Training of specialists to solve environmental problems in the system of higher technical education

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Abstract. The system of environmental education is widely developed in the Russian Federation. The paper presents the results of the analysis of the introduction of environmental aspects in the system of higher education in technical universities, the analysis of methods and solutions for the creation of curricula aimed at studying and overcoming environmental problems based on the experience of several decades of environmental training of specialists in technical universities. Methods of theoretical analysis, methods of observation, expert evaluation, method of systematisation of the obtained results were used; method of description was used to summarise the obtained information; method of justification, method of survey and others. Multilevel approach in the system of environmental education is presented. Polytechnic University for more than 25 years has been implementing educational programmes for training specialists in the field of environmental safety, taking into account the current problems of global ecology and sustainable development. The features of educational programmes and their focus on the formation of the necessary competencies for environmental safety, features of some disciplines, are shown. This approach makes it possible to train a new generation of specialists ready to make environmentally responsible technical decisions. The results of this study show the value of an integrated system approach in environmental education.

1 Introduction

Modern economic development of society is associated with global environmental problems such as climate change, depletion of natural resources, pollution of the world's oceans, air pollution, desertification, ozone layer destruction, and biodiversity reduction [1, 2]. These problems are primarily related to the increase in population and the development of various sectors of economic management, affecting both natural landscapes and the level of negative impact on the biosphere through emissions and discharges of pollutants and production and consumption waste generation. Underestimation of environmental problems can lead to environmental disasters of extreme nature, this requires not only discussions but also specific
technical solutions [3, 4, 5, 6]. An important direction in solving environmental problems, both global and local, is environmental awareness and education. In modern society, education should be considered as a system-forming factor. The rate of reduction of the negative impact of anthropogenic activities depends on the level of environmental awareness and awareness of personnel responsible for making economic decisions. The system of personnel training (university training, retraining, advanced training, in-house education, etc.) should contribute to the formation of environmental self-consciousness in each person, and environmental responsibility for decision-making in managers. The main principles of environmental education are systemic and continuous.

Personnel who ensure environmental safety of industry are trained in technical universities. Environmental education is designed to form in students an ecological worldview of the current state of the biosphere, as well as to promote understanding of the consequences of their professional activities for the environment. It is necessary in the process of training to cultivate a sense of environmental responsibility for decision-making and the necessary competences in the sphere of professional labour.

Analysis of the literature scientific sources on the development of environmental education in technical universities [7, 8] has shown that this problem is given considerable attention, studies of educational programmes are conducted [9]. However, at present the experience is insufficiently systematised, the results of education in training specialists in the system of higher technical vocational education to solve environmental problems, both local and global levels in the light of the requirements of sustainable development are generalised. At the same time, such studies will allow taking preventive measures at the stage of education and training of future specialists to create educational programmes aimed at technical solution of global environmental problems, reduction of environmental threats, formation of environmental responsibility for making economic decisions.

Thus, the purpose of this study is aimed at analysing the existing system of environmental education in technical universities, including the example of Moscow Polytechnic University, and developing recommendations to improve the system of training specialists in the field of environmental safety, taking into account the current problems of global ecology. In the work the questions were solved:

- analysis and identification of peculiarities of educational programmes in terms of environmental education in technical universities;
- development of recommendations for improving the system of training specialists to solve environmental problems.

The review of our own long-term experience (more than 25 years) of environmental training of specialists in technical universities allows us to identify systemic features and develop recommendations for improving environmental education.

## 2 Methods and results of the research

The methods used in this work were determined based on the goal and objectives of the research:

- theoretical analysis and study of scientific literature, legislative acts in the field of education, educational programmes;
- methods such as observation, conversation, survey, expert evaluation were used for empirical research;
- the method of systematisation of the results obtained;
- the method of description was used to generalise the obtained information, etc.

Modern trends in education are aimed at developing the economy and increasing the competitiveness of industries and products for the sake of satisfying consumer demand and making profit. In this approach, the principles of technical quality that guarantee consumer
demand for products are laid down in education, first of all. With the development of society, priorities in the creation of technical products changed, however, at the same time, all previous requirements were not cancelled, but summarised, between which it was necessary to find an optimal solution. Nowadays, technical products should satisfy the interests of all participants of economic activity, not only of the traditionally established tender of producer - consumer, but also of the main participant of Nature.

At present, the national education system does not sufficiently develop mechanisms designed to form a strategic ecological outlook of the future specialist, in which the environmental safety of the designed technical systems is preventively assessed taking into account the life cycle and the environmental responsibility for decision-making is formed. This is especially relevant for the implementation of the concept of sustainable development and reduction of environmental threats.

Referring to the possibility of realisation in Russia of the Government's stated decision on the transition to sustainable development, it is necessary to take into account the following problems in education:
- rational use and restoration of natural resources;
- solving scientific and technical problems in order to exclude irreversible changes in nature;
- organisation of systems of objective environmental monitoring of the country's territory, etc.

The conducted analysis has shown that the main normative documents regulating the activities of higher educational organisations in the field of the content of educational programmes are:
- federal state educational standards;
- professional standards.

The Federal Law "On Education in the Russian Federation" in Article 3, paragraph 3 states that one of the basic principles of state policy in the field of education is the humanistic nature of education, the priority of human life and health, respect for nature and the environment, rational use of natural resources. The latest generation of federal state educational standards (FSES HE) stipulates that the bachelor's degree programmes must include a discipline on life safety, which must develop students' ability to create safe living conditions to preserve the natural environment and ensure sustainable development of society. It is also stipulated in the FSES HE that when defining and developing professional competencies, the organisation uses professional standards that correspond to the professional activities of graduates.

Analysis of professional standards "Environmental Safety Specialist (in industry)", approved by the Order of the Ministry of Labour and Social Protection of the Russian Federation of 7 September 2020 N 569n, showed that the main type of professional activity is:

- Planning, organisation, control and improvement of environmental protection activities in organisations of industries in order to prevent (minimise) the negative impact of the production activities of an industrial organisation on the environment.

The standards presuppose mastering the skills of management in the field of environmental safety on the basis of knowledge of the specifics of industrial organisations' activities.

The analysis of the general concept of environmental education in technical universities has shown that three stages of environmental education can be distinguished:

1. Study of the discipline "Life Safety" included in all educational programmes. In this discipline, in accordance with the universal competence, the following issues related to environmental education are disclosed:
- general problems of technosphere safety;
- issues of environmental protection to ensure sustainable development.

2. Implementation of educational programmes of Bachelor's and Master's degree within the training direction "Technosphere Safety"

3. Teaching of special disciplines of ecological orientation, which are included in the educational programmes of various training directions.

Moscow Polytechnic University implements a bachelor's degree programme in the direction of "Technosphere Safety". This programme implies mastering universal competences such as:
- ability to ensure human safety and environmental preservation, based on the principles of safety culture and the concept of risk-oriented thinking;
- ability to carry out professional activities taking into account state requirements in the field of safety, etc.

The list of professional competences includes:
- carrying out environmental analysis of reconstruction projects of existing production facilities, new technologies and equipment being created in the organisation;
- development and ecological and economic substantiation of plans for the introduction of new environmental protection equipment and technologies in the organisation, etc.

Thus, the complex of taught disciplines provide mastering of professional competences in the sphere of ecological safety (these are such disciplines as: Environmental protection documentation on norms of permissible impact, Increase of ecological efficiency of production activity, Organisation of enterprises' activity on waste management, Processes and apparatuses of atmospheric purification, etc.). A number of technical disciplines are provided for the identification of sources of negative impact.

In order to form strategic ecological thinking aimed at minimising technogenic impact and implementing the concepts of "design for ecology", we introduce students to the basics of ecological design of technical systems. The discipline aimed at prevention/minimisation of negative environmental impact at the stage of creation of technical products (technical systems) - "Fundamentals of ecological design of products" was developed and included into educational programmes. The main disadvantage of the traditional system of environmental justification and selection of alternatives in the creation of technical systems is the delay of analysis and comprehensive environmental assessment from the process of making basic technical decisions. It is most effective to carry out environmental assessment at the stage of product development, as this lays the material base, which has a huge multiplicative impact on natural resources and the environment. For this purpose, it is necessary to create integrated teams that include various specialists. This approach assesses the impact of the product alternatives under consideration, taking into account:
- life cycle,
- the possibility of subsequent recycling,
- best available technologies, etc.

This makes it possible to manage the environmental safety indicators of technical systems and reduce the intensity of a number of environmental problems before they arise.

The authors propose to familiarise students with the method of improving the environmental safety of technical products based on the principle of "What-If". Application of this method to assess environmental safety will allow to predict the negative response in the environment when changing the structural and functional parameters of technical products during structural and parametric synthesis and optimisation. This method should be attributed to the group of qualitative methods of environmental safety assessment, at the same time it gives an idea of deviations of indicators of specific physical quantities and can serve as a basis for deterministic methods of analysis. Fig. 1 shows a model of using intermediate parameters of technical systems to improve environmental safety in the design process.
The most important principle of environmental education is to advance the teaching of disciplines of the natural sciences cycle in relation to basic professional disciplines. The training process should also include training to work in a group of different specialists and to search for and achieve consensus of all participants making decisions on the choice of alternative design options, including environmental criteria. The structure of such a group is shown in Fig. 2).

The introduction of the proposed approaches at the early stages of technical product design will allow preventive assessment of environmental safety taking into account the life cycle, which contributes to the formation of a strategic environmental outlook and environmental responsibility for technical decision-making [10].

After mastering the Bachelor's degree programme, graduates of our university can receive more in-depth training in the field of environmental safety through the Master's degree programme "Assessment and Management of Environmental Risks". The survey of students showed that such disciplines as "Risk management, system analysis and modelling",
"Assessment of environmental safety of technical systems", "Reliability of technical systems and anthropogenic risk", etc. are of great importance for the formation of competences to reduce environmental threats.

3 Discussion

When training human resources in the system of higher education, it is necessary to raise their awareness of environmental problems associated with the implementation of any economic activity, and to form environmental responsibility for decision-making. In the authors' opinion, the most modern approach is the formation of strategic environmental outlook and training in the skills of analysing and assessing environmental safety at the stage of creating technical systems. The scientific and methodological principles and theoretical goals of environmental education for the formation of strategic environmental outlook of a future specialist are proposed.

The principles are formulated as follows:
- development of strategic ecological thinking and training in the skills of analysis and assessment of environmental problems in different spatial and temporal coordinates - from current processes of local pollution to global impacts, taking into account the life cycle to implement the concept of sustainability;
- using a scientific approach to formalise the technogenic response at different points in the spatio-temporal field from the technical systems being designed.

Theoretical objectives:
- to analyse the design and development processes of technical systems to integrate environmental performance in the early stages of design;
- development of multi-level energy and material balances to find patterns and improve environmental safety at local and global levels;
- development of methods for quantitative assessment of ingredient and parametric impacts in the life cycle of technical systems;
- analysing the reliability of technical systems taking into account the changing environment, etc.

4 Conclusion

Thus, the normative legal acts of the Russian Federation enshrine the necessity of environmental education in the system of higher education, including technical education. The analysis of environmental education in technical universities has shown that there is a multistage scheme of environmental education. The set of disciplines, first of all, should ensure the formation of competences stipulated by FSES HE and professional standards. At the same time, special disciplines will allow to form strategic ecological thinking for solving global environmental problems. The integrated approach developed in technical universities in the field of environmental education will make it possible to train a new generation of specialists ready to make environmentally responsible technical decisions.

References

4. https://doi.org/10.1051/e3sconf/202343109007


