

Methodology for Developing an Adaptive Software Platform Designed to Manage Independent Learning

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Abstract: The article examines the methodology for developing an adaptive software platform designed to manage independent learning. A model of the platform based on the use of adaptive learning technologies, elements of artificial intelligence, and educational analytics is proposed, ensuring the personalization of the learning process in accordance with the individual characteristics of learners. The platform analyzes the level of knowledge, the pace of mastering educational material, and the results of learning activities, forming individual educational trajectories, learning materials, and recommendations. The work also reveals the functional structure of the platform, the algorithms of its functioning, and methodological approaches that ensure pedagogical effectiveness. The obtained results indicate that the use of an adaptive software platform contributes to improving the quality of independent learning, strengthening students' learning motivation, and improving the digital educational environment.

Keywords: Independent learning, adaptive platform, adaptive learning, software, artificial intelligence, educational analytics, personalized learning, digital educational environment, learning management, learning process.

Introduction: In the context of the rapid digital transformation of the education system, the organization of learners' independent learning using modern information and communication technologies is becoming particularly relevant. The development of artificial intelligence, data analysis technologies, and adaptive educational systems opens up new opportunities for the individualization of the educational process, improving the quality of mastering educational material, and forming self-education skills.

Modern digital educational platforms provide a wide range of tools for distance and blended learning; however, most of them are mainly focused on presenting educational content and controlling learning outcomes. At the same time, the individual characteristics of learners, their level of preparation, pace of mastering the material, educational needs, and motivation are not sufficiently taken into account. This

reduces the effectiveness of independent learning activities and requires the development of new approaches to managing the process of independent learning.

In this regard, the creation of adaptive software platforms capable of automatically analyzing educational data, determining the level of formation of learners' competencies, and forming individual educational trajectories acquires particular importance. The use of artificial intelligence methods, data mining, and adaptive algorithms makes it possible to provide personalized support for learners, timely feedback, and recommendations for further mastering educational material.

The development of a methodology for designing an adaptive software platform requires a comprehensive approach, including pedagogical, methodological, information-technological, and organizational aspects. Such a methodology should determine the principles of

building the platform architecture, mechanisms for adapting educational content, methods for assessing the results of independent learning, as well as algorithms for the intelligent support of learners at all stages of the educational process.

The relevance of the present study is determined by the need to improve the mechanisms for managing independent learning on the basis of adaptive digital technologies that ensure an increase in the effectiveness of the educational process and the development of learners' independence, critical thinking, and digital competencies.

The purpose of the study is to develop a methodology for creating an adaptive software platform designed to manage independent learning, ensuring the personalization of the educational process, intelligent analysis of the results of learning activities, and the formation of individual educational trajectories. The implementation of the proposed methodology will make it possible to improve the quality of learners' independent preparation, optimize teachers' activities, and ensure the effective use of modern digital educational technologies in the context of the digitalization of education.

LITERATURE REVIEW

The issues of organizing independent learning have been the subject of research by domestic and foreign scholars for many years. In the modern conditions of the digitalization of education, independent learning activity is considered one of the key factors in the formation of professional competencies, the development of critical thinking, and the ability for continuous learning.

The theoretical foundations of independent learning were laid in the works of Yu. K. Babansky, I. Ya. Lerner, M. N. Skatkin, V. P. Bepalko, and other researchers. They considered independent work as the most important component of the educational process, contributing to the development of learners' cognitive activity, independence, and responsibility. The works of the indicated authors reveal the principles of organizing independent activity, methods of pedagogical management, and criteria for assessing its effectiveness.

The development of digital educational technologies has significantly changed approaches to organizing

independent learning. The studies of T. Anderson, T. Bates, C. Bonk, and M. Moore note that modern digital educational environments provide broad opportunities for distance interaction, personalization of learning, and increasing the accessibility of educational resources. The authors emphasize the importance of using intelligent information systems capable of taking into account the individual characteristics of learners and providing continuous pedagogical support.

One of the promising directions in the development of digital education is adaptive learning systems. Peter Brusilovsky, Cristóbal Romero, Sebastian Ventura, Ryan Baker, Beverly Woolf, and other researchers made a significant contribution to the development of this field. Their works examine models of adapting educational content, intelligent methods of analyzing educational data, technologies for constructing individual educational trajectories, and the application of artificial intelligence in educational systems. Studies show that adaptive platforms contribute to increasing learning motivation, the quality of knowledge acquisition, and the effectiveness of independent work.

Research devoted to the application of Learning Analytics and Educational Data Mining technologies occupies a special place. The works of George Siemens, Dragan Gašević, Rebecca Ferguson, Ryan Baker, and Cristóbal Romero demonstrate the possibilities of analyzing large arrays of educational data for predicting learning outcomes, identifying learning difficulties, and forming personalized recommendations. The use of analytical tools makes it possible to correct the educational process in a timely manner and increase the effectiveness of independent learning.

In recent years, the possibilities of applying artificial intelligence and generative models in education have been actively studied. The works of John Woolf, Rose Luckin, Wayne Holmes, Xiaoxiao Du, as well as analytical materials of international organizations, show that intelligent digital assistants are capable of automating learners' support, providing personalized feedback, adapting educational materials, and supporting individual educational trajectories. At the same time, researchers note the need to develop pedagogically grounded models for the use of artificial intelligence in educational practice.

The studies of international organizations, in particular UNESCO, OECD, and the European Commission, emphasize that the introduction of artificial intelligence into education should be accompanied by compliance with the principles of transparency, ethics, personal data protection, and ensuring equal access to educational resources. These recommendations are an important methodological basis for designing modern adaptive educational platforms.

Despite the significant number of studies in the field of adaptive learning, most existing platforms are mainly focused on the personalization of educational content or the automation of knowledge control. The issues of comprehensive management of independent learning, the integration of pedagogical methods with intelligent adaptation algorithms, as well as the development of a universal methodology for creating adaptive software platforms that take into account learners' individual educational needs, level of preparation, motivation, and dynamics of learning achievements remain insufficiently studied.

Thus, the analysis of scientific literature shows that modern studies confirm the high effectiveness of adaptive educational technologies and intelligent learning support systems. At the same time, there remains a need to develop a scientifically grounded methodology for creating an adaptive software platform intended specifically for managing independent learning. Such a methodology should combine pedagogical, methodological, and software-technological solutions, ensure the intelligent adaptation of the educational process, and contribute to improving the quality of learners' independent learning activities.

RESEARCH METHODOLOGY AND EMPIRICAL ANALYSIS

The rapid development of digital education, the widespread introduction of artificial intelligence technologies into the educational process, and the spread of the concept of learner-centered education determine the need to search for new approaches to managing independent learning. The development of adaptive software platforms capable of taking into account the level of knowledge, the pace of mastering

educational material, educational needs, and individual characteristics of each learner is becoming particularly relevant.

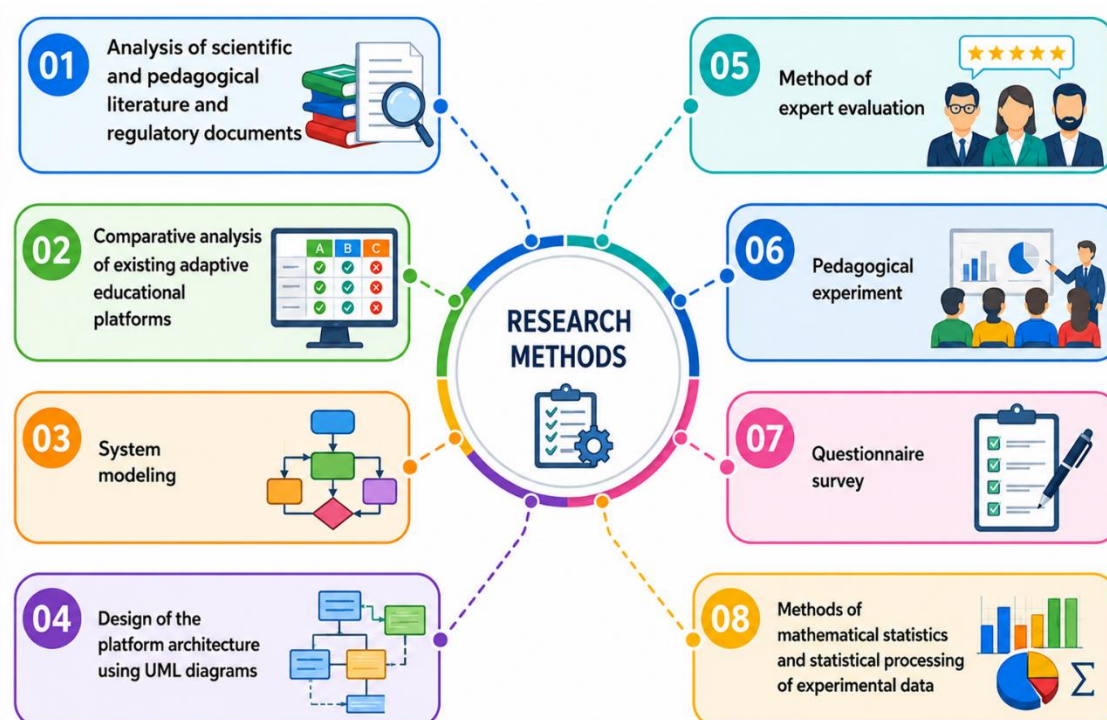
Adaptive Learning is considered as a set of pedagogical and information technologies that ensure the automatic adaptation of learning content, learning tasks, assessment methods, and recommendations in accordance with the individual characteristics of the learner. Such an approach makes it possible to carry out continuous monitoring of students' learning activities, analyze learning outcomes, and form individual educational trajectories.

Within the framework of the present study, an adaptive software platform is defined as an intelligent information system based on artificial intelligence technologies, Learning Analytics, Educational Data Mining, and recommendation algorithms, which carries out continuous monitoring of students' independent learning activities, analyzes the level of formation of their competencies, and automatically adapts educational content, learning tasks, and control tools in accordance with the individual characteristics of each learner.

The management of independent learning is considered not only as a process of providing learning tasks and controlling their completion, but also as a set of measures for planning, organizing, supporting, monitoring, and assessing students' independent learning activities. In this regard, in developing the proposed methodology, special attention was paid to the integration of pedagogical, psychological, and information-technological components.

The theoretical and methodological basis of the study consisted of systemic, competency-based, and learner-centered approaches, the concepts of adaptive learning, constructivism, and digital pedagogy. On their basis, a functional model of an adaptive software platform designed to manage independent learning was developed.

In the course of the study, the following methods were used:



In developing the methodology, the main functional components of the adaptive platform were identified:

- student model (Student Model);
- domain model (Domain Model);
- pedagogical model (Pedagogical Model);
- adaptation mechanism (Adaptation Engine);
- learning analytics module (Learning Analytics);
- recommendation module (Recommendation System);
- module for assessing and monitoring learning outcomes.

In the developed platform, all learner actions (time spent in the system, duration of studying topics, testing results, quality of task completion, level of activity, and other indicators) are automatically recorded and analyzed by the Learning Analytics module. Based on the obtained data, intelligent algorithms determine the level of mastery of educational material and form individual recommendations for further learning, as well as automatically select appropriate educational materials and tasks.

The empirical part of the study was conducted on the basis of higher education institutions with the participation of students from various fields of study. At the first stage, the existing problems of organizing independent learning, the level of students' digital competence, as well as their experience in using digital

educational platforms were studied.

The results of the questionnaire showed that most students experience difficulties in planning independent learning activities, selecting appropriate educational resources, and objectively self-assessing their level of knowledge. In addition, it was established that most of the learning management systems (LMS) used provide the same educational materials to all learners without taking into account their individual characteristics, which significantly reduces the effectiveness of independent learning.

During the pedagogical experiment, the developed adaptive software platform was implemented in the experimental group, while the control group continued learning using a traditional LMS. Upon completion of the experiment, indicators of academic performance, the level of students' independent activity, the quality of completing learning tasks, learning motivation, and the effectiveness of using the digital educational environment were compared.

The obtained results indicate that students in the experimental group demonstrated higher indicators of academic performance, independent learning activity, and quality of task completion compared to students in the control group. Personalized recommendations, automatic adaptation of learning tasks, and analytical reports generated by the system in real time had a particularly significant impact on increasing learning

motivation.

Thus, the results of the conducted methodological and empirical study confirm the scientific validity and practical effectiveness of the developed methodology for creating an adaptive software platform designed to manage independent learning. The proposed methodology ensures the personalization of the educational process, continuous monitoring of learning activities, the formation of individual educational trajectories, and an increase in the effectiveness of students' independent learning in the context of the digital transformation of education.

RESULTS

In the course of the study, a methodology for creating an adaptive software platform designed to manage students' independent learning was developed. The proposed methodology is based on the principles of learning personalization, intelligent analysis of educational data, the competency-based approach, and modern artificial intelligence technologies.

The developed platform includes interconnected functional modules: a user registration and identification module, a student model (Student Model), a domain model (Domain Model), a pedagogical model (Pedagogical Model), a module for adapting educational content, a recommendation system, a Learning Analytics module, and a system for monitoring learning outcomes.

A distinctive feature of the developed methodology is the use of an adaptive mechanism that makes it possible to automatically change the sequence of studying educational material, the level of task difficulty, and the form of presenting educational content depending on the individual characteristics of the learner. Based on the results of current control, task completion time, level of activity, and learning history, the system forms personal recommendations and an individual educational trajectory.

To verify the effectiveness of the developed methodology, a pedagogical experiment was conducted with the participation of students of a higher education institution. The experimental group used the developed adaptive platform in organizing independent learning, while the control group continued learning using a traditional learning management system.

The analysis of the results showed that the use of an adaptive software platform has a positive effect on the quality of independent learning. Students in the experimental group showed an increase in academic performance, increased activity in completing independent tasks, improved quality of mastering educational material, and growth in learning motivation. In addition, the number of missed assignments decreased, and the process of completing independent work became more organized and consistent.

The obtained results indicate that the application of intelligent adaptation algorithms ensures a more effective organization of independent learning compared to traditional digital educational systems.

DISCUSSION

The obtained results confirm the conclusions of modern studies in the field of adaptive learning, according to which the personalization of the educational process contributes to increasing the effectiveness of independent learning activities. Unlike traditional LMS, the developed adaptive software platform is not limited to providing the same educational content to all learners, but carries out its intelligent adaptation taking into account the individual characteristics of each student.

A special role in increasing the effectiveness of independent learning is played by the Learning Analytics module, which ensures continuous monitoring of students' learning activity. The analysis of learners' digital footprint makes it possible to identify emerging difficulties in a timely manner, predict a possible decrease in learning activity, and automatically form recommendations for further learning.

It should be noted that the developed methodology can be successfully integrated into existing distance learning systems (Moodle, Canvas, Google Classroom, and other LMS), expanding their functional capabilities through the application of artificial intelligence technologies and intelligent analysis of educational data.

At the same time, the conducted study has certain limitations. The experiment was conducted within one higher education institution and covered a limited number of participants. In addition, the study

considered mainly quantitative indicators of the effectiveness of independent learning. In further studies, it is advisable to expand the sample of participants, use machine learning methods to increase the accuracy of adapting the educational process, and also study the influence of generative artificial intelligence on the formation of individual educational trajectories.

CONCLUSION

As a result of the conducted study, a methodology for creating an adaptive software platform designed to manage students' independent learning in the context of the digital transformation of education was developed.

The proposed methodology combines pedagogical principles of organizing independent learning with modern information technologies, methods of Learning Analytics, Educational Data Mining, and artificial intelligence. The implemented adaptation mechanism ensures the automatic formation of an individual educational trajectory, personalized selection of educational materials, and constant monitoring of learning outcomes.

Experimental verification confirmed the effectiveness of the proposed approach. The use of the adaptive platform contributes to improving the quality of students' independent learning activities, developing learning motivation, increasing academic performance, and organizing the educational process more rationally.

The practical significance of the study lies in the possibility of implementing the developed methodology in the digital educational environment of higher education institutions to increase the effectiveness of independent learning, improve the mechanisms of personalized education, and support pedagogical decision-making based on the analysis of educational data.

The prospects for further research are related to the development of intelligent models for predicting educational outcomes, the use of generative artificial intelligence for the automatic formation of educational content, as well as the integration of the adaptive platform with national and international digital educational ecosystems.

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