Vol. 08, No. 1 (2026) 153-160, doi: 10.24874/PES08.01.016

Proceedings on Engineering Sciences

www.pesjournal.net

HR MANAGEMENT OF QUALITY 5.0 THROUGH SUSTAINABLE INNOVATIONS: HUMANISATION OF DIGITAL PERSONNEL'S LABOUR

Gulchechra A. Matkarimova
Anastasia A. Sozinova[1]
Aida S. Makeeva
Lyudmila A. Shvachkina
Timofey Y. Cherepukhin

Received 02.07.2025.
Revised 27.10.2025.
Accepted 10.11.2025.

Keywords:

HR management, Quality 4.0, Quality 5.0, Sustainable innovations, Humanisation of labour, Digital personnel, Fifth Industrial Revolution, Industry 4.0, Industry 5.0.

A B S T R A C T

The concept of Quality 5.0 emerged together with the Fifth Industrial Revolution and its components (Education 5.0, Society 5.0, and Industry 5.0). The relevance of its appearance was predetermined by the accumulation of social problems in society, which were threats to the uninterrupted functioning of companies in the main sectors of the economy, countries, and regions in the context of possible conflicts at the level of human resources and employers. This paper contains a conceptualisation of the notion of HR management of Quality 5.0 and presents the specifics of its formation. We establish that the key aspects of HR management of Quality 5.0 include digital transformation, connected with humanisation of production (interaction at the level of labour resources and machines) and resolution of social problems in order to raise the quality of life of digital personnel. We distinguish problems and opportunities for improving the activities of the subjects of the main sectors of the economy and adoption of commitments in the sphere of social corporate responsibility.

We also determine the directions for attracting interested parties (government bodies and regional and municipal authorities) to the improvement of the transition from the paradigm of HR management of Quality 4.0 to HR management of Quality 5.0. This transition cannot be based on individual initiatives of corporations and companies of small and medium businesses, but it is necessary for the well-balanced development of Society 5.0.

In this paper, we aim to identify the features of humanisation of labour of digital personnel in the conditions of HR management of Quality 5.0 with the use of sustainable innovations and developing a list of directions for improvement of HR management of Quality 5.0.

[1] Corresponding author: Anastasia A. Sozinova
Email: aa_sozinova@vyatsu.ru

1. INTRODUCTION

The Fifth Industrial Revolution introduced new challenges and opportunities in the economy and life activities of society and led to the emergence of such conceptual directions as Industry 5.0, Society 5.0, Education 5.0, and Quality 5.0. Quality 5.0 influences the growth of value-added manufactured products and provided services and economic sustainability. The concept of Quality 5.0 has a direct impact on Industry 5.0, creating new types of innovative products (services), which have qualities that were not observed with previous similar items. New products manufactured based on man-machine interaction are connected with the humanisation of digital personnel and higher indicators of quality. The connection between Quality 5.0 and Society 5.0 consists in the fact that goal-setting, related to an increase in consumer qualities of products and services and achievement of the optimal balance of price-quality, is ensured not due to the transition of the entire production process to robots but due to the balance of HR management and AI management. This connection creates new perspectives for individual development of labour resources due to time saved thanks to robots performing monotonous tasks that require constant attention. This allows for decent wages due to the high qualifications and complex competencies of digital personnel. The interconnection between Quality 5.0 and Education 5.0 is based on the latter providing a foundation for the former and, accordingly, creating new opportunities for the improvement of the quality of life of labour resources and the economic stability of employers.

Implementation of the Quality 5.0 concept with the use of sustainable technological innovations is based on the humanisation of HR management using the integration of digital personnel and AI. The goal of this paper was to elaborate on the list and features of the directions for the humanisation of digital personnel labour in the conditions of HR management of Quality 5.0 with the use of sustainable innovations. This goal involved the formulation of the aspects of HR management of Quality 5.0 with the help of sustainable innovations connected with humanisation and the determination of these directions' features.

2. EXPERIMENTAL SECTION

To identify a list and characteristics of the directions for HR management of Quality 5.0 with the use of innovations that contribute to sustainable development, we selected a range of appropriate methods and analysed theoretical and empirical works devoted to these issues.
We used a system approach to assess analytical material and theoretical and practical data; it enabled us to determine the key directions for the humanisation of Quality 5.0 management. The ranking method helps us distinguish the sectors of the economy that demonstrate high results in the considered sphere. The method of comparison allowed us to compare the results of the studied economic subjects in the sphere of humanisation of Quality 5.0 management. Using the segment method we determined the components of each direction of Quality 5.0 management.

To determine the aspects of humanization of HR management in the context of the concept of Quality 5.0 we have to assess the results of scientific research in this sphere.

Maljugić et al. (2024) substantiated the features of the notions of Quality 5.0, Society 5.0, Industry 4.0, and Industry 5.0. Apart from the contribution to the formation of conceptualisation of these notions, the authors dwelt on the systemic components connected with the Fifth Industrial Revolution, pointing to the fact that human-centrism (or humanisation) is the basis of the Fifth Industrial Revolution. The researchers proved the necessity for businesses and governments to adopt the idea that digitalisation must support the development of human benefits and quality of life and demonstrated that this model of the digital economy would contribute to economic stability.

Badowska and Szkultecka-Dębek (2023) conducted a complex study of the categories (division into subjective and objective categories) and the list of the indicators of the quality of life. The study of this indicator allowed establishing the importance of the focus on the indicator of the quality of life, not living standards (material indicators of well-being) during consideration of the human-centric approach as the basis of the Quality 5.0 concept.

Gambi, et al. (2022) presented a theoretical & methodological and practical assessment of the influence of human resources management methods on the indicators of the quality of companies' activities. Quality (including Quality 5.0) is affected the most by management methods connected with balanced control of the achievement of certain indicators. According to the authors, the focus of management methods aimed at personnel's responsibilities is also very effective. They could be used in the context of the increasing trust between the employer and digital personnel within the approach based on Quality 5.0 (technological support of human labour and provision of decent conditions of work).

Rajkumar et al. (2024) presented the main features of the Industry 5.0 concept, which is based on human-centrism caused by the necessity for the development of production in the context of creating a favourable climate for labour resources development. The scholars acknowledge that companies accepting responsibilities of the social character cannot be realised by business without the external influence of interested parties. The importance of this work for the presented paper is

predetermined by the focus on this social problem as a barrier to the formation of Industry 5.0 and Quality 5.0. Potočan et al. (2021) elaborated on the features of the formation of the Society 5.0 concept connected with the creation of a well-balanced model of social problem resolution, economic progress, and Industry 4.0 (based on digitalisation). Latino (2025) evaluated the modern approaches to determining the level of small and medium companies in the processing industry integrating the main provisions of Industry 5.0 and the roadmap for the improvement of this process. Based on corporate data of the four processing companies from Italy, the authors analysed the indicator of the maturity of the transition to Industry 5.0 and the realisation of the provisions of Quality 5.0. According to the scholars, the key problem for the sector of small and medium companies is connected with insufficient financial potential for purchasing and installing digital smart technologies.

Melkamu (2025) aimed to assess the state, problems, and prospects of using AI technologies in production process management at companies from developing countries (by the example of Ethiopia) and demonstrate the need to bridge and digital divide in knowledge and skills of labour resources. Kachkanbaeva et al. (2025) analysed the main aspects of quality formation with the use of AI under the influence of corporate information systems. The authors distinguished sich aspects as improvement of innovative development, data generation for machine learning, the use of stimuli for innovative development, and the formation of workplaces due to the emergence of new professions. Sergi et al. (2025) provided an example of the possibility of using big database analysis in the context of the management of world finance and climate risks. This research demonstrates the necessity for further interaction between ICT sector companies and targeted customers (governments, corporations, etc.) to ensure the creation of unique digital products required in the conditions of Industry 5.0.

Buitek et al. (2023) assessed the employers' measures in developing countries for attracting young talents who can raise the competitive positions of companies and the competitiveness of products (services). This research is particularly relevant in the conditions of transition from HR management of Quality 4.0 to the paradigm of HR management of Quality 5.0.

We can see the close attention of modern economic science to the issues of Quality 5.0 and accompanying components of the Fifth Industrial Revolution. However, more attention should be paid to the directions for the humanisation of digital personnel's labour in the context of the achievement of the goals of Quality 5.0.

3. RESULTS

It is necessary to study the main aspects of HR management of Quality 5.0 based on modern technologies to raise the level of sustainable development of subjects, economies, and countries on the whole. One aspect of humanisation of HR management of Quality 5.0 in the modern conditions of digitalisation is technological progress, aimed at implementation of social Sustainable Development Goals (Maljugić et al., 2024; Gambi, et al., 2022). It involves the priority on support of the quality of life: subjective indicators (professional and personal growth, satisfaction with labour and favourable environment, etc.) and objective indicators (social well-being) (Badowska & Szkultecka-Dębek, 2023). Technological progress in the context of the humanisation of labour is an important direction for HR management of Quality 5.0, but its assessment is rather difficult and requires methodological support.

Technological progress connected with the digital transformation of the processes of HR management of Quality 5.0 involves the inclusion of innovative sustainable technologies in production activities. We performed a comparative analysis of digital (including smart) technologies used in HR management of Quality 5.0 of digital personnel's labour (Table 1).

Digital personnel are treated in this paper as labour resources who use digital technologies during their work (Weritz, 2022; Rikharom & Chansanam, 2023).

Table 1. Digital technologies of HR management of Quality 5.0 of digital personnel's labour

	Digital technology	Specifics of using digital technologies	
		Quality 4.0	Quality 5.0
1	Internet of Things	Digital sensors, installed at the company's subjects, transfer information to management information systems. This is information about the indicators of production quality.	1. The parameter of technological support of human labour. Digital smart sensors, installed at the companies' objects, are used for monitoring and assessment of information about production quality in real-time. This technology contributes to the uninterrupted interaction of humans and machines and an increase in quality. New models of smart digital sensors ensure the collection and analysis of data about quality. Here machine learning technology is used. 2. The parameters of technological support for the improvement of consumer indicators of product quality. Due to the use of unique materials, modern nanotechnologies allow manufacturing digital sensors with unique qualities.

2	Machine learning	Training robots based on the data collected with the help of the Internet of Things big data analysis.	Data obtained with the help of the Internet of Things and big database analysis are used for machine learning, which contributes to the optimal interaction of humans and robots. This interaction ensures the growth of product quality and reduces the burden on humans in the context of monotonous tasks.
3	Cloud computing	Creation of conditions for storing, processing, and analysis of large volumes of information in real-time. This technology helps save costs on storing information on digital or paper carriers.	Execution of the same functions that are ensured within Quality 4.0. Additional conditions for data exchange at the man-machine level.
4	Robotics	Robots in various sectors of the economy are used to raise speed and quality with the preservation or improvement of the quality of products (services). They are based on other digital (including smart) technologies, namely machine learning, computer vision, analysis of big databases, etc.	Humans and robots interact, with robots accepting monotonous tasks and tasks requiring large physical strength. Humans perform tasks that ensure an increase in value-added of products and services.
5	Analysis of big databases	Analysis of large information flows and databases to make managerial decisions for improvement of quality indicators.	An increase in the opportunities for interaction between humans (completion of creative tasks) and machines (technical tasks involving machine learning)
6	Digital simulations and digital twins	Needs further dissemination	Allow creating a digital sample of the new type of product and assessing its effectiveness, saving approbation costs.
7	Blockchain	Needs further dissemination	Allows for control and safety in supply chains, which contributes to consumer and supplier protection. Blockchain helps create new workplaces, which is a sign of its human-centrism.
8	Augmented and virtual reality	Needs further dissemination	Used to raise the quality of the design of processes and products and improvement of personnel training in the remote form. This technology is to create new consumer qualities of products and services.
9	3D print	Used for the production of components of various objects and products to reduce profitability and quality	The focus is on the interaction between labour resources and AI to create more unique samples of 3D printing.

Source: Compiled by the authors based on (Innopharma Education, 2025; EpiSensor, 2025; Sljivic et al., 2024)

The Internet of Things is widely applied in various sectors of the economy. Over 2019-2024, companies in the energy sector demonstrated the highest results in the installation of digital sensors at production objects (with the number varying from 893.2 million in 2019 to 1,589.9 million in 2024) (Vailshery, 2024). Good results in the use of digital sensors are observed with retail and wholesale companies (1,283 million in 2024), companies in the waste and water management sector (372 million in 2024), and the transport sector (361 million in 2024). Even though companies in the mining and quarrying sector do not have a high level of digital sensor use, this indicator is constantly growing (from 13.9 million in 2019 to 18 million) (Vailshery, 2024). The importance of using IoT technology and digital sensors is caused by the fact that conditions of labour in coal and gold mines are rather dangerous. To deal with threats accompanying the work in the mines, managing companies have started developing and implementing the policy of labour resources protection based on the data collected and analysed in real time by digital sensors in mines and quarries. This measure is aimed at the protection of safe labour of human resources and requires investments because it is necessary to purchase and install digital sensors and monitor the results of the diagnostics.

An example of the effectiveness of using the Internet of Things and other adjacent technologies is seen in the functioning of the gold mines of the Indonesian company Agincourt Resources. This company performs HR management of Quality 5.0 of employees' work, ensuring their safety with the help of digital sensors (Agincourt Resources, 2025). This measure involves long-term investments in the purchase of these devices and an information management system. Apart from the humane purpose (protection of employees' health and life), the investments help save finances in the long term (medical treatment and expenditures for employees' families' support). Realising the priority of financial expenditures for monitoring the state of mines in real-time compared to expenditures for dealing with consequences of insufficient organisation of labour safety became the basis for the policy of the sustainable development of companies in the sphere of gold mining in the age of Quality 5.0. Since employees use digital data from sensors (collection and analysis of the indicators of mines' safety) they could be considered a new category of digital personnel. At the level of the companies of the mining and quarrying sector, additional training of personnel for their mastering new technological features of working at mines is conducted. This is also seen in HR management of Quality 5.0 of labour resources' work in

Agincourt Resources. Agincourt Resources works on the conditions of HR management of Quality 5.0 of labour resources' functioning in cooperation with technology company Solusi Monitoring Indonesia which specialises in the digitalisation of mines' functioning in remote and hard-to-reach areas (Agincourt Resources, 2025; Worldsensing, 2025). This includes the following aspects:

- Agincourt Resources has goldmines in a hard-to-reach region of South Tapanuli, where it is difficult to perform the monitoring of employees' safety involving additional labour resources. Despite the problems with access to the territory, Agincourt Resources and Solusi Monitoring Indonesia adopted responsibilities in the creation of a socially favourable climate for safe labour;
- The region of the goldmines is an area of residence of a unique species of orangutans, protection of which is the country's priority. Agincourt Resources and Solusi Monitoring Indonesia take measures to prevent threats to this species coming from gold mining activities.
- Solusi Monitoring Indonesia created a system of managing the monitoring of risks and the state of Agincourt Resources' gold mine. This system includes the installation of Worldsensing digital sensors, which use the local low-power Internet that covers remote areas. These digital sensors collect, with the help of computer vision, information about the state of the gold mine; thanks to the in-built piezometers, these sensors assess the level of the quality of water and adjacent territories. The gathered information is processed with the help of machine learning technology and transferred to the digital sensor's display and the database of the system of risk monitoring. Though the territory is not large, the local type of the Internet ensures the connection and risk assessment in real-time;
- Application of digital sensors allows for the protection of the ecosystem and creates effective and safe digital workplaces;
- Over 2021-2023, Agincourt Resources reduced the volume of gold mining due to the complexity of the organisation of processes, risks of injuries, and threats to employees' lives. Stable gold mining was performed in the mine's areas that are adapted to risks;
- From 2021 to 2023, Agincourt Resources retailed stable economic development of the local business sector. In 2021, the cost of purchased materials (works) from local manufacturers equalled $12.9 million, in 2022 - $16.2 million, and in 2023 - $20.2 million;
- Despite the reduction in production volume and profit, the company retained a decent quality of life for digital personnel. This included an increase in their competitiveness due to advanced training for digital transformations and support of the eco-system of the mine's territory, which influenced the future of human resources and their safety; also, the company raised wages and other social benefits, supporting digital personnel's social well-being.

The aspect of humanisation of HR management of Quality 5.0 is solving social problems of the quality of life (Maljugić et al., 2024; Gambi, et al., 2022; Potočan et al., 2021; Rajkumar, et al., 2024).

This aspect consists in the following:

1) The need to inform the companies from different sectors of the economy about the relevance of the organisation of production activities in the context of socially responsible development. Most companies in almost all countries do not want to voluntarily accept the concept of the Fifth Industrial Revolution and its components (including Quality 5.0). This is confirmed at the level of theoretical and empirical studies and based on the assessment of companies' corporate reporting. The trends for the growth of mortality and injuries, which are results of refusal to solve social problems, might facilitate the necessity for companies to accept social corporate responsibility. Transition to Industry 5.0 is predetermined, among other factors, by the impossibility of further admittance of deaths from production injuries and the use of human labour in complex conditions involving large physical burdens.

In the USA, the innovative economy and companies of the main sectors have a level of labour protection that is adapted to modern digital smart technologies. Improvement in protection from production traumas and reduction in the number of deaths at work are key aspects that are regulated by the government and controlled by unions and various public structures. In 2025, the United States Department of Labour increased fines for violation of norms and standards of safety of labour resources due to inflation trends (Yaniz, 2025). The fine for the intentional violation of rules in the here of production safety grew from $ 161,300 to $165,500; for unintentional mild and serious violations grew from $ 16,130 to $ 16,550. Fines and other sanctions for employers in various sectors of the economy are a restraining tool which help prevent the growth of the number of injuries and mortality at workplaces. Despite the existence of the legal and regulatory basis and institutional control over compliance with labour safety, as an important component of the quality of life in the age of Quality 5.0, the level of injuries and mortality aproduction is still high. This is true for developing and developed countries, including the USA. In 2023, at the U.S. companies of processing industry, the number of deaths in industrial accidents reduced by 13 (from 404 in 2022 to 391 in 2023) (Magill, 2024). Though this is not a sufficient result, the government started to use administrative measures to regulate companies' activities in the context of their implementation of the Sustainable Development Goals more actively. To deal with threats and risks in the sphere of production safety management, companies use sustainable innovations which ensure the improvement of labour conditions and contribute to the growth of product quality;

2) Organisation of the transformation of HR management of Quality 4.0 into HR management of Quality 5.0, based on the humanisation of digital personnel's labour. This is

supported by the involvement of the ICT sector participants, who create the information and technological infrastructure and develop innovative solutions for HR management of Quality 5.0 (Latino, 2025). The best results within this transformation are achieved by large and medium companies, which have sufficient finances.

In countries where the sector of small and medium companies accounts for the main part of the structure of the economy, the integration of HR management of Quality 4.0 to HR management of Quality 5.0 is more active. This is true for many EU countries. In this case, small and medium companies receive access to financing from EU funds, which contributes to better implementation of the humanisation of digital personnel's work.

4. DISCUSSION

Though the described aspects of humanisation of HR management of Quality 5.0 are similar to the aspects peculiar to the age of HR management of Quality 4.0, the benchmark of using their components is different because of the change in the concepts of social and economic development. Despite the presence of a strong technological component, Industry 4.0 belonged to the age of the Fourth Industrial Revolution, when industrial growth was achieved through new capabilities of digitalisation. Quality 4.0 was also a component of this paradigm and was concerned primarily with the growth of the quality of products (services) and processes through the use of technologies. With the start of the Fifth Industrial Revolution, all its components, including Quality 5.0, were aimed at the protection of human resources, their support in a complex technological world of machines, and the creation of conditions that would allow ensuring the optimal quality of their life with the help of adapted technologies. The humanisation of HR management of Quality 5.0 with a vivid focus on human-centrism is also aimed at the creation of favourable conditions for economic development and support of the environment.

The aspect of HR management of Quality 5.0 connected with digital transformations led to the adaptation of digital (smart) technologies to the Sustainable Development Goals, the key of which is support of the high quality of life of labour resources, environmental responsibility of production, and economic stability. Innovativeness of the ICT sector led to the emergence of new technologies and adaptation of the existing technologies to the concept of humanisation of HR management of Quality 5.0. Companies that work on the creation of sustainable digital technologies become valuable partners of industrial enterprises in various sectors. Their activities allow for the transition from the age preceding HR management of Quality 4.0 to HR management of Quality 5.0.

The priority of infrastructural support is observed in the second aspect of humanisation of HR management of Quality 5.0 (solving social problems of the quality of life). The government and local authorities could participate in the implementation of this direction, stimulating investments in the improvement of Internet quality and coverage and the creation of national computing capacities based on smart technologies. This measure allows raising the digital readiness of human resources to changes in HR management of Quality 5.0 and enables companies of the main sectors of the economy to realise the course towards the achievement of the SDGs more effectively. An example of the government's participation in the formation of the information and communication infrastructure is the experience of the UK. As of early 2025, the total volume of government investments in gigabit fibre broadband equalled 1.3 billion pounds, compared to 714 million pounds in 2024 (Unipart, 2025). These investments were aimed at the Internet's high quality and coverage in all regions (including islands and rural territories). The UK may be considered the leader in Europe by the volume of government investments in the Internet.

An example of a government investing in the creation of computing powers is the activities of the Canadian government. 2025 saw investments in the project of computing powers required for the functioning of the main infrastructures, equalling $725 million (Slavens & Sanathkumar, 2025). This measure was aimed at raising the capacities of the country's digital infrastructure.

5. CONCLUSION

Summing up the research results, it is possible to mention the growth of the ICT sector's dependence on demand from the main sectors of the economy due to new trends of HR management of Quality 5.0. This demand growth in the context of the business environment's adopting the necessity for considering not only the specifics of consumer preferences but also the need for humanisation in HR management in the model of formation of product quality. They influence the uniqueness and innovativeness of the characteristics and features of manufactured products and provided services.

Most of the subjects of the economy cannot independently make decisions on the adoption of social corporate responsibilities declared at the level of the UN, governments, national and international organisations, and supranational institutions. The use of coercive measures (administrative fines) for the absence of social corporate responsibility of companies from various sectors of the economy is one of the aspects of regulation. To accelerate these measures, we suggest increasing the government's participation in simulating the economic subjects to work on the socially-oriented corporate policy of HR management of Quality 5.0, which would create attractive conditions for raising the quality of life, involve environmental protection, and support the competitive qualities of products. Government and regional authorities investing in the information and

communication infrastructure is one of the important directions. It is also possible to work on initiatives for advanced training and retraining of personnel in the context of digital skills. Special financing should be allocated for the improvement of the digital literacy of personnel and adapt them to new professional responsibilities, which involve interaction with machines.

Quality 5.0 is the paradigm of management of the formation of the quality of processes, products, and services connected with the humanisation of labour of digital personnel, which is gradually replacing the paradigm of Quality 4.0 which is based on the digital transformation of production processes. New trends in society, economy, and technologies might create preconditions for the Sixth Industrial Revolution, the specific features of which will be determined in the context of ongoing transformations.

References:

Agincourt Resources (2025). *Sustainability Reports*. Retrieved from https://agincourtresources.com/sustainability-reports/

Badowska, M., & Szkultecka-Dębek, M. (2023). Indicators affecting the quality of life of an individual and society. *Journal of Health Policy and Outcomes Research*, *1*, 11-20. doi :10.7365/JHPOR.2023.1.2

Buitek, E. K., Kaliyeva, S. A., Turginbayeva, A. N., Meldakhanova, M. K., & Shaikh, A. A. (2025). How much does an employer's attractiveness matter to youth employment? Evidence from a developing country. *Asia-Pacific Journal of Business Administration*, *17*(1), 258-283. https://doi.org/10.1108/APJBA-02-2023-0086

EpiSensor (2025). Innovations in IoT Sensor Technology for Enhanced Data Collection. Retrieved from https://episensor.com/knowledge-base/iot-sensor-technology-enhanced-data-collection/

Gambi, L. D. N., Boer, H., Jorgensen, F., Gerolamo, M. C., & Carpinetti, L. C. R. (2022). The effects of HRM approach on quality management techniques and performance. *Total Quality Management & Business Excellence*, *33*(7-8), 833-861. https://doi.org/10.1080/14783363.2021.1903308

Innopharma Education (2025). Digital Transformation 101: What is Industry 5.0? Retrieved from https://www.innopharmaeducation.com/blog/what-is-industry-5-0

Kachkanbaeva, A. S., Juraev, K. T., Tikhomirov, Y. A., Kalitko, S. A., & Pakhomova, O. K. (2025). Kachkanbaeva et al., Advantages of product quality management based on corporate information systems for the growth of the AI economy. *Proceedings on Engineering Sciences*, *7*(1), 105-112. 10.24874/PES07.01A.001

Latino, M. E. (2025). A maturity model for assessing the implementation of Industry 5.0 in manufacturing SMEs: learning from theory and practice. *Technological Forecasting and Social Change*, *214*, 124045. https://doi.org/10.1016/j.techfore.2025.124045

Magill, K. (2024). Nearly 400 manufacturing workers died on the job in 2023. Retrieved from https://www.manufacturingdive.com/news/osha-bureau-labor-statistics-deaths-fatality-data-industry-2023/736047/

Maljugić, B., Ćoćkalo, D., Bakator, M. and Stanisavljev, S. (2024). The Role of the Quality Management Process within Society 5.0. *Societies*, *14*(7), 111. https://doi.org/10.3390/soc14070111

Melkamu, M. (2025). Artificial intelligence implementation challenges in industries: developing countries prospective. *Artif Intell*, *2*(01), 175-180. doi: 10.61552/JAI.2025.01.004

Potočan, V., Mulej, M., & Nedelko, Z. (2021). Society 5.0: balancing of Industry 4.0, economic advancement and social problems. *Kybernetes*, *50*(3), 794-811. https://doi.org/10.1108/K-12-2019-0858

Rajkumar, N., Nachiappan, B., Mathews, A., Radha, V., Viji, C., & Kovilpillai, J. (2024). Industry 5.0: The human-centric future of manufacturing. *Challenges in Information, Communication and Computing Technology*, 562-567. 10.1201/9781003559085-97.

Rikharom, R., & Chansanam, W. (2023). Essential Competencies for Digital Workforce of Provincial Office in Thailand Using Delphi Technique. *Journal of Information Science theory and practice*, *11*(4), 51-81, https://doi.org/10.1633/JISTaP.2023.11.4.4

Sergi, B. S., Popkova, E. G., Petrenko, E., Ergasheva, S. T., Aslanyan, M., & Mikayelyan, V. (2025). An Innovative Digital Platform for Socioeconomic Forecasting Climate Risks and Financial Management. *Journal of Risk and Financial Management*, *18*(5), 277. https://doi.org/10.3390/jrfm18050277

Slavens, S., & Sanathkumar, S. (2025). Digital infrastructure and data sovereignty as national priority projects. Retrieved from https://www.torys.com/our-latest-thinking/publications/2025/04/digital-infrastructure-and-data-sovereignty-as-national-priority-projects

Sljivic, M., Pavlovic, A., & Fragassa, C. (2024). A review of sustainable development of additive manufacturing in the conditions of digital and green transition. *Proceedings on Engineering*, *6*(2), 477-484. doi: 10.24874/PES06.02.005

Unipart (2025). From fields to fibres: UK Government invests £1.3 Billion into broadband. Retrieved from https://www.unipart.com/resource/uk-government-invest-broadband/

Vailshery, L. S. (2024). Number of IoT connected devices worldwide 2019-2034, by vertical. Retrieved from https://www.statista.com/statistics/1194682/iot-connected-devices-vertically/

Weritz, P. (2022). Hey Leaders, It's Time to Train the Workforce: Critical Skills in the Digital Workplace. *Administrative Sciences*, *12*(3), 94. https://doi.org/10.3390/admsci12030094

Worldsensing (2025). Using wireless IoT monitoring to improve gold mine worker safety. Retrieved from https://www.worldsensing.com/success-story/using-wireless-monitoring-to-improve-mine-worker-safety/

Yaniz, R. Jr. (2025). OSHA Adjusts Penalty Amounts for Safety Violations for 2025. Retrieved from https://ohsonline.com/articles/2025/01/15/osha-adjusts-penalty-amounts-for-safety-violations-for-2025.aspx

Gulchechra A. Matkarimova
Tashkent International University,
Tashkent, Russia
Matkarimova7000@mail.ru
ORCID 0009-0001-8500-7660

Anastasia A. Sozinova
Vyatka State University,
Kirov, Russia
aa_sozinova@vyatsu.ru
ORCID 0000-0001-5876-2823

Aida S. Makeeva
Jalal-Abad State University named after B. Osmonov,
Jalal-Abad, Kyrgyzstan
aumakeeva@mail.ru
ORCID 0009-0002-5312-5440

Lyudmila A. Shvachkina
Institute of Service and Entrepreneurship (branch) of Don State Technical University in Shakhty,
Shakhty, Russia
Shvachkina@mail.ru
ORCID 0000-0001-9067-0988

Timofey Y. Cherepukhin
Kuban State Agrarian University named after I.T. Trubilin,
Krasnodar, Russia
timofey-19@mail.ru
ORCID 0000-0001-7094-8938