SAFETY OF MAN-MACHINE INTERACTION IN THE DIGITAL ENVIRONMENT

Protasenko O.F.,
Ph.D., Associate Professor
Simon Kuznets Kharkov National University of Economics
Mygal G.V.,
D.Sc., Professor
The National Aerospace University "Kharkiv Aviation Institute" (KhAI)
Manakova H.O.,
an applicant for higher education in speciality 051 "Economics"
Simon Kuznets Kharkov National University of Economics

Introduction. The digital environment is an integral part of modern life. Moreover, today it is impossible to imagine both labour and daily activities without it. The digital environment makes it possible to perform a huge range of actions from simple (send or receive an e-mail, check the status of a bank account, find out the weather forecast, etc.) to complex (develop a training course, create an online shop, make an order, receive the services, etc.). Thus, the usage of the digital environment has many positive results for

society. However, there are also many problems. The most difficult problem is that the work of humans in a digital environment generates new types of man-machine interaction, which are poorly studied today. Hence, the mechanisms and consequences of their influence on humans, the level of their safety and efficiency are not clear. An example is e-learning systems. On the one hand, there is an individual approach to the organisation of the learning process (free choice of disciplines, training schedule, etc.). On the other hand, there is no or insufficient contact with the teacher, a lack of knowledge about the rational organisation of working time and place in conditions of free planning, etc. As a result, there are situations of overstrain, poorquality learning of knowledge, deterioration of physical and mental wellbeing due to prolonged work at the computer, etc.

Thus, it can be stated that today a new environment of human activity has been formed – the digital environment. But the issues of safety and efficiency of interaction between man and technics in the digitalization conditions are poorly studied today.

Literature review. Study the problem of safety of man-machine interaction in the digital environment should start with an analysis of the concept of "digital environment", its components and their place in it. The most common is the following definition: a digital environment is an integrated communications environment where digital devices communicate and manage the content and activities within it [1]. The definition shows that the concept is broad and includes both devices that transmit and receive information and various types of software for working with it. That is why the digital environment is the basis for Industry 4.0 and digital ecosystems.

Key components of the digital environment are Industry 4.0 and digital ecosystems. But what are they? Industry 4.0 is the massive introduction of cyber-physical systems into the production and service of human needs, including everyday life, work and leisure. A digital ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organisation, scalability and sustainability inspired by natural ecosystems. Both Industry 4.0 and digital ecosystems are the next stage in the development of ergatic systems, the main feature of which is to minimize the role of humans in their functioning. As a result of the transformation of ergatic systems into digital ergatic systems, human participation in their work has decreased. However, making essential decisions to ensure the safety of ergatic system functioning remains with a human [2-8].

New types of man-machine interaction are a logical consequence of the transformation of the ergatic system into digital ones. But they are insufficiently explored today. A detailed study of the features of the digital ergatic systems functioning will improve the safety and efficiency of man-machine interaction.

Based on this, the task is to study the degree of human immersion in the digital environment to optimize man-machine interaction using the example of the digital ergatic training system.

The aim is to apply the principles and concepts of human factors engineering and ergonomics to identify the most effective model for the functioning of digital ergatic systems.

Results and discussion. The problems of an operator and technics development in the digital environment have to be solved not separately but as a whole. For this, it is necessary to identify the crucial components of a digital ergatic system that ensure its safe and efficient

functioning. Based on the literary search [3, 5, 6], three components were identified – operator's digital mindset, digital tools and digital devices.

Operator's digital mindset is a set of attitudes, behaviours, and beliefs held by people or a group of people that influence curiosity about disruptive digital technology in an organization. In other words, a digital mindset is the operator's readiness to master and apply new technologies to accomplish the assigned tasks, the absence of internal psychological barriers during working in a digital environment.

Digital tools are programs, websites or online resources that can make tasks easier to complete.

Digital device is an electronic device that can create, generate, send, share, communicate, receive, store, display, or process information (e.g. computers, laptops, tablets, smartphones, etc.).

The components cannot exist in isolation from each other. A connecting element is needed to bring them together and ensure harmonious operation to ensure the safe and effective functioning of a digital ergatic system. Ergonomics acts as such a connecting element. The broad toolbox of ergonomics as a complex science combining engineering, psychological, social and environmental approaches make it possible to solve the problem (Fig. 1).

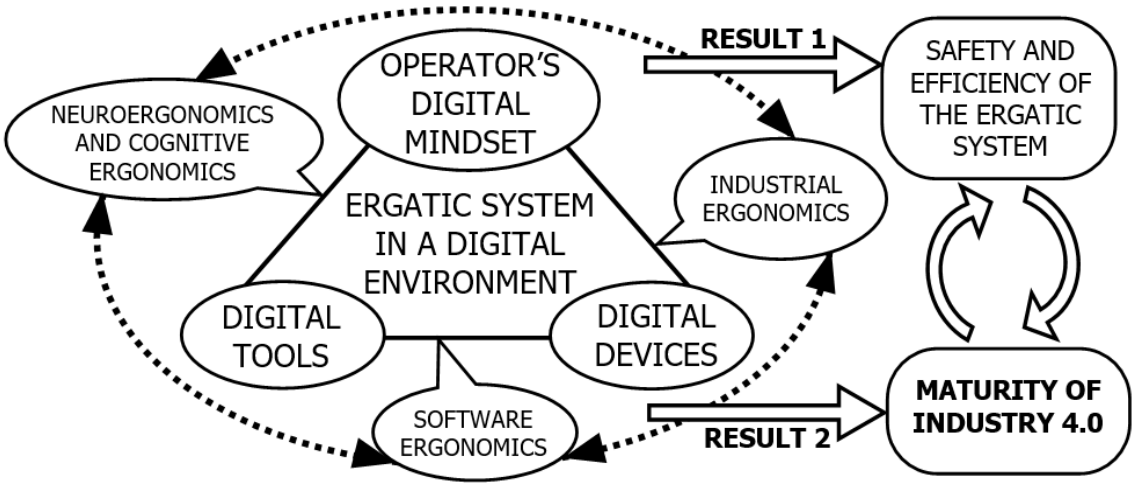

Fig. 1. The model of safe and effective functioning of a digital ergatic system

Thus, ergonomics ensures a balanced development of humans and technics in a digital environment, which is a precondition for the safe and effective functioning of the ergatic system, as well as the formation of a mature Industry 4.0.

The practical testing of the presented model gave interesting and some predictable results. We chose an ergatic system for research. The main elements of the system were students (70 people of the first-year study) and teachers (5 people) of the Simon Kuznets Kharkiv National University of Economics, as well as the digital system "Personal training systems the Simon Kuznets Kharkiv National University of Economics" (PTS). This digital system is an adapted model of the Moodle system (Modular Object-Oriented Dynamic

Learning Environment). It is a free web application that implements the ability to create sites for online learning.

The research included three stages. The first stage is to assess the balance of the ergatic system development. The stage included: 1) assessment of proficiency level of the digital technologies by students and teachers; 2) training teachers and students to work in the PTS system; 3) verification of participants provision with digital devices to participate in the study.

At the first stage of the study, the following results were obtained (Table 1).

Tabl

Ergatic system components

№	Component name	Component realisation	
		Students	Teachers
1	Digital mindset	100%*	100%**
2	Digital tools	PTS	PTS
3	Digital devices	100%***	100%***

* – the percentage of students who have the required level of proficiency in digital technologies, and passed the train to work in the PTS system;

** – the percentage of teachers who have the required level of proficiency in digital technologies, passed the train to work in the PTS system and received a certificate;

*** – the percentage of students and teachers who have the necessary digital devices to work in the PTS system (computers, laptops, tablets, smartphones), as well as constant access to the Internet.

According to the results, the ergatic system had a balanced state since all components develop synchronously and the level of their development had high indicators, which is a precondition for the safe and effective functioning of the system.

At the second and third stages of work, we investigated the ergatic system functioning in two modes, which differed by using digital tools and digital devices to perform the assigned tasks. At the second stage, we used a combined form of training: 50% of the material are tasks for consideration in the classroom accompanied by a teacher, and 50% are tasks for independent study. Students performed classroom tasks and independent ones using the PTS system. Students sent reports with completed tasks for verification through the PTS system. To analyse the students' progress, we created in the PTS system a grade book in which we recorded grades for completed tasks. At the third stage, we used distance learning: students studied the material by themselves in a mode suitable for them. They had to send reports on the completed tasks in a set time. As in the second stage, to analyse the students' progress, grades for completed tasks were recorded in a grade book.

At the end of the second and third stages, students and teachers passed the sociological surveys to determine the degree of their satisfaction with each form of learning and identify negative aspects of their work.

Based on the results of the second and third stages of the research, we built graphs of students' progress for mixed and distance learning (Fig. 2).

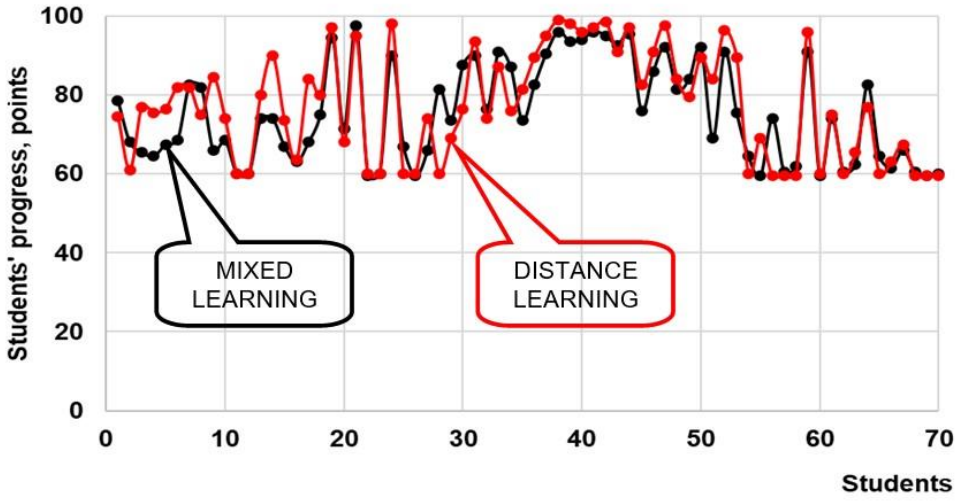

Fig. 2. Students' progress in cases of mixed and distance learning

Thus, we concluded that there were no significant differences in students' progress under mixed and distance learning. However, the analysis of subjective assessments of students' and teachers' satisfaction with different learning forms showed that mixed one was better perceived than distance one.

The research of man-machine interaction in the PTS system, operating based on the Moodle digital platform, showed the following results:

1) the essential components of the digital ergatic system, which determine the safety and efficiency of its functioning, are identified. These are digital mindset, digital tools and digital devices;

2) empirically established that mixed learning is better in comparison to distance one because it provides the safety and efficiency of the ergatic system in a digital environment.

Conclusions. Modern life is inseparably linked with the digital environment. The result is the transformation of ergatic systems into digital ones and the emergence of new types of man-machine interaction. According to this, the issues of organising the safe and effective ergatic systems functioning in the digital environment have gotten priority importance. In this regard, the aim was to study the features of the functioning of an actual digital ergatic system. It was found out that the essential components that determine the safety and efficiency of the digital ergatic system are digital mindset, digital tools and digital devices. The research of the actual digital ergatic system by these components revealed that it had a balanced state because its components developed synchronously and corresponded to the model of mature Industry 4.0. In addition, we substantiated the optimal form of man-machine interaction, in which the safety and efficiency of the ergatic system are ensured. This form of interaction is a mixed form of learning. It is also shown that the tendency to minimise the role of an operator in the digital ergatic system does not always have the expected positive result, which determines the need for further research on this issue.

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