

Applying Heuristic and Meta-Heuristic Approaches to Optimization in Modern Education within the SHIVA World

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Abstract. *The article examines the possibilities of applying mathematical heuristic and metaheuristic optimization methods in modern pedagogy in the conditions of the SHIVA world. It is shown that their use contributes to the optimization of the educational process, personalization of learning, and increasing the efficiency of pedagogical decision-making.*

Keywords: *modern pedagogy, SHIVA-world, mathematical optimization, heuristic methods, meta-heuristic methods, optimization of the educational process, genetic algorithms, adaptive learning, digital education, artificial intelligence.*

Introduction.

The modern educational environment is developing under conditions of high uncertainty, nonlinearity and continuous transformation, which requires a fundamental revision of traditional approaches to the management of pedagogical processes [1]. If earlier educational systems functioned mainly in relatively stable conditions, today they are influenced by global digitalization [2], artificial intelligence [3], rapid updating of knowledge, demographic changes, geopolitical factors and growing requirements for the quality of specialist training [4]. These processes are especially clearly manifested in the conditions of the concept of the SHIVA-world (Split, Horrible, Inconceivable, Vicious, Arising), which is characterized by fragmentation of social processes, high turbulence, uncertainty [5], dynamic systemic risks.

In such conditions, traditional decision-making methods based solely on expert assessments or classical mathematical models often turn out to be insufficiently effective due to the high dimensionality of the tasks [6], a large number of interdependent factors [7] and the need to respond quickly to changes in the environment (including the educational environment). Therefore, intelligent optimization methods are becoming increasingly important, capable of finding high-quality solutions to complex multi-criteria problems with limited computing resources and urgent time constraints [8]. A special place among such technologies is occupied by mathematical heuristic and metaheuristic optimization methods = because their application allows you to effectively solve the problems of forming individual educational trajectories, drawing up schedules, distributing pedagogical workload, adapting curricula, optimizing digital educational platforms, assessing educational outcomes and intelligent management of the educational process. Unlike traditional

exhaustive search algorithms, heuristic methods are oriented towards quickly obtaining satisfactory solutions, while metaheuristic algorithms provide for the search for solutions close to the global optimum, even with high complexity of the studied tasks [9]. In this regard, the study of the possibilities of applying mathematical heuristic and metaheuristic optimization methods in modern pedagogy is a relevant direction in the development of educational science and practice.

Results.

Modern pedagogy is gradually turning into a complex information and analytical system in which a large number of interconnected management decisions are made every day. Educational institutions operate under conditions of constant change in curricula, digital technologies, employer requirements and individual educational needs of students. At the same time, most pedagogical tasks are multi-criteria in nature, since it is necessary to simultaneously take into account academic success, psychological comfort, resource constraints, time frames and requirements of educational standards.

Mathematical optimization provides a toolkit for finding the most effective solutions to such tasks. However, classical optimization methods in many cases require strict mathematical formalization, convexity of functions or small sizes of the studied task. Real educational processes rarely meet these requirements, therefore the importance of heuristic methods is increasing.

Heuristic methods are algorithms based on the use of rational search rules, expert knowledge and accumulated experience in solving similar tasks. Their main feature is the ability to obtain high-quality solutions in a short time without the need to completely search through all possible options. In pedagogy, such methods are widely used for the formation of teaching schedules, the distribution of teaching load between teachers, the staffing of academic groups, the selection of educational technologies, the organization of distance learning and the management of digital educational resources.

However, as educational systems become more complicated, the effectiveness of individual heuristics decreases due to the high probability of falling into local optima. To overcome this limitation, metaheuristic optimization methods are used, which are universal global search strategies that can effectively explore a large space of possible solutions.

The most common metaheuristic technologies are genetic algorithms, evolutionary strategies, differential evolution, particle swarm algorithms, ant optimization, simulated annealing, search with prohibitions, harmonious search, algorithms of artificial immune systems and hybrid intelligent methods. All of the above approaches model various natural processes of self-organization and allow finding effective solutions to complex problems without strict mathematical constraints.

Of particular interest to pedagogy are genetic algorithms. Using the mechanisms of selection, inheritance and mutation, they allow to automatically form optimal curricula, adaptive educational trajectories and individual recommendations for students. Thanks

to the possibility of multi-criteria optimization, the academic performance of students, their educational preferences, level of training, cognitive features and limitations of the educational organization are simultaneously taken into account.

Particle swarm algorithms that model the collective behavior of social organisms are no less promising. They are effectively used in the intelligent adjustment of parameters of digital educational platforms, adaptation of e-learning systems and automatic selection of personalized educational resources.

Ant algorithms are successfully used in the optimization of routes for passing educational material, building logical connections between disciplines, forming individual sequences of studying topics and organizing adaptive e-learning. The gradual accumulation of “digital pheromone” allows the system to take into account the successful experience of previous students and use it to build the most effective educational trajectories.

Hybrid models that combine machine learning, artificial intelligence, and metaheuristic optimization methods are becoming increasingly popular. Such systems are capable of continuously analyzing large amounts of educational data, predicting academic success, identifying the risk of decreased motivation, automatically adjusting the content of learning, and adapting the educational environment to the individual characteristics of students.

These technologies are becoming particularly relevant in the conditions of the SHIVA world. The high dynamism of the environment requires continuous adaptation of educational programs, rapid updating of competency models, prompt implementation of new digital tools, and intellectual support of management decisions. In such conditions, metaheuristic algorithms become not just a mathematical optimization tool, but the most important element of adaptive management of the modern educational system.

An additional advantage of metaheuristic methods is the ability to work with incomplete, uncertain and contradictory information. Pedagogical processes rarely have full formalizability, therefore the ability of algorithms to function effectively in conditions of uncertainty significantly increases the quality of decisions made.

A promising direction for further research is the integration of metaheuristic methods with artificial intelligence technologies, digital twins of educational institutions, Educational Big Data Mining, Learning Analytics and generative artificial intelligence systems. The formation of such intellectual ecosystems will allow us to move from reactive management of the educational process to its proactive optimization and forecasting.

Conclusions.

Thus, modern pedagogy operates in the conditions of the SHIVA-world, characterized by high uncertainty, turbulence, nonlinearity and increasing complexity of educational processes. In such conditions, traditional methods of educational management do not provide the necessary efficiency of decision-making.

Mathematical heuristic methods allow obtaining high-quality solutions to complex pedagogical tasks with limited computing resources, while metaheuristic algorithms provide effective search for solutions in multidimensional spaces in the presence of a large number of constraints and optimality criteria. The most promising for modern pedagogy are genetic algorithms, particle swarm algorithms, ant optimization, differential evolution, simulated annealing, search with prohibitions and various hybrid intellectual models.

Their application contributes to the intellectual optimization of educational programs, personalization of learning, automatic formation of individual educational trajectories, improvement of digital educational platforms, prediction of academic results and increase of efficiency of management of educational organizations.

Further development of this scientific direction is connected with synergetic hybridization of methods of mathematical heuristic and metaheuristic optimization, artificial intelligence, machine learning, big data technologies and digital ecosystems [10], which will allow to create fundamentally new adaptive models of education management that meet the challenges of the modern global educational environment.

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Developing Intercultural Competence as a Prerequisite for Effective Interpersonal Interaction

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Abstract. The article substantiates the importance of developing cross-cultural competence for effective interpersonal interaction among professionals. It examines the role of combining classroom and extracurricular activities, utilizing ICT tools, and studying culture through art, literature, and media. The author describes how these methods impact the development of empathy, critical thinking, and reflection, which are essential requirements in the qualification profile of a modern manager.

Keywords: cross-cultural competence, interpersonal interaction, professional training, future specialists, critical thinking.