SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 238

DIGITAL COMPETENCIES IN SUPPLY CHAINS IN THE ERA OF INDUSTRY 5.0

Anna ŁUPICKA-FIETZ[1*], Anna Maria JESZKA[2]

[1] Poznań University of Economics and Business; anna.lupicka-fietz@ue.poznan.pl, ORCID: 0000- 0000-0003-1249-7547
[2] Poznań University of Economics and Business; anna.jeszka@ue.poznan.pl, ORCID: 0000-0002-6976-7408
* Correspondence author

Purpose: The purpose of this article is to identify and assess the key digital AND technical competencies necessary for effective supply chain management in the realities of Industry 5.0. under conditions of accelerated digitization.
Research methodology: the study was conducted using a diagnostic survey method, based on a CAWI questionnaire addressed to a purposively selected group of 34 senior managers - directors of logistics, purchasing and owners of companies operating in Poland and abroad. Competencies were assessed using a three-point Likert scale.
Results: The most frequently indicated competency was the ability to solve problems in a digital environment, considered a basic requirement for effective leadership. This included analytical, interpersonal and strategic skills. The importance of complex thinking, projective planning, general technological knowledge, and data and information analysis was particularly strongly emphasized. Both Polish and foreign market managers emphasized the need to develop competencies that allow them to operate efficiently in a complex and rapidly changing environment.
Research limitations/implications: The limitation of the study remains the small, purposefully selected sample of respondents, which limits the possibility of fully generalizing the results. However, the results obtained can serve as a starting point for further quantitative and qualitative research, taking into account industry and cultural differences.
Practical implications: The results of the survey can support HR departments and managers responsible for talent development in planning training programs to improve the skills of managers. Particular attention should be paid to developing digital skills linked to supply chain management in an integrated technology environment.
Social implications: The study emphasizes that the development of digital competencies must go hand in hand with social skills, supporting the human-centric nature of Industry 5.0. This approach can foster a sustainable work environment.
Originality/value: The article brings a new perspective to the issue of managerial competencies, highlighting their digital dimension in supply chain management in the medical equipment industry. It provides a valuable contribution to academia, business practitioners and HR departments.
Keywords: digital competencies, managers, supply chain, Industry 5.0, medical equipment sector, digital transformation.
Category of the paper: research paper.

1. Introduction

Supply chains are facing increasing complexity, are increasingly global in scope and are increasingly vulnerable to disruption. In this context, the skills to efficiently use digital technologies and tools that support decision-making and operational and strategic management to a high degree are becoming increasingly important The purpose of this paper is to identify and assess the digital competencies necessary to gain a competitive advantage in supply chain management in today's reality of rapidly changing conditions in the global economy.

Industry 5.0, dubbed the next industrial revolution, is a paradigm that places the interaction of humans and technology at the center. What was at the heart of Industry 4.0, i.e. automation and increased operational efficiency, is giving way to three new assumptions: technologies are to support employees and thus streamline processes and increase productivity, (human at the center), all activities are to foster environmental protection and technologies are to increase the positive impact on society (sustainability and social responsibility), and building production stability and security by designing processes and systems that are resistant to disruptions such as pandemics, conflicts. In this context, digital competencies become the foundation for realizing the potential of modern technologies. The topics raised, and especially the research conducted, fill the research gap on the role of digital and technical competencies in Industry 5.0. To date, no research has been conducted on the importance of digital and technical competencies in the context of Industry 5.0. Therefore, it is reasonable to ask, what is the importance of the identified technical and digital competencies in the era of digitization, supporting the human-centered approach in Industry 5.0? The structure of the article meets the need to justify the research gap. Digital competencies in supply chains were characterized, along with a relevant literature review of the Industry 5.0 era. This was followed by a literature review based on the identified research gap and a proposal of its own set of competencies for Industry 5.0. The next step was to present the characteristics of the research and the industry in which it was conducted, and to identify the importance of the selected medical equipment industry. The article concludes with a discussion and conclusions and recommendations that clearly indicate the importance of digital and technical competencies in Industry 5.0.

2. Literature review

Supply chain management needs not only digitization-related tools, but also new skills dictated by the economy's transformation to Industry 5.0. While Industry 5.0 offers a promising framework for human-centered, sustainable and resilient supply chains, its full potential has yet to be realized. As organizations seek to implement advanced technologies, they must also

address the challenges of workforce adaptation and the ethical implications of digital industrialization. They must incorporate social considerations into their operational strategies by ensuring a balance between technological advances and human-centered practices (Gladysz et al., 2023; Shi et al., 2023) . The emergence of new responsibilities, tasks, as well as roles, e.g., working with robots, equipment, algorithms, so that employees effectively interact with new technologies requires time and preparation. Digital competencies in particular can have a significant impact on supply chain optimization and efficiency, transparency and resilience. Although the concept of Industry 5.0 focuses primarily on the high-tech manufacturing environment, management competence in this aspect seems equally significant.

2.1. Digital transformation of the supply chain in the context of Industry 5.0

At the center of the dynamic changes associated with digitization is a human-centered approach, where technology does not replace humans, but enhances their capabilities and supports their potential and intelligence (Chidozie et al., 2024). A separate issue is the consideration of the most important factor in this transformation, i.e. people, employees at various levels and their approach to transformation and digitization in organizations (Tabrizi et al., 2019)

Digitization is the technological basis for change in organizations. Digital transformation in a broad sense has many definitions and figures reporting on various aspects of human activity, not necessarily related to industry and business (Kraus et al., 2021). Digital transformation is not limited to changing information into a digital format. In a sense, it can be defined as a fundamental rethinking of how organizations operate and deliver value using digital technologies and data-driven strategies (Kraus et al., 2021). Digital transformation in supply chains, on the other hand, can be linked to fundamental change that significantly alters business processes, structures and organizational culture between supply network partners as well.

Innovative technologies serve as building blocks for transformation and supply chain management practices to achieve sustainability and resilience in the face of changing challenges and disruptions (Agrawal et al., 2024).

The term Industry 5.0 can be seen as an umbrella term for the modern use of intelligent automation, data exchange and processing and manufacturing technologies, although the phenomenon is developing in parallel with the Industry 4.0 paradigm (Gladysz et al., 2023). Key digital tools relevant to supply chain digitization include (Chidozie et al., 2024; Madsen et al., 2023; Shi et al., 2023; Zouari et al., 2021):

- Internet of Things (IoT): IoT devices, embedded with sensors and connectivity, enable the collection of real-time data throughout the supply chain; this includes, for example, inventory levels or conditions during transportation.

- Big Data Analytics: big data analytics tools enable real-time processing of information to predict, for example, fluctuations in demand, supply shortages, advanced analytics allows to predict disruptions in the supply chain in time and respond to them more effectively, monitor inventory or track shipments.
- Blockchain technology: blockchain involves recording transactions throughout the supply chain, increases transparency, security, providing a verifiable history of products and processes.
- Artificial Intelligence (AI) and Machine Learning (ML): artificial intelligence (AI) and ML algorithms enable automation of repetitive tasks, optimization of complex processes. Technology improves demand forecasting or route optimization.
- Cloud computing: Cloud computing is "a model for enabling ubiquitous, convenient on-demand network access to a shared pool of configurable computing resources that can be quickly shared and released".
- Digitization facilitates faster order processing, precise delivery tracking and personalized interactions with customers. This leads to greater customer satisfaction and loyalty by meeting customer expectations for speed and transparency.

Digitization of the supply chain is emerging in an era where real-time communication and coordination is taking place (Zouari et al., 2021) .

Using advanced technologies, companies can analyze massive amounts of data to predict customer preferences, optimize delivery routes in real time and personalize interactions with customers. For example, artificial intelligence-based algorithms can adapt to changing demand patterns, ensuring efficient allocation of resources during peak hours (Gladysz et al., 2023).

Industry 5.0 is characterized by digital transformation and digital integration with an emphasis on technologies redesigned for human-centeredness, connectivity, sustainability and resilience (Durugbo, 2025).

The 5.0 paradigm places a strong emphasis on environmental and social sustainability. For supply chains, this translates into operational processes that minimize environmental impact, promote ethical sourcing and contribute to social well-being (Agrawal et al., 2024).

Three pillars on which Industry 5.0 is based (Breque et al., 2021; Coelho et al., 2023):

- Human-machine collaboration and human-centricity, which can lead to more efficient processes, enhanced collaboration and improved decision-making.
- Sustainability and social benefits, where Industry 5 0 can contribute to the development of environmentally friendly practices, the social impact of technological advances.
- Resilience, which many legacy manufacturing processes have lacked and making them resilient to any disruption (such as pandemic or conflict) is one of the pillars of Industry 5.0.

The most studied issue related to Industry 5.0 in a systematic review of the literature has recognized technologies such as artificial intelligence, big data, the Internet of Things, blockchain and cyber-physical systems (Madsen et al., 2023). Technologies such as are also mentioned (Chidozie et al., 2024; Shi et al., 2023).

Cobots, robots that collaborate with humans to help with tasks that require precision, improving productivity and safety in warehouses and manufacturing plants.

Digital Twins: digital twins, or virtual replicas of physical assets, processes and supply chains, are tasked with real-time monitoring, simulation and optimization.

Augmented (AR) and Virtual Reality (VR): These technologies are bringing significant changes to training and supply chain logistics. AR allows employees to access additional, contextual information, while VR allows for realistic training simulations.

AI-based decision support systems: The development of AI is leading to increasingly sophisticated analytical tools that, by leveraging massive data sets, support accurate decision-making and facilitate the management of complex processes in supply networks.

Research on Industry 5.0 highlights the growing importance of automation and robotics emphasizing the human-robot relationship (Coelho et al., 2023; Demir et al., 2019; Pizoń, Gola, 2023). A cyber-physical system today can take the form of autonomous production using human intelligence (Nahavandi, 2019). With the importance of cyber-physical systems knowledge and supervision in addition to supporting human-machine interaction (Grabowska et al., 2022). These technologies significantly affect supply chain processes and operations.

The literature emphasizes that in the next industrial revolution, the most important change is the shift in focus from technology-based progress (IoT, AI, digital twins, robotics, augmented reality, etc.) to worker-based progress. It is the industry to adapt to human needs, not humans to adapt to ever-evolving technology (Xu et al., 2021; Gladysz et al., 2023).

EC documents talking about the transformation of the European economy towards Industry 5.0. primarily emphasize the importance of human capital. Technology is there to serve people (Breque et al., 2021; European Commission et al., 2021).

To deepen our understanding of the changing landscape in the context of digital transformation and the ongoing transformation of the economy towards Industry 5.0, it is necessary to highlight the key digital and technical competencies needed to manage supply chains.

2.2. Digital competencies in supply chains in the reality of economy 5.0

The main obstacle to the digital transformation is the lack of an adequately prepared workforce, with an increase in the number of workers who are unskilled or have competencies that are not suited to the requirements of the modern economy. The world, which is gradually overcoming the problem of illiteracy, is now facing the challenge of more intensive education and the need for re-education (Wincewicz-Bosy, Lupicka, Stawiarska, 2017). An analysis of past studies by researchers and practitioners indicates a certain lack in the demands related to

digital and technical competencies related to humanocentricity, sustainability, and the resilience of businesses and supply chains to changing economic conditions. The shift away from the key tenets of Industry 4.0 in favor of digitization processes is increasingly apparent. As a result of a review of available scientific publications, reports and book studies, a new, more precise catalog of digital competencies corresponding to the challenges of the Industry 5.0 era is emerging. The modern manager, in order to meet the demands of building organizational resilience, should flexibly develop and adapt the skills he or she possesses. This means applying different sets of competencies depending on the context and specifics of the situation (Łupicka-Fietz, Jeszka, 2024).

Based on a review of the literature (European Commission et al., 2021; McLaren, 2021; Audrey, Paksi, 2021; Dwivedi et al., 2023; Song et al., 2021; Knut, Balaji, 2013; Gartner, 2023; APICS, 2014; Hoffman et al., 2005; Relich, 2015; Joerres, McAuliffe, 2016; Winter, Heindl, 2016; Davis et al., 2011; Bauer et al., 2015; Störmer et al., 2014; Pompa, 2015) identified the 16 most commonly identified digital and technical competencies relating to the operation of supply chains in the reality of Economy 5.0.

General digital skills

Basic digital skills and knowledge of software are essential for operating in the digital economy. General IT skills can be defined as the ability to use information and communication technologies and move freely in a digitized environment. General IT skills can include operating computer hardware, which involves running, configuring and basic maintenance of devices such as a computer, laptop or smartphone, using operating systems, including Windows and Linux, as well as managing files and folders (Majewski, 2018).We can also include creating and editing text documents, spreadsheets and multimedia presentations, as well as searching for information, assessing the reliability of sources, using email, video conferencing and instant messaging (Szeliga, 2020).

Of course, digital security is not insignificant, consisting of knowing how to protect data, using passwords and recognizing phishing or malware threats (Castells, 2010; Szeliga, 2020). When discussing basic digital skills, it is worth noting the ability to solve simple technical problems, such as restoring an Internet connection or changing device settings (European Union Agency for Cybersecurity [ENISA], 2021).

General IT skills are a "must have" for any adult. They are compared to the ability to write or read - they are essential competencies for both work and everyday life. General IT skills are basic abilities related to the use of information and communication technologies (ICT), including both the operation of computer hardware and the use of popular office applications, web browsers and basic communication tools. These competencies enable the user to function efficiently in the digital environment, and provide a foundation for developing more advanced digital skills.

Managing knowledge regarding the use and harm of digital technologies to the environment

Organizations are committed to operating in a sustainable manner. Knowledge of digital technology use and harm is the same as corporate social responsibility. Competencies include recognizing the negative impacts of technologies (e.g., CO_2 emissions, e-waste, energy intensity of data centers) and positive uses (environmental monitoring, closed-loop economy) (Malmodin, Lundén, 2018). Among other relevant issues related to this competency, it is worth mentioning awareness of the life cycle of digital devices (Forti, Baldé, Kuehr, Bel, 2020) and promoting digital sustainability by improving communication skills and educating employees and communities about the green aspects of technology (European Commission, 2022). Having this competency means being able to make environmentally friendly digital decisions, implement measures to reduce energy consumption, streamline business processes with minimal environmental impact, and foster a culture of environmental responsibility.

Data and information processing and analytics

Data science and analytics are among the most sought-after and rapidly growing disciplines. However, because the field crosses the boundaries of many disciplines and its skills are still evolving, it is often difficult to define its specific set of skills and competencies. This competency consists of the ability to acquire, collect, process, analyze and interpret data and information in order to make informed decisions and add value in various areas of activity. It includes both technical skills (analytical tools and methods) and a critical approach to data quality and reliability. This competency can include data acquisition and organization as the ability to search, select and collect data from various sources (internal and external), including big data (big data) (Kitchin, 2014). In addition, it is worth mentioning data processing, analysis, interpretation and visualization, presenting the results in a clear and useful way, using data visualization tools (e.g., dashboards, infographics) (Few, 2012; James et al., 2021). The practical application of this competency is evident in the use of data analytics to optimize processes, support business, scientific or administrative decisions (Davenport, Harris, 2007). Possession of this competency enables effective use of data for decision-making, enhancing innovation and competitiveness, identifying trends, and supporting transparency of evidence-based activities.

General knowledge of technologies

General knowledge of technologies refers to a basic understanding and knowledge of technologies used in the modern world, both in daily life and in professional activities. It includes awareness of the operation, capabilities and limitations of various technological solutions, as well as their impact on society, the economy and the environment. The scope of competence includes knowledge of the general mechanisms of digital, communication, production, transportation and energy technologies (Volti, 2017), awareness of their applications in various sectors, such as medicine, education, industry or administration (Volti, 2017), orientation to the development trends of modern technologies, such as artificial

intelligence, the Internet of Things, biotechnology and robotics, among others (Schwab, 2016), the ability to critically analyze the benefits and risks of technology, including ethical and environmental aspects (Mitcham, 1994), as well as an understanding of their impact on the labor market, communications, lifestyles and social relations (Castells, 2010).

General knowledge about organizations

General knowledge of organizations involves understanding the fundamental principles of organizations, including their goals, formal and informal structures, and management processes (Scott, 2015). It includes the ability to analyze key areas of operation, such as human resource management, financial management and operational processes, as well as an orientation to various types of organizations, whether commercial, public or non-profit (Daft, 2021; Mintzberg, 1993). This competency also includes knowledge of decision-making processes and information flow within the organization, awareness of the impact of the market, social, legal and technological environment on organizational operations, and the basic principles of adapting organizations to change and implementing innovations (Burnes, 2017; Hatch, 2018; Robbins, Judge, 2019).

Specialized and up-to-date knowledge of technologies and organizations

The competence of specialized and up-to-date knowledge of technologies and organizations consists of an in-depth knowledge of modern technological solutions and contemporary organizational structures and processes, enabling an understanding of development trends, assessment of the effects of innovations and their impact on organizational performance and the environment (Arthur, 2009; Daft, 2021; Schwab, 2016; Scott, 2015). It includes advanced technological knowledge of digital, information, production, energy and communication systems, including their capabilities, limitations and integration into organizational processes (Arthur, 2009; Schwab, 2016), as well as up-to-date knowledge of organizations, including contemporary structures, management models, decision-making processes, communication, and adaptation to change and the impact of the external environment (Daft, 2021; Scott, 2015). This competency also includes awareness of the direction of technology and management methods, and knowledge of potential benefits and risks, including ethical, environmental and social aspects (Burnes, 2017; Mitcham, 1994).

Statistical skills

Statistical skills are an important component of modern workforce competencies, as they refer to the ability to collect, compile, analyze, interpret and present data in such a way as to enable reliable conclusions and fact-based decision-making. They are defined in various ways in the literature. Moore, McCabe and Craig (2017) define statistics as the field that deals with the collection, analysis and interpretation of data, emphasizing that statistical competence boils down to the use of its methods in the decision-making process. Rumsey (2016) points out that they mean the ability to understand data and its variability, interpret results, and evaluate the quality of analyses. The American Statistical Association (2016) emphasizes the importance of so-called statistical literacy, understood as the ability to critically perceive statistical

information and put it to practical use in both professional work and everyday life. Utts (2003), on the other hand, emphasizes that statistical literacy includes the ability to analyze data under conditions of uncertainty and to draw conclusions using quantitative methods.

Ability to interact with modern interfaces

The ability to interact with modern interfaces is a competence that denotes the ability to effectively and consciously use various forms of human-computer communication. It refers to both classic graphical interfaces (GUIs) and newer developments such as touch screens, voice recognition systems, gesture-based interfaces, as well as augmented and virtual reality (AR/VR) technologies or conversational interfaces such as chatbots and voice assistants. An important component of this competence is the ability to adapt to new forms of interaction, to critically evaluate their functionality and to be able to use them in everyday life and work, especially in environments that require the use of advanced IT systems or tools to support business processes. There are a number of definitions in the literature that converge. Norman (2013) emphasizes that modern user interfaces should be viewed as tools that support human activities through intuitiveness, simplicity and the ability to minimize cognitive load. Hassenzahl and Tractinsky (2006) emphasize that an important aspect of this competence is the user's ability to experience the interface as useful, friendly and aesthetically pleasing, which influences the satisfaction and effectiveness of the interaction. On the other hand, Dix, Finlay, Abowd and Beale (2004) point out that interacting with interfaces involves mastering input/output techniques, understanding interaction models, and adapting to a variety of human-system communication modes.

Complex thinking

Complex thinking is the ability to translate vast amounts of data into abstract concepts that allow one to see and understand the nature and significance of change. It involves analyzing and solving problems of high complexity, ambiguity and variability. It involves identifying connections between multiple elements of a system, studying their interrelationships, and predicting the effects of decisions over the long term. This ability requires not only critical reflection and analytical thinking, but also creativity, flexibility and the ability to integrate information from different areas. The OECD (2018) defines complex thinking as the ability to solve problems in a dynamically changing environment that is characterized by multidimensionality and uncertainty Senge (2006) points out that complex thinking is closely related to systems thinking, which means the ability to grasp the whole by understanding the relationships and feedbacks between system elements. Csapó and Funke (2017), on the other hand, emphasize that it encompasses the ability to deal with problems that require understanding and controlling dynamic systems and anticipating the consequences of actions in the long term.

Cognitive load management

Cognitive load management is the ability to consciously direct and regulate one's mental resources in such a way as to effectively receive, process and use information in the process of learning, working or making decisions. It includes matching task complexity to cognitive

capacity, reducing distractions and optimally using working memory. Paas and Van Merriënboer (1994) emphasize the role of metacognitive strategies that enable control over the thinking process and better management of cognitive resources. Kirschner, Ayres and Chandler (2011) add that cognitive load management is particularly important in education and environments where rapid decision-making is required, and supports the development of digital skills.

Knowledge of various business and operational processes

This knowledge refers to the ability to recognize, understand and interpret the principles by which a business operates. It includes an awareness of core business areas - such as planning, production, logistics, marketing or finance - and recognizing their interrelationships and impact on organizational effectiveness (Hammer, Champy, 1993). Davenport (1993) stresses that it helps identify the stages of operational activities and identify ways to improve them. Porter (1985) points to its importance for competitive advantage, and Hammer (2010) and Davenport and Short (1990) link it to modern management methods such as business process reengineering.

Projective thinking

Projective thinking is the ability to anticipate potential events and possible developments, as well as to plan activities in a forward-looking perspective. Voros (2003) describes it as the process of foresight, which involves analyzing trends and creating scenarios. Miller (2007) emphasizes the role of data interpretation skills and imagination in creating alternative visions of the future. Sardar (2010) emphasizes that projective thinking plays an important role in adapting to uncertainty, and Slaughter (1995) sees it as a principle that shapes cultural resilience. Candy and Dunagan (2017) point to the importance of projective thinking in designing scenarios and preparing for future challenges.

Knowledge of new media

New media literacy refers to the ability to critically evaluate and use modern communication tools, such as social media, streaming platforms, websites and mobile applications (Jenkins, 2006). Livingstone (2009) emphasizes that it also includes understanding the impact of media on culture and social life. Castells (2009) emphasizes the multidirectional nature of communication in the digital environment. Buckingham (2003) points out that new media literacy involves building an informed online presence, recognizing risks and actively participating in digital culture.

Specialized digital skills

This competency includes advanced knowledge and practical skills in developing, implementing and maintaining information systems. Pressman (2014) describes it in the context of software engineering. Stallings (2017) emphasizes the importance of IT security, and Laudon and Laudon (2020) point to their role in information management. Sommerville (2016) adds that they also require knowledge of design methods such as Agile and DevOps.

Basic risk management knowledge

Basic risk management knowledge means understanding the principles of identifying, analyzing, assessing and evaluating, as well as controlling and monitoring risks to an organization. Risk management uses methods such as HAZOP, BowTie analysis or FMEA, among others.

Basic knowledge of business continuity management

This competency refers to knowing how to plan and implement processes that allow an organization to function despite disruptions. Herbane (2010) points to the need for a crisis approach, ISO (2019) sets standards in this area, and Bhamra, Dani and Burnard (2011) emphasize the importance of resilience and the ability to recover. The essence of business continuity management is the creation of contingency and so-called "Recovery" plans that will allow the organization to return to normal operations in a short period of time.

3. Research methodology

To carry out the research, the authors used a survey method, directing a questionnaire to a purposively selected group of respondents. The research sample included senior managers responsible for logistics and supply chains in manufacturing companies (including directors of logistics and purchasing departments), as well as owners and CEOs of companies in the medical device sector. The selection of participants, although it limited the sample size and did not allow it to be representative, ensured a high level of substantive responses due to their knowledge, professional experience and international perspective on team management.

A total of 34 responses were obtained, including 20 from Poland and 13 from foreign markets. Only top executives were qualified to participate in the survey, and the sample size was due to organizational constraints. The questionnaire was preceded by direct e-mail or telephone contact with potential respondents, during which the purpose of the survey, the manner in which it was to be conducted and the importance of the issue under study were presented. At the same time, detailed substantive and technical guidance was provided to participants.

The questions in the questionnaire were developed on the basis of a review of the literature on the subject and the results of pilot studies conducted in 2017 and 2018 (Lupicka, Grzybowska, 2017, 2018), which made it possible to verify the existing set of competencies and expand it to include the new digital and technical competencies currently required. Based on them, the existing survey tools were modified, expanding them to include issues of digital competencies in the context of Industry 5.0. The survey covered companies located in Europe, North America and East Asia, operating in the medical device manufacturing sector.

The survey was conducted in June 2023. The questionnaire was prepared electronically and distributed via email. The method used was CAWI (Computer-Assisted Web Interview), which allows respondents to complete the questionnaire themselves in an online form. Respondents were guaranteed full anonymity. The survey tool was based on a three-stage Likert scale, where 1 meant the lack of relevance of a given competence, 2 - no clear opinion, and 3 - relevance of the competence. The choice of a three-level scale allowed not only to assess the importance of the studied characteristics, but also to capture neutrality in the responses.

The research process was carried out in accordance with the ethical principles set forth in the *Code of Ethics for Research Employees* (Committee on Ethics in Science, 2020) and with the applicable data protection regulations (RODO).

4. Industry characteristics

The medical device industry is a key component of the global health care system, covering a wide range of products used in the diagnosis, therapy, monitoring and prevention of disease. According to the World Health Organization (WHO), there are about 2 million different types of devices on the market, categorized into more than 7,000 general groups - from simple tools such as bandages or syringes to high-tech devices including pacemakers and MRI machines (WHO, 2023).

The data states that the medical device market reached $542.21 billion in 2024, and could grow to $886.68 billion by 2032 (Fortune Business Insights, 2024). The sector's growth is determined primarily by demographic and epidemiological factors, such as aging populations, population growth, and the increasing number of lifestyle diseases, including diabetes, obesity, cardiovascular disease and cancer. Currently, there are more than 400 million people with diabetes worldwide, and this number could increase by half in the next few years, with an estimated 200 million diabetics in China and India alone (PARP, 2021).

Demographic factors play a special role in shaping the future of the market. In the near future, senior citizens will make up about 20% of the European Union's population, and in Japan up to a third of the population. The global population is also projected to increase by about a billion by 2030, reaching 8.6 billion, and nearly 10 billion by mid-century (PARP, 2021). At the same time, there is a growing demand for technological solutions to compensate for the limitations of aging and often outdated hospital infrastructure, especially in Europe and the United States. Implementing modern digital solutions is becoming a key way to improve the quality, accessibility and cost-effectiveness of health care systems (BCC Research, 2023).

5. Results

Analyzing the table below, it can be seen that for domestic respondents the most important digital and technical competencies are data and information processing and analytics, and complex thinking. In contrast, for foreign respondents, the most important competencies are cognitive load management and projective thinking. Common to both groups of respondents is the competency of projective thinking. On the other hand, as for the competencies rated lowest, there were similar indications in both groups, concerning statistical skills and knowledge of new media.

Table 1.
Digital and technical competencies in light of the survey

Digital and technical competencies	Domestic respondents		Foreign respondents	
	Mean	Standard deviation	Mean	Standard deviation
Knowledge management regarding the use and harmfulness of digital technologies to the environment	1,9	5,85	2,5	3,21
Data and information processing and analytics	3,0	11,54	2,5	5,13
General knowledge of technologies	2,2	6,50	2,8	5,77
General knowledge of organizations	2,3	6,50	2,6	5,77
Specialized and up-to-date knowledge of technologies and organizations	2,1	2,51	2,6	4,93
Statistical skills	2,1	2,51	2,2	4,04
Ability to interact with modern interfaces	2,1	5,13	2,5	4,16
Complex thinking	2,9	10,69	2,9	6,65
Management of cognitive load	2,4	7,02	2,9	6,65
Knowledge of various business and operational processes in the organization	2,7	9,07	2,5	4,04
Projective thinking	2,5	6,65	2,9	6,65
Knowledge of new media	1,9	4,16	2,0	1,15
Specialized IT skills	1,6	4,61	2,3	2,30
Basic knowledge of risk management disruptions	2,7	9,07	2,5	4,16
Basic knowledge of business continuity management operations	2,6	8,32	2,7	5,85
General computer skills	2,5	6,65	2,5	4,16

Source: own elaboration based on surveys.

Slight differences are also apparent in the case of the competence of knowledge management regarding the use and harm of digital technologies to the environment. Here, domestic respondents showed that this is not a significant competence, while for foreign respondents it is already more important. The same is true of the competence concerning general knowledge of technologies. Foreign respondents considered this skill to be quite significant, while domestic respondents did not report a high degree of importance for this competence.

Similar indications of the average degree of importance of the competencies in question for both groups were for basic knowledge of disruption risk management or basic knowledge of business continuity management. Summarizing the table, it can be noted that domestic respondents generally rated most competencies lower compared to foreign respondents.

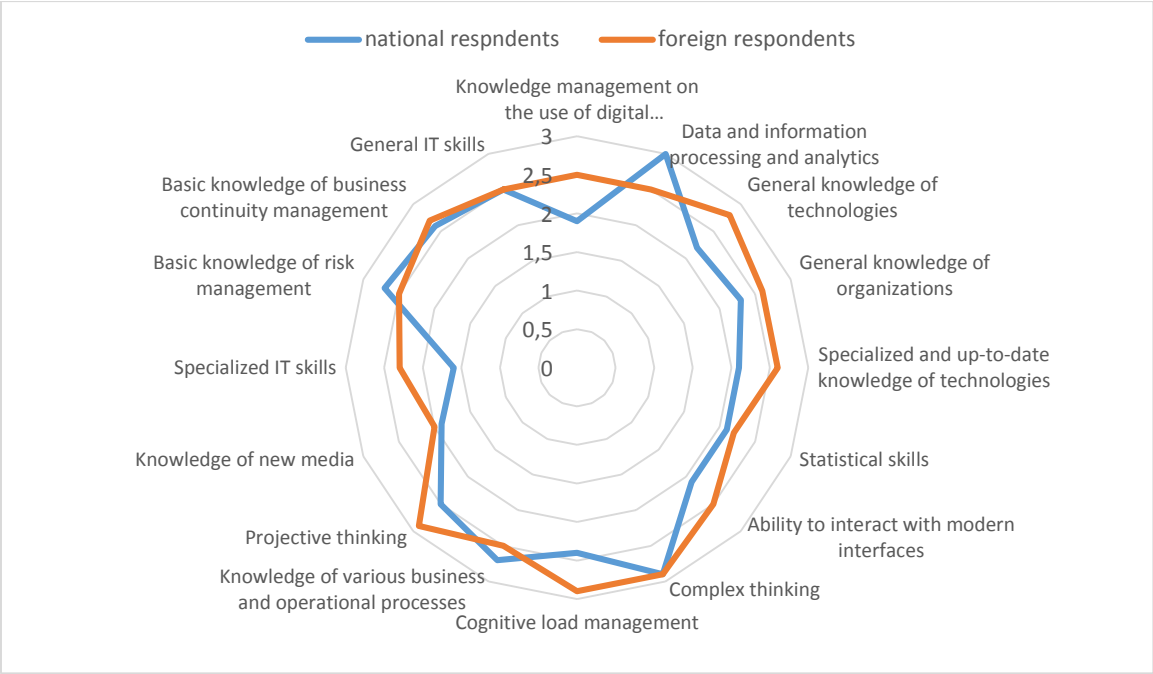

Figure 1. Digital competencies in the era of Industry 5.0.

Source: own elaboration based on the survey.

Analysis of the standard deviation results reveals mostly small differences in the distribution of responses between the Polish and foreign markets. The standard deviation (SD) determines the degree of dispersion of values in a data set, usually in relation to the mean of that group (Foltynowicz, Lupicka, Jeszka, 2024). In simple terms, the standard deviation indicates how much the values of a given quantity spread around the mean. The smaller the value of the deviation, the more the observations cluster around the mean. In the case of the "data and information processing and analysis" competence, a significant difference in the standard deviation becomes apparent - domestic respondents were more decisive in marking the same answer than foreign respondents. The situation is similar for the "complex thinking" competence. Despite the same mean, the standard deviation is incomparable. It can be seen that domestic respondents were also in this case more determined to mark the same answer than their foreign counterparts.

6. Discussion

Public reluctance towards artificial intelligence, including the use of IT expertise, stems from fears of new solutions to streamline processes and, above all, the feeling that these technologies limit traditional human work (Wincewicz-Bosy, Lupicka, Stawiarska, 2017). CEOs - the authors and implementers of these technologies - indicate that the development of AI-based systems and machines is unlimited. They intend to further improve functionalities,

introduce new analytical tools, especially in machine learning and advanced event processing. A variety of data will be used for this purpose, both from networks, supply chains and from individual actors involved in business processes.

Both customers implementing AI and those who are just considering its implementation, as well as their employees, the scientific and business communities - despite appreciating the benefits of artificial intelligence - express concerns about its risks, as strongly revealed by the results of surveys conducted, especially among domestic respondents. The indicated barriers and recommendations for its development were assigned to political-legal, economic, technological and socio-cultural categories (Wincewicz-Bosy, Lupicka, Stawiarska, 2017). Companies that have not yet decided to implement AI are looking for economic arguments. The difficulty is that it is still unclear how long the proposed solutions will last or how to accurately estimate the return on investment - especially in the absence of clear data on the savings generated by self-learning applications.

As a result, a development gap is emerging between companies that lack adequate information resources and large corporations, where artificial intelligence and digital competencies are becoming part of key decision-making structures, even at the board level (Wincewicz-Bosy, Lupicka, Stawiarska, 2017). This approach raises the question of whether new challenges will arise in the area of supply chain management and logistics, and what digital and technical competencies will be necessary to make sound decisions about the development of organizations and supply networks in the context of the transformation of the economy towards Industry 5.0.

In the reality of Economy 5.0, where the accent is on simultaneous economic, social and environmental development, as well as on improving technological skills and risk management competencies, human collaboration - a key capability in management, including in the area of supply chains - is becoming particularly important again.

Awareness of currently required skills, which should be included in personnel development policies, creates a need among employees for training, continuing education and upskilling, i.e. reskilling and upskilling activities. This challenge falls largely on Human Resources departments. Referring to the results of the survey, it is clear that the awareness of foreign respondents regarding the role of digital competencies is far greater than that of domestic respondents. This could be due to a number of reasons. One of them may be the higher level of development of foreign companies compared to Polish ones.

Referring to the DESI (2022) report, one can see the difference in the level of digitization of Poland compared to Europe. Our foreign colleagues see the need to integrate man and machine as an important challenge of managing non-collar workforce teams. Its key problem is the establishment of dependency vectors in joint (human-robot) decision-making and the related transparency of these decisions. Another reason is the continued lack of funding for Polish companies and opportunities to implement innovations. Entrepreneurs in the Polish market are struggling with problems such as the continuous increase in the minimum wage,

which results in the profits generated being used for salaries rather than for company development.

7. Conclusions

Based on the research, it can be concluded that in the face of constant and dynamic economic and technological changes, and especially in the context of the transformation towards Industry 5.0, digital and technical competencies are becoming increasingly important. This includes analytical, interpersonal and strategic skills. Respondents particularly emphasized the importance of such competencies as complex thinking, projective planning skills, general technological knowledge and data and information analysis.

Both Polish and foreign survey participants emphasized the need to develop competencies that enable them to function efficiently in a complex and rapidly evolving work environment. Differences in responses between groups may have been due to cultural differences or varying levels of digital maturity of individual organizations.

From the point of view of management practice, the results indicate the need to integrate the development of digital competencies into organizational strategies, especially in highly regulated and technologically advanced sectors, such as the medical device industry. They also underscore the importance of the interaction of technology and human capital, as without this synergy the implementation of the Industry 5.0 concept will not be possible.

It seems reasonable to conduct further research in this area. It is worth considering cross-industry analysis, in-depth qualitative research on the competencies of the future, as well as evaluation of the effectiveness of programs to develop digital and technical competencies in the context of the transformation of supply chains towards Industry 5.0.

The development of modern technologies is associated with the simultaneous emergence of new opportunities and challenges, especially in the context of its impact on the labor market and the difficulty of assessing the viability of deployments. Industry 5.0 accentuates the need to combine digital, technical and social competencies, as well as to systematically develop employees' skills. The results of the research show clear differences between Poland and countries with a higher degree of digitization, which is due, among other things, to limited funding opportunities for innovation and structural conditions of the labor market. Further implications for in-depth research may include:

1. the impact of digital competencies on the finances of supply chains in Industry 5.0,
2. the development of digital competencies based on informal connections that result in a willingness to share experience and acquired knowledge,
3. the impact of digital competence development on knowledge conversion in Industry 5.0 supply chains.

The above considerations and implications for further research will advance the understanding of the role played by digital competencies in supply chains in the era of Industry 5.0.

References

1. Agrawal, S., Agrawal, R., Kumar, A., Luthra, S., Garza-Reyes, J.A. (2024). Can industry 5.0 technologies overcome supply chain disruptions? A perspective study on pandemics, war, and climate change issues. *Operations Management Research, 17(2),* 453-468. https://doi.org/10.1007/s12063-023-00410-y
2. American Statistical Association (2016). *Guidelines for assessment and instruction in statistics education (GAISE) college report 2016*. American Statistical Association.
3. APICS (2014). *APICS Operations Management Body of Knowledge (OMBOK) Framework* (3rd ed.). APICS.
4. Arthur, W.B. (2009). *The nature of technology: What it is and how it evolves*. Free Press.
5. Audrey, A., Paksi, C. (2021). *Industry 5.0: A human-centric solution*. Springer.
6. Bauer, W., Hämmerle, M., Schlund, S., Vocke, C. (2015). Transforming to a hyper-connected society and economy - Towards an "Industry 4.0". *Procedia Manufacturing, 3*, 417-424. https://doi.org/10.1016/j.promfg.2015.07.200
7. BCC Research (2023). *The medical device market is booming in the future*. https://blog.bccresearch.com/the-medical-device-market-is-booming-in-the-future
8. Bhamra, R., Dani, S., Burnard, K. (2011). Resilience: The concept, a literature review and future directions. *International Journal of Production Research, 49*(18), 5375-5393.
9. Buckingham, D. (2003). *Media education: Literacy, learning and contemporary culture*. Polity Press.
10. Burnes, B. (2017). *Managing change*. Pearson Education.
11. Candy, S., Dunagan, J. (2017). Designing an experiential scenario: The people who vanished. *Futures, 86*, 136-153.
12. Castells, M. (2009). *Communication power*. Oxford University Press.
13. Castells, M. (2010). *The rise of the network society* (2nd ed.). Wiley-Blackwell.
14. Chidozie, B., Ramos, A., Ferreira, J., Ferreira, L.P. (2024). The Importance of Digital Transformation (5.0) in Supply Chain Optimization: An Empirical Study. *Production Engineering Archives, 30(1),* 127-135. https://doi.org/10.30657/pea.2024.30.12
15. Coelho, P., Bessa, C., Landeck, J., Silva, C. (2023). Industry 5.0: The Arising of a Concept. *Procedia Computer Science, 217*, 1137-1144. https://doi.org/10.1016/j.procs.2022.12.312
16. Csapó, B., Funke, J. (Eds.) (2017). *The nature of problem solving: Using research to inspire 21st century learning*. OECD Publishing.

17. Daft, R.L. (2021). *Organization theory and design* (13th ed.). Cengage Learning.
18. Davenport, T.H. (1993). *Process innovation: Reengineering work through information technology*. Harvard Business School Press.
19. Davenport, T.H., Harris, J.G. (2007). *Competing on analytics: The new science of winning*. Harvard Business School Press.
20. Davenport, T.H., Short, J.E. (1990). The new industrial engineering: Information technology and business process redesign. *Sloan Management Review, 31*(4), 11-27.
21. Davis, J., Edgar, T., Porter, J., Bernaden, J., Sarli, M. (2011). Smart manufacturing, manufacturing intelligence and demand-dynamic performance. *Computers & Chemical Engineering, 47*, 145-156. https://doi.org/10.1016/j.compchemeng.2012.06.037
22. Demir, K.A., Döven, G., Sezen, B. (2019). Industry 5.0 and Human-Robot Co-working. *Procedia Computer Science, 158*, 688-695. https://doi.org/10.1016/j.procs.2019.09.104
23. Dix, A., Finlay, J., Abowd, G.D., Beale, R. (2004). *Human-computer interaction*. Pearson.
24. Durugbo, C.M. (2025). Uncertainties of supply chain transition and integration for Industry 5.0: A review of operations management literature. *International Journal of Production Research, 63(18),* 6915-6937. https://doi.org/10.1080/00207543.2025.2489039
25. Dwivedi, Y.K., Hughes, L., Baabdullah, A., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M., Wamba, S. (2023). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 71*, 102642. https://doi.org/10.1016/j.ijinfomgt.2023.102642
26. ENISA (2021). *Cybersecurity skills framework*. European Union Agency for Cybersecurity. https://www.enisa.europa.eu/publications/cybersecurity-skills-framework
27. European Commission, Breque, M., De Nul, L., Petridis, A. (2021). *Industry 5.0: Towards a sustainable, human-centric and resilient European industry*. Publications Office of the European Union. https://doi.org/10.2777/308407
28. European Commission (2022). *The digital economy and society index (DESI) 2022*. Publications Office of the European Union. https://doi.org/10.2759/709723
29. Few, S. (2012). *Show me the numbers: Designing tables and graphs to enlighten* (2nd ed.). Analytics Press.
30. Foltynowicz, Z., Łupicka-Fietz, A., Jeszka, A.M., Kowalczyk, D. (2024). Evolution of social competencies in sustainable supply chains. *Sustainability, 16*(6), 2581. https://doi.org/10.3390/su16062581
31. Forti, V., Baldé, C.P., Kuehr, R., Bel, G. (2020). *The global e-waste monitor 2020: Quantities, flows and the circular economy potential*. United Nations University, United Nations Institute for Training and Research & International Telecommunication Union. https://ewastemonitor.info/

32. Fortune Business Insights (2024). *Medical devices market size, share & COVID-19 impact analysis*. https://www.fortunebusinessinsights.com/industry-reports/medical-devices-market-100085
33. Gartner (2023). *Future of supply chain: Building resilience in a digital-first world*. Gartner Research.
34. Gladysz, B., Tran, T., Romero, D., Erp, T. van, Abonyi, J., Ruppert, T. (2023). Current development on the Operator 4.0 and transition towards the Operator 5.0: A systematic literature review in light of Industry 5.0. *Journal of Manufacturing Systems, 70*, 160-185. https://doi.org/10.1016/j.jmsy.2023.07.008
35. Grabowska, S., Saniuk, S., Gajdzik, B. (2022). Industry 5.0: Improving humanization and sustainability of Industry 4.0. *Scientometrics*, *Vol. 127, Iss. 6*, pp. 3117-3144, doi: 10.1007/s11192-022-04370-1
36. Hammer, M. (2010). What is business process management? In: J. vom Brocke, M. Rosemann (Eds.), *Handbook on business process management, 1* (pp. 3-16). Springer.
37. Hammer, M., Champy, J. (1993). *Reengineering the corporation: A manifesto for business revolution*. Harper Business.
38. Hassenzahl, M., Tractinsky, N. (2006). User experience - a research agenda. *Behaviour & Information Technology, 25*(2), 91-97.
39. Hatch, M.J. (2018). *Organization theory: Modern, symbolic, and postmodern perspectives* (4th ed.). Oxford University Press.
40. Herbane, B. (2010). Small business research: Time for a crisis-based view. *International Small Business Journal, 28*(1), 43-64.
41. Hillson, D. (2002). *Effective opportunity management for projects: Exploiting positive risk*. CRC Press.
42. Hoffman, K., Parejo, M., Bessant, J., Perren, L. (2005). Small firms, R&D, technology and innovation in the UK: A literature review. *Technovation, 18*(1), 39-55. https://doi.org/10.1016/S0166-4972(97)00102-8
43. International Organization for Standardization (ISO) (2019). *ISO 22301:2019 Security and resilience - Business continuity management systems - Requirements*. ISO.
44. James, G., Witten, D., Hastie, T., Tibshirani, R. (2021). *An introduction to statistical learning: With applications in R* (2nd ed.). Springer.
45. Jenkins, H. (2006). *Convergence culture: Where old and new media collide*. New York: University Press.
46. Joerres, J.A., McAuliffe, C. (2016). *The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution*. World Economic Forum.
47. Kirschner, P.A., Ayres, P., Chandler, P. (2011). Cognitive load theory. In: R. Mayer, P. Alexander (Eds.), *Handbook of research on learning and instruction* (pp. 97-113). Routledge.

48. Kitchin, R. (2014). *The data revolution: Big data, open data, data infrastructures and their consequences*. SAGE Publications.
49. Knut, H., Balaji, M. (2013). *Next-generation supply chains: Efficient, fast and tailored*. PwC.
50. Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., Roig-Tierno, N. (2021). Digital Transformation: An Overview of the Current State of the Art of Research. *Sage Open, 11(3),* 21582440211047576. https://doi.org/10.1177/21582440211047576
51. Laudon, K.C., Laudon, J.P. (2020). *Management information systems: Managing the digital firm*. Pearson.
52. Livingstone, S. (2009). *Children and the internet*. Polity Press.
53. Łupicka, A., Stawiarska, E., Wincewicz-Bosy, M. (2017). *Contemporary challenges of supply chains*. TEXTER. Warsaw.
54. Madsen, D.Ø., Berg, T., Di Nardo, M. (2023). Bibliometric Trends in Industry 5.0 Research: An Updated Overview. *Applied System Innovation, 6(4),* 63. https://doi.org/10.3390/asi6040063
55. Majewski, P. (2018). *Fundamentals of computer science: An introduction to information technology*. PWN.
56. Malmodin, J., Lundén, D. (2018). The energy and carbon footprint of the ICT and E&M sector in Sweden 1990-2015 and beyond. *Sustainability, 10*(9), 3027. https://doi.org/10.3390/su10093027
57. McLaren, D. (2021). Industry 5.0 and the rise of resilience in supply chain systems. *Journal of Manufacturing Systems, 60*, 755-767. https://doi.org/10.1016/j.jmsy.2021.05.004
58. Miller, R. (2007). Futures literacy: A hybrid strategic scenario method. *Futures, 39*(4), 341-362.
59. Mintzberg, H. (1993). *Structure in fives: Designing effective organizations*. Prentice Hall.
60. Mitcham, C. (1994). *Thinking through technology: The path between engineering and philosophy*. University of Chicago Press.
61. Moore, D.S., McCabe, G.P., Craig, B.A. (2017). *Introduction to the practice of statistics* (9th ed.). W.H. Freeman.
62. Nahavandi, S. (2019). Industry 5.0-A Human-Centric Solution. *Sustainability, 11(16),* 4371. https://doi.org/10.3390/su11164371
63. Norman, D.A. (2013). *The design of everyday things*. MIT Press.
64. OECD (2018). *The future of education and skills: Education 2030*. OECD Publishing.
65. Paas, F., Van Merriënboer, J.J. . (1994). Instructional control of cognitive load in the training of complex cognitive tasks. *Educational Psychology Review, 6*(4), 351-371.
66. Pizoń, J., Gola, A. (2023). Human-Machine Relationship-Perspective and Future Roadmap for Industry 5.0 Solutions. *Machines, 11(2),* 203. https://doi.org/10.3390/machines11020203

67. Polish Agency for Enterprise Development [PARP] (2021). *Report: the medical device industry in Poland*.
68. Polmed (2021). *Medical device sector in Poland - size, impact, importance*. https://polmed.org.pl/raport-sektor-wyrobow-medycznych-w-polsce-wielkosc-oddzialywanie-znaczenie/
69. Pompa, C. (2015). *Emerging trends in supply chain management*. McKinsey & Company.
70. Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*. Free Press.
71. Pressman, R.S. (2014). *Software engineering: A practitioner's approach*. McGraw-Hill.
72. Relich, M. (2015). Knowledge acquisition for new product development with the use of an ontology. *Expert Systems with Applications, 42*(13), 6027-6041. https://doi.org/10.1016/j.eswa.2015.03.017
73. Robbins, S.P., Judge, T.A. (2019). *Organizational behavior* (18th ed.). Pearson.
74. Rumsey, D.J. (2016). *Statistics for dummies* (2nd ed.). Wiley.
75. Sardar, Z. (2010). The namesake: Futures; futures studies; futurology; futuristic; foresight-What's in a name? *Futures, 42*(3), 177-184.
76. Schwab, K. (2016). *The fourth industrial revolution*. World Economic Forum.
77. Scott, W.R. (2015). *Organizations and organizing: Rational, natural and open systems perspectives* (2nd ed.). Routledge.
78. Senge, P.M. (2006). *The fifth discipline: The art and practice of the learning organization*. Doubleday.
79. Shi, Y., Venkatesh, V.G., Venkatesh, M., Fosso Wamba, S., Wang, B. (2023). Guest editorial: Digital transformation in supply chains: challenges, strategies and implementations. *International Journal of Physical Distribution & Logistics Management, 53(4)*, 381-386. https://doi.org/10.1108/IJPDLM-05-2023-550
80. Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., Diakopoulos, N. (2017). *Designing the user interface: Strategies for effective human-computer interaction*. Pearson.
81. Slaughter, R.A. (1995). *The foresight principle: Cultural recovery in the 21st century*. Praeger.
82. Sommerville, I. (2016). *Software engineering*. Pearson.
83. Song, M., Fisher, R., Kwoh, Y. (2021). Technological innovation and digital transformation for sustainability: Industry 5.0 and beyond. *Sustainability, 13*(16), 8854. https://doi.org/10.3390/su13168854
84. Stallings, W. (2017). *Effective cybersecurity: A guide to using best practices and standards*. Addison-Wesley.
85. Störmer, E., Patscha, C., Prendergast, J., Daheim, C., Rhisiart, M., Glover, P., Beck, H. (2014). *The future of work: Jobs and skills in 2030*. UK Commission for Employment and Skills.

86. Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285.
87. Szeliga, M. (2020). *Information technology basics: A practical user's guide*. Helion Publishing House.
88. Tabrizi, B.N., Lam, E.Y., Girard, K., Irvin, V. (2019). *Digital Transformation Is Not About Technology*. https://api.semanticscholar.org/CorpusID:251920900
89. Utts, J.M. (2003). What educated citizens should know about statistics and probability. *The American Statistician, 57*(2), 74-79. https://doi.org/10.1198/0003130031630
90. Volti, R. (2017). *Society and technological change* (8th ed.). Worth Publishers.
91. Voros, J. (2003). A generic foresight process framework. *Foresight, 5*(3), 10-21.
92. Winter, J., Heindl, C. (2016). Digital transformation: How mature is your company? *Management Review Quarterly, 66*(2), 81-104. https://doi.org/10.1007/s11301-016-0110-y
93. World Health Organization [WHO] (2023). *Medical devices*. https://www.who.int/health-topics/medical-devices
94. Xu, X., Lu, Y., Vogel-Heuser, B., Wang, L. (2021). Industry 4.0 and Industry 5.0-Inception, conception and perception. *Journal of Manufacturing Systems, 61,* 530-535. https://doi.org/10.1016/j.jmsy.2021.10.006
95. Zouari, D., Ruel, S., Viale, L. (2021). Does digitalising the supply chain contribute to its resilience? *International Journal of Physical Distribution & Logistics Management, 51(2),* 149-180. https://doi.org/10.1108/IJPDLM-01-2020-0038