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Contemporary Mathematical Modelling for Crisis Management in Education & Science Sector

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Abstract. *The article substantiates the role of innovative mathematical modeling as a core tool for crisis management in education and science. Formalized models enable forecasting, risk assessment, resource optimization, and scenario analysis under uncertainty, supporting adaptive decision-making and strengthening the resilience and sustainable development of educational and research organizations.*

Keywords: *mathematical modeling, crisis management, education and science, uncertainty, forecasting, risk assessment, decision support, sustainability.*

Introduction. The current stage of development of all socio-economic systems (including educational and scientific systems) is characterized by increased environmental instability, increased uncertainty of socio-economic conditions, acceleration of technological transformations [1] and increased sensitivity of institutional structures to various types of crisis impacts [2]. Such impacts include financial constraints, demographic fluctuations, personnel shortages, digital divides, reduced efficiency of knowledge management, as well as risks associated with external shocks and structural imbalances in development [3, 4].

In these conditions, traditional management approaches, based mainly on intuitive decisions, retrospective analysis and linear forecasts, demonstrate limited effectiveness [5], [6]. There is an objective need to introduce scientifically based tools to support management decisions that can take into account the multifactorial nature of processes, nonlinearity of relationships and a high level of uncertainty in the functioning of educational and scientific organizations.

One of the most promising areas for improving anti-crisis management is innovative mathematical modeling, which allows formalizing complex socio-economic processes, quantitatively assessing the dynamics of key indicators, predicting possible development scenarios, and determining optimal response strategies [7], [8]. Mathematical models provide a transition from descriptive analysis to analytical and predictive management, which significantly increases the validity of decisions [9] and contributes to the stability of systems (including education and science systems) in crisis conditions [10].

Results. Education and science are multi-level socio-economic systems that have signs of openness, high internal differentiation and constant interaction with the external environment. Their functioning is determined by a complex interweaving of human capital, intellectual resources, material and technical infrastructure, information flows, financial support and institutional coordination mechanisms. Each of these elements is autonomous: a change in one parameter inevitably causes a chain reaction of transformations in other subsystems, which forms a nonlinear development dynamics.

The specificity of educational and scientific organizations is that a significant part of their results is intangible, manifests itself with a time lag and depends on the qualitative characteristics of the staff. This significantly complicates the assessment of management effectiveness and increases vulnerability to external crisis influences. Economic constraints, demographic changes, technological shifts, personnel migration and digital transformations can disrupt the stability of the system in a short time.

In such conditions, crisis management should be considered as a continuous, proactive process aimed not only at eliminating the consequences of negative events, but also at preventing them. It includes identifying potential threats, forming adaptation mechanisms, minimizing losses, as well as ensuring the restoration and further development of organizations. The effectiveness of this process is directly related to the availability of reliable analytical information that can reflect real trends and predict future changes. This necessitates the transition from intuitive management decisions to formalized methods of analysis based on quantitative assessments and scientifically sound models.

The practical use of mathematical modeling covers a wide range of tasks of crisis management. First of all, it is used to forecast the financial stability of organizations, budget planning and assessment of resource needs. Models allow you to identify possible deficits in advance and develop measures to prevent them.

Modeling plays a significant role in the analysis of investment projects and innovation programs. Formalized calculations make it possible to compare alternative development options, assess payback periods and choose the most effective investment directions.

In the field of personnel policy, models are used to forecast personnel needs, optimize workload, assess the effectiveness of professional development and prevent the loss of key specialists. This contributes to the preservation and increase of intellectual capital.

In addition, modeling is used to assess the quality of educational services, analyze the sustainability of research teams, plan digital transformation, and develop scenarios for responding to crisis situations. The scenario approach allows you to consider several possible scenarios and form preventive strategies, which significantly reduces the likelihood of negative consequences.

Conclusions. The analysis conducted allows us to draw a number of generalizing conclusions:

Firstly, educational and scientific systems are characterized by high complexity, nonlinearity and sensitivity to crisis impacts, which requires scientifically sound management methods.

Secondly, innovative mathematical modeling is a key tool for increasing the effectiveness of anti-crisis management, ensuring the formalization of processes, quantitative assessment of risks, forecasting the consequences of management decisions and choosing optimal strategies.

Thirdly, the complex use of deterministic, stochastic, dynamic, optimization and simulation models allows us to take into account the multidimensionality and uncertainty of the environment, which significantly increases the accuracy of the analysis.

Fourthly, the introduction of digital technologies and intelligent algorithms transforms modeling from a static analysis tool into an adaptive decision-making support system.

Fifth, the use of mathematical modeling contributes to increasing sustainability, rational use of resources, preservation and development of intellectual capital, as well as the formation of long-term competitiveness of educational and scientific organizations.

Thus, innovative mathematical modeling should be considered not as an auxiliary analytical method, but as a strategic basis for modern anti-crisis management, ensuring the transition to proactive, scientifically based and digitally oriented management in the field of education and science.

Prospects for future research. Further research in the field of innovative mathematical modeling for anti-crisis management of education and science should be aimed at creating more comprehensive, adaptive and predictive analysis tools.

A promising direction is the development of methods for working with uncertainty and risks, including scenario analysis, probabilistic forecasting and early warning tools for crises. This will increase the validity of strategic planning and ensure timely adaptation of organizations to environmental changes.

Of particular importance is the development of hybrid modeling [11], which combines economic and mathematical, statistical, simulation and expert methods. This approach allows you to combine quantitative rigor with taking into account behavioral and qualitative factors, which provides a more realistic description of processes and increases the practical effectiveness of anti-crisis solutions.

Significant opportunities are opened by the digitalization of modeling, which involves the use of big data analytics, intelligent algorithms and AI systems for

adaptive decision-making support [12] for the purpose of continuous monitoring of indicators and prompt adjustment of management actions. In general, further research should contribute to the formation of an integrated interdisciplinary management model that ensures the stability and effectiveness of the development of education and science in conditions of instability.

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Dual Form of Education as a Factor of Formation of Professional Competence of Future Teachers

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Abstract. *Theses are dedicated to the problem of the formation of professional competence of future teachers of vocational training in the process of their professional training in the conditions of a dual form of education. It is noted that the dual form of education is more focused on the use of not traditional, but active teaching methods aimed at developing abilities and forming abilities to adapt to the changing conditions of the labor market and applying them in future professional activities. The author emphasizes that in order to form the specified competence in the conditions of the dual form of education, it is necessary to create a practice-oriented educational environment adapted to this form in higher education institutions.*

Keywords: *competence of a teacher of professional training, dual pharmacy of education, dual education.*