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Research into the application of machine learning technologies for educational projects

Liana Budanova

Doctor of Science, Professor, Head of the Department of English Phylology and Translation, National University "Kyiv Aviation Institute", 03058, Kyiv, Lubomyra Guzara avenue, 1, Ukraine,

https://orcid.org/0000-0002-4840-6224

Olena Gumen

Doctor of Science, Professor, Department of English Phylology and Translation, National University "Kyiv Aviation Institute", 03058, Kyiv, Lubomyra Guzara avenue, 1, Ukraine,

https://orcid.org/0000-0003-3992-895X

Anastasiia Nebohatykh

Student, National University "Kyiv Aviation Institute", 03058, Kyiv, Lubomyra Guzara avenue, 1, Ukraine,

https://orcid.org/0009-0002-0599-8693

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Abstract: The purpose *of the study is to examine the possibilities and prospects for using machine learning (ML) technologies in education. In particular, modern approaches to implementing ML algorithms in educational processes, electronic*

educational platforms, and learning management systems are analyzed. Particular attention is paid to adaptive learning systems that are able to adapt to the individual needs of learners, automated knowledge assessment, as well as recommendation systems that contribute to the personalization of educational content. Separately, the possibilities of analyzing large volumes of educational data (Learning Analytics) to improve teaching efficiency and predict student success are explored. ***Methods*** *of analysis of scientific sources and systematization were used. The paper provides examples of the successful use of ML technologies in well-known educational projects and platforms, such as Coursera, Khan Academy, Duolingo, etc. It also examines potential risks and ethical aspects of using AI in education, including data privacy and the dangers of algorithmic bias.* ***The results*** *of the study indicate the significant potential of machine learning in transforming modern education, but its effective implementation requires interdisciplinary approaches, as well as the training of teachers to work with new technologies. Recommendations are proposed for integrating ML into curricula and developing educational projects using intelligent systems.* ***The conclusion*** *indicates the high relevance of the topic of machine learning in the modern field of education, which is associated with the flexibility of such a system.*

Keywords*: educational technologies, personalized learning, adaptive educational systems.*

ПЕДАГОГІЧНА АКАДЕМІЯ:
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Дослідження застосування технологій машинного навчання в освітніх проєктах

Буданова Ліана Георгіївна
доктор педагогічних наук, професор, завідувач кафедри англійської філології і перекладу, Національний університет «Київський авіаційний інститут», 03058, м. Київ, проспект Любомира Гузара, 1, Україна,
https//orcid.org/0000-0002-4840-6224

Гумен Олена Миколаївна
доктор технічних наук, професор, професор кафедри англійської філології і перекладу, Національний університет «Київський авіаційний інститут», 03058, м. Київ, проспект Любомира Гузара, 1, Україна,
https//orcid.org/0000-0003-3992-895X

Небогатих Анастасія Євгенівна
студентка, Національний університет «Київський авіаційний інститут», 03058, м. Київ, проспект Любомира Гузара, 1, Україна,
https://orcid.org/0009-0002-0599-8693

Анотація: ***Метою статті*** *є дослідження можливостей та перспектив використання технологій машинного навчання (ML, Machine Learning) у сфері освіти. Зокрема, аналіз сучасних підходів до впровадження ML-алгоритмів у навчальні процеси, електронні освітні платформи та системи управління навчанням. Особлива увага приділяється адаптивним навчальним системам, які здатні підлаштовуватись під індивідуальні потреби здобувачів освіти, автоматизованому оцінюванню знань, а також рекомендаційним системам, що сприяють персоналізації освітнього контенту. Окремо досліджено можливості*

аналізу великих обсягів освітніх даних (Learning Analytics) для підвищення ефективності викладання й прогнозування успішності студентів. ***Використано*** *методи аналізу наукових джерел та систематизації. У роботі наведено приклади успішного використання ML-технологій у відомих освітніх проєктах та платформах, таких як Coursera, Khan Academy, Duolingo тощо. Також розглянуто потенційні ризики та етичні аспекти використання ШІ в освіті, зокрема конфіденційність даних та небезпеку алгоритмічної упередженості.* ***Результати*** *дослідження вказують на значний потенціал машинного навчання у трансформації сучасної освіти, проте для його ефективного впровадження необхідні міждисциплінарні підходи, а також підготовка педагогів до роботи з новими технологіями. Запропоновано рекомендації щодо інтеграції ML у навчальні програми та розвиток освітніх проєктів з використанням інтектуальних систем.* ***Висновки*** *свідчать про високу актуальність теми машинного навчання у сучасній сфері освіти, що пов'язано з гнучкістю такої системи.*

Ключові слова: *освітні технології, персоналізоване навчання, адаптивні навчальні системи.*

Introduction. Artificial intelligence has become an integral part of the modern world, changing approaches to education, business, medicine, finance, and other industries. Its application in automation, data analysis and decision-making contributes to increased efficiency and innovation. High-tech AI solutions define a new stage of development in which intelligent systems help solve complex tasks, improve the quality of services, and shape the future of technological progress.

Modern educational projects actively implement the latest technologies to increase the efficiency of the educational process. One of the most promising technologies is machine learning (ML), which allows automating data analysis, personalizing educational materials, and adapting educational programs to the needs of

each participant in the educational process. Machine learning is a branch of artificial intelligence that focuses on developing algorithms and statistical models that allow computers to learn from data, make predictions, or make decisions [1]. ML technology research is a relevant issue in the development of the modern educational environment.

Literature review. A major study concerning machine learning in field of education was conveyed by Y. Xia, S.-Y. Shin, and K.-S. Shin [14], along with a paper by V. A. Melo-López, A. Basantes-Andrade, C. B. Gudiño-Mejía, and E. Hernández-Martínez, that focused on benefits of machine learning in inclusive education [9] were used as bases of the paper. The study also takes into account the survey by H. Oubalahcen and L. Tamym [11]. In their respective works, T. O. Ayodele [2], S. Naeem, A. Ali, S. Anam, M. M. Ahmed [10], W. Qiang, and Z. Zhongli [12] describe in detail the widely accepted classifications of the types of machine learning.

The paper, provided by N. Balasubramaniam, M. Kauppinen, A. Rannisto, K. Hiekkanen, S. Kujala [3], and the study by R. Vesselinov and J. Grego [13] focus on efficiency of machine learning in narrow fields and give examples of some ethical issues that may occur in process of education if ML is used. Some challenges of machine learning and compting systems as a whole in education were highlighted in the work by S. Z. El Mestari, G. Lenzini, H. Demirci [5], along with similar issues adressed in paper by D. Dhabliya, S. S. Dari, A. Dhablia, N. Akhila, R. Kachhoria, and V. Khetani [4].

Identification of previously unresolved parts of the general problem. The main points of discussion of the paper include potential benefits of applying machine learning in educational projects along with the challenges and ethical aspects of it.

Formulation of the article's objectives (task setting)

In recent times, machine learning (ML) is one of the most valuable fields of artificial intelligence (AI) that is transforming education. The application of ML in education provides a promising benefit both to the scientists and researchers and this

is the focus of this study. This paper reviews recent trends and advancements of ML in education focusing on areas such as personalisation of learning, predictive analytics, plagiarism detection, intelligent tutoring systems, gamification of learning and recommendation systems. After conducting the literature review we found out the current benefits and challenges of ML in education. The paper also provides insight into the applications and provide the recommendations to address the challenges of ML in the field of education.

Presentation of the main research material. Four main types of machine learning are distinguished, based in the desired outcome of the algorithm:

- supervised learning works based on an algorithm that creates a function that maps inputs to desired outputs. One standard formulation of the supervised learning task is the classification problem, where the learner is suuposed to learn a function that maps a vector at several imput-output examples of the function [2]. Programmer must explicitly teach the model what to search for in the given data. Such model is more accurate than unsupervised learning model;

- unsupervised learning is a type that allows a system to operate on particular data without external instruction. Such algorithms are better at solving more complicated tasks and don't require much labeled data, unlike supervised learning algorithms [10];

- semi-supervised learning combines labeled and unlabeled data for the functions of the algorithm [12];

- reinforcement learning works from an algorithm that learns a particular strategy of action from an observation of the world . Such model doesn't require labels (Fig. 1).

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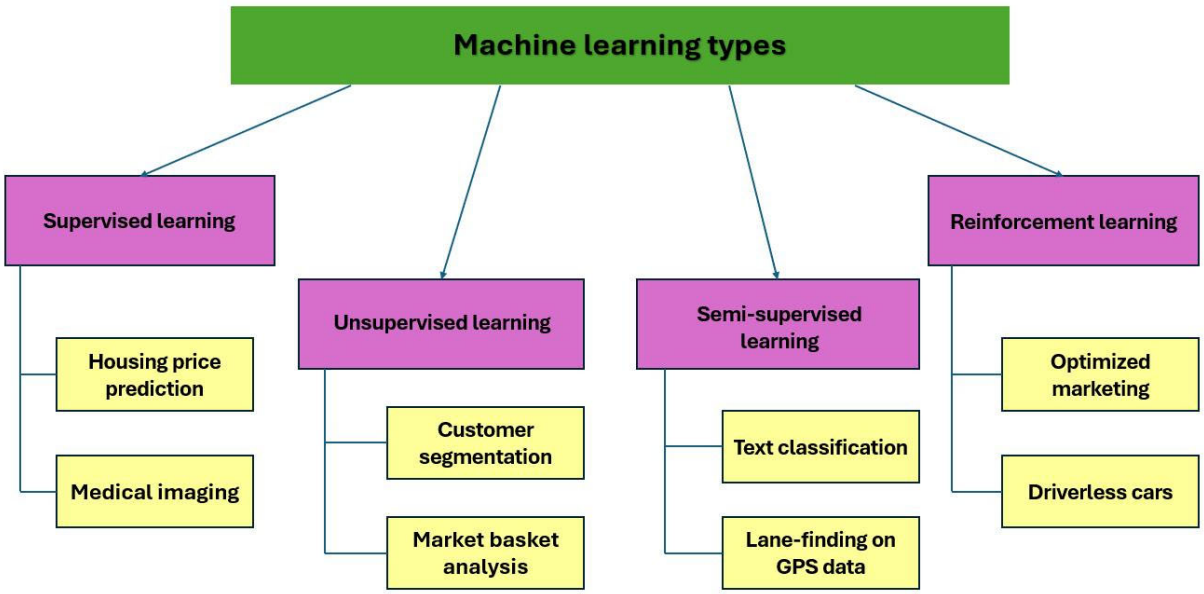

Fig. 1. Machine learning types

Source: compiled by the authors based on [2, 10, 12]

For scientific computing and machine learning that may be useful in educational field, such instruments as NumPy, or Numerical Python can be used (Fig. 2). According to the official site: "It is a Python library that provides a multidimensional array object, various derived objects (such as masked arrays and matrices), and an assortment of routines for fast operations on arrays" [16]. The library may be implemented in a variety of ways in machine learning for educational aid. NumPy works with multidimensional arrays, which require some level of understanding of IT-technologies to work with, but the service is open and provides guides for users willing to learn. Several studies discuss the efficiency of NumPy arrays, highlighting its wide usage field of machine learning and numerical computations [7, 15].

Machine learning offers numerous opportunities to enhance the efficiency and quality of the educational process. The key advantages for learners, instructors, and administrators integrating ML solutions into learning environments include the following:

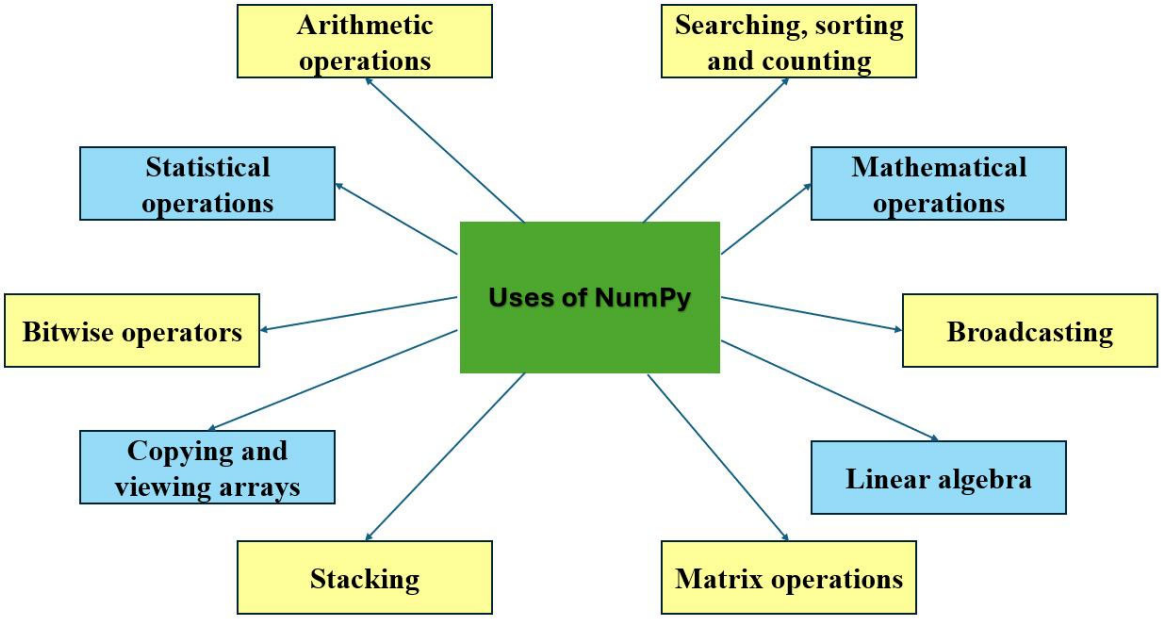

Fig. 2. Uses of NumPy in educational field

Source: compiled by the authors based on [7, 15, 16]

- Personalized Learning Paths. ML algorithms analyze student performance data, learning styles, and behavioral patterns to create individualized courses, recommending content at appropriate difficulty levels and pace. This deepens engagement and boosts learner motivation. Algorithms like that are often applied for language learning. Such strategy is present in platforms such as Duolingo and Edmondo, where Data-Driven Personalized Learning Model (DDPLM) is used for adapting learning paths for each learner. [14] Research on the effectiveness of the model has been conducted by R. Vesselinov and J. Grego in 2012, with the centre of the study being Duolingo platform [13].

- Adaptive Assessment and Instant Feedback. ML-driven systems can automatically generate test items of varying complexity and provide detailed feedback immediately. Students can correct mistakes right away, while instructors quickly identify group-wide knowledge gaps. An extensive research on adaptive assessment model was conducted by M. Kaleem, M. A. Hassan, S. K. Khurshid [8].

- Outcome Prediction and Early Intervention. By examining historical and real-time data, ML can forecast the likelihood of academic failure or dropout. Teachers can then offer timely support – extra tutoring, mentoring – before issues become critical. For prediction of educational issues such techniques as Random Forest and XGBoost show the best results among many others, which was estimated and summarized by M. Haileslassie and H. Tegegne during the course of their study [6].

- Intelligent Recommendation Systems. ML models curate personalized sets of materials (articles, videos, exercises) based on a student's prior interactions with the platform, helping them master challenging topics and broaden learning beyond mandatory syllabi. Overall, recommendation system models have been widely used in many fields, for example, commerce or social platforms. They enhance user experience by analyzing preferances and behaviours. In educational field intelligent recommendation can be used to help educators collect feedback from learners using AI, to further improve educational process. A study, conducted by H. Oubalahcen and L. Tamym in 2023 differentiates four common types of intelligent recommendation systems: content-based filtering (CBF); collaborative filtering (CF); knowledge-based (KB); and hybrid recommendation (HR), with each having special aspects, tailored for different needs [11].

- Instructor Workload Optimization. Automating routine tasks (grading quizzes, maintaining gradebooks, generating reports) frees instructors' time for creative lesson design, mentorship, and one-on-one student support. That is one of the most basic of functions that AI can have, as simple algorithms are present even in quiz platforms like Kahoot, Quizlet, or even Google Forms for automated grading; spreadsheets programs use functions that can help save time for filling out imformation, etc.

- Support for Inclusive Education. ML tools can adapt content for learners with special educational needs (e.g., automatic captions, text-to-speech, personalized interfaces), fostering a more accessible and equitable learning environment, while also significantly reducing educators' workload and improving their interactions with

learners. Some features that help in the field of inclusive education can be found on a variety of Google services or platforms like YouTube, with its automatic captions, automatic dubbing and video summaries. One of the recent researches has shown the relevance and importance of such services in modern time, providing concrete data that summarizes the results of conducted evaluations [9].

- Analytics for Strategic Management. Deep analysis of large educational datasets enables school and university administrators to make evidence-based decisions on program development, resource allocation, and overall quality improvement.

- Enhanced Engagement through Gamification. ML models personalize game mechanics (points, badges, difficulty levels) to match individual interests and achievements, encouraging regular participation and improving learning outcomes. Some quiz platforms (e.g. Kahoot) and language learning apps (Duolingo, LingoDeer, etc.) have shown the effectiveness of gamification throughout the years. It helps motivate learners and enhance engagement.

- Expanded Research Opportunities. Automated analysis of educational data accelerates pedagogical research, allowing faster testing of hypotheses about success factors and teaching method effectiveness. Such platforms Open AI’s GPT may accelerate the workflow and improve productivity due to its fast and quite precise system, that is constantly improving.

Consequently, machine learning can act as a powerful catalyst for educational transformation, delivering flexibility, efficiency, and inclusivity. To fully realize these benefits, institutions need well-planned implementation strategies, educator training, and continued attention to the ethical issues outlined in the next section.

The widespread implementation of machine learning technologies in educational processes brings significant advantages but also raises a number of challenges and ethical concerns. These issues require careful consideration from educators,

developers, and policymakers. The following are the key ethical aspects and challenges associated with the use of ML in educational settings:

- Protection of Personal Data. Machine learning systems rely heavily on large volumes of student data – including personal information, learning histories, test results, and behavioral analytics. This increases the risk of data breaches and violations of privacy. Ensuring robust cybersecurity, compliance with regulations such as the General Data Protection Regulation (GDPR), and transparent communication with users about data collection and usage are essential for ethical implementation. Still, there are possible risks that exist because of how the data is processed. Since data owners, students or teachers in this case, are separate from computational facilities, the data must be first uploaded to servers. However, even if the transmission channel is secure and the data is encrypted during transmission, usually computational facilities process data in a plain text format after being decrypted, so the problem of the third-party servers having the data in its original form arises. There is also a threat of attackers getting access to the data through a number of means, that ranges from the so-called black-box access, which means that the attacker has access to the model's inference results, to the so-called white-box access, where the attacker has full or partial access to the parameters or additional information about the model [5]. Programmers constantly work on concealing the "gaps" in AI models' security, but as of now some threats still remain.

- Algorithmic Bias. There are various types of machine learning bias. One of them is data slant, when the data used for training the model is not representative of the population that the model is intended to forecast for. Sometimes a computer bias also occurs, which means that the source of algorithmic bias is the mathematical decisions made within the model itself. One of the most harmful might be interaction bias within the model, which happens due to the model's patterns creating biased reaction among users, which results in bias feedback. Such algorithmic bias may lead to furthering discrimination, polarization or prejudices that are already held by users

[4]. ML algorithms can replicate or even amplify existing social and cultural biases if such patterns are present in the training data. For instance, a system might unfairly lower the predicted performance of certain student groups based on irrelevant correlations. To mitigate this, regular auditing of models, ethical frameworks for development, and bias detection tools are crucial. Post-processing techniques that follow the model's prediction stage are also an important step to reduce biases. They include calibration processes, adding re-valuing variables and re-ranking judgements made by the algorithm [4].

- Transparency and Explainability of AI Decisions. Educational contexts demand that decisions affecting students' learning and assessment be understandable and justified. However, many ML models, especially those based on deep learning, operate as "black boxes" – their internal logic is difficult to interpret. This lack of transparency can reduce trust in AI systems. Developing explainable AI (XAI) systems, which can clearly justify their conclusions, is a key priority for ethical use in education. In a research, that considers this problem [3] it was concluded that at present moment, transparency is among one of the prime issues that institutions and organizations, woking with AI, are highlighting.

- Responsibility and Accountability. When an ML system makes a mistake, it raises the question: who is responsible – the developer, the educational institution, or the system itself? This becomes particularly critical in areas such as grading, admission recommendations, or personalized learning paths, where decisions can significantly affect students' academic trajectories. The question of responsibility has been an acute one in field of AI development for some time now. It was relevant even back in 1996, when warnings were issued about the erosion of human responsibility due to the growing dependence on computer systems. Even though in recent years some regualtions and policies about AI accountability were released, there is still a possibility of unprecedented situations due to AI's fast development.

- Equal Access to Technology. With the development of AI, more and more open-access resources, that can help in education, are becoming available. However, many open platforms are not yet ideal and have room for improvement. Hence, not all educational institutions have the same level of access to ML technologies. This digital divide can lead to increased inequality among students from different regions or socio-economic backgrounds. Ensuring inclusivity and equal opportunity is a fundamental ethical principle when deploying AI in education.

Conclusions. In today's digital transformation of education, machine learning technologies play an increasingly important role in improving the quality, accessibility, and personalization of the learning process. The paper examines the main areas of use of ML in the educational sector, including adaptive learning, automated knowledge assessment, intelligent learning support systems, and educational data analysis (Learning Analytics).

Due to ML algorithms, educational systems can analyse student behaviour, identify gaps in knowledge, predict learning outcomes, and shape individual development trajectories. Such opportunities open up new approaches to teaching focused on the needs of each learner. The paper also analyses examples of ML implementation in well-known online platforms (e.g. Duolingo, Edmodo, Coursera), where ML is used to adapt content, predict user success, and increase engagement in learning.

Special attention is paid to the challenges and ethical aspects associated with the use of ML in the educational environment: personal data protection, algorithmic bias, and the need for transparency in the functioning of AI systems.

It is concluded that machine learning has significant potential for improving the quality of education, but its effective use requires an integrated approach, close cooperation between educators, data analysts, and information technology specialists.

In the context of the ongoing digital transformation of education, machine learning technologies are playing an increasingly important role in enhancing the

quality, accessibility, and personalization of the learning process. This study examines the main directions of applying machine learning in the educational sphere, including adaptive learning, automated knowledge assessment, intelligent tutoring systems, and learning analytics.

Through ML algorithms, educational systems can analyze student behavior, identify knowledge gaps, predict learning outcomes, and create individualized learning pathways. These capabilities open up new approaches to teaching that are tailored to the needs of each learner. The paper also analyzes real-world implementations of ML in popular online platforms (such as Duolingo, Edmodo, Coursera), where machine learning is used to adapt content, forecast user performance, and improve engagement.

Special attention is given to the challenges and ethical considerations associated with the use of ML in educational environments, such as data privacy, algorithmic bias, and the need for transparency in AI systems.

The study concludes that machine learning has significant potential to improve the quality of education; however, its effective implementation requires a comprehensive approach and close collaboration between educators, data analysts, and IT specialists.

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