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A Role of Education System in Creation of Safety Culture

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The human factor is one of the main causes of accidents, violations of safety requirements in management and design solutions, the operation of dangerous objects. Low safety culture, way of thinking and behavior is often caused by the fact that man himself is the source of danger.
This paper represents the analysis of specific industrial failures. The role of human factors in the causes of their occurrence is described. It is shown that the value of culture in general in the post-industrial society is extremely high. Culture is able to harmonize the interests of people and the technosphere, while the culture of safety is a general tool for such harmonization. Safety culture is formed in the process of education and depends largely on the level of competence of employees and management at various levels of competence in security related subjects.
The paper studies the concepts of the basis for safety education, which is formed from synergetic principles and techniques of interdisciplinary training. The grounds of the security education are civilizational changes, changes of cultural values, scientific and educational paradigms; humanistic, pedagogical, national, pragmatic, conceptual, and terminological base, the content of which is disclosed and justified. The general and particular features of human factors and safety culture in Russia, the former Soviet Union, the Eastern European States and Western European countries are discussed.
The creation of human-friendly environment is the major task for engineering. The experience of training process organization in the field of security in Russia and CIS countries is described. A successfully implemented study programme is described, that aims training and formation of security competencies. Also, presented the system of organization of educational process, feed-back system and the results of implementation of the education model in the field of security in Russia. The system of training in the field of industrial and environmental safety, occupational safety and protection in emergency situations.

1. Human Factor and Safety

There is an obvious connection between technical failure and their associated disasters and knowledge, culture and public morality. The present-day human habitat is technosphere - biosphere that has been transformed by humanity for its needs. Engineering plays the key role in creating a human-friendly technical environment. Humanity is faced with the need to be aware of many factors and to apply a rational approach when creating an environment that ensures proper living conditions for the humanity.
The main causes of man-made disasters are the people, who design, operate and maintain production facilities and who take decisions in emergency situations. The study of man-made disasters often reveals that they are human factors that are responsible for their occurrence, development and associated strong negative effects.
The table summarizes the human factor failures, which according to experts, became the main cause of recent large-scale industrial disasters.
The development of modern, industrial civilization and the fact that technical facilities become more energy demanding increase the role of the human factors in industrial disasters. This occurs despite the introduction of automation and remote manufacturing systems. Discrepancies in control systems design and failure to ensure safety can result in major accidents.

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Table 1. Accidents and their causes

Accident	One of the reasons caused by the human factor
Chemical production plant in Seveso, Italy 10 July 1976.	Deliberate divergence from standard operating procedure during the product synthesis. The accident would not have happened if the flow process had not been stopped immediately after the synthesis, if overheated steam had not been used in the heating system, if there had been forced cooling of the reactor and the stirring process had continued until the mixture had cooled to reach the temperature when any runaway reactions would be impossible.
Three Mile Island nuclear power plant (*Three Mile Island accident,* USA, Pennsylvania) 28 March 1979.	Maintenance errors (pilot-operated relief valves of emergency pumps were not opened) and inadequate training of maintenance staff who performed incorrect operations guided by ambiguous level gauge indicators.
Chemical production plant in Bhopal, India 3 December 1984.	Safety breach and insufficient protective measures.
Chernobyl nuclear power plant, USSR (Ukraine) 26 April 1986	Maintenance errors, which lead to incompliance with technical regulations during the systems test.
Fukushima nuclear power plant, Japan 11 March 2011	Human factors, but not natural disaster was the major reason of Fukushima-1 nuclear accident. This was the conclusion by the experts of the Japanese parliamentary commission. The commission has established that the main cause of the accident was major negligence by the supervisory bodies and Tepco (Tokyo Electric Power Company), the operator of Fukushima-1, as well as poor accident management. The commission also listed Japanese mentality among the reasons – shifting of the responsibility, blaming the management, as well as failure to adopt advanced international modernization and safety practices.

2. Safety Culture and Education

Society is undergoing great change, and this is accompanied by the shift of cultural and scientific educational paradigms. The process of transition to the post-industrial stage of industrial society is marked by the emergence of global risk society and shifts in the value systems of present-day high-risk society.

Growing technological and anthropogenic impact on the environment and the increasing number and severity of hazards of the outer world have become present-day reality. These objective tendencies as well as the need for sustainable development of the human society force the shift of priorities in the socio-economic development of modern society towards environmental and social safety. Objective social factors include changes in science and technology aimed to develop risk theory and study natural and technological hazards and ways to reduce their negative impact on the human and natural environment. These factors demand we improve the education so as to put more emphasis on environmental safety issues, prepare the individual to perceive rapidly changing everyday reality and ensure personal and collective safety.

Presently, developed countries list environmental, personal and collective safety issues among priority development tasks in their policies and ideology.

In the present day the benefits for society is the main criterion of effective education. Great Russian writer Leo Tolstoy wrote that the main criterion of good education is its importance for human life. Albert Einstein formulated it as follows: ‘Caring for the human and their life should be the main goal in science. Never forget about it in your drawings and equations’.

Studies by many well-known scientists - philosophers, social and political scientists, physicists, environmental scientists, engineers and educational experts Ulrich Beck (1992), G.Bechmann (2010), Anthony Giddens – (1999), N. Luhmann (2006), V. S. Stepin (1999), V. N. Kuznetsov (2002), etc. are devoted to the research of transition to risk society. They see the process as a new inevitable social phenomenon and emphasize the need in substantial paradigmatic changes in the content of science, education, human knowledge, world vision, way of thinking, activities and culture.

The humanity has too little time to understand the structure of the world through trial and error. It is time to develop and introduce noxological education.

Noxological education involves personality, upbringing and development, targeted to build behavioural norms, competences and world vision and ensure life safety and safe activities of both the individual and the society. Noxology - is the science that studies the hazards of the outer world (derived from Latin noxius - 'dangerous, harmful' and Greek logos - 'teaching').

An integrated approach to safety could be achieved through eliminating the borders between the humanities and sciences. Synthesis of various sciences allows a new methodological approach to research and teaching techniques, which could be called noxological approach characterized by:

- classification of various material and social phenomena and processes based on their being either 'dangerous' or 'safe';
- optimizing the pace of social development as well as the development of technosphere and biosphere based on making material and energy processes more efficient to ensure sustainable development of risk society;
- significance and importance of axiological and culturological factors in scientific research and teaching methodologies;
- the fact that all scientific research is integrated to form metadiscipline about life safety and safe activities.

Let us introduce a few definitions to safety studies.

Individual's noxological culture (synonym - personality's safety culture) - is a set of norms, views and presuppositions related to the individual's perception of danger and risks as well as personal, public and national safety.

Noxological culture of the society (synonym - society safety culture) - is a set of views and presuppositions related to dangers, risks, emergencies and health threats that may affect human life and activities shared by all members of the society and social groups, alongside with the norms, presuppositions and social and technical achievements aimed to minimize risks.

Noxological worldview (risk oriented worldview) - integrated worldview and concept of the individual's place in the world, their self-attitude, attitude to the environment, life stances, ideals, beliefs, cognitive principles and values, which treat safety as the main priority in human life and everyday activities.

Risk thinking - is the way reality is reflected in conclusions, concepts, theories, judgements that assess and analyse danger and risk as an objective factor.

Noxological competences - are the knowledge and skills in identifying danger, reducing risks, ensuring safety, as well as readiness and ability to utilize them in everyday life and professional activities.

Noxological competence - is an integral personality characteristic, preconditioned by the individual's noxological culture, noxological worldview and noxological competences.

Concepts of safety education based on synergetic principles and interdisciplinary teaching approaches have been thoroughly researched in a number of papers (Aleksandrov A.A., 2013, Devisilov V.A., 2008, 2010, 2011) and noxological education has been introduced in Russia.

3. Russian Higher Education in Safety

The chart (Fig. 1) shows competence building techniques in the field of safety and safety culture implemented in the Russian system of higher education. The system presented on the chart is still being developed and some stages have only recently been introduced at some of the Russian universities. Ecology and Industrial Safety Department of Bauman Moscow State Technical University was the first to introduce and promote safety education at Russian educational institutions.

One of the core disciplines in safety education is Health and Safety, compulsory academic subject on the curriculum in any field and speciality according to the Russian standards of higher education. The discipline is meant to build safety competence in students based on the acquired knowledge and promote safety worldview. It includes eight modules:

1. Introduction to safety. Basic concepts and definitions.
2. The individual and technosphere.
3. Identification of hazardous factors of human habitat and their impact on the individual.
4. Protection of the individual and the habitat against natural, technogenic and anthropogenic hazards.
5. Ensuring safe and comfortable living conditions for the individual.
6. Psychophysiological and ergonomic basics of safety.
7. Emergency situations and ways to handle them.
8. Life and health safety management.

This extended group of disciplines and specialities in the field of Technospere Safety and Environmental Engineering has been created in Russia. The disciplines are meant to train safety specialists at three levels - Bachelor's, Master's (or Specialist degree) and postgraduate degree programmes.

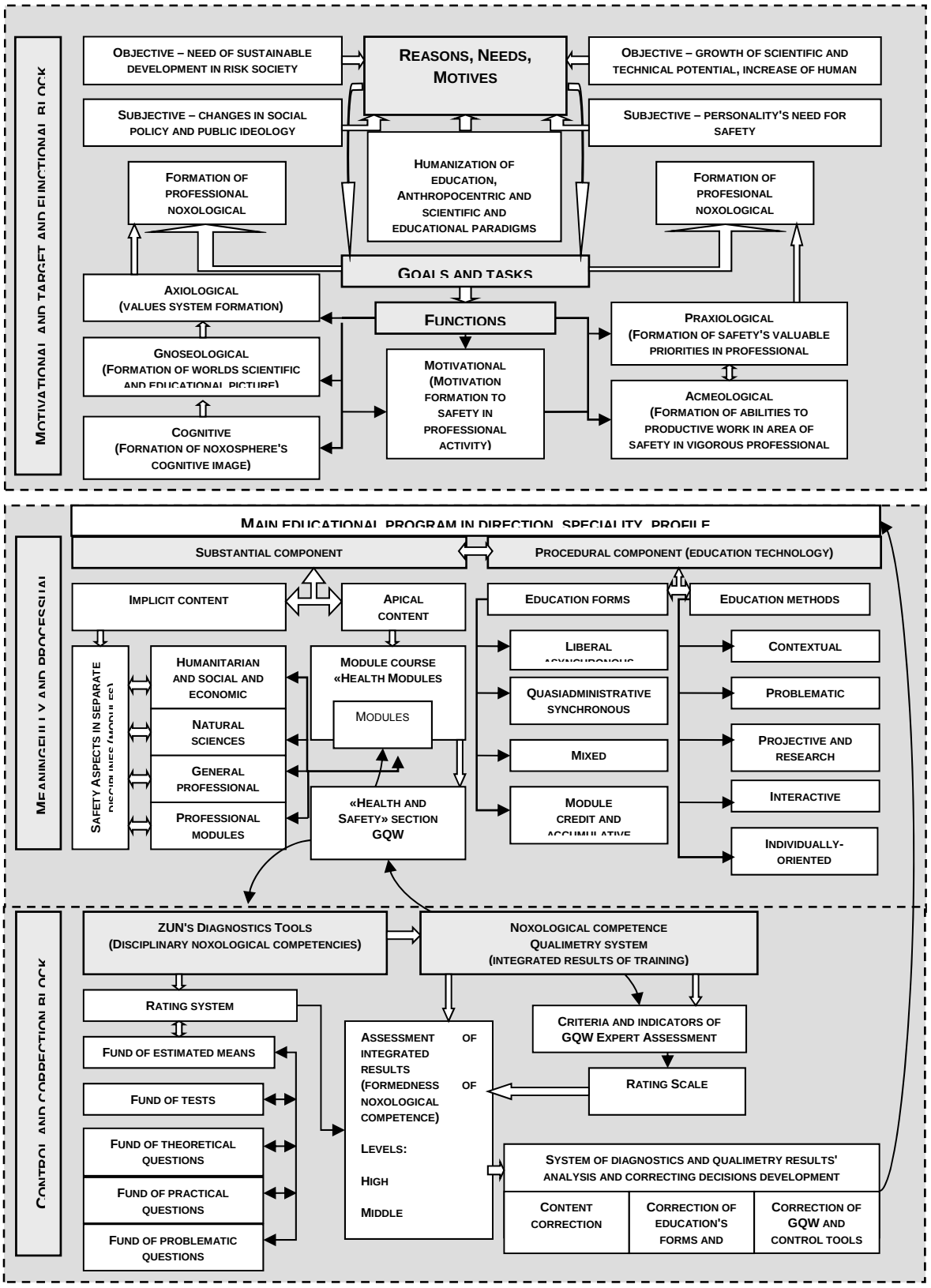

Fig. 1: Competence building techniques in the field of safety and safety culture implemented in the Russian system of higher education

Core specialities in Bachelor's degree course include: 1 Industrial Safety; 2. Occupational Safety; 3. Environmental Safety; 4. Protection in Emergency Situations; 5. Nuclear and Electromagnetic Safety; 5. Environmental Protection and Environmental Engineering; 6. Water Resources Management.
Fire Safety is also on the academic curriculum.
A number of Master's degree academic programmes are available at Russian universities. Current academic programmes include: 1 Acoustics of the Human Habitat; 2. Multipurpose Utilization of Water Resources; 3. Industrial Risk Management and Protection in Emergency Situations. New academic programmes are being presently devised: 1 Occupational Safety and Professional Risk Management; 2. Protection of the Atmosphere. Means and Techniques.
Bauman Moscow State Technical University benefits from international experience and cooperates with the European and Chinese universities when devising academic programmes in safety and environmental protection. Multipurpose Utilization of Water Resources programme was devised in cooperation with Italian universities (the University of Genoa) and was awarded an international certificate. Professor of the University of Genoa delivers lectures in Risk Assessment and Safety Monitoring at Bauman Moscow State Technical University on a regular basis. Students and professors of the department take part in internship programmes run by the European universities. Cooperation with the Chinese universities was organized by the Association of Technical Universities of Russia and China, the initiative of Bauman Moscow State Technical University and Harbin Institute of Technology.
Bauman Moscow State Technical University has developed the concept and didactics of noxological education that are being implemented in the academic curriculum. Presently, a new world vision is being formed, and integrated knowledge about the new world should lay the corner stone of new noxological worldview and risk oriented thinking. A human-centered approach in education is only possible through integrating various modern teaching techniques and new approaches. Coherent concept of present-day society, which is viewed as 'individual – machine - habitat' system, can only be communicated through integrating the knowledge in the humanities, sciences as well as technical knowledge. Such synergism is not a goal in itself, but is crucial for studying the individual, the society, the nature and technology, whose symbiosis forms technosphere.
At the moment integration of scientific knowledge is in process. It is also important that teaching techniques and methodologies should undergo similar integration.

4. Conclusions

Noxological education is gaining importance in the academic curriculum due to the human-sizedness of 'individual – machine - habitat' system and the key role the human plays in it. As the science about hazards and safety of human-sized systems involving complex cause-and-effect relations between their elements based on various branches of science about the individual, technology, nature, as well as physical, chemical, biological and psychological processes of development and self-organization noxology should benefit from synergetic approach.
Synergetic principles in studying 'individual - machine - habitat' systems requires interdisciplinary approach, which allows to reveal the complexity of the form and the content as well as the multiplicity of interrelations and establish causal links between them.
Various academic disciplines contain some segmentary knowledge about the individual and their relation with the environment, however only partial and implicit, which brings about pressing need in more systematic knowledge. It would be too naive to hope that creating a discipline that would embrace all the knowledge about the individual and their place in the world is possible. However, it is necessary to create the concept base for applied use in various subject fields, which could form the basis of sociocultural education in post-industrial society and become the means to study the individual and present-day post-industrial risk society, embracing not only traditional subjects and disciplines, but benefitting from interdisciplinary ties.
Synergetic principles and interdisciplinary approach in noxological education would equip the graduates with the instruments and ability to independently analyse and assess professional risks both their own and those of colleagues in other fields. A university graduate should be aware of the impact of their and their colleagues' professional activity on natural, social and technogenic environment in the long-term perspective and be able to communicate such ideas to others.
Noxological education based on interdisciplinary approach can form the basis of noxological worldview and risk oriented thinking and create safety culture to meet present-day challenges.
Noxology (health and safety) is a new and unique phenomenon in science and education, a synergetic unity, which requires further integration of knowledge about the world, including the humanities, sciences and technology. Only such combination can embrace the complexity of relations between the individual and the environment, reveal hazards and shed light on cause-effect relations that predetermine the level of risks.

We hope for further cooperation with overseas universities in the field of safety education aimed to form safety culture. The cooperation can have the form of student and teacher exchanges, on-site internships at leading universities and companies as well as collaboration in devising academic disciplines and further training programmes.

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