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Innovative Methods of Training Truck Drivers in International Logistics

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ABSTRACT

The article provides a comprehensive analysis of innovative training methods for long-haul truck drivers in the context of international logistics, taking into account contemporary requirements for road safety, professional responsibility, and regulatory compliance. The relevance of the study is determined by the increasing complexity of logistics processes, the intensification of international freight transportation, the diversity of national traffic regulations, and the growing demands for professional driver training. The paper examines the transformation of traditional driver training approaches towards interactive, technology-mediated, and behavior-oriented educational interventions. Particular attention is paid to the use of simulation-based training and augmented and virtual reality technology as tools for the safe practice of complex, rare, and potentially dangerous driving scenarios. Special emphasis is placed on gamification and serious game - based approaches as means of increasing learner engagement, self-regulation, and the sustainability of professional driving behavior. Based on the synthesis of findings from recent systematic and empirical studies, it is substantiated that the effectiveness of these methods depends not just on the use of technology, but on the quality of instructional design, the validity of training scenarios, the availability of measurable performance indicators, and adherence to the principle of safety compatibility. It is concluded that innovative training methods for long-haul truck drivers should be conceptualized as elements of a continuous professional development system aimed at risk reduction, enhancement of road safety, maintenance of regulatory compliance, and adaptation of drivers to these diverse conditions of the international road environment.

KEYWORDS

long haul truck drivers; international logistics; innovative training methods; simulation-based training; augmented and virtual reality; gamification; professional driver training.

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Інноваційні методи навчання водіїв вантажівок міжнародній логістиці

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АНОТАЦІЯ

У статті наведено комплексний аналіз інноваційних методів навчання водіїв вантажівок на далекі відстані в контексті міжнародної логістики, враховуючи сучасні вимоги до безпеки дорожнього руху, професійної відповідальності та дотримання нормативних вимог. Актуальність дослідження визначається зростаючою складністю логістичних процесів, інтенсифікацією міжнародних вантажних перевезень, різноманітністю національних правил дорожнього руху та зростаючими вимогами до професійної підготовки водіїв. У статті розглядається трансформація традиційних підходів до навчання водіїв у бік інтерактивних, технологічно опосередкованих та поведінково-орієнтованих освітніх втручань. Особлива увага приділяється використанню навчання на основі симуляції та технологій доповненої та віртуальної реальності як інструментів для безпечного відпрацювання складних, рідкісних та потенційно небезпечних сценаріїв водіння. Особливий акцент робиться на гейміфікації та серйозних ігрових підходах як засобах підвищення залученості учнів, саморегуляції та сталості професійної поведінки водіїв. На основі синтезу результатів нещодавніх систематичних та емпіричних досліджень обґрунтовано, що ефективність цих методів залежить не від справедливого використання технологій, а від якості навчального планування, обґрунтованості навчальних сценаріїв, наявності вимірюваних показників ефективності та дотримання принципу сумісності безпеки. Зроблено висновок, що інноваційні методи навчання водіїв вантажівок на далекі відстані слід розглядати як елементи системи безперервного професійного розвитку, спрямованої на зниження ризиків, підвищення безпеки дорожнього руху, дотримання нормативних вимог та адаптацію водіїв до різноманітних умов міжнародного дорожнього середовища.

КЛЮЧОВІ СЛОВА

водії вантажівок на далекі відстані; міжнародна логістика; інноваційні методи навчання; навчання на основі симуляції; доповнена та віртуальна реальність; гейміфікація; професійне навчання водіїв.

1. Introduction

The rapid development of the transport industry and the increase in requirements for the professional skills of truck drivers necessitate the introduction of innovative training methods into the system of their professional training. An important component of this process is the integration of the latest technologies into the educational process, which contributes to improving the quality of education and the formation of professional competencies necessary for safe and effective activity in the real conditions of operation of motor vehicles.

The use of innovative teaching methods using computer simulations, interactive educational platforms, as well as virtual reality modeling during classes allows for a deeper understanding of the complex technical, engineering and technological aspects of the professional activities of truck drivers. This approach contributes to the development of decision-making skills in non-standard road and production conditions, increasing the level of professional readiness and adaptability of future specialists to the requirements of the modern transport environment.

Innovative methods of teaching disciplines related to road transport are increasingly focused on combining theoretical training with practical activities, which contributes to the formation of competitive personnel in the field of freight transportation. The experience of higher education institutions allows us to conclude about the effectiveness of the implementation of disciplines aimed at mastering computer diagnostics of cars, mechatronics of automotive systems, as well as modern software for technical maintenance and control of vehicles. This ensures not only the assimilation of theoretical knowledge but also the formation of program learning outcomes necessary in the professional activities of truck drivers.

2. Literature Review

The professional training of truck drivers is shifting towards technology-driven paradigms. Modern research, such as by Shliakhetko et al. [12], emphasizes that developing human capital is vital for maintaining competitiveness in the evolving European labor market.

A central theme in the literature is the use of simulation-based training (SBT). Alonso et al. [2] and Sætren et al. [11] substantiate that simulators are effective for practicing complex maneuvers and improving safety awareness in a risk-free environment. Technical precision in simulator design remains a critical factor for achieving professional outcomes [6].

The integration of Virtual Reality (VR) and AI represents another major trend. Cheng et al. [5] demonstrate how AI-driven VR environments better prepare drivers for unpredictable road conditions and diverse regulatory requirements [1]. Furthermore, Alyamani et al. [3] and Wallius & Köse [13] highlight the role of gamification and serious games in increasing learner engagement, particularly for mastering unfamiliar traffic rules and eco-driving techniques.

Despite these advancements, there is a need for a more holistic analysis of how these innovative methods can be integrated into specialized training for international logistics. This study addresses this gap by systematizing these interventions and their impact on driver readiness.

3. Problem Statement

The purpose of the study is to analyze innovative methods of training truck drivers in the context of international logistics. To achieve the goal, the study provides for the solution of the following tasks: to analyze modern scientific approaches to training truck drivers; to systematize the main types of simulation and gamified educational interventions used in the training of vehicle drivers; to characterize the possibilities of gamification and the use of simulations combined with virtual reality as effective, innovative training methods.

4. Methods and Materials

The methodological basis of the study is the general scientific methods of analysis, synthesis, generalization and comparison of modern scientific sources devoted to the training of heavy-duty transport drivers in the conditions of international logistics. The work uses the approach of a systematic

review of scientific publications on the use of simulation training, augmented and virtual reality technologies, as well as gamified educational solutions in the professional training of drivers. To interpret the results, methods of theoretical generalization and comparative analysis of the effectiveness of innovative educational technologies from the standpoint of road safety, regulatory compliance and the formation of professional behavior of drivers were used.

5. Results and Discussion

Innovative training methods in the field of training truck drivers involved in international logistics transportation are formed under the influence of a complex of interrelated factors. First, there is a systematic strengthening of requirements for traffic safety and compliance with the entire set of mandatory rules, standards, in particular regarding work and rest regimes, the internal corporate culture of carrier companies and cross-border logistics transportation in general. Second, there is a transformation of the logistics environment, which includes the functioning of ports, hubs, distribution centers, multimodal nodes, etc. Accordingly, the need to adapt to different requirements and specifics of road culture in different countries is changing. Third, the role of digitalization of adult education is increasing, which is accompanied by the active use of interactive educational formats, in particular, the introduction of AI-based training modules, the use of the latest simulators, and augmented virtual reality.

Innovations in the system of professional training of truck drivers are not limited to the implementation of individual technological tools, but involve a conceptual reorientation of the educational process - from the translation of theoretical knowledge to the formation of sustainable operational skills, the development of situational awareness and the ability to make informed decisions in conditions of increased risk. Accordingly, the key criterion for the quality of training is the presence of an evidential connection between educational interventions and changes in behavioral and safety indicators of professional activity.

In view of this, the most promising are educational approaches that provide the opportunity to safely practice complex maneuvers and non-standard production situations, organize training in the format of short modules integrated into working time intervals, as well as increase the level of involvement and self-regulation of education seekers through the use of gaming and interactive mechanisms, provided that the risks of cognitive overload and distraction are controlled.

One of the most obvious and at the same time methodologically complex innovative directions in the training of vehicle drivers is training using simulators and virtual reality (VR) technologies. The first scientific research in the field of creating a virtual environment using digital technologies was initiated at the Massachusetts Institute of Technology (USA) more than fifty years ago. The further development of this research led to the emergence of applied solutions in the field of education, in particular in the first attempts to implement augmented reality (VR) technologies in 2006–2007 during the development of educational games [5]. Modern augmented reality mobile applications focused on educational goals usually implement two basic scenarios of user interaction with the environment: first, the use of a special marker to which a virtual object is attached; secondly, overlaying a layer of virtual objects on the entire space of the image obtained from the device's external camera.

In foreign studies, we observe different approaches to classifying the use of virtual reality technologies in the educational process [5]. In particular, it is customary to distinguish the following types: books with augmented reality elements that perform a transitional function between the physical and digital environment; educational games; specialized training programs; object modeling systems; applications aimed at training professional skills. At the same time, when forming appropriate educational content, you can use three-dimensional models, audio and video materials, additional text explanations, as well as hyperlinks to external information resources. Static images can be transformed into 3D models that allow interaction with the user and the possibility of modification, and virtual objects can adapt to real objects.

Historically, simulators as a training tool began to be actively used since the 1940s, gradually acquiring the status of an effective and safe means of training specialists in environments with a controlled level of risk. In the initial stages, due to the high financial costs, the development of simulators was available mainly to government agencies, and one of the first and largest customers was the United States Army. In the 1960s–1970s, with the advent of digital computers and computer graphics, the first

"full-purpose" simulator in history was created by order of the military – an aviation simulator that reproduced both the physical cockpit and virtual flight scenarios [5].

Further technological progress, in particular the development of microprocessors, display technologies, projection systems and controllers, contributed to a significant reduction in the cost of such solutions. As a result, not only government agencies but also large private companies joined the development of simulators. This, in turn, led to the emergence of simulators for various types of vehicles, including aircraft, sea vessels, submarines, cars and trucks. It is indicative that already in the 1970s, at least 28 driving simulators were developed in the world [2].

Initially, simulators were used mainly for training in situations that were either too dangerous to practice in real conditions or economically unprofitable due to high costs. Over time, the scope of application of simulators has expanded significantly, and along with educational and research purposes, they have also become actively used in the entertainment industry.

Today, the use of simulators for driver training is gradually gaining the status of one of the key tools in road safety research, primarily due to their ability to repeatedly reproduce the same conditions and a high level of control over experimental variables [14]. An additional advantage of such systems is the guarantee of safety for research participants and the relatively lower cost of training, compared to field conditions [14]. The more computer technologies develop, the larger the category of people who can access the use of intermediate and entry-level simulators [14]. For example, during the COVID-19 pandemic, there was a significant increase in demand for entry-level simulators due to their accessibility and low cost of ownership, which confirms the feasibility of using inexpensive solutions in the driver training system [14].

Research has shown a positive relationship between specific driving competencies and gaming activities. Simulations built using game mechanics can effectively act as a catalyst for the development of various aspects of learning in the context of road safety and the training of future drivers [4]. Other researchers have analyzed the effectiveness of immersive driving simulations in the learning process by placing users in a predetermined starting position and asking them to follow voice instructions while navigating a route in the simulator [7]. All errors made were recorded and compared with users' reports of their personal perceptions of the quality of task performance. The results of the study showed that participants make more errors than they realize, indicating the significant potential of simulators for correcting behavior and improving driving skills [7].

According to their functional purpose, simulators for driver training are traditionally divided into three main groups: educational, the main purpose of which is to achieve educational results, reduce risks and prevent road accidents. Within this group, professional and amateur simulators are distinguished; research, which is used to study individual aspects of the functioning of transport systems or behavioral characteristics of drivers; and entertainment, focused mainly on providing users with leisure-related activities [6].

Taking into account physical and technical parameters, simulators are classified according to several characteristics, among which the leading place is occupied by visualization systems (in particular, the viewing angle and type of projection), image resolution, which determines the degree of user immersion in the virtual environment, the type of driver's cabin (the presence or absence of a sensor cabin that reproduces the conditions of driving a real vehicle) [8], sound system parameters, the presence of feedback systems, as well as the use of moving platforms capable of simulating acceleration and other dynamic effects [10].

According to the software characteristics, the most common forms of using simulators are simulation of the driving process, which is used mainly for educational and training purposes; full-fledged simulations focused on professional driver training; game formats, which are used mostly in an entertainment context; as well as systems with the ability to quickly configure training scenarios in real time [9].

At the current stage of education development, simulators are so integrated into the driver training system that in several countries their use is a mandatory element of the procedure for obtaining a driver's license [11]. One of the advantages of such training is the ability to carry out accurate analytical measurements of vehicle movement parameters and driver reactions to simulated road situations. In addition, simulators provide a high level of reproducibility of training scenarios, which allows you to repeatedly practice complex and potentially dangerous situations without a threat to the participants in

the training process, as well as increase the objectivity of the assessment of results, since all students are in the same conditions.

It is also interesting to note that in some countries where women have recently been granted driving licenses, simulators have played a crucial role in promptly meeting the demand for training that would have been difficult to meet in a short period of time without the availability of these technologies [1].

Another group of innovative teaching methods in the professional training of truck drivers is methods based on the use of gamification. The main task of using games in the training of truck drivers is to overcome the chronic problem that educators face in the context of adult education - the low level of involvement and perception of many training programs as formal and disconnected from real practice. Within the framework of such training, gamification is understood as the purposeful introduction of game mechanisms into a non-game context in order to increase learning motivation, develop self-control and ensure the consistency of completing training tasks, in particular those related to the correction of professional behavior.

For the field of international freight transportation, two interrelated areas of gamification are particularly promising. The first of them concerns the formation of an environmentally friendly and safe driving style, which indirectly reflects smooth maneuvering, rational use of fuel and a reduction in the number of risky actions. The second area is related to compliance with regulatory requirements and correction of driver behavior in an unfamiliar road environment, which includes other traffic rules, differences in road infrastructure and the specifics of expectations regarding the behavior of road users in different countries.

Educational interventions with gamification elements can have a significant impact on the formation of an environmentally friendly driving style, which is associated with a decrease in energy consumption [2]. There are different types of gamification mechanisms (oriented towards achievement, social interaction and narrative elements), as well as their psychological and behavioral consequences [13]. The researchers believe that special attention should be paid to the study of risks and key parameters of pedagogical design, in particular, potential driver distraction, time relevance of feedback, the need for individualization of educational influences and transparency of gamification goals. For truck drivers, these warnings are of fundamental importance, since any motivational system in the field of transport must be compatible with safety requirements, reinforce normatively correct behavior, and not create additional incentives for risky actions [13].

An empirically oriented example of the application of game mechanisms in the context of driver training is presented in the study by Alyamani and al. [3], in which the authors analyze the use of gamification in a simulated environment and prove that such interventions contribute to better adaptation of driver behavior to the “traffic flow” and other regulatory requirements, reducing the number of errors in situations of interaction with unfamiliar traffic rules [3].

Thus, we can say that, compared to traditional forms of training, innovative approaches, in particular the use of simulations, virtual reality and gamification, have a common conceptual basis - they translate professional training of drivers into a mode of increased interactivity, ensuring regular feedback and objectivity in the context of assessing learning outcomes. However, it is worth emphasizing that it is fundamentally important to realize that the effectiveness of interactive training methods is determined not by the fact of using technologies, but by the quality of pedagogical support [12]. For example, the proposed simulations should be based on valid indicators and scenarios that adequately reflect the professional tasks of truck drivers and ensure the transfer of the acquired skills to real activities. Gamification, in turn, should function as a motivational component integrated into a system of measured behavior and clearly defined learning goals, minimizing the risk of distraction and preventing dangerous behavioral manifestations, etc.

6. Conclusions

Summarizing the above, we would like to note the following: innovative teaching methods for truck drivers should be considered as a transition to a system of continuous professional training, within which simulation technologies, including virtual reality, ensure safe practice of critical and rare scenarios and carry out standardized control of task performance. The role of gamification is mainly to increase engagement, develop self-regulation and sustainability of drivers’ learning behavior. The

practical value of using these methods lies in their compliance with real professional risks, compliance with regulatory requirements and the possibility of scaling training in a limited time without loss of quality and with preservation of the evidence-based scientific base as a basis for using these methods.

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