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CONTRIBUTION OF ERGONOMICS TO THE DEVELOPMENT OF INDUSTRY 5.0

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Abstract: *his paper aims to identify the role of ergonomics in the advancement of Industry 5.0, with the aim of attaining a human centric approach. It presents four key ergonomic principles: incorporating human operators in the design of equipment, using the knowledge of the workplace, engaging the teams in the design process, and understanding the constraints of technology. The paper proves that these principles are ergonomic and related to Industry 5.0's human-centric approach. Thus, these principles can be used to design systems and environments that are more appropriate for people, considering their strengths and weaknesses, which is in line with Industry 5.0's vision of designing industrial processes with people at the center.*

Key words: *Ergonomics, human-centric approach, design process, Industry 5.0.*

1. INTRODUCTION

Industry 5.0 was announced by the European Commission. Specifically, it was introduced by the Directorate-General for Research and Innovation, with key contributions from Maija Breque, Lars De Nul, and Athanasios Petridis from Unit F.5 — Industry 5.0.

The concept and vision of Industry 5.0 were outlined in a policy brief published in January 2021. This new industrial paradigm seeks to go a step further than the orientation of Industry 4.0, with a focus on sustainability, human-orientation, and resilience in European industries [1].

The announcement and details are in line with the overall strategies of the European Commission that aims to advance the industry as a driver of economic growth while promoting its positive impact on society and the environment.

The focus of consideration in this paper is how to achieve one of the main three goals of Industry 5.0 – the human-centric approach. The previously mentioned document of the European Commission outlines the benefits of using the human-centric approach and provides a basic notion about this approach. But of course, this

document does not provide detailed instructions on how to achieve the human- centric approach in Industry 5.0. As members of the Executive Committee of the Federation of European Ergonomics Societies (FEES), the authors of this paper believe that Ergonomics has a crucial role in the establishment and realization of the human-centric approach for Industry 5.0.

Considering that the word ergonomics was not mentioned in this EU document, we believe that it is important to emphasize the importance of the involvement of ergonomics in the theory and practice of the human-centered approach of Industry 5.0.

Having that in mind, in this paper, four initial, basic ergonomic principles that refer to the establishment of the human-centric approach for Industry 5.0 will be presented. After that, it will be explained why these principles can be considered ergonomic. Finally, the connection of these four ergonomic principles will be established with the human-centric approach of Industry 5.0.

2. FOUR ERGONOMIC PRINCIPLES FOR HUMAN-CENTRIC APPROACH

Below will be presented four basic ergonomic principles that should be considered when we want to implement a human-centric approach in industry. The importance of these principles will be pointed out, and their construct validity will be shown in a concise form through references previously published in connection with each of these principles.

2.1 Principle 1: To include in the design of the equipment/installation the human operator with his capacities and limitations

The human operator is an important aspect of the design of equipment and installations since they are usually the primary determinant of the performance and safety of a system [2]. This involves knowledge of the strengths and weaknesses of the operator and can be obtained using ergonomic factors in the design [3].

The human operator should be considered as an essential component of closed-loop control systems and thus the bioscientists and engineers, including the ergonomists, should work hand in hand [4]. When it comes to cobotic systems, the human operator's part is especially significant, and the assessment of their knowledge and skills is crucial in the design [5].

2.2. Principle 2: There is a huge expertise at the workplaces, developed by the operators. Understand it, use it before any change!

Several studies show that one of the key factors is the ability and need to use the operators' expertise in the workplace. Kaasinen et al. [6] point out that the solutions should enable and involve the workers and let them co-design their workplace and share their expertise. Ohashi and Yuki [7] also describe the possibilities of using expert systems and knowledge management in the practical knowledge of operators for job scheduling and productivity improvement. The study of Cellier et al. [8] also emphasizes the importance of expertise in dynamic conditions where the expert operators provide better inference, anticipation and understanding of the processes. Altogether, these results provide evidence for the principle that operator knowledge should be considered and employed prior to any modifications in the workplace.

2.3. Principle 3: To include the teams in the design process

The involvement of teams in the design process is well supported by various studies, as pointed out in this paper. Smith et al. [9] stress the importance of a process-oriented approach that is based on a model that considers the roles of people, processes, and tools. McCreery and Bloom [10] also stress the importance of work teams that are consistent with the organization's competitive and manufacturing strategies. Smith [11] talks about cross-functional design teams that involve professionals from different departments. Hoffman and Court [12] describe a different approach to the formation of project teams, which is based on the company's structure and implies the obligation and involvement of employees. Altogether, these studies highlight the importance of team inclusion in the design process suggesting that it should be more strategic and systematic.

2.4. Principle 4: Technology cannot solve all problems - it may lead to delusion

The World Economic Forum [13] notes that although technology, particularly from the Fourth Industrial Revolution, is transformative, it is not the solution to all the problems facing humanity. This is because we rely on machines and we become vulnerable to bugs and system breakdowns. This is the case because although technology enhances efficiency in the organization, it also brings about new challenges [14]. Spath et al. [15] argue that technology providers should ensure that their products are relevant to the market and the users while Hofstra and Dean [16] argue that contracts should be reviewed to ensure that the technology meets the operational needs. Probert et al. [17] have outlined a five-step approach to developing a business case for technology investment, which includes identifying the value of technology and the benefits that may be realized. Fox [18] also points out that the assessments of potential benefits should be matched with the assessments of potential disbenefits, reliability, and utilization. These studies emphasize the necessity of the analysis of the existing operation and requirements prior to the introduction of new technologies.

Technology as we have seen is not a silver bullet, it needs to be integrated with human ingenuity and applied ethically to solve multifaceted challenges. How the principles can be implemented in practice, especially principles 1-3, can be seen in [19; 20].

3. ERGONOMIC NATURE OF THE PRINCIPLES

Principles 1, 2, 3, and 4 outlined in the paper can be considered ergonomic principles in essence because they align closely with the core goals and approaches of ergonomics as a discipline. Principle one directly resonates with the fundamental ergonomic approach of designing systems, products, and environments to fit the capabilities and limitations of the human users. Ergonomics acknowledges that people have limitations that are physical, cognitive, and psychosocial, and designs should be made to conform to these limitations for safety, productivity, and health. This principle is also in line with the user-centered approach that is core to ergonomics since it involves the human operator's capabilities and limitations in the design process.

The second principle focuses on the use of practical knowledge and experience of the people who are involved in the work processes. Ergonomics also focuses on the fact that the context and the reality of the work environment can be best appreciated by the workers themselves. This principle is consistent with the ergonomic approach of engaging end-users in the design and development process since they have a wealth of knowledge about potential issues, risks, and opportunities for optimization.

Participatory ergonomics is an approach that is well-known in the field of ergonomics and is directly supported by the third principle of the framework. Participatory ergonomics is a process of working with workers and teams in order to identify, assess and address the physical and organizational demands of their work systems, tools and environments. This principle acknowledges the fact that the people who will be affected by the changes should be involved in the process, which is a fundamental ergonomics concept. This way, solutions that are developed

by teams are more likely to be effective in the context of the work environment as they are designed with the team's needs and limitations in mind.

While principle four may not seem overtly ergonomic at first glance, it reflects a fundamental understanding of ergonomics referring to that technology cannot solve all human factors and organizational issues that are associated with the workplace. Ergonomics appreciates the fact that work, tools and people are interrelated and that any technological intervention must be done with people in mind. This principle is against the overuse of technology and forgetting the human element that sometimes comes with it, which generally may cause stress, low morale, and even safety risks.

In essence, these four principles align with ergonomic principles because they prioritize the human element, emphasize user-centered design, promote participatory approaches, and recognize the limitations of technology-centric solutions. By incorporating these principles, organizations can develop systems, processes, and environments that are better suited to the needs, capabilities, and limitations of the people who will be using them, which is the core goal of ergonomics.

4. ABOUT THE CONNECTION OF FOUR ERGONOMIC PRINCIPLES WITH HUMAN CENTRIC APPROACH OF INDUSTRY 5.0

The first principle supports the human-centric approach in a direct manner by stating that the design of equipment, installations and processes should be done with consideration of the abilities and limitations of the human operators. A human-centric design does not focus on the technological possibilities of the design but rather on how the technology will interact with the human operators. Applying ergonomic principles and human factors knowledge to the design, it is possible to minimize the physical and mental load on the people who will be using the design, increase safety, and allow the operators to work with the design solution effectively.

The second principle also supports the human-centric approach since it takes into consideration the practical knowledge and experience of the operators. This principle shifts the focus from operators as passive receivers of changes from above to their active participation in identifying needs and developing solutions. The operators' experience, which has been gained in many years, can help to identify the strengths and weaknesses of the work environment, possible problems, and possible solutions. Thus, by involving such knowledge from the very beginning, the solutions that are being created are more likely to be appropriate for the real-life context of the workplace, which in turn will have a positive impact on the organization and its employees. In essence, both principles put the human operator in the middle of the design and implementation process, and not as an add-on or a mere recipient of predetermined design solutions. This human-centric approach not only increases the probability of success for Industry 5.0. It also fits into the overall objective of promoting sustainable and healthy workplaces for people.

Principles three and four also strongly reinforce the human-centric approach that is central to Industry 5.0. Principle 3 directly embodies a human-centric approach by actively involving the operators and workplace teams in the design and development process. Rather than having solutions imposed on them from the top-down, the teams who will be directly impacted by the changes are given a voice and an opportunity to shape the solutions.

This way, the teams are involved in the design process and their knowledge, experiences, and perceptions can be integrated into the design, thus creating solutions that are more appropriate for the team's environment and more likely to be implemented. This approach ensures that the teams feel that they are part of the process and this increases the likelihood of successful implementation.

In addition, by respecting the teams' opinions and their knowledge, this principle acknowledges the worth and self-organizing capacity of the human factor in the industrial system. It does not view the teams as mere targets of technology implementation, but as key stakeholders whose engagement is critical in the

creation of appropriate and long-lasting solutions.

The fourth principle helps to prevent the overemphasis on technology and underlines the importance of people's involvement. It acknowledges the fact that technology is a useful tool, but it should not be seen as a solution to all the problems or as a way of eliminating the human element in decision making and management.

This principle also helps to remind us that technology has its drawbacks and that people can be easily deceived, thus emphasizing the need to stay focused on people. It underlines the importance of understanding the social, organizational and human factors in which technology is applied instead of perceiving technology as a standalone solution.

This principle also aligns with the goal of creating sustainable and fulfilling work environments. If technology is implemented without considering its impact on human factors, it can lead to unintended consequences, such as increased stress, alienation, or a disregard for human well-being.

In combination, principles three and four underline the importance of integrating technology into industrial processes while at the same time not forgetting the human aspect. They support the human-centric approach by engaging teams and operators in the design of the solutions and by acknowledging the risks of the technology-based approach.

This is a clear indication that both technological and human aspects should be considered to achieve the intended goals of Industry 5.0., for instance, a human-centered approach. One cannot advance or innovate merely by concentrating on the technical aspect but must incorporate human aspects, experiences, and perspectives.

5. CONCLUSIONS

The incorporation of ergonomic factors into the creation of Industry 5.0 is essential to the company's human-oriented objectives. The four principles of ergonomics discussed in this paper can be considered as the basis for the creation of a genuinely human-oriented environment in industrial conditions. This way, organizations

can design more efficient, long-lasting, and friendly workers' environments by considering human operators' capabilities and restrictions, utilizing workplace knowledge, engaging teams in the design process, and acknowledging the limitations of technology.

These principles are in line with the objectives of Industry 5.0, underlining the role of human beings in the process of the development of technologies. Thus, it can be concluded that as the industry develops, it is critical to balance, on the one hand, technological advancements and on the other – the human aspect. These principles are beneficial to be implemented by industries for designing a work environment that should not only improve productivity and efficiency but also provide better standards of living for workers.

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Contribuția ergonomiei la dezvoltarea Industriei 5.0

Această lucrare explorează contribuția ergonomiei la dezvoltarea Industriei 5.0, concentrându-se pe realizarea unei abordări centrate pe om. Prezintă patru principii ergonomice cheie: includerea operatorilor umani în proiectarea echipamentelor, utilizarea expertizei la locul de muncă, implicarea echipelor în procesul de proiectare și recunoașterea limitelor tehnologiei. Lucrarea stabilește natura ergonomică a acestor principii și legătura lor cu abordarea centrată pe om a Industriei 5.0. Prin incorporarea acestor principii, organizațiile pot dezvolta sisteme și medii mai bine adaptate nevoilor, capacităților și limitărilor umane, aliniindu-se cu obiectivul Industriei 5.0 de a crea procese industriale centrate pe om.

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