

## **Adapting Pedagogy to SHIVA and WARMI Realities: The Role, Types & Specifics of Evolutionary Technologies**

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**Abstract.** *The article considers the features of the main types of evolutionary technologies (evolutionary computing) and the prospects for their application in modern pedagogy in the conditions of the SHIVA and WARMI world. It is shown that the use of evolutionary technologies contributes to increasing the adaptability, efficiency and intellectualization of educational systems in the conditions of digital transformation and high environmental uncertainty.*

**Keywords:** *modern pedagogy; evolutionary computing; evolutionary technologies; digital pedagogy; genetic algorithms; genetic programming; artificial intelligence; intelligent educational systems; SHIVA-world; WARMI-world.*

### **Introduction.**

The modern field of pedagogy is experiencing one of the most large-scale stages of transformation in the entire history of its development [1]. The rapid spread of digital technologies, artificial intelligence, intelligent analytics, big data and adaptive educational platforms is accompanied by a significant complication of the environment of the functioning of educational systems [2]. If earlier educational policy was focused mainly on relatively stable socio-economic conditions, today the development of education takes place in conditions of continuous variability, high uncertainty, turbulence and the emergence of complex systemic risks [3]. On the other hand, the modern external environment of the functioning of all types and types of socio-economic systems is increasingly characterized by modern concepts (with respect to the current external conditions of uncertainty, turbulence and systemic risks [4]), which reflect the transition to a new phase of social development, in which traditional models of forecasting, management and decision-making become insufficiently effective [5]. The SHIVA world is characterized by rapid changes, chaotic processes, information overload, high interconnectedness of events and acceleration of technological innovations. The WARMI concept complements this characteristic with the need to ensure the stability of educational systems, their adaptability, intelligence and ability to self-organize in conditions of constant external influences.

In such conditions, the relevance of the use of intellectual methods of mathematical prescriptive modeling is increasing, capable of functioning effectively in the absence of strict (often NOT formalized) mathematical models of complex and complex processes under study [6]. Among such technologies, a special place is

occupied by evolutionary computations (Evolutionary Computation), which is a class of bioinspired methods of artificial intelligence based on the principles of natural evolution, heredity, selection and adaptation [7]. Indeed, unlike traditional optimization algorithms, evolutionary technologies are able to find high-quality solutions in complex multi-criteria problems characterized by a large number of parameters, non-linearity, incompleteness of the initial information and high dynamics of changing conditions [8]. That is why these methods are becoming a promising tool for the development of new generation intelligent educational systems [9] in modern complex and difficult external conditions.

Taking into account all of the above, the main goal of the article is to study the features of different types of evolutionary technologies and determine the prospects for their use in modern pedagogy in the conditions of the SHIVA and WARMI world.

### **Results.**

Evolutionary computing is one of the most dynamically developing areas of artificial intelligence and computational optimization, based on mathematical modeling of the mechanisms of natural evolution. Such an approach allows you to effectively solve complex multi-criteria tasks characterized by high dimensionality, non-linearity and the absence of a strict mathematical model = and modern pedagogy belongs to such complex systems. The educational process is determined by the interaction of a large number of participants, factors and constraints, which are constantly changing under the influence of technological, social and economic transformations. Therefore, the use of evolutionary computing becomes one of the most promising directions for the intellectualization of the management of educational processes, the design of digital educational platforms, and the creation of adaptive educational systems.

*Genetic algorithms:* in modern pedagogy, genetic algorithms are used in the construction of individual educational trajectories, automatic formation of educational plans, intelligent distribution of the educational load, drawing up schedules, personalization of educational content and choosing the optimal sequence of studying disciplines. Thanks to the ability to take into account many criteria at the same time, such algorithms allow to significantly increase the efficiency of digital educational systems, especially in conditions of high variability of the educational environment.

*Evolutionary strategies:* the high efficiency of evolutionary strategies is manifested when solving problems of continuous optimization inherent in intelligent educational platforms. These methods can be used to adjust parameters of artificial intelligence models, optimize knowledge assessment systems, adapt the complexity of educational material, adjust learning rates, and manage parameters of digital educational services. Due to their high resistance to environmental changes, evolutionary strategies are well suited to the requirements of educational systems operating in the conditions of the SHIVA and WARMI worlds.

*Evolutionary programming:* in modern pedagogy, this approach is used in the development of intelligent learning agents, digital teacher assistants, virtual consultants and adaptive educational services. As experience is gained, such systems are able to independently change the algorithms for interacting with students, adjust their own consulting strategies, take into account the behavioral characteristics of different categories of users and gradually increase the efficiency of the educational process without the need for constant intervention by developers.

*Genetic programming:* for modern pedagogy, genetic programming opens up new possibilities for the automatic generation of intelligent educational solutions. Such technologies allow you to create adaptive test tasks, intelligent simulators, digital laboratories, automated tools for assessing knowledge, and even dynamically form individual educational scenarios corresponding to the level of preparation of a particular student. This significantly expands the possibilities of personalizing learning and reduces the complexity of developing digital educational resources.

*Differential evolution:* in the educational sphere, differential evolution can be used in the intelligent analysis of educational data, optimization of parameters of neural network models, prediction of academic success, identification of factors of educational success and improvement of recommender systems of digital educational platforms. The high computational efficiency of this method makes it especially promising in processing large arrays of educational information.

*Coevolutionary algorithms:* the modern educational environment is precisely such a coevolutionary system in which students, teachers, educational content, digital technologies, labor market requirements and professional competencies change simultaneously. The use of coevolutionary algorithms allows us to study the dynamics of such relationships, predict the development of educational ecosystems and choose the most effective strategies for managing educational processes in conditions of high uncertainty.

*Memetic algorithms:* for modern pedagogy, memetic algorithms are of particular interest in the development of intelligent adaptive educational platforms, personalized learning systems and digital ecosystems of continuous education. The combination of global evolutionary optimization and local intelligent learning allows us to take into account the individual characteristics of students, ensure high flexibility of the educational process and quickly adapt to environmental changes. Hyperheuristic evolutionary technologies: for modern pedagogy, this approach opens up broad prospects for building fully adaptive educational platforms of the new generation. Such systems will be able to automatically select optimal teaching methods, methods of presenting educational material, knowledge testing algorithms, the level of complexity of tasks and the strategy of interaction with each student, depending on their individual characteristics, current learning results and the dynamics of the educational process.

*Comparative analysis of different types of evolutionary technologies.* The analysis shows that different types of evolutionary computing are oriented to solutions of different classes of pedagogical tasks and have their own advantages. Genetic algorithms are most effective in combinatorial optimization and personalization of educational processes. Evolutionary strategies demonstrate high performance when setting the parameters of intelligent learning models. Evolutionary programming allows you to create adaptive digital educational services, while genetic programming provides automatic generation of new algorithms and educational scenarios. Differential evolution is highly effective in analyzing big educational data and training intelligent models. Coevolutionary algorithms allow you to model the development of complex educational ecosystems, and memetic algorithms ensure the highest quality solutions by combining global and local optimization. Hyperheuristic technologies represent the next stage in the development of intelligent educational systems that are able to independently choose the most effective methods of functioning.

*Prospects for use in the conditions of SHIVA and WARMI worlds.* In the modern conditions of digital transformation, education is gradually moving from the automation of individual processes to the formation of intelligent self-learning educational ecosystems. The concepts of the SHIVA and WARMI worlds provide for the need to ensure high adaptability, stability, flexibility and the ability of educational systems to function effectively in a rapidly changing external environment, limited information and the constant emergence of new challenges. These requirements are best met by evolutionary technologies that have the ability to independently adapt to changing conditions, carry out multi-criteria optimization and find high-quality solutions without a previously known model of the studied process. The most promising direction for further research is the hybrid integration of various types of evolutionary computing with technologies of artificial intelligence, machine learning, intelligent analytics, Big Data, digital twins and generative models [10], which will allow the formation of a new generation of self-learning intelligent educational systems capable of functioning effectively in the conditions of the educational environment.

### **Conclusions.**

Modern pedagogy will gradually switch to the use of intelligent computing technologies that ensure the effective functioning of educational systems in conditions of high environmental dynamics. The most promising direction is evolutionary computing, based on modeling the mechanisms of natural evolution and having high adaptability to uncertainty, multi-criteria and changing conditions.

The analysis showed that different types of evolutionary technologies have their own sphere of effective application. Genetic algorithms are most effective in solving combinatorial problems and personalizing learning; evolutionary strategies - for parametric tuning of intelligent educational models; evolutionary programming - for

developing adaptive digital pedagogical agents; genetic programming - for automatic synthesis of educational algorithms; differential evolution - for global optimization of continuous models; coevolutionary algorithms - for the dynamics of educational ecosystems; memetic algorithms - when creating highly effective adaptive educational systems; hyperheuristic technologies – with the intelligent selection of optimal teaching methods and pedagogical management.

In the conditions of the SHIVA and WARMI world, further optimal anti-crisis development will be associated precisely with the design and implementation of self-learning hybrid IT ecosystems, which integrate evolutionary computing, artificial intelligence, machine learning, intelligent analytics and Big Data technologies. Such hybrid-scenario use of different types of evolutionary technologies will significantly increase the adaptability, sustainability, efficiency and quality of educational processes, providing intellectual support for pedagogical decision-making and accelerating the digital transformation of education.

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