The Insights into the Implementation and Interdependence of AI and Technological Humanism in Manufacturing Companies

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Abstract: Manufacturing companies are gaining advantages through the introduction of new technologies, but problems related to human resources, management, and organization have been identified. Industry 5.0 represents a new concept whose goal is to enable the synergy of people and machines. Its part concerning technological humanism is gaining more and more importance due to the very rapid development of new technologies, and it is especially important when considering the application of Artificial Intelligence in companies and the related consequences for the organization and employees. As Artificial Intelligence represents systems capable of performing complex tasks that historically only a human could do, it's influence on human workers is very significant and therefore there is a need for deeper research and understanding. The conducted empirical research provides a technological-humanistic insight related to the implementation of artificial intelligence that companies should consider in order to enable successful collaboration between man and machine.

Keywords: artificial intelligence; manufacturing companies; technological humanism

1 INTRODUCTION

Global business today is faced with major and turbulent changes, and manufacturing companies, due to the specific nature of their business, are exposed to numerous challenges. As a result, the manufacturing sector has the need to improve its existing activities in terms of increasing adaptability and flexibility, in order to meet the changing needs of its customers and the corresponding market. [1]. Therefore, organizations must commit to implementing a series of organizational changes in order to improve their business, most of which are related to the implementation of new technology. Digital transformation in the manufacturing industry has recently shown increasingly intensive development, and with its technological innovations, it enables its development and a consequent future supported by artificial intelligence, human-robot collaboration, smart solutions, automated production, with changed qualification requirements, completely new job profiles, but also potential job losses. [2].

Artificial Intelligence (AI) represents an important part of Industry 5.0. In its strictest definition, AI stands for the imitation by computers of the intelligence inherent in humans [3], referring to the simulation of human intelligence by a system or a machine, with the goal to develop a machine that can think like humans and mimic human behaviours, including perceiving, reasoning, learning, planning, and predicting [4]. As its integration in the workplace creates many challenges and opportunities [5], considering its influence on human workers is very important for the company at present, and will be even greater in the future. Therefore, there is a need for deeper research and understanding of the involvement of AI in the operations of companies and the entire business system, taking into account its rapid development and its aspects, including interaction with people and its consequences. Manufacturing companies represent very sensitive organizations because many of them are still oriented towards traditional production processes, routines and corresponding organisation, even after implementing digital solutions. AI could provide compounding benefits to the manufacturing industry, but at the same time, the AI solutions also require a thorough understanding of the possible trade-offs involved and the specific needs and capabilities of the company and stakeholders [6].

Technological humanism views technology in the service of humans and recognizes that automation, due to the adoption of digital technologies, is able to encourage instantaneous and delocalized activities thereby increasing flexibility and dynamism, but at the cost of a greater amount of insecurity and uncertainty in the work system [7]. With regard to the implementation of technology and its possible consequences, the concept of technological humanism encourages the preservation of the ethical centrality and primacy of humans in automated environments [8]. This concept incorporated into businesses considers not only how new technologies, tools, and methods will enable better business results, but also how these factors can influence the creation of a more humane and sustainable business environment [9]. Besides focusing only on automation and optimization, it considers the aspect of participation of involved people with the aim of increasing human capabilities [10] and in the production environment it observes technology with the aim of encouraging human development with social integration, in enterprises that have the purpose of achieving joint action of all social subjects in the creation of shared values [11].

As AI increasingly becomes a standard component of production processes [12] and represents an important part of ever-widening digitalization, in these conditions it is crucial to discuss humanism, which is important for the people involved [10]. By implementing technological humanism companies are able to remove possible obstacles from the internal environment related to the human factor, which have been identified as more significant than extrinsic barriers in terms of impact in the digitalisation process [13]. This can then be positive for establishing an appropriate organizational culture and factors that influence the management and development of the necessary skills and expertise of employees.

2 ARTIFICIAL INTELLIGENCE (AI) AND TECHNOLOGICAL HUMANISM

In present time, AI is being increasingly adopted in manufacturing, leading to work design, responsibilities, and dynamics changes [14] and it is considered distinct from digitization and integration of information technology [6]. It can increase the productivity of the entire enterprise and the human worker [12], while at the same time its involvement in complex socio-technical environments such as production systems changes the role of the operator and his duties and responsibilities at the workplace [5]. AI enables manufacturing companies to gather and analyse copious amounts of data, identify patterns and insights, and automate processes, enabling faster and more informed decisions that improve operations and product development [6], from being only supportive, to taking decisions and action autonomously. Since the industrial environment will be redefined by the synthesis of AI and human skills, it is crucial to empirically analyse this evolutionary path [12]. Also, it is of great importance to include all individual goals of successful AI implementation in the company's comprehensive production and business system, taking into account aspects of this new technology and social factors [15]. The above is marked by certain problems that are noticeable in the present, and due to the extremely fast development of AI, they need to be solved in order to avoid their repetition and multiplication in the future. AI has been demonstrated to have a "black box" syndrome, owing to absence of insights into how systems operate, prompting several negative implications [16]. In addition, human users are reluctant to adopt techniques that are not directly interpretable, tractable, and trustworthy [17].

Since it has been identified that business organizations need to consider not only how new technologies will enable better results for their business, but also how they can influence the creation of a more sustainable environment focused on human needs [9], in this sense, the implementation of digital transformation in companies should be part of a joint effort to transform the way of doing business by integrating digital technologies so that actors directly and indirectly cooperate on a common understanding of all aspects of new technologies within and outside their business organizations [18]. The corresponding approach should be human-cantered and must meet both industrial and human needs [19]. This approach represents the concept of technological humanism, which enables the synergy of man and machine, and represents one of the most important new trends in the world of work [8]. It is based on the view that the implementation of new technologies must guarantee human beings the ability to preserve dignity and moral autonomy within automated globalization [7], and on the foundations of digital humanism which represents an ethics for the digital age that interprets and shapes the process of digital transformation in accordance with the core concepts of humanist philosophy and practice, which then encourages the development of human-centred innovations [10]. Since understanding socio-technical systems requires an equal consideration of all three factors in the form of business, technology and people in terms of responsibility for the successful implementation of digital transformation [20],

within the concept of technological humanism, the need to introduce the role of a smart operator is recognized and fulfilled in terms of a paradigm shift from the simple implementation of automated and independent activities towards a human-oriented cyber-physical system [21]. In it, the employee as an operator must benefit from technologies that do not hinder him, but rather enable his development and lead him to perform each action with confidence without mental or physical stress or uncertainty [21]. Accordingly, technological humanism strives to improve the quality of human interaction with digital solutions in a dynamic environment and complex industrial systems [22]. In this area, it is recognized that technology has not yet sufficiently supported the transformation towards a globally sustainable society by providing tools that are aligned with the logic of pan-humanism, anthropo-relational humanism and digital humanism in all social and business relationships [23].

In the case of implementation and use of AI solutions in the business of production organizations, the goal is to enable successful relationship between man and machine, respecting the criterion that technology is at the service of man and his development, well-being and fulfilment, which is contained in the concept of technological humanism. In this way, its fundamental premises can be fulfilled in terms of ensuring the leadership and centrality of the human being within automated environments, as well as protecting human freedoms and eradicating inequalities and gaps associated with the exponential development of technology [8]. The reality is that workplaces are reshaped as a result of the use of AI in production, encouraging the need to develop an approach to successful collaboration between man and machine [14], and to conduct research related to the AI aspect of such enterprise transformation while respecting the norms of technological humanism.

3 RESEARCH OF THE DEGREE OF USE OF ARTIFICIAL INTELLIGENCE (AI) IN RELATION TO THE DEGREE OF IMPLEMENTATION OF TECHNOLOGICAL HUMANISM IN THE COMPANY

The reason for the present research was the results of previous case studies, conducted on a sample of two small Croatian manufacturing companies. The first case study was conducted to determine the level of employee awareness and knowledge about Industry 5.0 and consequences of its implementation on the company and on them personally in line with the concept of technological humanism according to the newly developed model. The concept of technological humanism was presented through its five components that constituted a research model [24], as shown in Fig. 1.
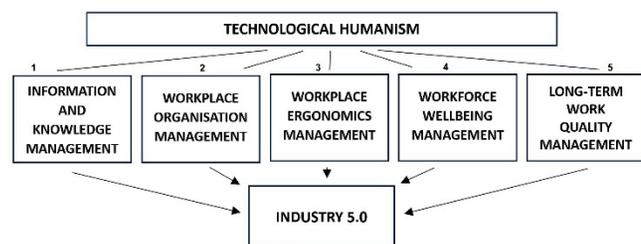

Figure 1 Graphic representation of the technological humanism model [24]

The results of this first case study showed that there was a statistically significant difference in the answers regarding the survey respondents work category in the case of model components 2, 3 and 4, as top management showed significantly difference perceptions in relations to categories of operational non-production and production workers [24].

The second case study focused on the technological-humanistic aspect of using robotic systems and AI in production, organization, and management depending on the employee's job position in the company, on a sample of the same two companies and using the same model of technological humanism as in the first case study. The case study results did not indicate statistically significant differences between work positions within the aspects of the application of robotics and using AI in production, organization and management in relation to the principles of technological humanism, but the results revealed a trend that indicates a possible difference in the perception of AI technology use and its consequences by top management compared to other categories of employees [25].

The aforementioned findings and the call to conduct new research in this area on a larger sample, including larger companies, resulted in the implementation of a new research. It aimed to investigate whether there is a statistically significant relationship between the degree of use of AI in the company's operations, and the level of implementation of technological humanism in the organization, and through the obtained results to gain information into the way these companies are organized and the associated management in the conditions of implemented AI technology, considering the fulfilment of the humanistic settings included in the concept of technological humanism. The basis of the approach for this research was the newly developed technological humanism model from the previous literature [24]. The novelty in the approach of this research is the modification of that model in the way of combining its separate components that consider workplace organization and ergonomics management into one. This was done for the reason that it is expected that although today's companies might have separate departments that deal with workplace organization and ergonomics, they would need to be united within the concern that workplace positions are organized and processes are aligned with aspects of technological change in accordance with the required ergonomics of the workplace.

The surveyed domains followed the adapted technological humanism model components (1-4):

1) **Training and education of human resources in the application of new technologies**

It is considered that the importance of soft skills and specific abilities of human resources within the process of digital transformation emphasizes the importance of including knowledge about new technologies in the routine practice of the organization [26], so effective business requires the establishment of a learning organization, which continuously changes and improves using lessons from experience [27]. It has been recognized that modelling the knowledge and expertise of workers is one of the main challenges of digital transformation [19], so in addition to a well-supported knowledge management system, it is also important to increase the involvement of employees in creating new organizational culture and ensure transparent communication in the organization [28].

2) **Organization of workplace and ergonomics in accordance with the implementation of new technologies**

The adoption of advanced technologies requires significant worker effort [29] and results in the demanding task of implementing appropriate organizational ergonomics. The specific consequences of digitalisation on people can concern both physiological and psychological areas and possible disturbances. Related disorders are described as Cyber-syndrome, which appears in conditions of frequent human interactions with cyberspace, and as a result, a new direction in ergonomics has been established – Cybergonomics [30].

3) **Use of procedures and processes to achieve employee satisfaction in changing working conditions**

The employee as an operator must benefit from technologies that do not hinder him, but rather enable his development and lead him to perform each action with confidence without mental or physical stress or insecurity [21]. Accordingly, it is necessary to establish an organization that positions the employee as an operator in a digital environment as a controller of production systems where the well-being of workers is a high priority, in such a way that he strategically uses technology to improve the quality of the working environment [22]. For this reason, a system should be established within the company to review and consider employee satisfaction in changing working conditions before negative consequences occur.

4) **Implemented system for long-term management of the quality of work of employed human resources**

Technology has affected almost all organizations in terms of changes in processes, procedures, and management, so organizations today are looking for technology-oriented employees for their operations at all levels [31]. These new conditions also establish new rules and approaches to people's work [32] and the implementation of smart manufacturing creates a challenging work environment for employees in a way that results in new types of situations and contexts of their workplaces [33]. In such circumstances, employees must be able to understand complex situations, find innovative solutions, and adapt to a constantly changing environment. [34]. In order to ensure quality in the company's work in the long term, it is necessary to establish a system that, on the one hand, ensures continuous training and development of employees, which is a key stage in ensuring the future quality of the workforce [35], and acquires new ones with a high level of necessary competencies, while on the other hand, includes the necessity of replacing workers who do not meet the required conditions [24].

From a random selection of contacted manufacturing companies, fifteen of them agreed to participate in the research. The research was conducted on companies that are all privately owned, and they were small, medium and large enterprises with annual revenues ranging from EUR 2,5 to 201 million, with the number of employees ranging from 21 to 955. The companies covered several branches of industry and included the processing of wood and wood products, the production of metal, rubber and plastic products, electrical

equipment, paper and paper products, and the production of food products and beverages. The respondents were members of top management as individuals responsible for decision-making and management of the company. They were asked to answer questions on the one hand indicating the degree of the use of AI systems in the company they manage, and on the other hand to give an assessment of the degree of implementation of each of four components of technological humanism in their organization. The questionnaire was based on a five-point Likert scale. Before completing the questionnaire, members of top management were informed about the purpose of the research and the necessary focus on evaluating the degree of application of AI systems in their business related to production, i.e. related processes and activities. In order to avoid the possibility that respondents have their own interpretations regarding AI use, which than can influence their answers and limit the potential of reasoning based on the gained data, they were informed with AI solutions for manufacturing companies ranging from being only supportive, to making decisions and action autonomously. Accordingly, they responded in a way to assess the degree of application of AI technology in their organizations in relation to the current real situation in production. Within the part of the questionnaire that related to technological humanism, according to the presented model, it contained one question for each of its components that described its essence.

Based on the results of each component of the applied model of technological humanism, an additional variable was derived in the form of the results of technological humanism, as their arithmetic mean. Tab. 1 provides an overview of the results of descriptive statistics relating to the relationship between the use of AI systems in the company and components of the adapted research model of technological humanism (1-4).

Table 1 Total statistical data, descriptive statistics

Variable	Descriptive Statistics							
	Mean	Valid N	Median	Mode	Freq	Min	Max	Std.Dev.	Skewness
The use of AI systems	1,80	15,00	2,00	1	7	1	4	0,94	1,04
Component 1	3,07	15,00	3,00	3	8	2	4	0,70	-0,09
Component 2	2,80	15,00	3,00	3	11	1	4	0,68	-1,34
Component 3	3,33	15,00	3,00	4	7	2	4	0,72	-0,63
Component 4	3,00	15,00	3,00	3	7	1	5	1,00	0,00

Based on the sample of companies studied, the results of descriptive statistics show a mean value of 1,80 (median of 2,00) in relation to the use of AI systems on a scale of 1,00 to 5,00, which is below average. Looking at the four components of the technological humanism model, the highest mean value of 3,33 (median 3,00) is recorded by component 3, which refers to the use of procedures and processes to achieve employee satisfaction in changing working conditions, and the lowest mean value of 2,88 (median 3,00) is recorded by component 2, which refers to the organization of workplace and ergonomics in accordance with the implementation of new technologies. The results from the sample of companies studied indicate a greater tendency to ensure employee satisfaction as a psychological factor than the organization of workplace and ergonomics as a predominantly physiological factor within the concept of technological humanism.

The presentation of the results of inferential statistics gives an insight into the mutual relations and associations between the variables. Tab. 2 gives an overview of the Spearman's rank correlation results pertaining to the relationship of the use of AI systems in a company, the components of the technological humanism adapted research model (1-4), and the Technological Humanism score. Statistically significant values are marked in bold.

Table 2 Spearman's rank correlation results

Variable	Spearman Rank Order Correlations					
	Marked correlations are significant at p <,05000					
	AI Use	Comp. 1	Comp. 2	Comp. 3	Comp. 4	TH Score
AI Use	1,00	-0,06	-0,27	0,38	**0,71**	0,34
Comp. 1	-0,06	1,00	**0,80**	-0,05	0,06	0,60
Comp. 2	-0,27	**0,80**	1,00	-0,04	-0,01	0,55
Comp. 3	0,38	-0,05	-0,04	1,00	**0,79**	0,70
Comp. 4	**0,71**	0,06	-0,01	**0,79**	1,00	0,74
TH Score	0,34	0,60	0,55	0,70	0,74	1,00

It can be seen that the use of AI systems in a company has no statistically significant association with the Technological Humanism Score. This could be a problem for the surveyed companies if they would like to make the transition towards Industry 5.0, because the use of AI systems and components of technological humanism are an integral part of it [15]. Considering that the respondents were members of top management responsible for decision-making and defining policies and processes within the digital transformation of the company, and that the implementation and use of AI solutions is a very sensitive area that includes a wide range of possible organizational impacts [36], the lack of establishing an organization that supports the human factor, for which they are responsible, is concerning.

It is observed that the use of AI systems has a statistically significant association with only one component of technological humanism, namely Component 4, which represents the existence of an implemented system for long-term management of the quality of work of employed human resources. Component 4 is important and demanding within the organization because it includes continuous improvement, professional development and investment in people, and on the other hand, managing the replacement of human resources that do not meet the required conditions [24]. Further analysis of the interrelationship of variables shows that Component 4 records a statistically significant association with Component 3, which represents the degree of use of procedures and processes to achieve employee satisfaction in changing working conditions. This statistically confirmed association indicates that the companies surveyed associate the psychological characteristic in the form of employee satisfaction with having and acquiring a quality workforce in the long term.

Component 1, which represents the training and education of human resources in the application of new technologies, is very important in the implementation of AI solutions because it enables the acquisition of skills related to AI technology, which results in its competent use, reduced misunderstandings and minimization of risks [37]. The absence of its statistically significant association with the use of AI systems in the surveyed companies represents a potential problem when implementing these digital solutions.

Observing the mutual relationship between the components of technological humanism, Component 1 records a statistically significant association with Component 2, which represents the degree of the organization of workplace and ergonomics in accordance with the implementation of new technologies. This enables an effective transition with training and education aimed at adapting employees to different workplace conditions in the company brought about by the introduction of new technologies.

4 CONCLUSION

Artificial Intelligence (AI) is a technology that has already been implemented in various spheres of life and business, so that it can be called just relatively new. As it enables actions and functions that no technological solution from the past could perform independently, it represents a tool that requires understanding, clear interpretation, tractability and reliability trustworthiness. In order to achieve long-term benefits from AI use for people and organizations that include that this technology is at the service of people, it is necessary to include technological humanism, which is dedicated to ensuring the protection of human dignity in the technological developments accompanying the digital age [8] and which represents an important part of Industry 5.0. Published research in the field of AI, Industry 5.0 and technological humanism has shown possible differences of viewpoints from the top management in relation to other employees. This could result in an organizational structure set up by top management that does not correspond to the needs or expectations of other employees regarding the humanistic approach to the implementation of new technologies.

A new study conducted on a sample of a larger number of companies from different manufacturing sectors shows the absence of a statistically significant association between the use of AI systems and the implementation of the concept of technological humanism. Since members of the top management are responsible for decision-making and the organization of the company, the results show the extent to which they take into account the humanistic needs of employees. Based on the results of the statistical analysis and statistically significant associations, an association is visible between the use of AI systems in the company in a way that ensures the success of the company's business through the long-term provision of a quality workforce, and the absence of most of the components that denote the sociological values of technological humanism, which includes physiological and psychological factors, important for the well-being of employees. This may be a cause for concern because the implementation of AI technology was not associated to the human aspects of business, which may result in the failure of its effective use [38]. Within the companies studied, the fundamental goal of AI, which should be the preservation of human values and the advancement of social good [39] has not been met, and the possible impact of advanced AI systems, which could result in consequences for human life and society with the potential to lead to practically irreversible changes [36] has not been considered. If the implementation of AI as a new sophisticated technology, which brings numerous benefits but also risks, is not handled correctly from the very beginning, the damage done can be very difficult to repair and could have significant negative consequences on the company and people as a whole.

Since the research was conducted on a small sample of companies, this paper calls for new research in the field of AI implementation in the manufacturing sector. It contributes to the existing knowledge base by identifying areas that need to be focused on, so that the application of AI technology in manufacturing can be of real benefit to the company and people. Attention should also be paid to the specific areas identified in this paper when implementing Industry 5.0, as AI is an integral part of it.

5 REFERENCES

[1] Ryalat, M., El Moaqet, H., & Al Faouri, M. (2023). Design of a smart factory based on cyber-physical systems and Internet of Things towards Industry 4.0. *Applied Sciences, 13*(4), 2156. https://doi.org/10.3390/app13042156

[2] Jeske, T., Würfels, M., & Lennings, F. (2021). Development of digitalization in production industry–Impact on productivity, management and human work. *Procedia Computer Science, 180*, 371-380. https://doi.org/10.1016/j.procs.2021.01.358

[3] Sheikh, H., Prins, C., & Schrijvers, E. (2023). Artificial intelligence: definition and background. In *Mission AI: The new system technology*, Cham: Springer International Publishing, 15-41. https://doi.org/10.1007/978-3-031-21448-6_2

[4] Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., & Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation, 2*(4). https://doi.org/10.1016/j.xinn.2021.100179

[5] Passalacqua, M., Cabour, G., Pellerin, R., Léger, P. M., & Doyon-Poulin, P. (2024). Human-centered AI for industry 5.0 (HUMAI5.0): Design framework and case studies. In *Human-centered AI*, Chapman and Hall/CRC, 260-274. https://doi.org/10.1201/9781003320791-27

[6] Plathottam, S. J., Rzonca, A., Lakhnori, R., & Iloeje, C. O. (2023). A review of artificial intelligence applications in manufacturing operations. *Journal of Advanced Manufacturing and Processing, 5*(3), 10159. https://doi.org/10.1002/amp2.10159

[7] ESADE. (2020). *Humanismo Tecnológico o cómo hacer al ser humano el centro de la automatización global*. Madrid.

[8] ESADE. (2020). *Humanismo tecnológico, Conclusiones del Foro de Humanismo Tecnológico*, Madrid, 2020.

[9] Tavares, M. C., Azevedo, G., & Marques, R. P. (2022). The challenges and opportunities of era 5.0 for a more humanistic and sustainable society—a literature review. *Societies, 12*(6), 149. https://doi.org/10.3390/soc12060149

[10] Werthner, H., Ghezzi, C., Kramer, J., Nida-Rümelin, J., Nuseibeh, B., Prem, E., & Stanger, A. (2024). *Introduction to digital humanism: A Textbook*. https://doi.org/10.1007/978-3-031-45304-5

[11] Hernando, A. (2022). *Humanismo digital: la tecnología al servicio de las personas y del propósito de las empresas*. Institute for Social Innovation. Barcelona.

[12] Dmitrieva, E., Balmiki, V., Lakhanpal, S., Lavanya, G., & Bhandari, P. (2024). AI Evolution in Industry 4.0 and Industry 5.0: An experimental comparative assessment. BIO Web of Conferences. *EDP Sciences, 86*, 01069. https://doi.org/10.1051/bioconf/20248601069

[13] Chauhan, C., Singh, A., & Luthra, S. (2021). Barriers to industry 4.0 adoption and its performance implications: An

empirical investigation of emerging economy. *Journal of cleaner production, 285*, 124809. https://doi.org/10.1016/j.jclepro.2020.124809

[14] Rožanec, J. M., Novalija, I., Zajec, P., Kenda, K., Tavakoli Ghinani, H., Suh, S., ..., & Soldatos, J. (2023). Human-centric artificial intelligence architecture for industry 5.0 applications. *International journal of production research, 61*(20), 6847-6872. https://doi.org/10.1080/00207543.2022.2138611

[15] Tóth, A., Nagy, L., Kennedy, R., Bohuš, B., Abonyi, J., & Ruppert, T. (2023). The human-centric Industry 5.0 collaboration architecture. *MethodsX, 11*, 102260. https://doi.org/10.1016/j.mex.2023.102260

[16] Chamola, V., Hassija, V., Sulthana, A. R., Ghosh, D., Dhingra, D., & Sikdar, B. (2023). A review of trustworthy and explainable artificial intelligence (xai), *IEEe Access*. https://doi.org/10.1109/ACCESS.2023.3294569

[17] Zhu, J., Liapis, A., Risi, S., Bidarra, R., & Youngblood, G. M. (2018). Explainable AI for designers: A human-centered perspective on mixed-initiative co-creation. *The IEEE Conference on Computational Intelligence and Games (CIG2018)*, 1-8. https://doi.org/10.1109/CIG.2018.8490433

[18] Peter, M. K., Kraft, C., & Lindeque, J. (2020). Strategic action fields of digital transformation: An exploration of the strategic action fields of Swiss SMEs and large enterprises. *Journal of Strategy and Management, 13*(1), 160-180. https://doi.org/10.1108/JSMA-05-2019-0070

[19] Ciccarelli, M., Papetti, A., & Germani, M. (2023). Exploring how new industrial paradigms affect the workforce: A literature review of Operator 4.0. *Journal of Manufacturing Systems, 70*, 464-483. https://doi.org/10.1016/j.jmsy.2023.08.016

[20] Koldewey C., Hobscheidt D., Pierenkemper C., Kühn A. & Dumitrescu R. (2022). Increasing firm performance through industry 4.0 - A method to define and reach meaningful goals. *Sci., 4*(4), 39. https://doi.org/10.3390/sci4040039

[21] Salvatore M., & Stefano R. (2021). Smart operators: How Industry 4.0 is affecting the worker's performance in manufacturing contexts. *Procedia Computer Science, 1*(180), 958. https://doi.org/10.1016/j.procs.2021.01.347

[22] Alves, J., Lima, T. M., & Gaspar, P. D. (2023). Is industry 5.0 a human-centred approach? A systematic review. *Processes, 11*(1), 193. https://doi.org/10.3390/pr11010193

[23] Hofkirchner, W. (2021). The Future of anthroposociogenesis: panhumanism, anthroporelational humanism and digital humanism. *The 2021 Summit of the International Society for the Study of Information Proceedings, 81*(1), 114. https://doi.org/10.3390/proceedings2022081114

[24] Vukelić, Ž., Cajner, H., & Barić, G. (2024). Research model of the degree of technological humanism in manufacturing companies in the transformation towards Industry 5.0. *Tehnički glasnik, 18*(3), 410-417. https://doi.org/10.31803/tg-20240502091110

[25] Vukelić, Ž., Cajner, H., & Trstenjak, M. (2024). The aspect of technological humanism in the implementation of robotic systems (RS) and artificial intelligence (AI) in Industry 5.0. In *Proceedings of the 15th International Scientific Conference MMA-Flexible Technologies* (pp. 143-146). Novi Sad: Faculty of technical sciences, Department of production engineering. https://doi.org/10.24867/MMA-2024-04-004

[26] Pech, M., & Vaněček, D. (2022). Barriers of new technology introduction and disadvantages of industry 4.0 for industrial enterprises. *Serbian journal of management, 17*(1), 197-206. https://doi.org/10.5937/sjm17-30453

[27] Schermerhorn, J. R. (2013). *Management*. Hoboken: John Wiley & Sons.

[28] Olsson, A. K., Eriksson, K. M., & Carlsson, L. (2025). Management toward Industry 5.0: A co-workership approach on digital transformation for future innovative manufacturing. *European Journal of Innovation Management, 28*(1), 65-84. https://doi.org/10.1108/EJIM-09-2023-0833

[29] Adel, A. (2022). Future of industry 5.0 in society: Human-centric solutions, challenges and prospective research areas. *Journal of Cloud Computing, 11*(1), 1-15. https://doi.org/10.1186/s13677-022-00314-5

[30] Pouyakian, M. (2022). Cybergonomics: Proposing and justification of a new name for the ergonomics of Industry 4.0 technologies. *Frontiers in Public Health, 10*, 1012985. https://doi.org/10.3389/fpubh.2022.1012985

[31] Adisa T. A. (2024). *HRM 5.0: Unpacking the digitalisation of human resource management*. Springer. https://doi.org/10.1007/978-3-031-58912-6

[32] Tomašević, A. N. (2023). Reshaping the future of work: Navigating the impacts of lifelong learning and digital competences in the era of 5.0 industry. *Social informatics journal, 2*(1), 1-6. https://doi.org/10.58898/sij.v2i1.01-06

[33] Sony, M., & Naik, S. (2020). Critical factors for the successful implementation of Industry 4.0: A review and future research direction. *Production Planning & Control, 31*(10), 799-815. https://doi.org/10.1080/09537287.2019.1691278

[34] Leon, R. D. (2023). Employees' reskilling and upskilling for industry 5.0: Selecting the best professional development programmes. *Technology in Society, 75*, 102393. https://doi.org/10.1016/j.techsoc.2023.102393

[35] Li, L. (2022). Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. *Information Systems Frontiers*, 1-16. https://doi.org/10.1007/s10796-022-10308-y

[36] Gruetzemacher, R., & Whittlestone, J. (2022). The transformative potential of artificial intelligence. *Futures, 135*, 102884. https://doi.org/10.1016/j.futures.2021.102884

[37] Markus, A., Pfister, J., Carolus, A., Hotho, A., & Wienrich, C. (2024). Effects of AI understanding-training on AI literacy, usage, self-determined interactions, and anthropomorphization with voice assistants. *Computers and Education Open, 6*, 100176. https://doi.org/10.1016/j.caeo.2024.100176

[38] Ejsmont, K. (2021). The Impact of Industry 4.0 on Employees—Insights from Australia. *Sustainability, 13*(6), 3095. https://doi.org/10.3390/su13063095

[39] Tsanov, I. (2024). The role of social psychology in the creation of ethical AI systems. In *IEEE International Conference Automatics and Informatics (ICAI2024)*, 142-147. https://doi.org/10.1109/ICAI63388.2024.10851581

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