obtained by them (taking into account problems with the quality and reliability of information found in the web). The results obtained also show that the curricula do not match the actual economic and technological conditions in this respect. Only 4.4% of respondents admit that they met the term "Industry 4.0" during academic classes, and in addition only in one particular class. One may wonder about the causes of this and what actions should be taken to improve this situation. These issues may be an interesting subject for further research.

It is optimistic that respondents see the benefits of implementing Industry 4.0 solutions and assess that they represent the future of manufacturing activities. There is therefore a need to intensify efforts to broaden knowledge about Industry 4.0, to awaken the need to use its solutions and to acquire practical skills in this field. One should strive to broaden the awareness of future employees – era 4.0 engineers and sensitize them to the issues of Industry 4.0 through appropriate educational programmes, seminars and workshops so that when entering into professional life they might have proper preparation for functioning in the environment of Industry and Economy 4.0 and seek to apply such solutions in future workplaces. At the same time, one should also take into account the fact that they are simultaneously a group of potential future consumers who should also be prepared to operate in the conditions of Economy 4.0.

It would seem that establishing Industry 4.0 as one of the EU's priorities and allocating a specific pool of financial resources from European funds to finance investments in Industry 4.0 should cause an avalanche increase in interest in such solutions. Practice shows, however, that these are not sufficient and dominant factors conditioning development in this area. Equally important is the attitude of users of modern technologies, on the side of both suppliers and customers, their belief in the validity and effectiveness of such solutions and skills (mainly among employees) that Industry 4.0 requires.

Therefore, it seems that the implementation of Industry 4.0 solutions should necessarily be accompanied by a popularization campaign. Perhaps part of the financial resources allocated for investments in this area should be redirected to awareness and educational activities of future users of these solutions (in the aspect of this study, primarily future engineers of the 4.0 era). This would certainly avoid leaving future opportunities unexploited and thus wasting the financial resources involved in investments related to Industry 4.0. It is necessary to ensure a good education system that will equip future 4.0 engineers with the skills and qualifications necessary in this environment.

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