responsible regulation, especially under conditions of crisis. Ensuring a balance between technological development, security and human rights protection remains a key challenge for modern governance.

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DATA MINING FOR FORECASTING ACADEMIC SUCCESS AND ARCHITECTING PERSONALIZED TRAJECTORIES

У статті досліджуються можливості застосування методів інтелектуального аналізу даних (Educational Data Mining) у системах управління навчанням для прогнозування академічних досягнень студентів та формування персоналізованих освітніх траєкторій. Розглянуто алгоритми машинного навчання – Random Forest, k-Nearest Neighbors та штучні нейронні мережі – як інструменти раннього виявлення студентів з ризиком відрахування на основі поведінкових даних з платформ Moodle та Canvas. Проаналізовано застосування графових згорткових мереж і мультимодальних даних для адаптивної рекомендації навчального контенту відповідно до індивідуального рівня знань. Окремо розглянуто практику впровадження EDM-підходів в українських університетах в умовах воєнного стану, зокрема досвід НУБіП України та Львівської політехніки. Обґрунтовано, що інтеграція предиктивних алгоритмів з адаптивними освітніми системами дозволяє трансформувати освіту від реактивного оцінювання до проактивної підтримки здобувачів вищої освіти.

Ключові слова: *інтелектуальний аналіз даних, персоналізована освітня траєкторія, машинне навчання, прогнозування академічної успішності, системи управління навчанням, адаптивне навчання.*

This paper investigates the application of Educational Data Mining (EDM) methods within learning management systems for predicting students' academic outcomes and constructing personalized educational trajectories. Machine learning algorithms – including Random Forest, k-Nearest Neighbors, and Artificial Neural Networks – are examined as tools for early identification of at-risk students through behavioral data collected from platforms such as Moodle and Canvas. The use of Graph Convolutional Networks and multimodal data for adaptive content recommendation aligned with individual skill levels is analyzed. Special attention is given to the practical implementation of EDM approaches in Ukrainian universities under wartime conditions, with reference to the experience of the National University of Life and Environmental Sciences of Ukraine and Lviv Polytechnic National University. The study concludes that integrating predictive analytics

with adaptive learning systems enables a paradigm shift from reactive grading to proactive student support, reducing late-stage dropout rates and enhancing educational effectiveness.

Keywords: *educational data mining, personalized learning trajectory, machine learning, academic performance prediction, learning management systems, adaptive learning.*

Education keeps leaving behind the old days of uniform curricula that treat every student the same. In today's digital classrooms, every click, quiz answer, and moment spent watching a video creates a rich digital trace. Educational Data Mining (EDM) serves as the powerful tool that turns all this raw information into useful knowledge.

Modern algorithms do not just passively observe students but actively forecast their academic outcomes and automatically tailor educational paths to fit individual cognitive needs. By leveraging these tools, institutions go from reactive grading to proactive support. Before a system can guide a student, it must understand their current trajectory. Students generate massive amounts of behavioral data within Learning Management Systems (LMS) like Moodle and Canvas. By analyzing metrics such as time spent on specific modules, attendance, and forum interactions, machine learning models can predict if a student is struggling long before the final exam. Algorithms like Random Forest, k-Nearest Neighbors, and Artificial Neural Networks are exceptionally good at finding hidden patterns in this data.

A good example comes from the Polytechnic Institute of Portalegre in Portugal, where these same algorithms successfully identify students facing a high risk of dropping out. In such early-warning systems, the focus stays on high recall so that fewer struggling students slip through unnoticed. It is much better to offer extra help to someone who turns out fine than to miss a student who quietly leaves.

Knowing a student needs help is only half the battle, the next step is providing a customized route forward. Instead of forcing everyone through the exact same sequence of textbook chapters, advanced systems use Graph Convolutional Networks and multimodal data to recommend content that matches a student's real-time skill level. The algorithm strengthens digital educational pathways that lead to high student comprehension. If a specific sequence of topics causes students to fail, that path quickly deletes from the system. This allows the educational platform to continuously adapt based on collective success. Additionally, process mining analyzes event logs to spot moments where students struggle with difficult courses, often repeating them. By identifying these obstacles, curriculum designers can fix issues with course prerequisites.

EDM applications must always adapt to local realities and constraints. While global assessments like TIMSS and PISA provide massive datasets for understanding general, worldwide learning trajectories, local implementation requires highly customized solutions. Despite severe challenges like underfunding and infrastructure damage during the ongoing war, Ukrainian universities demonstrate massive technological resilience. At the National University of Life and Environmental Sciences of Ukraine, Moodle data is actively mined to match course content with specific individual learning styles. Furthermore, Lviv Polytechnic National University integrates AI and IoT to predict outcomes, effectively bridging the gap between big data analysis and personalized learning environments. Consequently, educational continuity is maintained even under the most extreme crisis conditions.

In the end, current situation shows that data mining is far more than an administrative sorting tool, it is the foundation of a living, breathing educational ecosystem. By combining predictive algorithms with adaptive, swarm-optimized trajectories, education transforms into a highly personalized experience. Therefore, academic institutions can foster deeper student success, drastically reduce late-stage dropout rates, and prepare learners for the dynamic complexities of the modern digital economy.

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CONSERVATION TILLAGE AS AN ALTERNATIVE TO TRADITIONAL PLOWING IN MODERN AGRICULTURE

У статті розглянуто безвідвальний обробіток ґрунту як ефективну альтернативу традиційній оранці в умовах сучасного землеробства. Проаналізовано основні переваги цієї технології, зокрема збереження структури ґрунту, підвищення рівня вологи, зменшення ерозійних процесів та раціональне використання енергетичних ресурсів. Висвітлено роль сучасної сільськогосподарської техніки у впровадженні ґрунтозберігаючих технологій.
Ключові слова: *безвідвальний обробіток ґрунту, традиційна оранка, ерозія ґрунту, збереження вологи, родючість ґрунту, ресурсозбереження, сучасна агротехніка.*

The article considers non-moldboard tillage as an effective alternative to traditional plowing in modern agriculture. The main advantages of this technology are analyzed, including preservation of soil structure, moisture retention, reduction of erosion processes, and rational use of energy resources. Particular attention is paid to the role of modern agricultural machinery in the implementation of soil-conserving technologies.
Keywords: *non-moldboard tillage, traditional plowing, soil erosion, moisture conservation, soil fertility, resource saving, modern agricultural machinery.*

Due to the deterioration of the ecological condition of agriculture, studies and tests of new soil-protective technologies were conducted in many countries as early as the 20th century. Their basis consisted of minimizing the number and depth of soil tillage operations, regulating the runoff of rain and meltwater, and leaving part of the stubble on the field surface in order to increase the soil's resistance to erosion. However, studies have shown that not all new technologies can completely solve the problem of the ecological optimization of agriculture. Mechanical tillage, which is the basis of most agricultural technologies, has a dual impact on the soil. On the one hand, it contributes to the creation of favorable conditions for plant growth and ensures optimal crumbling and structure of the cultivated layer. On the other hand, intensive mechanical tillage can lead to the destruction of soil structure, disturbance of air and water balance, especially when tilling excessively wet or overly dry soils, as well as to the intensification of the mineralization of organic matter. Thus, depending on the method, depth, and frequency, mechanical tillage can act both as a factor improving the soil environment and as a cause of its degradation.

In the cultivation of grain, industrial, and forage crops, most farms seek to optimize costs while treating the land carefully by applying scientifically based crop rotations, organic fertilizers, soil protection from erosion, and other important agrotechnical measures. Every year, the issue of accumulating and conserving moisture in the soil becomes more acute. Under such conditions, soil tillage plays a leading role both in crop formation and in preserving and increasing soil fertility. Only through mechanical influence on the soil by the working elements of various machines and implements can optimal conditions for the development of the root system of cultivated plants be created and the efficient use of fertilizers and plant protection products ensured. It is known that up to 30–35% of fuel in the technological chain of growing field crops is spent on soil preparation. This is where a significant reserve for resource savings exists, which, together with the need to preserve soil