INTELLIGENT SYSTEM FOR ADAPTIVE MANAGEMENT OF THE EDUCATIONAL PROCESS IN GENERAL SECONDARY EDUCATION INSTITUTIONS BASED ON ARTIFICIAL INTELLIGENCE TECHNOLOGIES

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Annotation: The paper proposes the structure of an intelligent system for adaptive management of the educational process in general secondary education institutions based on artificial intelligence technologies, integrating educational data acquisition and integration, machine and deep learning, learning analytics, and predictive modeling to assess students' current knowledge states, identify learning difficulties, and develop personalized learning pathways. The use of an adaptive decision-making mechanism and a continuous feedback loop enables the generation of recommendations tailored to students' individual educational needs and the adaptive refinement of intelligent models, thereby creating the prerequisites for improving the personalization, flexibility, and effectiveness of the educational process while preserving the leading role of teachers in educational decision-making.

Key words: artificial intelligence; adaptive learning; general secondary education; machine learning; learning analytics; personalized learning pathway; learning outcome prediction; decision support system.

ІНТЕЛЕКТУАЛЬНА СИСТЕМА АДАПТИВНОГО УПРАВЛІННЯ НАВЧАЛЬНИМ ПРОЦЕСОМ У ЗАКЛАДАХ ЗАГАЛЬНОЇ СЕРЕДНЬОЇ ОСВІТИ НА ОСНОВІ ТЕХНОЛОГІЙ ШТУЧНОГО ІНТЕЛЕКТУ

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Анотація: У роботі запропоновано структуру інтелектуальної системи адаптивного управління навчальним процесом у закладах загальної середньої освіти на основі технологій штучного інтелекту, яка поєднує збір та інтеграцію освітніх даних, машинне і глибоке навчання, навчальну аналітику та прогнозування для оцінювання поточного стану знань учнів, виявлення навчальних труднощів і формування персоналізованих навчальних траєкторій. Використання адаптивного механізму прийняття рішень і контуру безперервного зворотного зв'язку забезпечує формування рекомендацій відповідно до індивідуальних освітніх потреб учнів та адаптивне уточнення інтелектуальних моделей, що створює передумови для підвищення персоналізації, гнучкості й ефективності навчального процесу при збереженні провідної ролі педагога у прийнятті освітніх рішень.

Ключові слова: штучний інтелект; адаптивне навчання; загальна середня освіта; машинне навчання; навчальна аналітика; персоналізована навчальна траєкторія; прогнозування навчальних результатів; система підтримки прийняття рішень.

The relevance of research on an intelligent system for adaptive management of the educational process is determined by the need to ensure the continuity and quality of general secondary education in Ukraine under martial law, when air-raid alerts, the forced displacement of students and teachers, and periodic transitions between face-to-face, distance, and blended learning complicate the implementation of traditional educational models. Unequal access to educational resources and differences in the pace of learning increase the need for individualized instruction and the timely

identification of gaps in students' knowledge. The use of artificial intelligence technologies enables automated analysis of learning outcomes, prediction of the level of learning material acquisition, and adaptive formation of personalized learning pathways in accordance with the student's current level of preparation and dynamics of academic performance. An intelligent adaptive management system can support teachers in making decisions regarding the selection of learning materials, task difficulty, and the need for corrective measures, while preserving the leading role of the teacher in the educational process. The development of such a system will contribute to improving the resilience, flexibility, and personalization of the educational process in general secondary education institutions in Ukraine under wartime challenges and during the subsequent recovery of the educational environment. The structural diagram of the intelligent system for adaptive management of the educational process in general secondary education institutions based on artificial intelligence technologies is presented in Figure 1.

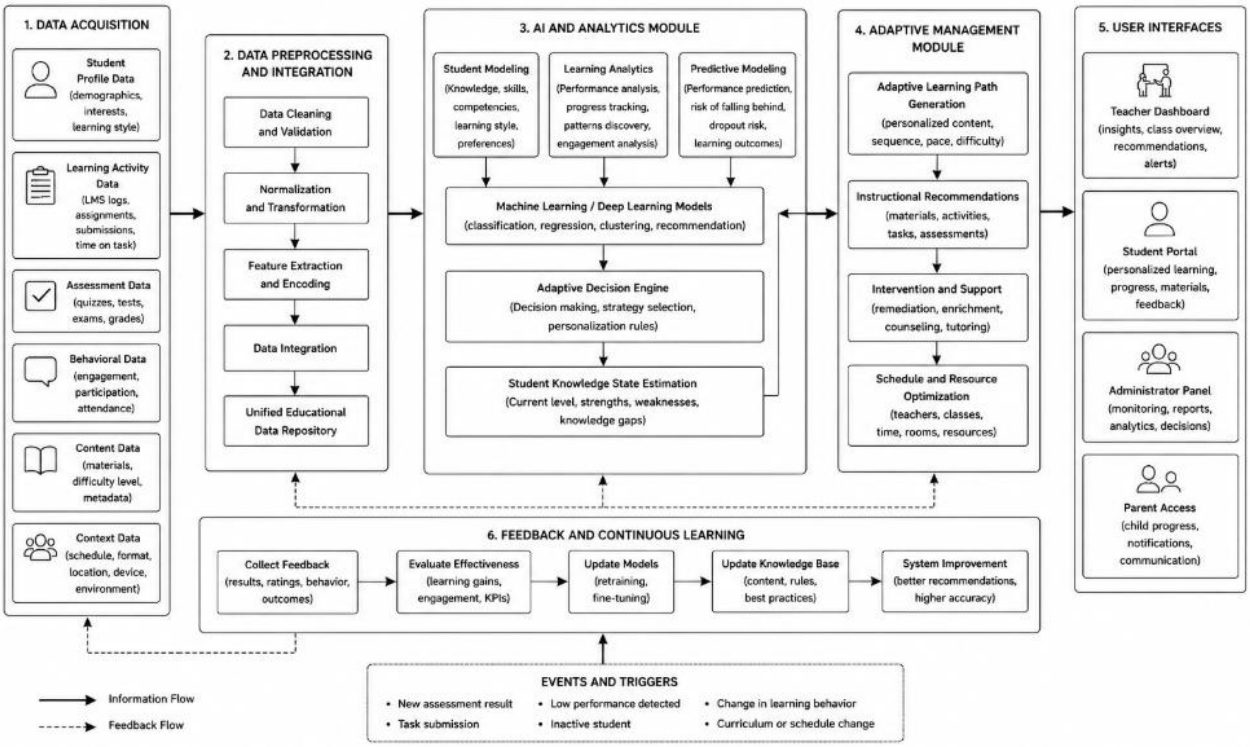

Figure 1 – Structural Diagram of the Intelligent System for Adaptive Management of the Educational Process in General Secondary Education Institutions Based on Artificial Intelligence Technologies

The operating principle of the developed structure of the intelligent system for adaptive management of the educational process (Fig. 1) is based on the continuous collection of educational data, their intelligent analysis, the generation of personalized learning decisions, and the subsequent refinement of models based on the results of students' learning activities. The Data Acquisition block forms the primary information environment of the system and integrates Student Profile Data, information on learning activities (Learning Activity Data), results of tests, examinations, and assessments (Assessment Data), indicators of engagement, attendance, and participation in the educational process (Behavioral Data), characteristics of learning materials (Content Data), as well as contextual information (Context Data) describing the learning format and schedule, devices used, and conditions of access to the educational environment. The collected information is transmitted to the Data Preprocessing and Integration block, where data cleaning and validation, normalization and

transformation of parameters, extraction and encoding of informative features, and integration of heterogeneous information streams are sequentially performed. As a result, the Unified Educational Data Repository is formed, serving as a unified source of prepared and structured data for further intelligent analysis.

The central component of the structure is the AI and Analytics Module, which provides intelligent assessment of the current state of the educational process and prediction of its future dynamics. The Student Modeling component creates a digital learning profile of each student, taking into account their knowledge, skills, competencies, individual characteristics, and learning preferences, while Learning Analytics analyzes academic performance, learning progress dynamics, task completion patterns, and the level of student engagement. The Predictive Modeling component is used to predict learning outcomes and provide early identification of the risk of a student falling behind or other unfavorable learning trends. The obtained characteristics are transferred to the Machine Learning/Deep Learning Models, where classification, regression, clustering, and recommendation algorithms are applied, and their results are then transmitted to the Adaptive Decision Engine to select an appropriate learning strategy and personalization rules. Based on these results, the Student Knowledge State Estimation component determines the student's current level of knowledge, identifies strengths and weaknesses, and detects existing gaps in the acquisition of learning material, thereby forming the information basis for adaptive management of the educational process.

The results of the intelligent analysis are transmitted to the Adaptive Management Module, which directly generates control actions for the educational process and maintains a bidirectional information link with the AI module to refine the decisions made. The Adaptive Learning Path Generation component creates a personalized learning pathway by selecting the content, sequence, pace, and level of difficulty according to the student's current knowledge state. Based on this pathway, Instructional Recommendations determines appropriate learning materials, assignments, types of learning activities, and assessment tools, while Intervention and Support is activated when learning difficulties are detected and provides remedial materials, advanced tasks, consultation, or other forms of educational support. The Schedule and Resource Optimization component optimizes the use of time, learning facilities, teaching resources, and digital resources in accordance with the developed adaptive learning strategies.

Human interaction with the intelligent system is implemented through the User Interfaces block, which includes the Teacher Dashboard, Student Portal, Administrator Panel, and Parent Access. The teacher interface provides access to information about the learning progress of the class and individual students, as well as to system-generated recommendations and alerts; the student portal provides personalized learning materials, assignments, progress information, and feedback; the administrator panel is used for monitoring, analytics, and management decision-making; while the parent interface enables monitoring of learning progress, receiving notifications, and information exchange with the educational institution. Thus, the results generated by the AI module do not replace pedagogical decision-making but are transformed into informational and recommendation-based support for participants in the educational process.

The information loop is closed by the Feedback and Continuous Learning block, which receives the results of actual learning activities and compares them with the predictions and recommendations generated by the system. The Collect Feedback component accumulates learning outcomes, assessment results, behavioral indicators, and other interaction data, after which Evaluate Effectiveness assesses knowledge gains, student engagement, and key performance indicators, Update Models performs retraining and fine-tuning of the AI models, while Update Knowledge Base updates educational content, rules, and accumulated practices. The System Improvement component uses these results to improve the accuracy of analysis and the quality of subsequent personalized recommendations, while the dashed feedback links return the refined information to the data preprocessing, AI analysis, and adaptive management blocks. A separate Events and Triggers loop

provides an event-driven mechanism for system operation: a new assessment result, task completion, detection of low academic performance, prolonged student inactivity, changes in learning behavior, or modifications to the curriculum or schedule initiate a new cycle of analysis and adaptation

CONCLUSIONS. As a result of the research, a structure of an intelligent system for adaptive management of the educational process in general secondary education institutions is proposed, which integrates educational data collection and integration, machine and deep learning technologies, predictive analytics, and mechanisms for generating personalized learning pathways. The use of an adaptive decision-making mechanism and continuous feedback enables dynamic assessment of students' knowledge states, timely identification of learning difficulties, and generation of recommendations for teachers and students according to their individual educational needs. The proposed system creates the prerequisites for enhancing the personalization, flexibility, and resilience of the educational process while preserving the leading role of the teacher in educational decision-making.

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