TECHNOSPHERE SAFETY

Original article
UDC 331.45
https://doi.org/10.23947/2541-9129-2022-4-12-21

Gaming Computer Technologies in Safety Training at the Agro-Industrial Complex Enterprises

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Abstract

Introduction. The topic under consideration is updated by official domestic statistics, according to which more than a third of employees work in harmful and dangerous conditions. During the production process, people get injured and maimed, lose their ability to work. Dozens of fatal incidents are recorded at workplaces every year. The purpose of the study is to show the advantages and prospects of the introduction of gaming computer technologies in the training of workers in labor protection in the agro-industrial complex (AIC).

Materials and Methods. The scientific literature devoted to the educational possibilities of digital gaming solutions is considered. In relation to the topic of this study, the potential of a number of computer games, virtual, augmented and mixed reality technologies is evaluated. The well-known and commercially available gaming software is considered in relation to the topics and objectives of occupational safety training. The strengths and weaknesses of this approach are noted.

Results. The paper shows how to prepare for the introduction of gaming computer technologies into the occupational safety training system. In particular, it is necessary to identify and systematize the causes of accidents and injuries at work, to focus on industry (in this case, the most typical for agriculture). Special attention should be paid to organizational risks, because if they are neglected, personnel will work in initially dangerous conditions and high-quality training may be useless. The approaches to the organization of training, conducting classes, checking and consolidating knowledge are considered. Digital gaming products that have proven themselves in occupational safety training in various industries, including the agro-industrial complex, are presented. Variants of such training are considered. The use of digital gaming technology tools for the qualitative development of safety techniques, the formation of safe behavior skills and motivation to prevent injuries is justified.

Discussion and Conclusion. The results of the work allow us to assert that gaming computer technologies can be successfully used for teaching occupational health and safety in agriculture. This approach has serious advantages in terms of organization, visibility, cost-effectiveness and safety. Certain disadvantages of the method are likely to hinder the widespread implementation of such solutions in occupational safety training at agricultural enterprises for some time. However, in the medium term, it is possible to predict the solution of the identified problems due to the development of the digital games market, virtual technologies and the development of domestic analogues

Keywords: gaming computer technologies, virtual reality, augmented reality, mixed reality, safety training, accident causes, agro-industrial complex.

For citation. Kontareva V. Yu., Belik V. V. Gaming Computer Technologies in Safety Training at the Agro-Industrial Complex Enterprises. Safety of Technogenic and Natural Systems, 2022, no. 4, pp. 12–21. https://doi.org/10.23947/2541-9129-2022-4-12-21

Introduction. Since September 1, 2022, training and testing of knowledge in the field of occupational safety are more clearly systematized and regulated. Participation is mandatory not only for performers, but also for management, employers, and individual entrepreneurs. Training should provide knowledge, skills and abilities that allow developing competencies to ensure occupational safety, preserve life and health. Among the mandatory activities are:

– briefings;

– on-the-job internships;

– first aid practicing;

– mastering the skills of using personal protective equipment (PPE);

– occupational safety training[1,2].

According to data for 2017–2020, an average of 33.5 % of workers are employed in harmful and hazardous working conditions in Russia, and 18.4 % are engaged in heavy work[3]. During this time, 8313 people suffered from disability (an average of 2078 people per year), 530 incidents were with a fatal outcome (an average of 133 cases per year). A sufficiently high level of injury can be caused by multitasking in the implementation of technological processes, a wide range of work, a variety of equipment, tools and machines, seasonality, climatic and weather conditions, irresponsiveness to the introduction of innovations in occupational safety, etc.[4]

The work objective is to study the possibility of occupational safety and health training in the agro-industrial complex using adapted gaming computer technologies.

Materials and Methods. Domestic and foreign scientific and applied works are considered, which describe the educational capabilities of digital gaming solutions. In relation to the topic of this study, the potential of some computer games, as well as virtual, augmented and mixed reality technologies is comprehensively assessed. The products are especially noted that allow you in the learning process to:

– interact with objects on the screen;

– simulate the situation using virtual glasses or a helmet;

– recreate an environment close to the real one;

– combine physical and digital objects.

The well-known and available gaming software on the market is considered in relation to industrial hazard factors, topics and goals of occupational safety training.

[1] Labor Code of the Russian Federation. State Duma. Federation Council. Consultant Plus. Available from: http://www.consultant.ru/document/cons_doc_LAW_34683/ (accessed 03.09.2022). (In Russ.).

[2] On the procedure for occupational safety training and verification of knowledge of occupational safety requirements. Decree of the Government of the Russian Federation No. 2464 of 12.24.2021. Consultant Plus. Available from: http://www.consultant.ru/document/cons_doc_LAW_405174/ (accessed 03.09.2022). (In Russ.).

[3] Working conditions. The proportion of employees of organizations engaged in harmful and (or) hazardous working conditions, by type of economic activity (since 2017). Federal State Statistics Service. Available from: https://rosstat.gov.ru/working_conditions (accessed 03.09.2022). (In Russ.).

[4] Kontareva V. Yu. Injury analysis and organization activities industrial safety in the agricultural sector. Sovershenstvovanie tekhnologii proizvodstva, pererabotki i ekspertizy kachestva pishchevoi produktsii: mat. of All-Russ (national) scientific-practical conf. 2019, p. 79–86. Central Scientific Agricultural Library. Available from: http://www.cnshb.ru/jour/j_as.asp?id=147227 (accessed 22.10.2022). (In Russ.).

Results. When organizing training and testing of knowledge on occupational safety at the enterprises of the agro-industrial complex (AIC), it is necessary to identify and systematize general and specific, industry-specific causes of accidents and injuries. According to statistics, the main ones are:

– the impact of moving, flying, rotating objects, parts of operated machines on workers;

– falls;

– collapses and landslides;

– fires (exposure to smoke, fire, flame);

– the impact of electric current (Fig. 1).

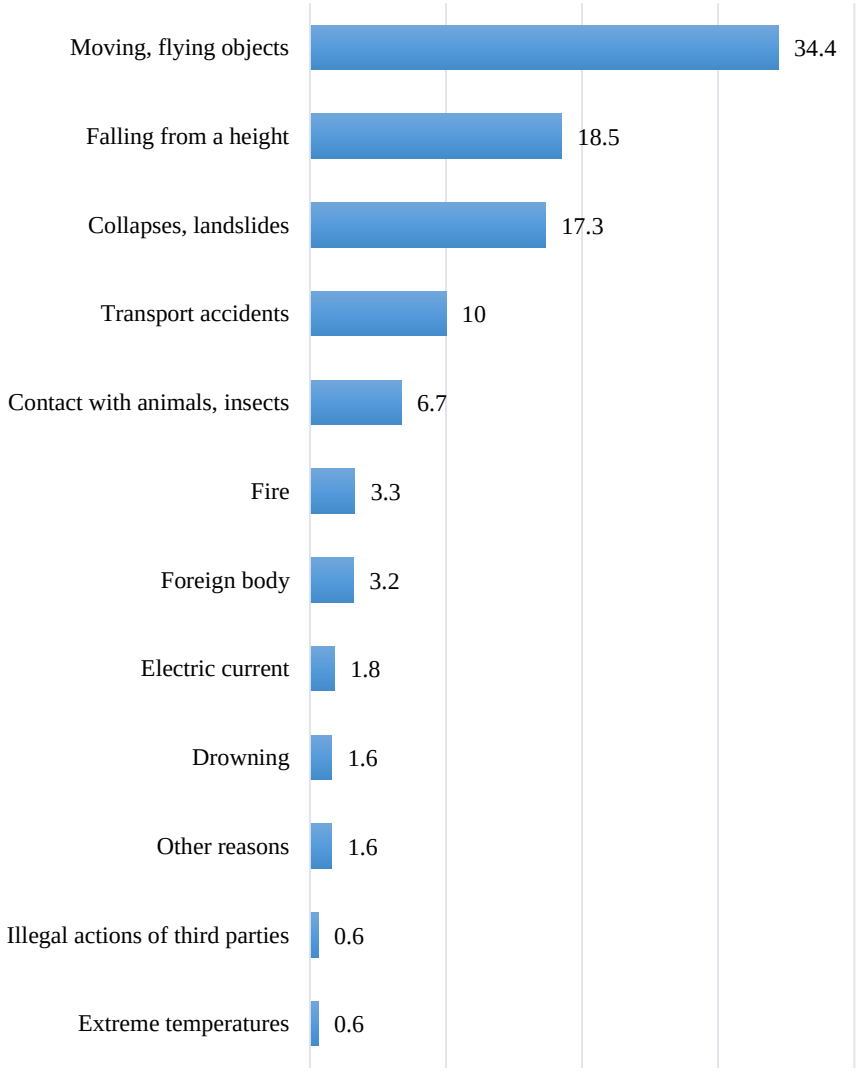

Fig. 1. Main causes of accidents in agriculture, %

It is important to identify the causes of accidents of an organizational nature (Fig. 2):

– unsatisfactory organization of work;

– ignoring training and testing of knowledge on occupational safety;

– lack of instruction;

– violation of labor regulations and discipline;

– unsatisfactory maintenance of workplaces, etc.

Significant causes of injuries in agriculture:

– non-compliance with safety requirements, including during the operation of mechanisms and equipment;

– violations of labor regulations and labor discipline by employees;

– absence or non-use of personal protective equipment, etc. [1–3].

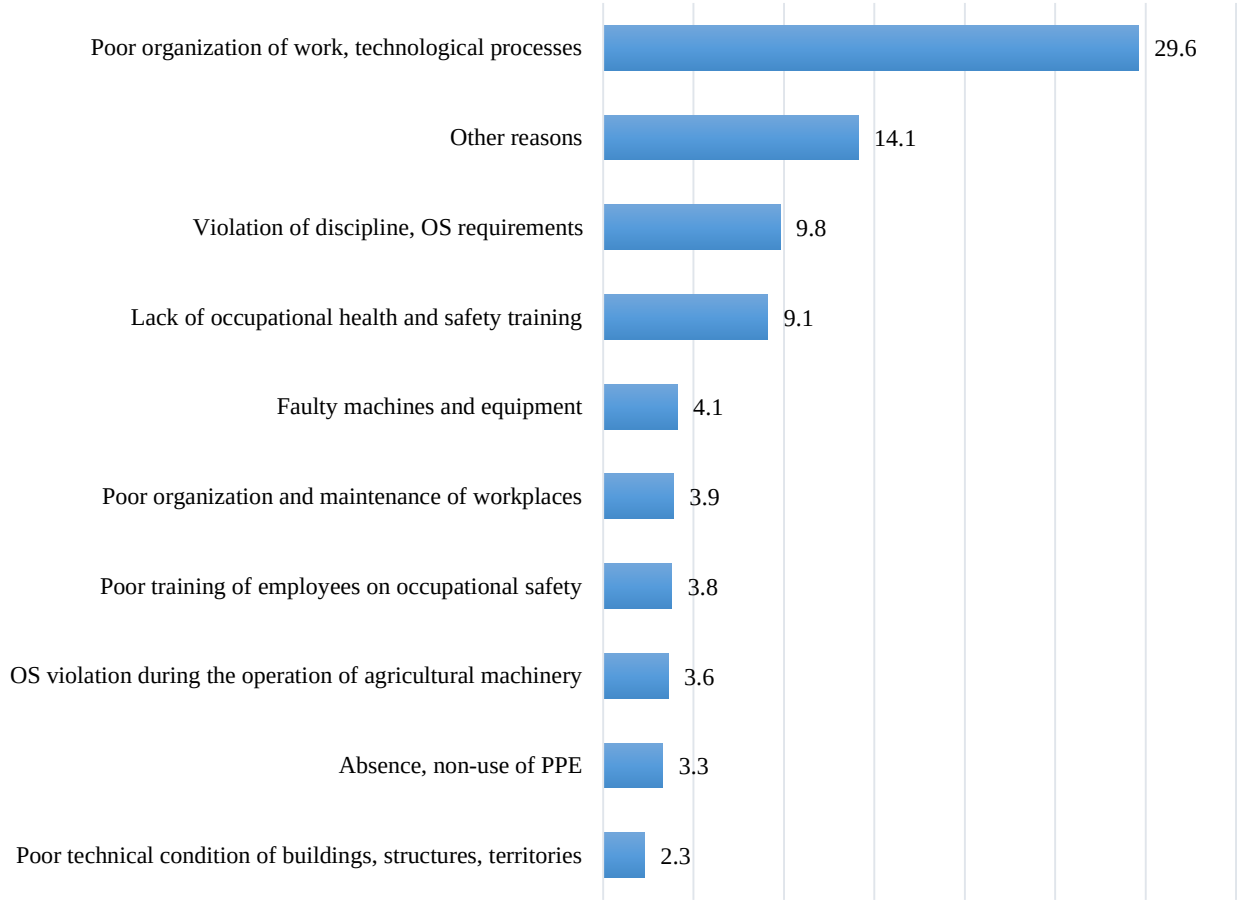

Fig. 2. Main organizational causes of accidents in agriculture, %

According to the authors of works [4, 5], high-quality training and testing of knowledge on occupational safety form safe behavior skills among employees, which contributes to injuries prevention. Passive types of training include traditional classroom and distance forms. Active ones include internships, drilling of operations on simulators and (or) training workplaces, mannequins. Theory is learned in passive learning, as a rule, to a minimum extent, if it is not supported by practical skills development[5]. Active training consolidates skills and competences, but it is more difficult to organize it because of the cost. This approach requires more time, human, material and financial resources. Such expenses are not always advisable.

The main disadvantages of both approaches are:

– they do not give a complete picture of real hazardous production situations;

– they do not provide a sufficient level of training for workers with low literacy;

– they do not allow you to hold the attention of the audience for a long time [5].

In connection with the above, it seems promising to use digital game forms for training and testing knowledge in the field of occupational safety and health [6].

[5] Anikina O. M. Geimifikatsiya proizvodstvenno-tekhnicheskogo obucheniya. Nauchnye issledovaniya i innovatsii: proc. of V internat. scientific-practical conf. Saratov, 2021. p. 306–311 (In Russ.).

Gaming computer technologies are successfully used as educational resources in medicine, mining, agriculture, sports, construction, defense, safety, labor protection, etc. [5] (Table 1).

Table 1

Basic gaming computer technologies

Technology	Brief description	Example
Computer game	Game participants interact with objects on the screen	BUT-Safety Digital game on safety, labor protection. Objective — to test and consolidate knowledge
Virtual reality (VR)	Experience is simulated using virtual glasses or a helmet. Immersion in a 3D environment close to a real one	HSE VR simulator Working out actions on industrial and environmental safety, occupational safety and civil protection
Augmented reality (AR) and mixed reality (MR)	Recreated situation combines physical and virtual objects modeled by computer technology. A smartphone or tablet is enough to use AR	ARgument.Safety The service to reduce injuries and emergencies instructs on the use of equipment, warns about possible dangers, forms a culture of occupational safety

The data in Table 1 make it possible to judge the educational potential of gaming technologies. They allow you to work out the reaction to:

– hazardous and harmful production factors;

– fire threat and fire;

– energy accidents;

– failures in the operation of machinery and equipment.

In addition, digital solutions are used to clarify:

– legal and theoretical principles of occupational safety;

– fundamentals of safe behavior in the workplace;

– rules of first aid to victims.

So you can teach how to use personal protective equipment, conduct an instruction and test your knowledge. Technologies should be correlated with the topics and objectives of training (Table 2).

Table 2

Use of gaming computer technologies depending on the topic and objective of training

Hazard factor	Topic of training	Training objective	Technology
Chemical, physical, biological	Hazardous and harmful production factors, their impact on the employee, protection from them	Identification of sources of danger	Augmented virtual environment (System for Augmented Virtuality Environment Safety — SAVES) [7]
		Hazard awareness and safety training	Virtual learning environment using experimental Kolb's learning theory [8]
Risk of falling		Identification of hazard sources	SAVES
		Identification of unsafe conditions and multiple choice solution	AR application on the Microsoft HoloLens platform
Fire hazard	Fire safety	Emergency response	Harry’s Hard Choices Game [9]
Operation of agricultural machinery and equipment	Safety in the operation of agricultural machinery and equipment	Improving operational skills and awareness of the machinery and equipment safety	Modeling in a computer-aided design system

Hazard factor	Topic of training	Training objective	Technology
		Hazard identification, risk assessment, control of the operation of machinery and equipment	Safety training program of the University of Waterloo [10]
			Trouble Tower Game [11]
		Solution to situational problems during the operation of machinery and equipment	"Serious game" [12]
Non-compliance with safety requirements or erroneous actions	Safe working methods, fundamentals of safety and labor protection	Training in safe working methods and labor protection, search for safe options	Personalized learning support system in the game [13]
		Study of ergonomics, safety, documents, procedures, equipment, workplaces, technological processes	Manufacturing Training System (MTS) Augmented Reality and Gamification System [14]
			"Digital Ergonomics" and "Serious Game" [12]
Electricity	Electrical safety	Risk analysis, learning the basics of electrical safety	Electrical safety training game[6]
		Hazards, risk assessment, establishment of control measures	University of Waterloo Safety Program [10]
Non-use, improper use of personal protective equipment	Personal protective equipment (purpose, application)	Application of personal protective equipment	Virtual learning environment using the experimental Kolb's learning theory [8]

Let us consider the options for such training. For example, an adaptive personalized in-game learning support system [12] focuses on the rules for maintaining health and safety in the workplace. The player practices the skills of occupational health and safety. Before the start of the test, he/she fills in a short profile so that the system takes into account his/her level of training in advance.

"Digital Ergonomics" and "Serious Game" [14] give a general and detailed idea of occupational safety. In the first case, "Digital Ergonomics" is better suited. It is designed to spread safety culture among the staff. "Serious Game" teaches specific safety procedures and allows you to test skills.

Virtual learning environment using the experimental Kolb's learning theory [10] provides the practice of:

– hazard identification;

– risk assessments;

– control;

– finding out the current effectiveness.

The use of gaming computer technologies in the study of the subjects under consideration does not contradict legislative norms. As an example, let us consider the occupational safety briefings: introductory, primary (at the workplace), repeated, unplanned, targeted. According to the current laws and regulations, their forms and methods are determined by the employer, which means that he/she can use one or another digital solution. Checking the knowledge about labor protection, the employer is also guided by local regulations.

The organizer independently selects technical means and visual aids for training on more complex topics: practicing skills in providing first aid to victims and the use of personal protective equipment.

Thus, it is permissible to use computer games, virtual, augmented and mixed reality technologies to study a number of topics on occupational safety.

[6] Shilov A. V, Shampanov S. O, Yamshchikov S. A. Obuchayushchaya komp'yuternaya igra po elektrobezopasnosti. Electronic Library of the Belarusian-Russian University. Available from: http://e.biblio.bru.by/bitstream/handle/1212121212/12542/343-344.pdf?sequence=1&isAllowed=y (accessed 22.10.2022). (In Russ.).

Table 3 presents possible options for the participation of different categories of employees in occupational safety training using gaming computer technologies.

Table 3

Participation of various categories of employees in the study of industrial safety standards with the help of gaming computer technologies

Technology	Type of training	Topic of training	Category of employees
AR, MR	Introductory briefing	Hazard sources. Actions in an emergency	Newly hired employees
	Occupational safety briefing at the workplace	Hazard sources established by a special assessment of working conditions and occupational risks. Working conditions, harmful, hazardous factors	All employees, except those exempt from briefing by order of the employer
	Verification of knowledge of labor protection requirements	Labor protection	Workers who have been instructed and trained in labor protection
VR	Internship at the workplace	Working out practical skills of safe performance of work	Employees who have successfully passed instruction and training on labor protection
	First aid training	First aid for loss of consciousness, respiratory arrest, bleeding, injuries, etc.	Those, who are authorized to instruct and provide first aid. Workers who manage machines and mechanisms. Others (by the decision of the employer)
	Training on the use of PPE	Personal protective equipment	Employees using PPE, the use of which requires practical skills

Discussion and Conclusion. The considered gaming computer technologies can be adapted for teaching occupational health and safety in agriculture. This approach can increase the success of solving such educational tasks as: instructing, illustrating theoretical material, consolidating and verifying knowledge, working out skills.

Let us list the advantages of the introduction of digital gaming technologies in the occupational safety training:

1) greater flexibility in choosing the time of classes;

2) high-quality interactive simulation of real experience [6, 15];

3) focusing the player's attention on specific tasks: what to do, what to avoid [5];

4) low costs (in comparison with the development of skills when using real machines in a real production situation) [16];

5) complete error safety in the gaming environment;

6) the possibility to conduct part of the training remotely [17].

The disadvantages that limit the spread of gamification as a popular learning technology should also be noted:

1) lack of interaction with real working materials [18];

2) psychosomatic reactions of players (dizziness, headache, eye fatigue) [19];

3) unavailability at some enterprises (especially in agriculture) of high-speed Internet, as well as 3D, VR, AR, MR technologies [20].

It is worth noting that with the development of digital technologies, it will be possible to overcome the shortcomings noted above. Solutions will become more accessible, the range of games will significantly expand, and the realism of simulations will increase. In addition, domestic analogues can be developed for various industries and activities.

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Received 05.09.2022

Revised 30.09.2022

Accepted 30.09.2022

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Claimed contributorship:

V. Yu. Kontareva — formulation of the basic concept, analysis of the research results, revision of the text, correction of the conclusions. V. V. Belik — formulation of the goals and objectives of the study, preparation of the text, formulation of the conclusions.

Conflict of interest statement

The authors do not have any conflict of interest.

All authors have read and approved the final manuscript.