The formation of ergonomic thinking when designing complex information systems in the conditions of socio-technogenic development of the world

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Abstract. The paper considers the problems of ergonomic thinking, its formation and evolution when designing information systems in the conditions of socio-technogenic development of the world. Special attention is paid to the analysis of the ergonomic thinking evolution in the design of human-technology-environment systems. The main purpose of this work is to study the process of formation and further development of ergonomic thinking since the very beginning of ergonomics as a science. The paper considers the main approaches to the definition of ergonomic thinking, on which basis definitions are proposed that take into account all the features and directions of the evolution of ergonomic thought. Special attention is paid to the development of the main directions and factors of ergonomics according to the periods of its formation.

1 Introduction

The category of ergonomic thinking is a dyad, one of its components is ergonomics, which first arose in 1949 to denote the science that studied the peculiarities of human activity. Originally it was just a psychological branch, but at the end of the twentieth century ergonomics transformed into an interdisciplinary science with an independent status and started to study the interaction of society with technology and the environment.

The second component of the dyad is thinking, which has been sufficiently developed in the philosophical literature. Nowadays, there are many approaches to the classification and typology of thinking. For example, pedagogical concepts of thinking were developed by such scientists as P.Ya. Galperina, L.V. Zankova, V.V. Davydova and other authors.

In order to understand what type of thinking needs to be formed in the conditions of socio-technogenic development of the world, it is necessary to consider what processes from the point of view of brain physiology it is directed at. So A.L. Shamis in his paper "Thinking: Definitions, Types, Diagrams of the Process" draws attention to the fact that in order to give a simple functional definition of thinking, it is necessary to pay attention to the following processes "... 1) the construction of an active hierarchical model of the environment in the brain, necessary and sufficient for the perception of the environment, and the control of active

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purposeful behavior in a multi-extreme environment; 2) the implementation of the process of active perception of the environment; 3) the implementation of the process of controlling behavior in a multi-extreme environment; 4) the implementation of the process of active training; 5) solving non-algorithmic (creative) tasks" [1 p. 4].

During its existence as a science, ergonomics has come a long way. It had a significant impact on the environment and humans, transforming science, its methodology and practice. Ergonomics made the most significant change in people's thinking, which influenced the artificial world they created - the technosphere. Every year, public thinking becomes more and more ergonomic, focused not only on how to connect the components of complex technical objects and entire systems to optimize them and improve their efficiency, but also how the developed equipment, technical systems and technologies will affect the person who works with them, as well as the environment.

1.1 Prerequisites for the formation of ergonomic thinking

The formation of ergonomic thinking is the result of the evolution and development of scientific and practical achievements in the field of ergonomics.

The formation of ergonomic thinking refers to the period of appearing ergonomics as a science. In the USSR the first reports on ergonomics, it was called ergology at that time, were made in 1921 by V.M. Bekhterev and V.N. Myasishchev. The first applied works in the field of ergonomics (1921-1930) belong to Soviet scientists A.A. Bernstein, S.G. Gelgerstein, N.M. Dobrotvorsky, N.V. Zimkin, N.A. Epple. During that period, the problems related to ergonomic thinking were not raised, but the problems related to labor psychology were actively discussed, which later formed the basis of ergonomic thinking. Only since the 1970s engineering psychology and ergonomics have separated completely into two scientific fields. Since that period, the first mentions of ergonomic thinking have appeared in the works of Soviet scientists.

The first mentions of ergonomic thinking can be found in the works of V.P. Zinchenko and V.M. Munipov "... A comet called ergonomics flew by, flared up and faded, scattering myriads of sparks that fertilized the thinking of specialists in various fields of activity. When creating something (making any changes to the artificial environment), it has become common for them to think about how a person will act and feel in the "man-technical means—environment" system ..." [2]. During that period, research in the field of human factors and ergo design came to the fore, and ergonomic thinking turned towards efficiency, convenience and operability of human-technology systems.

1.2 Directions of developing ergonomic knowledge and thinking

Since the 1980s, various directions in the field of ergonomics have gradually appeared. In this regard, ergonomic thinking has gradually evolved as well, and the main issues to which it is directed have been the issues of sustainable development of the human-technology-environment system.

There are not many special works devoted to ergonomic thinking in the domestic and foreign literature. So in the monograph "The formation of an ergonomic educational environment in the School-University system" L.P. Akulova defines ergonomic thinking in education as "thinking aimed at determining ergonomic effectiveness and identifying ways to improve it with the systematic application of ergonomic knowledge about physiological, psychophysiological, anthropological, psychological and social aspects of personality in the design of the educational process that affects the learning environment" [3]. In the work "Formation of a personal safety culture of a future tutor at a university based on an ergonomic approach" [4], the author notes that the development of ergonomic thinking plays an

important role in the humanization of education culture. This paper focuses on the fact that ergonomic thinking is aimed at creating conditions that meet the needs and capabilities of students, teachers and other participants in the educational process. The ergonomic approach allows taking into account anthropological features, psychological aspects of perception, communication, physical and emotional well-being of all participants in the educational process. It contributes to creating comfortable and effective educational environments where everyone can reach their potential and achieve success. Based on the mentioned above, it can be concluded that ergonomic thinking is an important component in improving the culture of education in the direction of a more humane and inclusive approach.

In the paper "Fundamentals of ergonomics and work safety", the authors note that the design of human activity is based on thinking, and the main mode of activity of the managing operator is operational thinking [4].

The problems of conception ergonomic thinking are raised in the paper of S.A. Yuditsky, where the author writes "… In modern psychology and ergonomics, it is generally accepted that thinking is characterized by the unity of conscious and unconscious, left-hemisphere concepts and right-hemisphere images" [5]. The author also notes that spatial thinking is a kind of figurative, thereby speaking about spatial ergonomic thinking.

In foreign papers, some attention is also paid to the problems of ergonomic thinking. Thus, in [6] it is shown that ergonomic thinking involves a multiphase and nonlinear process, it is associated with decision-making called abductive inference. Abductive inference is related to how people formulate requests through perception or comprehension of a phenomenon, if questions and answers are based on information collected as a result of observing the real causes surrounding the problem. Tom Brown's article [5] describes the application of ergonomic thinking. According to the author, "... what is supposed to be is not some specific invention or innovation process, but the whole system developing around it." Ergonomic innovation processes are based on the diagnosis of work situations, which should include both formal and informal aspects of the environment. To speed up and strengthen the results as a method of increasing productivity ergonomics influence should take into account the features of the system, organizational culture and comply with the principle of sustainable development, which automatically implies special attention to social responsibility in the techno-biosphere environment.

In [7,11], the authors stress that actions resulting from ergonomic thinking should anticipate real inconsistencies with environmental requirements and create technical devices, equipment, workstations and work systems in which the principles of sustainability, safety and environmental friendliness are clearly observed. In [8,12], the authors note the influence of ergonomic thinking on the modeling of systems in order to achieve sustainability, including ecology. In their opinion, system modeling is connected with ergonomics not only semantically, but also because of its sociotechnical equivalence. The approach to system modeling is based on the search for answers – just like the processes of ergonomics – and assumes the relationship between environmental constraints and work planning, in order to achieve maximum sustainability of systems.

M. Santos in his paper [9,10], speaking about ergonomic thinking, offers a methodology that serves as a basis for combining many aspects of ergonomics. This methodology is based on the sociotechnical idea that any technical system, being a part of technosphere, should keep a balance between the technical and environmental component.

2 Materials and methods

The research objective is to study various approaches to the concept of ergonomic thinking and as a result, to form the concept of ergonomic thinking in the conditions of socio-technogenic development of the world [13]. To achieve this objective, a number of problems

were identified within the scope of this paper: 1. To analyze the prerequisites for the formation of ergonomic thinking 2. To analyze the main directions of the development of ergonomic knowledge and ergonomic thinking 3. To define ergonomic thinking by combining different points of view. The research methodology is based on the integration of the philosophical approach with the ergonomic approaches, which ensures their interpenetration and complementarity. The main theoretical and methodological basis used in this study covers the concept of socio-technogenic development of the world, which claims that human activity involves simultaneous subordination and control over nature by means of the developed technology. Several scientific methods are used throughout the research, including analysis, synthesis, analogy, comparison, specification and classification.

3 Results

To conduct research, the authors analyzed the papers published in the following databases: Elibrary, Scopus, Business Source Complete, Google Scholar, Emerald Publishing, Academic Search Premiere, Web of Science, Discover и Ergonomics Abstracts for the period of 1920-2022. Such keywords as ergonomic thinking, ergonomics, global ergonomics, green ergonomics, eco-ergonomics, ergonomics of sustainable development, human factor and sustainable development were used to search for scientific publications. To select the papers from those found in databases, the following significance criteria were used: papers in the field of ergonomics, in which the focus was on ergonomic thinking and on ergonomics of sustainable development. Abstracts and papers were selected if they related to problems connected with ergonomics and thinking, as well as related to the design of sustainable technical systems. To analyze the papers received and select the appropriate material, we used the intelligent information system of ergonomic examination, design and training. This system classified papers according to the subject of analysis, allowing to select suitable works for research quickly.

The initial search resulted in finding 7628 publications. Further analysis allowed to identify 73 publications that show the best correlation with the selection criteria for this study.

Based on the analysis of the recommended 73 papers, a table "Development of ergonomics directions" is compiled, which includes time periods, directions of research in the field of ergonomics, the main factors and requirements.

Table 1. Development of ergonomics directions [Compiled by the authors].

Time period	Appearing direction of ergonomics	Main factors	Requirements
1920-1949	Human engineering	Technical	Requirements for the equipment
1950-1969	Organizational ergonomics	Organizational	Requirements for the personnel
1970-1989	Cognitive ergonomics	Mental	Mental and physiological requirements
1990-1999	Physical ergonomics Global ergonomics Eco-ergonomics	Anthropological Factors of sustainable development Environmental factors	Environmental requirements
2000-2009	Neuroergonomics	Factors of interaction between human - machine	Requirements for comfort
2010-2019	Computer ergonomics	Interface	UA/UX requirements
2020-2023	Adaptive ergonomics	Artificial Intelligence factors	Information requirements

4 Discussion

The main idea in forming ergonomic thinking in the conditions of sustainable development of the socio-technogenic world is that it is impossible to use a formal approach to decision-making, all recommendations should function as a roadmap, preventing a situation of instability in the interaction of the human-technology-environment system.

In the conditions of the socio-technogenic development of the world, it is necessary to rethink the approach to the use of technical systems and artificial intelligence everywhere replacing high-level specialists. This approach is necessary because an increase in the share of artificial intelligence and automated technical systems in decision-making creates only the illusion of increased security and sustainability.

Based on the mentioned above, it should be noted that in order to ensure the sustainable development of the socio-technogenic world, convergence of knowledge, interdisciplinary approaches and strategies are necessary. The lack of ergonomic, and in particular eco-ergonomic thinking formed, in the design of technosphere facilities this will lead to a lack of predictive risk control, which increases the severity of eliminating consequences that affect humans and the environment.

Thus, the material observed brings to the conclusion that the formation of ergonomic thinking is an integral part of the socio-technogenic and socio-natural development of the world. This type of thinking is necessary for the formation of stable interaction of complex technosphere systems with complex biosphere systems. Combining the results of the analysis the following definition of ergonomic thinking is proposed which main focus is to minimize global problems of humanity and to transfer to sustainable techno-biospheric development of the world. So, ergonomic thinking is a system and spatial thinking aimed at decision-making and determining ergonomic efficiency, anticipating inconsistencies in the requirements for sustainability, safety, convenience and environmental friendliness of the environment, allowing to design and make technical devices, equipment, workstations and systems that comply with the principles of joint sustainable development of such systems as man-technology-environment ones.

5 Conclusion

The formation of ergonomic thinking is slow. The main reasons are insufficient attention to ergonomic issues in the educational process. As mentioned above, mastering the principles of ergonomics is an effective tool for the formation of ergonomic thinking. The main purpose of acquiring and forming ergonomic thinking is to ensure the operation safety of human-machine-environment systems. The formation of ergonomic thinking is important for achieving sustainability and security in the conditions of socio-technogenic development of the world.

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