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FEATURES, PROBLEMS AND PROSPECTS OF DATA MINING AND DATA SCIENCE APPLICATION IN EDUCATIONAL MANAGEMENT

Abstract. Technologies, methods and the corresponding applied toolkit of Data Mining, and with the passage of time Data Science - are currently extremely relevant, important technologies that rapidly continue their horizontal and vertical scaling, development and distribution - starting from classic industries for innovations in IT (intelligence services, telecommunications, Internet trade, banking) and continuing its spread in other fields (education, science, culture, etc.). Moreover, the mentioned



scaling of the use of Data Mining technologies, and with the passage of time also Data Science, is relevant not only for national and sectoral management (for example, for the Ministry of Education in general and for its directions/departments), for regional management (at the level of regions or districts, local authorities), but also for the micro level of individual state/municipal/private institutions, organizations and enterprises [1].

Modern educational management in the conditions of the post-covid stage, in the global conditions of further personal digitalization, taking into account the realities of Industry 5.0, taking into account Big Data, taking into account the emergence and spread of generative artificial intelligence - faces dynamic and complex, multicollinear challenges, which determines the urgent need for a total increase efficiency, adaptability, competitiveness and, finally, multifunctional optimization.

It is Data Mining technologies, and later Data Science, that will provide state education management institutions, educational organizations and institutions with powerful innovative methods/algorithms and appropriate tools of multidimensional in-depth analysis of large educational data for the search for hidden patterns/patterns, their understanding/interpretation, proactive detection /monitoring of anomalies and potential threats, prediction and further optimization of various educational management tasks at operational, tactical and strategic levels.

The article proves that in the field of educational management, Data Mining and Data Science technologies have great potential for systematically increasing the effectiveness of educational management and university science. The impact of Data Mining, and more recently Data Science, is felt in various aspects of the modern innovative university environment, starting with the adaptation and optimization of the educational process and the development of new programs/courses/trainings, and ending with the application of classical machine learning and deep machine learning to achieve breakthrough scientific results (for example, in the field of machine linguistics).

In this article, a study of the existing experience, features, potential problems and further prospects for the operational implementation and effective use of technologies, methods/algorithms and applied tools of Data Mining and Data Science in modern educational management, taking into account the post-covid consequences in the field of education and taking into account the current impacts and the consequences of war.

Keywords: Data Mining, Data Science, educational management, machine learning, university science



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ОСОБЛИВОСТІ, ПРОБЛЕМИ ТА ПЕРСПЕКТИВИ ЗАСТОСУВАННЯ DATA MINING ТА DATA SCIENCE В ОСВІТНЬОМУ МЕНЕДЖМЕНТІ

Анотація. Технології, методи та відповідний прикладний інструментарій Data Mining, а з плином часу і Data Science - є наразі надзвичайно актуальними, важливими технологіями, які стрімко продовжують своє горизонтальне та вертикальне масштабування, розвиток та розповсюдження - починаючи з класичних індустрій для інновацій в ІТ (розвідувальні служби, телекомунікації, інтернет торгівля, банківська справа) та продовжуючи своє розповсюдження і в інших галузях (освіта, наука, культура тощо). Причому, згадане масштабування використання технологій Data Mining, а з плином часу і Data Science, актуальне не тільки для загальнодержавного та галузевого

управління (наприклад, для міністерства освіти загалом та його окремих департаментів), але і для регіонального управління (на рівні областей або районів, місцевої влади), але і для мікрорівня окремих державних/комунальних/приватних установ, організацій і підприємств [1].

Сучасний освітній менеджмент в умовах постковідного етапу, в глобальних умовах подальшої персональної цифровізації, зважаючи на реалії Industry 5.0, зважаючи на Big Data, враховуючи появу та розповсюдження генеративного штучного інтелекту - стикається з динамічними та комплексними, мультиколінеарними викликами, що обумовлює нагальну потребу у тотальному підвищенні ефективності, адаптивності, конкурентності та, нарешті, і мультифункціональній оптимізації.

Саме технології Data Mining, а згодом і Data Science, нададуть державним установам з управління освітою, освітнім організаціям та закладам потужні інноваційні методи/алгоритми та відповідні інструменти багатовимірного поглибленого аналізу великих освітніх даних для пошуку прихованих закономірностей/шаблонів, їх розуміння/інтерпретації, проактивної детекції/моніторингу аномалій та потенційних загроз, передбачення та подальшої оптимізації різних задач управління освітою на оперативному, тактичному та стратегічному рівнях.

В статті доведено, що і в сфері освітнього менеджменту, технології Data Mining та Data Science мають великий потенціал для системного підвищення ефективності освітнього менеджменту та університетської науки. Вплив Data Mining, а в останній час і Data Science, відчутний в різних аспектах сучасного інноваційного університетського середовища, починаючи з адаптації та оптимізації навчального процесу та розробки нових програм/курсів/тренінгів, і закінчуючи застосуванням класичного машинного навчання та глибокого машинного навчання для досягнення проривних наукових результатів (наприклад, і в сфері машинної лінгвістики).

У цій статті проведено дослідження наявного досвіду, особливостей, потенційних проблем та подальших перспектив оперативного впровадження та ефективного використання технологій, методів/алгоритмів та прикладних інструментів Data Mining та Data Science у сучасному освітньому менеджменті, з урахуванням post-covid наслідків в сфері освіти та зважаючи на поточні впливи та наслідки війни.

Ключові слова: Data Mining, Data Science, освітній менеджмент, машинне навчання, університетська наука



Formulation of the problem. Data Mining and Data Science play an increasingly important role in today's hi-tech world, where data (and knowledge derived from it) is one of the most valuable resources and a new type of asset that can and should generate added value [2 - 4].

After all, all individuals and legal entities, state and local authorities have been generating, registering and storing (in databases, data warehouses) huge volumes of heterogeneous structured and semi-structured information (quantitative, qualitative, text, hypertext, transactional, geo-information, multimedia, meta-information, etc.) for years, regarding all aspects of its business, technological and managerial activities. In addition, the rapid development and spread of Big Data, Web 4.0 and Web 5.0, IOT, FinTech, blockchain in recent years caused an additional avalanche-like increase in stored data [5, 6].

These big data contain significant potential for finding and formalizing hidden new regularities (knowledge, patterns), which are the basis for making optimal and effective managerial and technological decisions [7].

In the modern conditions of the development of the global economy, and in connection with the emergence of new branches of economic activity in the field of informatization, the application of innovative technologies for the extraction, cleaning, processing, analysis and analytics of extremely large arrays of heterogeneous data leads to the obtaining of additional competitive advantages by users at the state, regional, and branch level and corporate levels of management, which is especially relevant in the conditions of crisis phenomena [8-10].

Data Mining and Data Science are interdisciplinary fields that combine methods, algorithms, and tools from various fields, including statistical analysis, applied mathematics, computer science, and necessarily domain-specific knowledge and heuristics [11-13].

The subject of Data Mining and Data Science is the collection, cleaning, processing (in particular, transformation), analysis and analytics of all types of big data, further evaluation and interpretation of the results - potentially useful, but hidden regularities [14-15]. One of the key aspects of Data Mining and Data Science is the use of not only statistical analysis, SQL queries and intelligence visualization - but also, mainly, various methods and algorithms of both classical machine learning and shallow/deep artificial neural networks for automated detection and formalization of hidden regularities in large batch and/or streaming big data [16-18]. This makes it possible to obtain new classification and regression models that allow making rational and effective decisions based on the analysis and analytics of the accumulated volumes of heuristics (having structured, semi-structured, or even unstructured forms [19]).



Analysis of recent research and publications. The fundamental questions of the theory of classical Data Mining were revealed in the publications by such scientists as: Lovell Michael C., Charemza Wojciech W. and Deadman Derek F., Fayyad Usama Smyth Padhraic, Piatetsky-Shapiro Gregory, Taipale Kim A, Kantardzic Mehmed, Han Jiawei and Kamber Micheline, Seltzer William, Kamber Micheline and Pei Jian, Olson D. L., Azevedo A. and Santos M. F., Coenen Frans, Lukasz Kurgan and Petr Musilek, Hastie Trevor and Tibshirani Robert and Friedman Jerome and other.

The main foundations of the theory of Data Science were considered in the publications by such scientists as: Wu C. F. Jeff, Hayashi Chikio, Escoufier Yves and Hayashi Chikio and Fichet Bernard, Tony Hey and Stewart Tansley and Kristin Michele Tolle, Yau Nathan, Davenport Thomas H. and Patil D. J., Emmert-Streib Frank and Dehmer Matthias, Nate Silver, Cao Longbing, Murtagh Fionn and Devlin Keith, Dhar V., Donoho David and other.

The basic specifics of the use of Data Mining technologies and then Data Science in the field of education, were partially investigated in their works by such scientists as: Siemens G., & Long P., Romero C. & Ventura S., Baker, R., Rudolph J. & Caporossi G., Reich J., Guo P. & Zhang Y. & Liu, L. and others.

However, the urgent issue of systematic implementation and effective application of Data Science in education (taking into account all potential threats and limitations in the field of ethics and protection of private data), at all levels of educational management, especially in the current crisis conditions, remained unresolved.

The purpose of the article. It can be unequivocally and reasonably stated that in the modern conditions of the development of the global information economy, in connection with the emergence of new branches of economic activity and state administration in the field of total informatization (and therefore the corresponding need for the actual adaptation of the sphere of professional and higher education) and in the conditions Big Data - the application of Data Mining for structured data, and then Data Science for large semi-structured and unstructured data - leads to the obtaining of additional competitive advantages by users, corporations and government structures at the regional and interstate levels [20], and therefore to an increase in their efficiency, capitalization, which is especially relevant in the conditions of macroeconomic crisis phenomena.

That is why, taking into account the above arguments, not only the effective and total implementation of Data Mining technology, and later Data



Science, not only in the practice of educational management at the general state, branch, regional and local levels, but also the introduction of relevant changes to the list and the content of both professionally oriented educational and professional specialties (computer science, system analysis, applied mathematics, cyber security, statistics), and even humanitarian specialties (for example, as optional or even mandatory training courses within such humanitarian specialties, such as Data Journalism, Digital Accounting, Telemedicine, etc.).

The above determines the additional relevance of not only a careful study of the main directions of the possible impact of Data Mining technologies, and later Data Science, on educational management, but also an analysis of the main stages of the development of Data Mining and Data Science in the university environment, an analysis of the features of scientific and practical research and projects regarding Data Mining and Data Science in University Science.

The main part of the research. Data Science, or the science of data, includes various interdisciplinary methods, techniques and applied tools for collection, processing, analysis and analytics, further evaluation and interpretation of new knowledge obtained in order to use it for making effective management decisions, which is especially relevant in modern multi-crisis and post-crisis conditions.

Modern educational management also faces complex challenges and the need to effectively use all accumulated data to make the most effective decisions in order to further improve the quality and efficiency of the educational process.

The synergy of Big Data, Data Mining, and Data Science technologies provide educational institutions with the opportunity to effectively collect, process, and analyze large volumes of educational (and related) data in various formats in order to build first accurate and complete descriptive, then predicative models, and at the next stage, it becomes it is possible to solve complex optimization problems in the field of educational management [21]. The application of advanced statistical analysis methods, EDA in combination with machine learning allows to identify hidden patterns, trends, establish unknown dependencies and obtain fundamental new knowledge from data, which contributes to a better understanding of the educational process and its effective management and further optimization of educational resources.

It is Data Mining and Data Science that provide educational institutions with powerful intelligent data analysis and analytics tools for better understanding, classification, forecasting, monitoring and optimization



of the entire complex of educational management functions at all levels of education. In the context of educational management, first of all, Data Mining technology, and in the context of globalization and total digitalization - Data Science technology, help to gain a deeper understanding of learning processes, student achievements, teaching effectiveness and management of educational resources.

Below will be formalized the 5 main, according to the authors, aspects of the influence of Data Mining and Data Science technology on educational management, the corresponding advantages and challenges.

1. Intelligent monitoring of all available streaming and packet data 24/7/365, detection of anomalies and potential threats. Use of Big Data technologies for search, extraction, verification, cleaning and various transformation of educational batch structured and large streaming semi- and unstructured data; followed by the application of Data Mining and/or Data Science for analysis and analytics in the mode of 24/7/365 detection of outliers and frauds (which becomes especially relevant during martial law).

2. Individual educational learning trajectories, adaptive options for socialization and personalized soft skills. Data Mining allows you to implement personalized approaches to the selection of applicants, personalized training and personal development. Analysis of data on educational achievements and individual characteristics of students, their interests and abilities - allows to create individual study plans, recommendations of selective study courses and personalized academic mobility and to carry out their 24/7/365 support and adaptation [22]. Adaptive learning systems based on Data Mining and in some cases Data Science - can be adjusted to the needs and abilities of each student, providing more effective learning results not only through the results of increasing the formal success of students, but also through improved socialization and soft skills in the conditions of post-covid education . An important result of the use of personalization in Data Mining and Data Science is the timely detection of individual educational losses, organizational student difficulties and problems with their involvement in the educational process, which will help not only with the timely management response of curators and tutors, but will also result in the automated generation of various personalized options for individual programs of support and additional assistance for students (especially taking into account the current military situation in Ukraine).

3. Forecasting and making optimal resource decisions in the field of educational management. Data Mining technologies help managers of educational institutions to perform effective monitoring, analysis and



predictive analytics of almost all aspects of education management, for example, such as:

- attitude of students to educational and professional programs, curricula, compulsory and elective courses;
- workload of teachers and support staff, workload of classrooms and laboratories;
- calculate the planned and actual financial cost of individual and group educational trajectories, etc. in the scenario mode.

For example, based on the analysis of the popularity of courses and training programs, it is possible to make decisions about the reasonable expansion or reduction of the offered programs, training courses, trainings, optimally distribute the teaching staff and available resources of classroom and laboratory funds in such a way as to satisfy the demand of students and ensure optimal use of resources.

An in-depth analysis of the above-mentioned functional data allows to reveal not only hidden dependencies and trends, but also to analyze anomalies and threats in management data 24/7/365, which improves the effectiveness and relevance of informed management decisions and the constant optimization of tactics and strategies of educational management (which especially relevant in the conditions of crisis phenomena).

4. Ethical and confidential issues, security issues. The use of Data Mining in educational management can also result in problems of personal data protection, and the use of Data Science - even create new ethical problems and the threat of hidden discrimination, which can cause distrust in these tools both on the part of the student community and their parents, and on the part of teachers . Therefore, the collection, storage, analysis of personal data of students and teachers, moreover, mainly predictive analytics and its use - requires strict compliance with the relevant privacy rules (for example, GDPR) and ensuring their formalized, limited and, sometimes, even personalized use. Educational institutions and organizations must ensure strict protection not only of primary personal data of students from unauthorized access, distribution and use, but also protection and very limited and formalized internal use of machine learning results based on such personal data of students.

It is also necessary to be especially careful about the application of deep machine learning algorithms, since in this mode it is quite difficult to detect distortions and biases of the trained model of a deep neural network in time, which can result in the manifestation of prejudice, discrimination and injustice in the automated making of educational management decisions (based on the results of using such an incorrectly trained deep neural network).



5. In university science (for example, philology [23]), Data Mining or Data Science is used to analyze both accumulated heuristic and generated experimental data (in particular, the results of the LLM approbation), modeling of various phenomena and situations, researching regularities in the form of sequences, associations, classifications, clustering, time series analysis. Moreover, the above-mentioned types of regularities are first investigated in the data retention mode, then in the data distillation mode, and only after the qualitative and effective performance of the previous two stages - the anomaly and fraud detection mode becomes available. Therefore, Data Science technology allows philological scientists not only to test/verify the accuracy and completeness of linguistic models proposed directly by the scientist and/or obtained as a result of machine learning, but also to discover completely new, previously unknown (but hidden in large volumes of accumulated semi-structured packet linguistic data) non-trivial knowledge in various areas of philological science, in particular in machine linguistics.

Next, it is considered necessary to highlight the key stages and directions of the development of Data Science in the university environment:

1. The emergence of specialized training courses, and then corresponding educational and professional programs. The development of Data Science in the environment of higher education began with the appearance in the curricula in the late 1990s and early 2000s of selective specialized training courses aimed at training students in Business Intelligence (assuming that students acquire competencies in the field of OLAP, data visualization, statistical data analysis and classical methods machine learning on small structured data). Later, in the mid-2000s, universities introduced already mandatory educational disciplines/courses in Data Mining (which were supposed to ensure that students acquire competencies in the field of EDA, in-depth descriptive statistical analysis of data and predicative machine learning, in particular with the use of shallow artificial neural networks), but still exclusively within the relevant professional specialties: computer science, applied mathematics, statistics. In the early 2010s, two trends could be observed in the field of higher education:

- the tendency to disaggregate the academic discipline of Data Mining into its separate components (multidimensional statistical data analysis, intelligence data visualization, classical machine learning, artificial neural networks (shallow) still exclusively within the relevant professional specialties: computer science, applied mathematics, statistics - but both at the bachelor's and master's levels.



- the trend of the appearance of both optional and mandatory relevant academic disciplines in the educational and professional programs of economists, managers and other humanitarian specialties at both the bachelor's and master's levels.

At the end of the 2010s, a clear trend towards the emergence of specialized master's programs in Data Science (which included not only all the above competencies, but also the study of deep machine learning of all architectures; the study of the specifics of analytics and analysis of large structured, semi-structured and unstructured data; the study of the specifics of Data Science not only in batch mode, but also in the organization of effective streaming Data Science, in particular in the mode of anomaly detection and detection of potential threats in data 24/7/365).

2. Interdisciplinary approach: Data Science is distinguished by the fact that it combines various fields of knowledge, such as statistics, computer science, applied mathematics, database engineering, etc. and quickly finds its effective application in virtually all areas of the economy, state and local management and science. Universities began to create interdisciplinary programs to prepare students to work effectively in these interdisciplinary projects. This has made it possible to create research teams of various specialists and experts who can work together on in-depth data analysis (of various forms and formats) and solving complex problems at the intersection of different industries and levels of economy and social life.

3. Research laboratories and projects: many universities have created special research laboratories and projects with a focus on Data Science, first with the participation of leading IT companies, and later also with product companies (in the fields of network offline retail, logistics, telecommunications, etc.). These laboratories allow students and scientists to interact with real data and problems and adapt methods/algorithms of in-depth intellectual analysis of data to solve specific current problems. This creates an educational and research environment that promotes the further development of Data Science in universities with the involvement of external additional sources of R&D funding.

4. Academic conferences and journals: specialized forums appeared in the university environment in the late 1990s, then, in the early 2000s, web pages, then, later in the mid-2000s, separate sections at conferences and in the late 2000s - even sections in specialized journals devoted to Data Mining. Later, in the 2010s, specialized scientific and practical conferences, specialized scientific journals and web portals and aggregators dedicated to Data Science in general became widely popular.



These trends, events and activities allow scientists and students to share their research and new knowledge in this field, contribute to the development of new ideas and stimulate further innovative research in the field of Data Science in universities and colleges.

Considering the above, it is considered appropriate to present the results of the analysis of the subject of Data Mining and Data Science in university research centers.

University research centers are an important component of the academic environment, where scientists, students and other specialists conduct research in various fields of knowledge. These centers began to play a significant role in the development of Data Mining, and in the future, Data Science, as they allow planning, organizing and implementing both important fundamental and applied topical interdisciplinary scientific projects and tasks, solving complex practical problems and contributing to the general progress of innovative technologies in management. University research centers specializing in Data Mining, and later Data Science, gather in effective teams scientists, students and industry experts in the fields of statistics, applied mathematics, system analysis, big data and other domain areas. This multi-disciplinary and multi-level synergistic collaboration creates an enabling environment for the exchange of knowledge, ideas, skills and experiences, which in turn helps to develop sophisticated hybrid and distributed methods/algorithms and technologies for the analysis and analytics of big structured, semi-structured and unstructured data. University research centers in Data Science usually conduct scientific projects aimed at solving practical problems in various fields, such as public and local administration, education, medicine, finance, transport, energy, telecommunications, e-commerce, etc. University data science research centers also play a very important role in training young scientists and master's students. They provide opportunities to involve students in research work, internships and participation in projects. This contributes to the development of their skills in analysis and analytics of various volumes and formats of data, which also prepares them for both scientific careers and careers in the field of corporate business and public administration in the field of Data Science and related functional areas.

Also, the authors consider it appropriate to present the results of the analysis of the project topics Data Mining and Data Science using the data of university communities.

University communities are engaged in various projects that use data to solve specific problems or research. These projects may involve analyzing data, making predictions, identifying patterns, and developing recommendations



based on the findings. One of the typical projects developed by university communities is the analysis of data on student achievement and academic success. Using information about grades, attendance, class participation, and other metrics, researchers can identify factors that influence students' academic performance. It helps universities to improve teaching methods, develop individualized approaches and support for students, which improves their performance and satisfaction with their studies. Another type of project involves research in various scientific fields. For example, university communities can conduct projects on the analysis of biological data (in particular, genetic, medical, pharmaceutical) to identify genetic mutations or study epidemiological relationships, etc. Data from such studies help to improve methods of diagnosis and treatment of various diseases, as well as to expand knowledge about genetic and epidemiological factors affecting health. University communities can also engage in projects using data to address social or environmental issues. For example, it can be the analysis of data on environmental pollution, the identification of energy consumption patterns, or the development of climate change forecasting tools. These projects contribute to the understanding of complex problems and help in developing strategies to solve them.

Conclusions. Data Mining and Data Science includes various interdisciplinary methods, techniques and applied tools for collection, processing, analysis and analytics, further evaluation and interpretation of new knowledge obtained in order to use it to make effective management decisions, which is especially relevant in modern multi-crisis and post-crisis conditions [24-25].

Data Mining and Data Science are extremely important technologies that are rapidly progressing and gaining more and more widespread use in management. Data Mining and Data Science can potentially change not only all functional areas of current, tactical and strategic educational management, but also increase the efficiency and productivity of university science.

The impact of Data Mining and Data Science is currently felt in various aspects of the modern European university environment, starting with changing approaches to learning and developing new programs, and ending with the use of data analysis and machine learning to obtain new scientific insights [26].

Data Mining and Data Science make it possible to effectively analyze large volumes of batch and even streaming (which is especially relevant in machine linguistics) data, identify previously unknown hidden regularities/patterns, predict educational events and indicators (in the form of classification or regression), identify hidden anomalies in the data - and on this basis to make timely, reasonable and effective decisions.



However, the emergence of new challenges related to large semi-structured and unstructured data in education management systems does not always allow classic machine learning methods/algorithms to effectively and efficiently respond to such challenges. In summary, we can say that it is the hybrid use of deep machine learning (which involves the use of deep neural networks of various specialized architectures) and classical machine learning methods with the involvement of Map Reduce technology (for scaling simple algorithms for processing structured data) in combination with various ensemble ML modes - allows you to get answers to the above-mentioned modern challenges and problems of big data analytics of educational information management systems [27-30].

Universities play an important role in the development of Data Science, offering students relevant academic disciplines and specialized master's study programs and promoting scientific research in this field within the third level of education. Thus, universities not only gradually created new educational courses (dedicated to data analysis), they were constantly updated and supplemented, but also created new educational plans of the appropriate focus. This allowed innovative universities to combine students' theoretical competencies with the analysis of practical cases, the performance of complex laboratory work and the use of the obtained results in student university science.

Data Science research centers and projects create significant opportunities for mutually beneficial cooperation between university communities and the industrial sector, service sector, network retail - thanks to faster implementation of innovations and transformation of knowledge into practical results.

Data Science has great potential for application in educational management, however, its systematic and effective implementation requires attention to several aspects:

- first of all, it is necessary to collect the maximum amount of high-quality and reliable data, which requires customized adjustment of the process of collecting, storing and processing data of various formats in batch and stream modes;

- secondly, the effective use of Data Mining and, especially, Data Science requires the presence of competent specialists who understand and have experience in the specifics of educational management, and have knowledge and skills in: data preparation for machine learning, configuration of hyperparameters and parameters of machine learning, organizing its hybrid and distributed implementation and further evaluating and testing its results (and all this using specialized application software).



It should be noted separately that the successful use of both Data Mining and, mainly, Data Science in educational management requires the establishment of constant objective two-way communication between Data Engineers, Data Analysts, Data Scientists and the teaching community, educational specialists and managers of all levels. Such Pub-Sub communication between these two groups is a key factor for the effective implementation of data analysis and analytics in educational management: because data analysts must understand the features/specificities of the educational environment and the requirements of educational management, while educational professionals/managers must be able to put specific questions and identify needs so that analysts can find optimal data-driven solutions.

However, the implementation of both Data Mining and, mainly, Data Science is accompanied by challenges and potential threats related to ethics, confidentiality and tolerant observance of all individual rights and freedoms of students and teachers. It is necessary to ensure the confidentiality and privacy of personal data of students, adhere to the principle of fairness and avoid negative impact on students due to inequality or discrimination. In addition, it is important to ensure that technology and resources are accessible to all students, particularly those who may be marginalized or have limited access to digital resources (for example, given the current military situation in Ukraine).

For the successful and timely introduction of such dynamic areas as Data Mining and Data Science into educational management, it is also necessary to create a favorable organizational culture (within both individual educational institutions and within local and national bodies of sectoral education management), which will contribute constant innovation, synergistic interaction between data analysts and teaching staff, educational managers, student self-government, educational professional unions, to encourage advanced training in the field of Data Mining and Data Science.

Therefore, for the successful use of Data Mining and Data Science in educational management, it is necessary to take into account these challenges, not only establish and update relevant rules and standards, but also carefully monitor their compliance, perform their timely adaptation and revision.

The optimal use of Data Mining and Data Science in educational management will contribute to the growth of productivity, effectiveness, quality and flexibility of the educational process, contributing to the comprehensive and individual development of the future generation of citizens.

In conclusion, it can be argued that Data Mining and Data Science are indispensable components of innovative competitive educational management in the post-covid era, in the conditions of Industry 5.0 and future global geopolitical instability.

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