

Application of Artificial Intelligence in Education. Problems and Opportunities for Sustainable Development

Valentyna YUSKOVYCH-ZHUKOVSKA¹,

Tetiana POPLAVSKA²,

Oksana DIACHENKO³,

Tetiana MISHENINA⁴,

Yana TOPOLNYK⁵,

Roman GUREVYCH⁶

¹Private Higher Education Establishment

“Academician Stepan Demianchuk International University of Economics and Humanities”, Ukraine, valivanivna@i.ua

²South-Ukrainian National Pedagogical University named after K.D. Ushinsky, Ukraine, solistriya@gmail.com

³Mariupol State University, Ukraine, djoksana@gmail.com

⁴ Kryvyi Rih State Pedagogical University, Ukraine, t.mishenina@gmail.com

⁵SHEE “Donbas State Pedagogical University”, Ukraine, yannetkatop@gmail.com

⁶Vinnitsia Mykhailo Kotsiubynskyyi State Pedagogical University, Ukraine, r.gurevych2018@gmail.com

Abstract: *The article is devoted to the application of artificial intelligence in education and highlighting opportunities and problems in the context of sustainable development. The current state of introduction of artificial intelligence technologies in the educational process is analyzed. The technologies of artificial intelligence, which are most often used in the educational process are generalized into the following categories: cognitive services; virtual, mixed and augmented reality; Internet of things and peripheral computing; metacognitive scaffolding. The advantages of using the artificial intelligence in educational processes depending on the impact on its beneficiaries are generalized: students, teachers, students' parents, heads of educational institutions, local governments. It is proved that the learning process can be significantly effective through the use of artificial intelligence technologies and the creation of individual training programs based on the use of analytical data obtained from the application of these technologies. It is found that the main advantage of using artificial intelligence in education is the individualization and personalization of the educational process. The benefits are pointed out which heads of educational institutions and local governments receive from the use of artificial intelligence technologies in the educational process in order to ensure sustainable development, including transparency and accountability of decisions, rational and energy efficient use of resources. Discussion issues of confidentiality and depersonalization of students' data who are processed by artificial intelligence during the educational process are revealed; it is recommended to differentiate the responsibility for access, storage and use of personal and confidential data by educational institutions. Prospects for further scientific research are outlined - further personalization and individualization of the educational process.*

Keywords: *informatization of education, artificial intelligence in education, sustainable development, individualization of education, personalization of education, information and communication competence.*

How to cite: Yuskovych-Zhukovska, V., Poplavska, T., Diachenko, O., Mishenina, T., Topolnyk, Y., & Gurevych, R. (2022). Application of Artificial Intelligence in Education. Problems and Opportunities for Sustainable Development. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 13(1Sup1), xx-xx. <https://doi.org/10.18662/brain/13.1Sup1/>

Introduction

The interest of scientists in recent decades in the problem of the artificial intelligence (AI) use in education remains relevant - there are still discussions about the need for its use in education. The issues of collecting, storing, using and disseminating personal and confidential data of students who use AI technologies also remain debatable. From a technical point of view, the issues of AI technology allow to achieve significant or “breakthrough” economic progress. Usually this is due to the automation of various technological processes, conducting a significantly different level of quality analytics. AI technologies are actively implemented in all industries and therefore education is no exception.

AI provides the opportunity to use a large scale of knowledge that is in some way structured and suitable for use in the educational process to solve certain educational problems and which is personalized for each student. “Smart” learning devices, various software educational applications, adaptive intelligent virtual assistants, chatbots - today this is the stage of application of AI in education and this stage passes. We agree with scientists and develop the idea of the true potential of AI in education - the development of a more effective perception and understanding of human learning processes, its measurement and awareness (Gerasymova et al., 2019; Nerubasska & Maksymchuk, 2020; Nerubasska et al., 2020; Palamarchuk & Poltorak, 2020).

The global tendency of AI use in education is noted as the automation of various processes. Any process of explaining educational material can be automated and presented to the learner in a format that is as personalized as possible for his age, physiological and psychological characteristics and properties, and this display format can be adaptive and rapidly changing depending on changes in the dominant type of perception information (so-called “audials”, “visuals”, “verbals”, “kinesthetes” which are defined by the VARK method) (VARK, 1987). In this way, students receive the most effective and accessible training, which will stimulate the ability to research and the ability to solve everyday problems.

The potential for the AI use in education is extremely powerful. In addition to the ability to personalize and individualize the educational process, it is also an opportunity to collect and analyze great amounts of information, identify problematic issues that humanity does not have answers to today or anticipate potential difficulties in the future and find scenarios to reduce their negative impact on humanity. The more multimodal data will be processed - the better the awareness of the

educational material content and the more scenarios will be invented to apply the acquired knowledge in real everyday life.

At the same time, a number of humanitarian studies note the consequences of using AI as negative, namely: rising unemployment (Ford, 2013), the potential for manipulation of public opinion (Yang, 2019), interference in private life (Winkler-Schwartz, 2019).

Researchers' interest of AI using in education remains relevant and, in our opinion, will remain relevant in the future. Therefore, the search for scenarios for the AI use in education, the maximum prevention of the negative consequences of AI on humanity, the development and strict adherence to various standards and policies for the use of AI in education remain relevant today.

The purpose of the research is to study and summarize scenarios for the use of AI technologies in education in the context of sustainable development.

Literature review

In general, today the use of AI technologies in the educational process is not new and is actively explored among the European and world scientific community, as well as national one.

Ukrainian scientists study the methods and tools of artificial neural networks and the possibility of their application to assess the performance of higher educational institutions, systematize the tools of machine learning (Milkevych & Redich, 2021), explore various methods of predicting final grades of students using recurrent neural network (RNN) from the electronic journal stored in the educational system (Bukreev & Serdiuk, 2019).

Moroz I. (2017) devoted his works to the application of neural networks in the intellectualization of distance education, which identifies the following types of AI tasks to solve the problem of assessing the quality of education: classification of students, search for relationships between parameters, data clustering, forecasting (Moroz, 2017).

The works of Kocharian A. and Viktorova L. (2021) are devoted to the application of AI in education, focusing on the personalization and individualization of the educational process on the example of learning a foreign language by students.

A review of the foreign researchers' work allows to state a systematic approach to the use of AI technologies in education - from the need to develop, implement, monitor compliance with national standards and policies (Chassignol et al., 2018), development and implementation of

corporate standards at the educational level to technology clustering (Lopez-Belmonte et al., 2020) and the development of scenarios for the use of AI in education (Yang, 2019) for each participant in the educational process (Matsuda et al., 2020).

Our analysis and author's experience demonstrate that the use of AI technologies in the educational process is not new in research. However, despite the large number of such studies, they remain relevant due to the emergence of new technologies and their rapid development, which stimulates the constant search for new scenarios for their application.

Artificial intelligence technologies as a trend in education

One of the trends in modern education is the individualization and personalization of learning. By individualization of learning process we mean the organization of such a system of interaction of learning participants, during which the individual features of each are used as fully and effectively as possible (Osadcha et al., 2021). By personalization we mean the organization of such a system of interaction of participants, during which students acquire socially significant, unique and individual properties and qualities that allow them to effectively perform a social role (Osadcha et al., 2021).

The use of modern information and communication technologies (ICT) allows to successfully implement individualization and personalization of learning. The use of AI technologies is especially promising for solving personalization problems. Artificial intelligence – is “an organized set of information technologies, using which it is possible to perform complex tasks using a system of scientific research methods and algorithms for processing information obtained or independently created during working process, as well as create and use their own knowledge bases, decision-making models, algorithms to work with information and identify ways to achieve the objectives” (Concept for the development of artificial intelligence in Ukraine, 2020).

The following AI technologies have been successfully proven in education today: machine learning, in-depth learning and language recognition, language processing, computer vision. The use of AI tools and methods allows to create complex digital learning environments that are as individual, flexible, inclusive and interesting for students.

In general, the issue of AI use in education is consistently relevant and constantly attracts the attention of both Ukrainian and foreign researchers. Thus, the number of queries in the Google search engine for the period 2016-2021 of the keyword “Artificial Intelligence” shows a

consistently high rate among foreign researchers and for the keyword “Artificial intelligence” among Ukrainian researchers (there is a surge in queries since 2014).

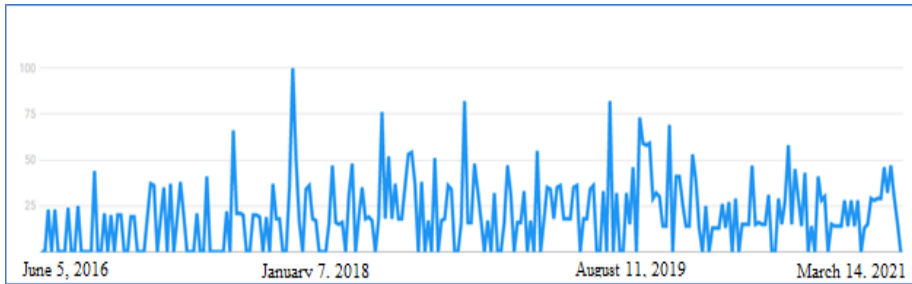
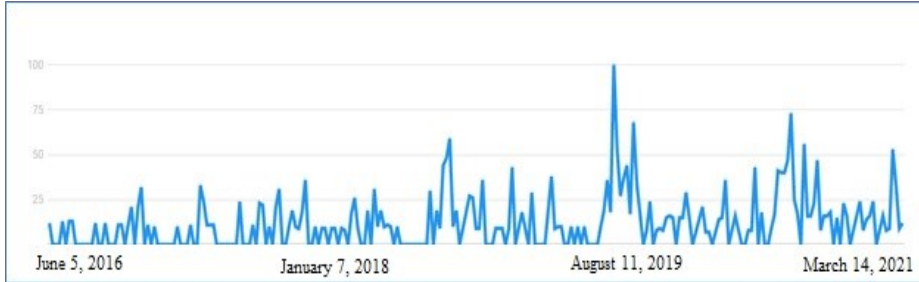


Fig. 1. Quantitative indicators of Google queries for the keywords “Artificial Intelligence” (in Ukrainian), “Artificial Intelligence” (in English) for the period 2016-2021 (Screenshot).

Source: Google

The interest of AI is due to the intensive pace of industrialization and urbanization, technological progress and globalization processes in general. At the same time, these processes make us think about the issue of environmental protection and social responsibility, the search for sustainable development. In Ukraine, since 2019, the priority of sustainable development has included the issue of digitalization, one of the tasks of which was to create a “state in a smartphone”. In 2020, the Cabinet of Ministers of Ukraine approved the Concept of AI Development in Ukraine, which provides for eight key areas of state policy in the field of artificial intelligence to achieve sustainable development: education and human capital; science and innovation; cyber security; defense; governance; legal regulation and ethics; justice.

The main task of education in AI development, specified in the Concept of AI development in Ukraine (2020), is to provide qualified personnel through the spread of digital literacy among students, creating specialized AI educational programs, inclusion of AI issues in educational programs in various specialties, introduction of AI technologies in education.

Based on the analysis of available research, we will try to systematize and classify AI technologies used in the educational process.

1. Cognitive services. These are AI products that can perform tasks that previously could only be performed by humans. Examples of cognitive technologies are computer vision, machine learning, natural language processing, language recognition, and robotics. Analyzing Microsoft collection of cognitive services, developers group them into the following functional categories (Azure Cognitive Services, 2021).

1.1. Category “Vision”, which includes AI technologies for image and video content recognition. Examples of such application programming interfaces (APIs) are: Computer Vision, Emotion, Face, Video and Content Moderators.

1.2. Category “Speech Recognition” involves understanding and synthesizing oral speech, recognizing people by voice. Examples of such APIs are: Custom Speech, Speaker Recognition and Bing Speech API.

1.3. Category “Natural language processing” involves understanding, word processing and “prediction” of what a person expects. Examples of such APIs are: Bing Spell Check, Language Understanding, Linguistic Analysis, Text Analytics, Web Language Model.

1.4. Category “Knowledge” aims to add meaning to the text and combine them with other general meanings and concepts. Examples of such APIs are: Academic Knowledge, Entity Linking, QnA Maker, Language Exploration.

2. Virtual, mixed and augmented reality that can radically change education, making learning a more exciting process (Windows Mixed Reality, 2017). Experts in the field of educational technology already predict that in the future inexpensive versions of such technologies will replace textbooks and take the learning process outside the classroom (Lopez-Belmonte, 2020). AI will not only implement these technologies, but also analyze their effectiveness and optimize the benefits they can provide.

3. Internet of things and peripheral computing. Today, there are more Internet of things devices than humans, and researchers predict that by 2025, the number of such devices will exceed 40 billion (The Growth in Connected IoT Devices, 2019). Educational institutions already use a variety

of devices to control heating and lighting in the premises; use biometrics and other devices to ensure the safety of students on the territory of the institution.

Peripheral computing, in turn, is needed to address shortcomings in cloud-based programs and services. Cloud computing may not always meet the required response time requirements. Internet of Things technology often requires high bandwidth, minimal latency, and reliability, which is why peripheral computing is important. This means that there is no need to send data for processing to the cloud storage - data processing is even faster.

4. Metacognitive scaffolding, which provides assistance to the learner only when necessary, with a gradual reduction or minimization of the intervention of the teacher as the student's competence increases (Matsuda et al., 2020). The use of AI in education allows not only to determine when and in what applicants need help, but also to monitor when to increase or decrease the amount of assistance provided during the educational process. Applicants themselves benefit from the findings of their training; they become the main users of AI technologies and services, not just data subjects (Hung & Tsai, 2020).

5. Personalization and individualization of the educational process. AI is able to implement personalized (Kocharian & Viktorova, 2021) and individualized learning, allowing obtaining huge amounts of data and formulating conclusions that can be used to develop an educational trajectory that takes into account the individual needs and abilities of students.

Advantages of using Artificial Intelligence technologies for participants of the educational process

Researcher's works on the search for scenarios for the use of AI in the educational process can be summarized by the following beneficiaries (stakeholders):

- Education obtainers who can get personalized and individualized training with the help of AI.
- Pedagogical and scientific-pedagogical workers who use AI technologies to improve the quality of the educational process, improve their own pedagogical skills.
- Heads of educational institutions who, with the help of AI technologies, can more effectively manage and lead the processes of change in the institution.

- Developers of e-learning resources who, using AI technologies, can create e-learning resources with more efficient use and lower costs compared to others.

AI technologies allow these stakeholders to obtain a much larger amount of generalized and systematized data. World experience confirms - AI is able to perform a number of application tasks, such as: document processing, automation of the procurement process, processing requests and comments from users, data security issues. The tendency of spreading AI technologies in the field of education is becoming more obvious and is moving from the category of “document automation” to the category of “automation of the educational process”. Intelligent educational environment is becoming a promising tool for self-education of students. The COVID-19 pandemic, quarantine, restrictive measures and mass transfer of students to distance learning in almost all countries of the world have only further actualized the tendency - intellectual educational environment is becoming promising not only in distance learning but also in self-education, including lifelong learning. Thus, the intellectual educational environment allows to automate the pedagogical functionality of the teacher, which in a large array of educational content and e-learning tools, e-learning platforms is becoming increasingly relevant and is being in demand (Karpukhin & Lobazhevych, 2019).

Thus, the use of AI technologies by students provides the latter, regardless of age and level of success, social status and financial security, a number of benefits that can significantly improve the quality of learning and learning outcomes. In many countries, much of the data is already being collected and analyzed for further decision-making. These can be school graduation grades, results of state exams (in Ukraine - the results of the External Independent Assessment), the tendency of success and “failure” of each student, information on participation in international competitions and grant programs, as well as other quantitative data. The process of collecting, analyzing and interpreting such data is a resource-intensive process. At the same time, the construction of an individual learning trajectory for the learner should take into account individual preferences, abilities and capabilities. Therefore, one of the areas of AI technologies research in education is the direction of solving the processes of formation and use of personal educational environment for the implementation of individual trajectories to study the “educational behavior” of the learner (Zharska & Zinkovska, 2014).

The obtained results of educational data allow to reveal regularities and interdependencies and visualize the process of perception of educational

material, the degree of formation of full perception and awareness of the material. The use of AI technologies for the processing of such data is already possible today, subject to integration with existing educational LMS, which allow to individualize and personalize the learning process. Examples of such LMS are: Moodle, NEO LMS, Learn.com, Edmodo, eCollege, aTutor and others. These LMS allow to determine the following data for each student: time spent on training; reasons for termination of training; level of use of prompts; level of application of notes; participation in commenting on educational material; participation in group projects and/or discussions and debates; time spent on passing test tasks; use of auxiliary resources; return to the passed educational material, etc. The use of AI in turn allows to interpret these data, which in turn implements the principle of adaptability, the principle of assessing the knowledge of students on the basis of analytical data on the application of machine learning methods and automated data collection on the actions of applicants in LMS.

Thus, learners who receive educational services using AI technology have the opportunity to access personalized information and draw conclusions about key aspects of their own success, as well as to identify other factors that may provoke changes in motivation or learning effectiveness. The ability of AIs not only to analyze a large flow of data, but also to establish links between different data sources, allows to identify gaps or opportunities for development in real time. Thus, AI develops a targeted, individual educational trajectory for each student, taking into account all its features and capabilities. Personalization with the help of AI provides an optimal educational environment in which students can maximize their full potential. This leads not only to improved performance, but also to a change in the attitude of the student to the learning process itself, a change is in the level of the involvement, a change is in the system of the values.

In addition, it is worth noting that it is generally accepted that automation and AI are radically changing the labor market and that interpersonal skills, empathy and creativity will be important for future work. The demand for social and emotional skills, such as the ability to solve problems and interact with others, in the labor market is constantly growing (Emotion and Cognition, 2019). That is why the awareness of the relationship between the worldview and the emotional state of the student, its ability to interact and cooperate with others and the ability to learn has led to educational reform with a shift in emphasis on these skills. The works (Sensing Curiosity in Play and Responding, 2016) have shown that AI and multimodal social computing can help improve cognitive, social and emotional skills (Khaimovych et al., 2019).

Private companies already have experience in applying the results of data analysis and machine learning to analyze their own business (Khaimovych, 2015), and in the long run these applications are more likely to penetrate into the field of education. They provide ample opportunity to develop the social and emotional skills needed for learning, as they allow teachers to personalize learning and analyze both qualitative and quantitative data to assess the level of mastery of these skills and, if necessary, help to master them.

Effective use of AI can allow teachers to make the learning process more exciting through the use of immersion technologies in a virtual environment, the creation of individual training programs based on the use of analytical data obtained from the use of these technologies. By analyzing all available data sources and formulating conclusions that can be used to create individual educational trajectories, AI allows teachers to save a lot of time.

Enthusiastic and interested learners acquire a much larger amount of knowledge, and this knowledge is stored in their memory for a longer time (A hierarchical conceptualization, 2006). Pleasure is not only a favorable condition for learning. This is both an expected outcome of sustainable society, and in some national curricula (for example, in the UK since 2003) it is given the same importance as health and safety (Every child matters, 2003).

At the same time, AI allows the heads of educational institutions to identify all the teachers' strong characteristics and systematize strategies for cooperation that will maximize the combined skills of the entire teaching staff. This provides an opportunity to develop mentoring and mutual learning through free and constant access to quantitative and qualitative data.

In its turn, the effective use of AI technologies provides teachers with a similar opportunity to access learning at any time and in any place and allows them to develop skills without leaving work.

It is worth noting another advantage of the use of AI, which is received by the heads of educational institutions – and it is the efficient use of resources (Zacharis, 2016) and the management of students' academic failure (Arpaci, 2020). Incomplete education in an educational institution is a problematic issue not only for students, but also for the institution as a whole - from reputational risks to unjustified resources use. Academic failure is not the only reason for incomplete education. The ability to identify or predict the probability of incomplete education by analyzing a large amount of data about them is quite high. Such analysis with the help of AI allows to

take measures to prevent such a situation and promotes more efficient use of their resources.

AI, used in the educational process, promotes more active involvement and communication of parents, local governments for decision-making processes and sustainable development, the management of educational institutions. The basis for it is an effective communication where can be personalized not only educational trajectories, but also the ways to choose communication with each participant in the educational process (Chassignol et al., 2018), including parents.

Thus, summarizing the various approaches and scenarios for the use of AI in the educational process, we can say that its effective use, use of data and analytics allows to develop the educational process to more exciting, individual and effective one.

Thus, we can summarize the following advantages and features of the use of AI in the educational process.

1. AI allows to automate repetitive learning and search processes through the use of data. However, AI is different from robotics, which is based on the process of applying hardware. The purpose of AI is not the automation of manual labor, but the reliable and continuous execution of numerous large-scale computerized tasks. Such automation requires human participation for the initial setup of the system and the correct formulation of questions. AI can automate basic actions in education, such as certification (Wilson & Czik, 2016).

2. AI performs in-depth analysis of large amounts of data using neural networks with many hidden levels. Deep learning models require a huge amount of data, as on the basis of which students learn. Therefore, the more data, the more accurate the model.

AI-based programs are a source of feedback for both the learner and the teacher. AI systems have successfully proven themselves in online learning to monitor student 's performance and timely inform teachers about existing problems with a course success. Such AI systems create conditions for effective improvement of the educational process and timely introduction of relevant changes. AI programs help students choose majors based on the areas in which they succeed.

3. Deep neural networks allow AI to achieve an unprecedented level of accuracy. For example, Alexa, Google Search, and Google Photos are based on in-depth learning, and the more often we use these tools, the more effective they become. Google adapts search results to users based on location, Amazon provides recommendations based on previous purchases, Siri meets personalized needs and adapts to teams. These features of

intelligent systems can change the way information is sought and used in educational institutions and academia in general (TeachThought Staff, 2019).

4. AI allows to get the most out of data analysis. The data contains the right answers – there is just a need to find them with the help of AI technology. Since data plays a much more important role today than ever before, it can provide a competitive advantage to educational institutions. When using the same technology in a competitive environment, the one who has the most accurate data wins. It is the opportunities of AI that education seekers can receive personalized and individualized learning, the opportunity for social and emotional development, the formation of skills of the XXIst century, the unlimited opportunities for people with disabilities. Teachers, in turn, use their working time more efficiently and save time, the ones who are more involved in the process of using AI technologies, can focused on cooperation and professional development more. Heads of educational institutions and local governments have access to the analysis of a large amount of data, which allows much more efficient decision-making and use of available resources, to predict the results for a more sustainable development of society.

5. At present, the debatable issues regarding the replacement of AI by teachers remain incorrect. Quite often, David Thornburg's (1999) statement that “any teacher who can be replaced by a computer deserves it” (Thornburg, 1999) can be considered controversial. Currently, there are no technologies that can reproduce and, moreover, replace the countless skills and qualities of a professional teacher.

However, AI is consistently and confidently changing the role of teachers. AI can perform tasks such as assessment, can help learners improve learning, and can even replace real learning. AI systems can be a source of expertise to which students can direct their questions, or even take the teachers' place for the basic materials of the course. However, in most cases, AI will only change the role of the teacher to the role of facilitator (Watts, 2019).

In order to maximize the effective use of AI technology in education, we recommend to follow the algorithm:

- Determining the needs of students;
- Identification of AI technologies that can solve or significantly optimize these needs;
- Defining the strategic goals of the educational institution;
- Identification of AI technologies that can help achieve certain strategic goals of the educational institution;

- Development of internal policies and corporate standards that define AI technologies that can address (or optimize) the needs of students and achieve the strategic goals of the educational institution;
- Reasonable ways to monitor the performance of AI technologies by ensuring transparency and accountability, identifying performance indicators and safety indicators that need to be constantly analyzed and monitored.

Discussion issues of application of artificial intelligence technologies in the educational process

Examining the implementation of modern technologies in the educational process and AI technologies, including in the context of sustainable development of society, we consider it necessary to approach this issue systematically and comprehensively. Therefore, the study of the AI technologies use in the educational process would not be complete if we did not mention other discussional questions that lead or may lead to certain undesirable consequences when using AI. The decision-making process for choosing a particular AI technology must be conscious, systematic, consistent and responsible.

The efficiency of AI is ensured by a large array of data that the user (or database owner) discovers. Most of this data is depersonalized, but the results of recent cybersecurity research should force school leaders to take a more responsible approach to this issue (Pal, 2020).

In order to ensure the effective personalization of education of the student there is a need to obtain and process the maximum possible amount of data about him, including his activities on social networks, analysis of his search history, geolocation of his stay and others. Therefore, the vast majority of AI systems provide the registration using a Google, Microsoft or Facebook account.

Analyzing the Privacy Policy of Google (Privacy Policy and Terms of Use, 2021), Microsoft (Control the confidentiality of your data, 2021) or Facebook (Facebook. Questions from Senator Booker, 2021), we can provide the following user data: search engine query keywords, YouTube browsing analysis, linking the account to certain geolocation objects (shops, cinemas, shopping malls, etc.) and many others. In addition, Facebook collects much more data about its users: cursor movements on the user's device; names and file types on the user's device; call log and SMS history of messages from devices running the Android operating system; list of users and frequency of interaction with them, etc.

A separate open issue is the observance by educational institutions of the Law of Ukraine “On Information” and the Law of Ukraine “On Personal Data Protection”, according to which an educational institution must not only obtain written consent to the collection, processing and use of personal data of students, but also to ensure their proper preservation, damage or unauthorized access. To implement these provisions of the laws it requires not only technical support, but also the development and implementation of corporate standards and policies at the institution level.

Given the insufficient amount of research among domestic researchers on the risks of using AI in the educational process, we propose at this stage to differentiate responsibilities for access, storage and use of personal and confidential data of educational institutions.

Conclusions

Artificial intelligence has a key role in implementing the idea of personalized learning - the adaptation of learning, its content and pace to the specific needs of each student. It provides the ability to obtain data from a variety of sources, verify this data and analyze it using analytics and machine learning. In this way, the powerful potential of AI in education can be revealed, and its use can act as a catalyst for the transformation of the education system for all stakeholders, from individual learners to local governments, which will promote and ensure sustainable development.

AI technologies can change any industry, but their possibilities are not limitless. The main limitation of AI is that learning is possible only on the basis of data, otherwise it is impossible. This means that any errors in the data will be reflected in such training results.

Modern AI systems are focused on clearly defined tasks. A system designed to identify the individual characteristics of students will not be able to implement the assessment of the same students. A system configured to detect plagiarism in the students' work will not be able to provide adaptive learning. These systems are characterized by a very narrow specialization. They are designed to perform one specific task, and today they are very far from human multitasking.

AI systems, analyzing the behavior of students (and all participants in the educational process in general) during the educational process, create a digital footprint. This digital footprint is a commodity on the market. And it can be both individual and collective. Therefore, the issue of identifying learners and understanding what data will be collected, analyzed and used remains relevant. It is no more important to understand the scenarios for using such a large flow of data from students. Therefore, promising thing is

not only the direction of research aimed at developing AI systems in the educational process, but also the use of a large flow of data generated by students and the impact of the digital footprint in the future.

In any case, today AI has already contributed to the formation of practices and opportunities for all participants in the educational process to ensure sustainable development. And its smart, transparent and responsible use brings real benefits to pupils, students, teachers, school leaders, parents, administrators and providers and will continue to be a powerful catalyst for change in education reform.

References

- A hierarchical conceptualization of enjoyment in students (2006). *Learning and Instruction*, 16, 323–338. <https://psycnet.apa.org/record/2006-11990-004>
- Arpaci, I. (2020). What drives students' online self-disclosure behaviour on social media? A hybrid SEM and artificial intelligence approach. *International Journal of Mobile Communications*, 18(2), 229–241. <https://www.inderscienceonline.com/doi/abs/10.1504/IJMC.2020.105847>
- Azure Cognitive Services (2021). <https://azure.microsoft.com/en-us/free/cognitive-services/>
- Bukreev, D. & Serdiuk, I. (2019). Metod vykorystannia neironnoi merezhi dlia prohozuvannia efektyvnosti roboty studentiv [A method of using a neural network to predict the effectiveness of students]. *Information technologies in education and science*, 11, 61–64.
- Chassignol, M., Khoroshavin, A., Klimova, A., & Bilyatdinova, A. (2018). Artificial Intelligence trends in education: a narrative overview. *Procedia Computer Science*, 136, 16–24. <https://doi.org/10.1016/j.procs.2018.08.233>
- Emotion and Cognition in the Age of AI: white paper. (2019). *The Economist Intelligence Unit; commissioned by Microsoft*. <https://info.microsoft.com/ww-landing-Emotion-and-Cognition-in-the-Age-of-AI-whitepaper.html?lclid=en-us>
- Every child matters. (2003). *Department for Education and Skills*. <https://www.gov.uk/government/publications/every-child-matters>
- Facebook. (2021). *Questions from Senator Booker*. <https://www.commerce.senate.gov/services/files/ed0185fb-615a-4fd5-818b-5ce050825a9b>
- Ford, M. (2013). Could artificial intelligence create an unemployment crisis? *Commun*, (56), 37–39. <https://doi.org/10.1145/2483852.2483865>
- Gerasymova, I., Maksymchuk, B. M., Bilozerova, M., Chernetska, Y., Matviichuk, T., Solovyov, V., & Maksymchuk, I. (2019). Forming Professional Mobility

- in Future Agricultural Specialists: the Sociohistorical Context. *Revista Romaneasca Pentru Educatie Multidimensionala*, 11(4Sup1), 345-361.
<https://doi.org/10.18662/rrem/195>
- Hung, J. & Tsai, C. (2020). The Effects Of A Virtual Laboratory And Meta-Cognitive Scaffolding On Students' Data Modeling Competences. *Journal of Baltic Science Education*, 19(6), 923. <https://doi.org/10.33225/jbse/20.19.923>
- Karpukhin, S., & Lobazhevych, V. (2019). Ispolzovanie iskustvenoho intellekta v obrazovanii: perspektivy I problem [The use of artificial intelligence in education: prospects and problems]. *Philosophy and culture of the information society: Seventh International Scientific and Practical Conference, HUAP, St. Petersburg*, 206–209.
- Khaimovych, A. (2015). Rozrobka shablonu vymoh do systemy informatsiinoho zabezpechennia v konteksti rozrobky novykh materialiv iz zaluchenniam velykykh danykh [Development of the requirements template for the information support system in the context of developing new materials involving Big Data]. *CEUR Workshop Proceedings*, 1490, 364–375.
<https://doi.org/10.18287/1613-0073-2015-1490-364-375>
- Khaimovych, I., Ramzaev, V., & Chumak, V. (2019). Multimodalnaia klasterizatsia sotsialnykh setei v sotsialnom demfirovanii s ispolzovaniem BIG DATA (polucheie znanii iz dannykh) [Multimodal clustering of social networks in social damping using BIG DATA (obtaining knowledge from data)]. *CEUR Workshop Proceedings, 2019*, 948–960.
<http://repo.ssau.ru/bitstream/Informacionnye-tehnologii-i-nanotehnologii/Multimodalnaya-klasterizaciya-socialnyh-setei%CC%86-v-socialnom-demfirovanii-s-ispolzovaniem-BIG-DATA-poluchenie-znani%CC%86-iz-dannyh-75747/1/paper123.pdf>
- Kocharian, A., & Viktorova, L. (2021). Zastosuvannia shtuchnoho intelektu ta chatbotiv pid chas vyvchennia inozemnoi movy [Use of artificial intelligence and chatbots when learning a foreign language]. *Innovative pedagogy*, 32 (2), 166 -173. <https://doi.org/10.32843/2663-6085/2021/32-2.33>
- Kontroluite konfidentsiiniest svoikh danykh [Control the confidentiality of your data]. (2021).
<https://account.microsoft.com/account/privacy?refd=lifehacker.ru&ru=https%3A%2F%2Faccount.microsoft.com%2Fprivacy%3Frefd%3Dlifehacker.ru&destr=privacy-dashboard#/>
- Kontseptsia rozvytku shtuchnoho intelektu v Ukraini [The concept of artificial intelligence development in Ukraine]. (2020).
<https://zakon.rada.gov.ua/laws/show/1556-2020-%D1%80#Text>
- Lopez-Belmonte, J., Moreno-Guerrero, A., Lopez-Nunez, J., & Hinojo-Lucena, F. (2020). Augmented reality in education. A scientific mapping in Web of Science. *Interactive Learning Environments*, 1 – 15.
<https://doi.org/10.1080/10494820.2020.1859546>

- Matsuda, N., Weng, W., & Wall, N. (2020). The Effect of Metacognitive Scaffolding for Learning by Teaching a Teachable Agent. *International Journal of Artificial Intelligence in Education*, 1–37.
<https://doi.org/10.1007/s40593-019-00190-2>
- Milkevych, K., & Redich, O. (2021). Vykorystannia shtuchnykh neuronnykh merezh v otsyntsi pokaznykiv dialnosti zakladivvyshchoi osvity [The use of artificial neural networks in the evaluation of performance indicators of higher education institutions]. *Series Scientific works of University of the State Fiscal Service of Ukraine students*, 49.
http://ir.nusta.edu.ua/bitstream/123456789/6867/1/6863_IR.pdf#page=52
- Moroz, I. (2017). Zastosuvannia neiromerezh v intelektualizatsii dystantsiinoi osvity [The use of neural networks in the intellectualization of distance education].
<http://clar.nung.edu.ua/bitstream/123456789/8251/1/7889p.pdf>
- Nerubasska, A., Palshkov, K., & Maksymchuk, B. (2020). A Systemic Philosophical Analysis of the Contemporary Society and the Human: New Potential. *Postmodern Openings*, 11(4), 275-292. <https://doi.org/10.18662/po/11.4/235>
- Nerubasska, A., & Maksymchuk, B. (2020). The Demarkation of Creativity, Talent and Genius in Humans: a Systemic Aspect. *Postmodern Openings*, 11(2), 240-255. <https://doi.org/10.18662/po/11.2/172>
- Osadcha, K., Osadchyi, V., Spirin, O., & Kruhlyk, V. (2021). Realizatsiia individualizatsii ta personalizatsii navchannia zasobamy Moodle [Implementation of individualization and personalization of learning by means of Moodle]. *Youth and the market*, 1, 187.
<https://doi.org/10.24919/2308-4634.2021.228274>
- Pal, D., Funilkul, S., & Zhang, X. (2020). Should I Disclose My Personal Data? Perspectives from Internet of Things Services. *IEEE Access*, 9, 4141 -4157.
<https://doi.org/10.1109/ACCESS.2020.3048163>
- Palamarchuk, V., & Poltorak, A. (2020). Features of Guaranteeing the Security of the Integrated Global Financial Space. *Modern Economics*, 20(1), 215-225.
[https://doi.org/10.31521/modecon.V20\(2020\)-34](https://doi.org/10.31521/modecon.V20(2020)-34)
- Polityka konfidentsiynosti ta Umovy vukorystannia* [Privacy Policy and Terms of Use]. (2021). <https://policies.google.com/privacy?hl=ru#infocollect>
- Sensing Curiosity in Play and Responding. (2016). *The ArticLab*, Carnegie Mellon University. <http://articulab.hcii.cs.cmu.edu/projects/scipr/>
- TeachThought Staff. (2019). *10 roles for artificial intelligence in education*.
<https://www.teachthought.com/the-future-of-learning/10-roles-for-artificial-intelligence-in-education/22.03.2019>

- International Data Corporation. (2019). *The Growth in Connected IoT Devices Is Expected to Generate 79.4ZB of Data in 2025, According to a New IDC Forecast*. <https://www.idc.com/%20getdoc.jsp?containerId=prUS45213219>
- Thornburg, D. (1999). *Technology in K-12 Education: Envisioning a New Future*. <https://eric.ed.gov/?id=ED452843>
- Vark. (2022). *A guide to learning preferences*. <https://vark-learn.com>
- Viktorova, L. (2021). Perspektyvy zastosuvannia suchasnykh tekhnolohii ta shtuchnoho intelektu u zakladakh vyshchoi osvity zi spetsypichnymy umovamy navchannia [Prospects for the application of modern technologies and artificial intelligence in higher education institutions with specific learning conditions]. *Current issues of the humanities*, 35(2). http://www.aphn-journal.in.ua/archive/35_2021/part_2/35-2_2021.pdf#page=180
- Watts, E. (2019). *9 ways to use Artificial Intelligence (AI) in education*. <https://bigdata-madesimple.com/9-ways-to-use-artificial-intelligence-ineducation/23.03.2019>.
- Wilson, J. & Czik, A. (2016), Automated essay evaluation software in English Language Arts classrooms: Effects on teacher feedback, student motivation, and writing quality. *Computers & Education*, 94–109. <https://doi.org/10.1016/j.compedu.2016.05.004>
- Microsoft HoloLens. (2017). *Windows Mixed Reality: An Evolution for Education*. <https://www.youtube.com/watch?v=7Xv8A9vqeBw>
- Winkler-Schwartz, A. (2019). Artificial Intelligence in Medical Education: Best Practices Using Machine Learning to Assess Surgical Expertise in Virtual Reality Simulation. *Journal of Surgical Education*, 76 (6), 1681 – 1690. <https://doi.org/10.1016/j.jsurg.2019.05.015>
- Yang, K., Varol, O., Davis, C., Ferrara, E., & Flammini, A. (2019). Arming the public with artificial intelligence to counter social bots. *Human Behavior and Emerging Technologies*, 1(10), e:115, 48 – 61. <https://doi.org/10.1002/hbe2.115>
- Zacharis, N. (2016). Predicting student academic performance in blended learning using Artificial Neural Networks. *International Journal of Artificial Intelligence and Applications*, 7(5), 17 – 29. <https://airconline.com/ijai/V7N5/7516ijai02.pdf>
- Zharska, I., & Zinkovska, D. (2014). Osoblyvosti doslidzhennia povedinky spozhyvachiv osvitnikh posluh v Internet-seredovycshchi [Features of research of behavior of consumers of educational services in the Internet environment]. *Business Inform*, (6), 404–412. http://nbuv.gov.ua/UJRN/binf_2014_6_71