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Transportation Research Procedia 63 (2022) 2186–2193

Transportation Research Procedia

www.elsevier.com/locate/procedia

X International Scientific Siberian Transport Forum

Environmental simulation games for transport workers

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Abstract

The whirlwind-speed development of new technologies, the transition to the sixth wave of innovation is accompanied by the increasing complexity of the transport system, appearance of new types of fuel and transport vehicles, development of information technologies in transport and, in fact, complete lack of knowledge about their possible negative impact on the socio-ecological-economic system. To develop due strategies for responding to the emerging environmental challenges and threats, it is necessary to have the knowledge, skills and abilities to assess the dependence of ecological safety in transport on the level of environmental awareness of all stakeholders of the transport system. The research methodology includes four stages, from the analysis of the current state of knowledge in the sphere of sustainable development risk management and formation of risk civilization towards the characterization of environmental safety of the transport system and environmental education system, use of proper methods and assessment of the interrelation safety – risk – education in terms of sustainable development of the transport system. The dependence established in the course of the research can serve as an element evaluating the impact of knowledge, abilities and skills of the transport system stakeholders on the extent of environmental risks and ecological safety in transport.

Keywords: risk; sustainability; simulation games; ecological culture; transport

1. Introduction

The whirlwind-speed development of new technologies, the transition to the sixth wave of innovation is accompanied by the increasing complexity of the transport system, appearance of new types of fuel and transport vehicles, development of information technologies in transport and, in fact, complete lack of knowledge of their

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2352-1465
10.1016/j.trpro.2022.06.246

possible negative impact on the socio-ecological-economic system in Russia, including sustainable and safe development of the transport system. (Chung, 2021; Chatti, 2021; Stanley, 2020; Barrella et al, 2013). The combination of these factors leads to intense risks of the modern society and is likely to be accompanied by an increase in accidents and transport disasters.

The stability and safety of the transport system in the country, being a key element of the country's infrastructure and architecture (Ainger et al, 2014) play an important role for "smooth" transition of the Russian economy to the risk-oriented closed-loop economy. The sustainable transport system should have the following features:

- maintain food supply, industrial, environmental and other types of the country's security, "Strategic …". (Pei et al, 2010; Liu et al, 2013).
- include strategies for responding to environmental risks and benefits (Barrella et al, 2013).
- measure, maintain, and achieve ecological indicators of sustainable development as well as material circulation indicators and 306 GRI indices, "Circulytics 2.0…", "GRI 306: WASTE 2020", "How GRI … ".
- be based on ecological outreach and continuous environmental education of all stakeholders, "Decree …" 2015 (Keong, 2021; Kopnina 2019).

A group of scientists from Washington (USA) undertook research addressing the approach of transport enterprises to sustainable development, based on strengths and weaknesses, opportunities and threats (Barrella et al, 2013). The researchers from the United Kingdom, the United States and Denmark, aimed at exploring the transport systems comprehensively in terms of global sustainable development goals, worked out a methodology involving inclusive, interactive, and iterative approach to defining the criteria of sustainable transport (STA) as based on a multi-factor and multi-criteria analysis – for a high-speed railway project in the United Kingdom. This approach makes it possible to ensure a reproducible algorithm for creating a due structure and process of stakeholder engagement in selecting and defining a comprehensible, exhaustive and non-overlapping set of STA criteria (Marsden et al, 2011; Barradale et al, 2018).

The introduction of the principles, goals, and indicators of sustainable development in the curricula of natural sciences and humanities at higher educational transport-profile institutions of the country is necessary in order to secure comprehensive safety of operational activities of transport enterprises and supply chains, social and environmental projects and corporate governance in terms of negative impact on the environment. The tentative results of integrating the sustainable development principles into the present higher education system through the introduction of new forms of learning resulting in sustainable changes in the educational process participants' behaviour in everyday life are shown in a paper by Pia Piroschka Otte devoted to the theoretical foundations of integration of sustainable development in higher education through training based on practical experience (Logachev et al, 2021; Otte, 2016).

To form a dynamic model of due ecological behavior, emphasis is placed on the introduction of simulation games in the educational process. The history of introduction of simulation training games began in 1932 and is actively developing nowadays. The dynamic model of ecological behavior is an integral part of the individual's ecological culture (EC) and, as a consequence, it affects the level of environmental safety in the course of work and household chores. Therefore, the issue of predicting the level of environmental safety during labor and household activities, as based on simulation games in environmental education and ecological outreach, is relevant and requires development and detailed study (Logachev et al, 2020). The introduction of ecological-profile simulation games into the educational process as its component or as an independent educational programmed requires the creation of an innovative educational model comprising interrelated elements: types and variations of games united by a common goal, methodology and content (Gaykalova et al, 2010).

The concept of sustainable development of the transport system architecture in the Russian Federation should contribute to the formation of sustainable human capital, reduction of environmental pollution, preservation of biodiversity, mitigation of climate change effects and conservation of natural resources (Marsden et al, 2011). When evaluating the sustainability of transport systems, an approach involving selective assessment can be used for two types of goals: functional (ensuring and guaranteeing safety in operational activities, production and supply chains) and impact-based (protecting the environment and reducing the respective impact) (Barradale et al, 2018).

As follows from the above, the issues of assessing environmental and sustainable development risks, ensuring environmental safety, educating the stakeholders of global transport projects and national transport systems are among the most pressing concerns of the global agenda for the development and survival of civilisation, and they have become even more acute in 2019-2020 due to the COVID-19 virus pandemic. However, despite the obvious interrelation and additive effects, assessment of dependence and influence of these factors in the aggregate is paid

insufficient attention. Therefore, the purpose of the research was to assess the role of environmental education in ensuring ecological safety and sustainable development of the transport system on the basis of modern international methodologies for the choice of boom-and-bust economy indicators, sustainable development parameters as well as GRI- and ESG standards.

2. Materials and methods

The major research methods used in the paper are logical-intuitive (logical analysis, logical-graphical analysis, comparative analysis, SWOT analysis) and theoretical (graphical methods, namely, plotting graphs, charts, Ishikawa diagrams).

The analytical review included the sources with high level of reliability and reporting depth of presented data, as well as modern research methods on the subject of the research, from general to particular. In the course of the analysis of exploration maturity of the issue in question, international and national strategies were explored at the first stage, as well as the relevant concepts, declarations in the domain of boom-and-bust economy, sustainable development and standards providing a methodology for achieving the goals set by the high-level international treaties and declarations in this sphere (Logachev et al, 2020). At the second stage of the scholarly sources analysis, the studies considering stability of transport systems and industries were addressed. The third stage is devoted to the prerequisites and development of the methodology for building a due environmental education system. Subsequently, the publications exploring the methodology for assessing the level of environmental safety and risk at all stages of the transport systems life cycle were studied. The above sequence and the selection of relevant essays made it possible to achieve the goal of the research and to gain new knowledge.

It was determined by the authors previously that the level of environmental safety is influenced by the level of ecological culture of the individual, the state of development of environmental legislation, the ecological risks and working conditions. To explore their mutual influence on the level of environmental safety, analytical management methods based on matrix diagrams were applied (Gaykalova et al, 2010).

Thus, the environmental safety model construction requires the use of a broad range of mathematical research methods.

3. Results and discussion

The use of simulation games in the educational process increases the level of environmental safety of work and household activities. This is since environmental simulation games are aimed at developing participants' knowledge, awareness and due activities in the field of ecology and nature management. This, in turn, enhances the individual's ecological culture.

The above conclusions allowed the authors to propose a scheme for increasing environmental safety of labour and household activities, based on the use of environmental simulation (Fig. 1).

As can be seen from Figure 1, environmental safety increases in magnitude at each subsequent stage, and the amplitude of its values grows. The graphic dependence of environmental safety on the previously specified values has the following form: as to the form – nonlinear regression, as to the linkage direction – direct regression (positive). This matches the authors' view on the mechanism of influence of environmental simulation games on ecological safety of labour and household chores.

Fig. 1. Scheme for increasing environmental safety of labour and household activities.

As noted earlier, environmental culture is formed by such factors as environmental awareness, activity and education. Our research has shown that in order to determine the relationship between these three parameters, the study of their pairwise relationship and their cumulative interaction is necessary. This will make it possible to predict the progress of the participants' ecological culture at the early stages of introducing the environmental simulation games into the educational process.

The authors offer a single measurement scale of 100 points for each indicator:

0-25 points – low level.

26-50 points – average level.

51-75 points – high level.

76-100 points – very high level.

Determining the mathematical relationship between the three indicators requires further research, but it has already been shown that the solution of this objective will bring the practice of using environmental simulation games to a new, higher level with a view to improve the ecological safety of labour and household activities.

In addition to the individual's ecological culture, the formation of environmentally safe work and household activities is influenced by working conditions, elaboration level of environmental legislation and ecological risks.

The integration of two C-shaped matrix diagrams leads to the formation of a new structure – a cube with the internal space represented by environmental safety of a particular labour and household activity (Fig. 2).

The linearisation of the cube image made it possible to obtain its flat representation – a conceptual metamodel of ecological safety of the transport system. It represents a radial-ring structure and includes three main components: the metamodel core, various aspects and system interrelations.

The links within the conceptual system of environmental safety of labour and household activities are represented by epimorphic (E) and automorphic (A) relations (Fig. 3). Epimorphic bonds are relations between the aspects of the conceptual system developed by the authors; automorphic relations represent the extent of influence of an aspect upon itself. The bonds presented in the conceptual system can be described on the basis of the mathematical laws.

The integral properties of an object (H) represent the interaction of environmental safety and the indicators influencing it – the aspects (Fig. 3) which can also be described on the basis of mathematical laws.

The authors assumed that the length of bonds H between environmental safety (W) and various groups of aspects in the conceptual metamodel is equal to 1. Applying the golden section law made it possible to split them into segments of differing lengths and to construct a scale showing the level of environmental safety of labour and household activities on the basis of the obtained segment lengths (Fig. 4).

The developed scale of environmental safety level of labour and household activities was applied to relations H reflecting the integral properties of the conceptual metamodel object. When shifting from the conceptual metamodel centre towards the periphery, the level of environmental safety of labour and household activities decreases.

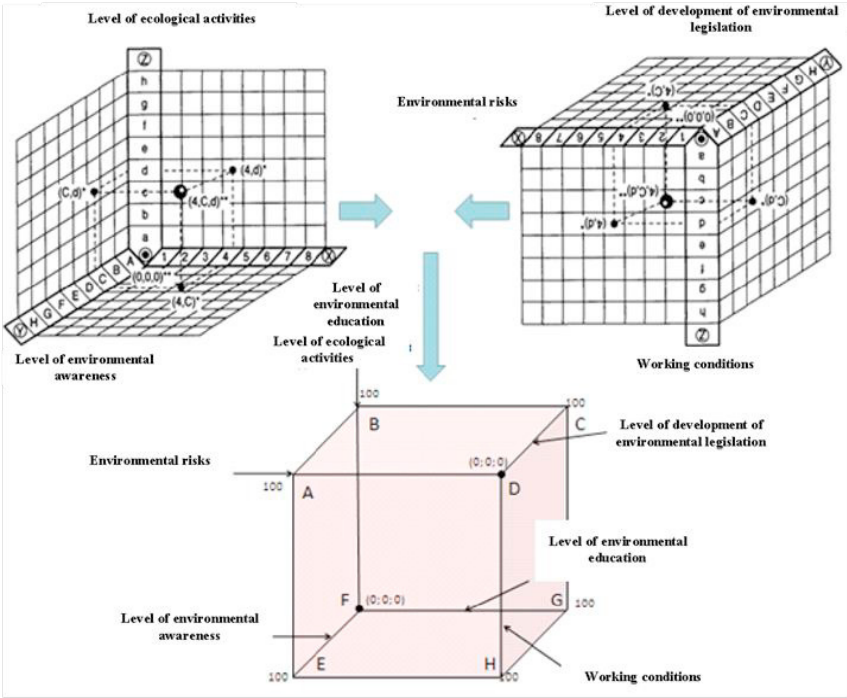

Fig. 2. Scheme for constructing a cubic model of environmental safety.

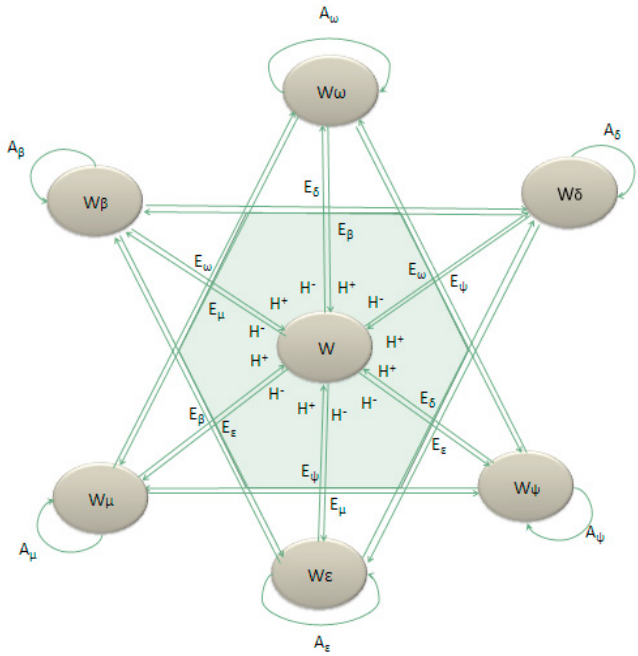

Fig. 3. Conceptual metamodel for environmental safety of labour and household activities: Wμ, Wψ, Wω – informational aspects; Wβ, Wδ – structural aspects; Wε – functional aspect; –; H – integral properties of the object; E-epimorphic relations; A – automorphic relations.

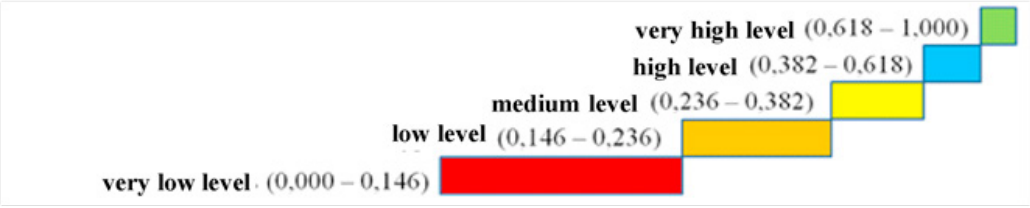

Fig. 4. Scale of environmental safety level based on the golden section law.

The next stage of the research will involve the analysis of impact of simulation games developed and applied in practice by the authors on environmental safety of labour and household activities. For this purpose, upon completion of the games, the average values for such categories as awareness, knowledge and activity will be determined on the basis of the previously obtained results of assessing the games participants' ecological culture.

The number of modern-time human-induced and, as a consequence, environmental catastrophes in transport systems, including in the Russian Federation, along with the investigation of results thereof, lets one assert the obvious logical connection between the factual ecological risk of harm to humans' health and the environment and the level of environmental education and awareness of transport system stakeholders (decision-makers, government officials, the society and other life cycle participants).

The higher the stakeholders' level of environmental education and awareness, the lower the probability of occurrence of environmental disasters, less damage to the environment and harm caused to the population of a particular region. If the cumulative level of ecological education, awareness and culture decreases, the probability of the above increases. It should be noted that the realization of ecological risks largely depends on the level of environmental education of the decision makers and risk managers in developing risk response strategies. At the same time, the damage to public health is largely determined by the level of people's ecological education and culture.

The major contribution to the overall level of environmental education, awareness and culture of transport system stakeholders is made by the internal concerned parties (decision makers, shareholders, managers, engineers, skilled and unskilled workers, and other staff). The decision makers set environmental and social policies for the country's transport system architecture; they are the regulators of sustainable development and transition risks. The engineers and managers provide for the use of modern technologies to achieve due indicators of sustainable development goals and closed-loop economy targets; they are the regulators of environmental risks. The high level of environmental education and culture of skilled and unskilled workers and other involved staff ensures compliance with instructions, regulations, and regulatory acts of the environmental legislation.

The data obtained during the present research and the analysis of scholarly sources made it possible to identify certain dependencies. A prognostication diagram was constructed on their basis, showing the extent of ecological risk depending on the frequency of accidents; economic damage caused by environmental pollution; level of environmental education, awareness, and culture of stakeholders (Fig. 5).

The method developed by the authors can be used for predicting environmental damage and developing response strategies during state environmental expert evaluation, internal environmental audit, and preparation of GRI- and ESG reports. The given research has shown that environmental education has a great impact in terms of ecological safety.

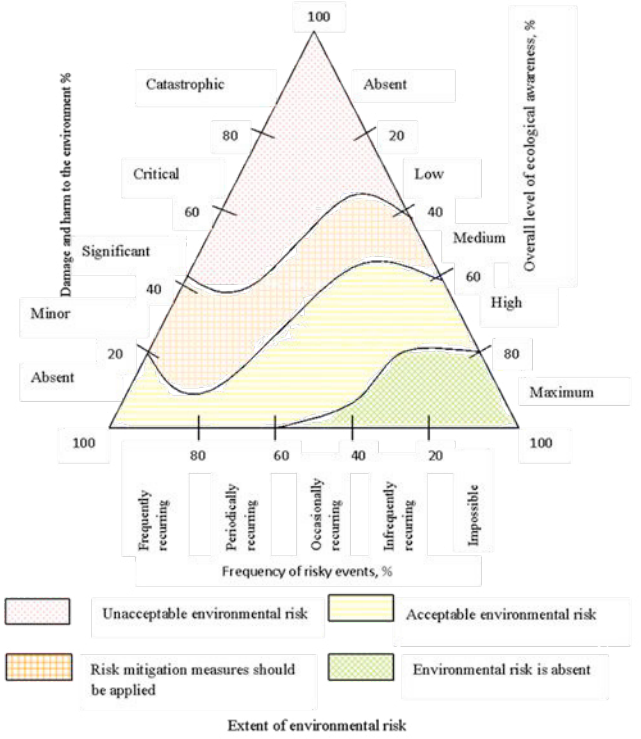

Fig. 5. Prognostication diagram for extent of environmental risk.

4. Conclusions

The development of GRI- and ESG reporting, rating and ranking systems based on them, along with the systems of voluntary certification of compliance, reliability, insurance (reinsurance) of environmental risk requires modernization of the environmental education system at specialized higher educational establishments, of the corporate governance system; it calls forth the changes in social and ecological policy for the entire architecture of the country's transport infrastructure.

As part of the response to the emerging ecological challenges and threats, it is necessary to increase the level of environmental education and awareness of interested parties, to incorporate proper knowledge and develop relevant skills pertaining to sustainable development in the course of realization of secondary vocational and higher specialized education programmers, to improve the information policy of organizations and enterprises in relation to their shareholders, as concerns timely disclosure of information on environmental and social changes in the transport system architecture.

It would be proper to create a concept of green funding of the transport system to raise investments for ESG projects, including educational and awareness-raising ones, which involve transition of the transport system and the regions to the principles of boom-and-bust low-carbon economy.

Another possible step involves integration of a complex security monitoring system into the transport system architecture and its IT infrastructure, with prompt information support for decision-makers and stakeholders in respect of current state of their assets.

References

Ainger Ch., Fenner R., 2014. Sustainable Infrastructure: Principles into Practice. ICE Publishing, London. https://www.doi.org/10.1680/SIPP.57548

Barradale M.J., Cornet Y., 2018. Developing Assessment Criteria for Sustainable Transport Appraisal. Transportation Research Record: Journal of the Transportation Research Board 2672.3, 104–117. https://www.doi.org/10.1177/0361198118799033

Barrella E.M., Amekudzi A.A., Meyer M.D., 2013. Evaluating Sustainability Approaches of Transportation Agencies through a Strengths, Weaknesses, Opportunities, and Threats Framework. Transportation Research Record 2357.1, 41–49. https://www.doi.org/10.3141/2357-05

Chatti W., 2021. Moving towards environmental sustainability: information and communication technology (ICT), freight transport, and CO2 emissions. Heliyon 7.10, 1-8. https://www.doi.org/10.1016/j.heliyon.2021.e08190

Chung S.-H., 2021. Applications of smart technologies in logistics and transport: A review. Transportation Research Part E: Logistics and Transportation Review 153, 102455. https://www.doi.org/10.1016/j.tre.2021.102455

Duff H., Vignoles V.L., Becker M., Milfont T.L., 2021. Self-construals and environmental values in 55 cultures. Journal of Environmental Psychology 79, 101722. https://www.doi.org/10.1016/j.jenvp.2021.101722

Gaykalova A.V., Nekrasova M.A., 2010. Perspectives for the use of simulation games in improving the level of environmental safety during employment and household activity. Journal of International Scientific Publications: Ecology & Safety 4.2, 239–268.

Keong Ch.Y., 2021. Global Environmental Sustainability. Elsevier, 452 p. https://www.doi.org/10.1016/B978-0-12-822419-9.00001-1

Kopnina H. 2019. Green-washing or best case practices? Using circular economy and Cradle to Cradle case studies in business education. Journal of Cleaner Production 219, 613–621. https://www.doi.org/10.1016/j.jclepro.2019.02.005

Liu W., Lund H., Mathiesen B.V., 2013. Modelling the transport system in China and evaluating the current strategies towards the sustainable transport development. Energy Policy 58, 347–357. https://www.doi.org/10.1016/j.enpol.2013.03.032

Logachev M.S., Orekhovskaya N.A., Seregina T.N. et al., 2021. Information system for monitoring and managing the quality of educational programs. Journal of Open Innovation: Technology, Market, and Complexity, 7(1), 93. https://www.doi.org/10.3390/JOITMC7010093.

Logachev M.S., Kozhvnikov E.V., Brusentsova L.S. et al., 2020. Problem of quality of educational programs: automated assessment method. Revista Inclusiones 7(S3-1), 312–323.

Logachev M.S., Zhukova G.S., 2020. Problems of professional education in Russia: quality monitoring of educational programs. Revista Inclusiones 7, 263–274.

Marsden G., Ramani T.L., Zietsman J. et al., 2011. Framework for Sustainability Assessment by Transportation Agencies. Transportation Research Record: Journal of the Transportation Research Board, 2242, 9–18. https://www.doi.org/10.3141/2242-02

Otte P.P., 2016. Integrating Sustainable Development in Higher Education through Experience-based Learning: Insights from Experts in Team (EiT) for Developing a Combined Theoretical Framework. Journal of Education for Sustainable Development 10.1, 131–159. https://www.doi.org/10.1177/0973408215625550

Pei Y.L., Amekudzi A.A., Meyer M.D., Barrella E.M., Ross C.L., 2010. Performance Measurement Frameworks and Development of Efficient Sustainable Transport Strategies and Indicators. Transportation Research Record 2163.1, 73–80. https://www.doi.org/ 10.3141/2163-08

Stanley J., 2020. Workshop 7 report: Assessing the wider benefits of public transport projects. Research in Transportation Economics 83, 100914. https://www.doi.org/10.1016/J.RETREC.2020.100914

Zafar M.W., Qin Q., Malik M.N., Zaidi S.A.H., 2020. Foreign direct investment and education as determinants of environmental quality: The importance of post Paris Agreement (COP21). Journal of Environmental Management 270, 110827. https://www.doi.org/10.1016/j.jenvman.2020.110827