Artificial Intelligence in Education: AIEd for Personalised Learning Pathways

Olga Tapalova[1] and Nadezhda Zhiyenbayeva[2]
[1] Department of General and Applied Psychology, Abay Kazakh National Pedagogical University, Almaty, Kazakhstan
[2] Department of Special Education, Abay Kazakh National Pedagogical University, Almaty, Kazakhstan
olgatapalova9@gmail.com
otapalova@gmail.com

Abstract: Artificial intelligence is the driving force of change focusing on the needs and demands of the student. The research explores Artificial Intelligence in Education (AIEd) for building personalised learning systems for students. The research investigates and proposes a framework for AIEd: social networking sites and chatbots, expert systems for education, intelligent mentors and agents, machine learning, personalised educational systems and virtual educational environments. These technologies help educators to develop and introduce personalised approaches to master new knowledge and develop professional competencies. The research presents a case study of AIEd implementation in education. The scholars conducted the experiment in educational establishments using artificial intelligence in the curriculum. The scholars surveyed 184 second-year students of the Institute of Pedagogy and Psychology at the Abay Kazakh National Pedagogical University and the Kuban State Technological University to collect the data. The scholars considered the collective group discussions regarding the application of artificial intelligence in education to improve the effectiveness of learning. The research identified key advantages to creating personalised learning pathways such as access to training in 24/7 mode, training in virtual contexts, adaptation of educational content to personal needs of students, real-time and regular feedback, improvements in the educational process and mental stimulations. The proposed education paradigm reflects the increasing role of artificial intelligence in socio-economic life, the social and ethical concerns artificial intelligence may pose to humanity and its role in the digitalisation of education. The current article may be used as a theoretical framework for many educational institutions planning to exploit the capabilities of artificial intelligence in their adaptation to personalized learning.

Keywords: AIEd technologies; artificial intelligence; machine learning; personalised learning; prevalent behaviour patterns; sustainable development goals (SDGs).

1. Introduction

Digital transformation has become an important growth diver improving the quality of life. Digitalisation has an impact on global, innovative, inclusive and sustainable growth in different sectors (Dignum, 2021). Access to large volumes of data and the increasing role of digital technologies have inspired the development of computational science, led to the growth of different industries and facilitated a rapid transition to e-science on the national scale. With the development of intelligent computing in recent years, computer literacy has become the main skill that pushed industrial innovations. Moreover, it has been seen as a driver of economic growth within organisations (Tedre et al., 2021). The availability of cheap computing power and large data volumes have led to machine learning developments. Digital tools sparked commercial and research interest in artificial neural networks. Neural artificial intelligence and machine learning techniques are now being used for real-time language processing, translation, image analysis, self-driving cars, autonomous vehicles, automated customer service systems, fraud detection, process control, synthetic art, service robots and so forth (Tuomi, 2018; Shestak et al., 2020).

Artificial intelligence transforms all aspects of socio-economic life and integrates communication technology into virtual reality. Artificial intelligence in education has changed not only the education system but knowledge sharing approaches to learning, cognition and development of civilization (Kaur, 2021). The main challenge is that education has not accepted the educational value of technology, and for this reason, the launch of artificial intelligence in education has been postponed for many years. Nevertheless, applied sciences, industry, finance and medicine have undergone digital transformations (Luckin and Cukurova, 2019). The digital transformation of education has significantly influenced the adoption of technology by secondary and high educations around the world. It has also heated the interest in artificial intelligence in education (AIEd) in terms of research and its practical application in modern education.

On the other hand, on a worldwide scale, intensification of digital technology adoption in the learning process is uneven among educational institutions and remains a key issue in learning quality improvement for many developed countries (Fahimirad and Kotamjani, 2018). Thus, the use of artificial intelligence (AI) in the context of enhancing the sustainable development of society requires many institutions to work cohesively as a result of the interaction of multiple factors. For example, not every public education policy is internationally coherent, which comes with subjective efficiency and rationality of learning processes (Pedro et al., 2019). Although the scientific and technological advancement of civilisation in the form of an AI product can facilitate student access to education, collaborative environments, and intelligent learning systems to support teachers, the use of this tool is still a challenge rather than a fact (Flogie and Aberšek, 2022). As a consequence, research on the personalised learning establishment by means of AI implementation in the educational environment is quite relevant at this time.

The present research aims to investigate the possibilities of AIEd to build personalised learning pathways. For this, the following objectives are set:

- - define a term, concepts, and subsets of artificial intelligence;
- - explore the possibilities of AIEd and investigate the personalised approaches to knowledge acquisition and professional competencies development;
- - analyse the case studies that illustrate the implementation of AIEd;
- - explore the benefits of AIEd for personalised learning;
- - identify and describe the social and ethical concerns AI may pose to humanity and its role in the digitalisation of education.

The increased role of artificial intelligence has forced the modern generation of students to acquire knowledge and skills much faster. Nevertheless, addressing socio-economic problems, artificial intelligence has raised broad social concerns and may lead to unexpected outcomes (Zhang et al., 2021). AIEd opens up new opportunities in educational practice. In its short history, AIEd has undergone several periods, which are characterized by three paradigms in which AI methods are used in different ways to solve education and learning problems. In the first paradigm, AIEd tools used to represent knowledge models and direct cognitive learning in which learners are recipients of educational services. In the second paradigm, AIEd tools used to support learning while students work alongside AI. In the third paradigm, AIEd tools used to enhance learning opportunities while students participate in learning. In general, the development trend of AIEd has evolved to empower the learner and personalize learning process, allow learners to reflect on learning and inform AI systems to adapt accordingly, and lead to the iterative development of personalized, learner-cantered, data-driven learning (Ouyang and Jiao, 2021). The concept of personalized learning is not something new in the field of education, but with the advent of artificial intelligence and big data analytics, new ways of implementing it are opening up (Magomadov, 2020). The digital learning environments offer the potential for personalised learning pathways. On the contrary, empirical evidence suggests that even if something is personalised, it does not automatically promote the learning experience. Adapting to learner characteristics that are not strongly related to learning processes (such as learning styles), or using static modelling as the basis for adaptation, can be seen as potential culprits for ineffective personalization attempts in teaching practice. In contrast, the use of dynamic modelling to assess and adapt to appropriate learner characteristics can lead to learning success that can only be rivalled by individual learning (Tetzlaff, Schmiedek, and Brod, 2021).

Intelligent Learning Systems (ITS) have a great potential for educators teaching distance learning courses. Digital tools forced the learning system to change drastically and move from face-to-face to distance modes of delivery. The AIEd can foster collaborative learning by supporting the adaptive groups based on student personal profiles, facilitating online group interactions, or summarizing discussions (Zawacki-Richter et al., 2019). The main idea of intelligent learning systems is that the student interacts with an adaptive interface that personalises the learning process depending on the user's profile and academic achievements. On the other hand, the main strength of AI data-driven systems is that they can process very complex data streams in real-time. For the next generation of intelligent learning systems, it means that these systems will require user interfaces (UIs) that collect real-time student behaviour patterns, as well as historical data that can be used to develop the student's profile. Informally, it is known as the principle of "no AI without UI". Consequently, there will be significant commercial interest in promoting various types of sensor technologies and user interfaces in educational courses. They will help to access data from other sources related to learners behaviour patterns such as social networks and gaming platforms (Tuomi, 2018).

Artificial intelligence, available to teachers and students, help educators to craft courses that are customised to their needs. It creates growing awareness of new technological solutions that provide alternatives for students and promote new teaching and learning methods. The advances in artificial intelligence have led to the development of personalised pathways in education. AI simulates human listening (machine translation, speech recognition), speech (speech synthesis, human-computer dialogue), observation (computer vision, recognition images, text recognition), thinking (theorem proving), learning (machine learning, intelligent adaptive learning) and action (robotics) (Huang, Saleh, and Liu, 2021). Today, AI is one of the tools used in Learning Analytics to analyse students knowledge (as well as their learning engagement strategies) in order to restructure effective personalised learning pathways and develop supportive strategies in all stages of education. Learning analytics models are most commonly used in two spheres: decision support systems and personalised learning systems. Decision support systems use predictive analytics that proposes forecasts about future student outcomes and visualises information in graphs and tables. Teachers examine information on specific students achievements using AIEd. Personalised learning systems help to analyse the mastery of the skills, provide students with the best educational activities and encourage students to learn at their own pace as they master skills and progress toward learning goals. Personalised learning leads to the building of customised learning pathways that make learning more effective and emphasise learner-specific goals related to the learning objective (Baker, 2021). Immersive technologies and artificial intelligence promote practical and innovative education through digital tools and virtual learning platforms (Klašnja-Milićević and Ivanović, 2021).

Education and business environment are interlinked, controlled and supported by information systems. The technological advances and the growing importance of artificial intelligence facilitate the research on the advantages of technological innovations and new strategies for education (Lam et al., 2021; Owoc, Sawicka, and Weichbroth, 2019). In recent years, artificial intelligence and robotics have generated great interest among the public, governments and prominent scientists. The role of digital tools in business and education is undeniable. The digitalisation of education has an important impact on the educational approaches and the role of teachers and students in the educational process. In this regard, the higher education system demands to teach individuals how to perform in a new economy and adapt society to a new way of life (Cox, 2021). Artificial intelligence creates new opportunities for education providers and bridges the gap between technological innovations and their implementation in education (Zhang and Aslan, 2021). Technological developments and pedagogy must go hand in hand. Effective collaboration between education professionals and artificial intelligence is extremely important because educational technologies cannot exist in a vacuum. Communication in educational establishments, the labour market and students who acquire professional skills and competencies are interlinked (González-Calatayud, Prendes-Espinosa, and Roig-Vila, 2021).

2. The Term, Concepts and Subsets of Artificial Intelligence

Artificial intelligence is defined as a wide-ranging branch of automated decision making without human involvement. It covers different areas from conditional logic to neural networks. Machine Learning (ML), a subset of AI, means decisions or predictions made by data-driven technology. Machine learning methods powered by AI include deep neural networks (DNN), also known as deep learning (DL) (Figure 1). Machine learning, artificial intelligence, and deep learning are widespread and integrated across data-driven industries that create AI-based products and services. The growing interaction between humans and AI has resulted in the development of human-centred machine learning (HCML) (Kaluarachchi, Reis, and Nanayakkara, 2021).

Artificial intelligence is based on algorithms, a set of rules and instructions that computers follow while performing problem-solving operations to complete the final goal. Algorithms provide instructions for AI and machine learning systems. Machine learning is based on statistical learning methods and uses data and algorithms to perform tasks that usually require human intelligence. Machine learning algorithms analyse data to identify the patterns and build a model and then calculate future values based on these models (Akgun and Greenhow, 2021). In general, the machine learning effectiveness depends on the data and its characteristics, as well as the performance of the learning algorithms. Machine learning algorithms include methods of classification analysis, regression, data clustering, feature design, dimension reduction, association rule learning and reinforcement learning to build data-driven systems. Choosing the correct learning algorithm for the application in a specific area can be a challenge. The final goal of different learning algorithms may differ. The outcomes of different learning algorithms in one subset may differ greatly because of the initial characteristics and input data (Sarker, 2021). Machine learning means the ability of systems to learn by the use of data and automate the process of building analytical models and solving related problems. The challenges in machine

learning include the data collection processes considered one of the most critical factors for learning. Machine learning requires time to analyse series data and explore its potential use in scenarios. The main functions are collecting, cleaning, analysing, visualising, and developing functions (Roh, Heo, and Whang, 2019). Deep learning is machine learning based on artificial neural networks. For many applications, deep learning models are superior to shallow machine learning models and traditional approaches used in data analysis (Janiesch, Zschech, and Heinrich, 2021).

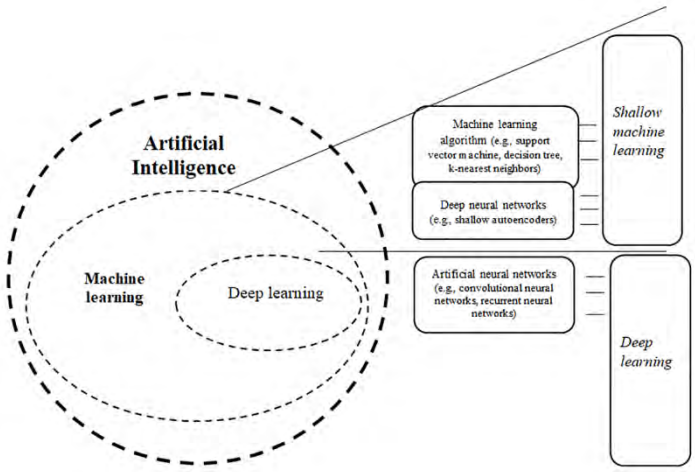

Figure 1: Artificial intelligence concepts and subsets

* Author's development (Goodfellow, Bengio, and Courville, 2016; Kaluarachchi, Reis, and Nanayakkara, 2021)

On the other hand, across-the-board popularity of machine learning has stemmed from agricultural training. Thus, for example, several European universities in the UK, Greece and Italy have proved a positive impact of machine learning due to its intensification of the use of data in the multidisciplinary agri-technologies domain (Liakos et al., 2018). Apart from this, there are also studies dedicated to identifying and distinguishing between sick and healthy wheat crops claiming using machine learning. More precisely, this technology has facilitated the development of a new system capable of identifying healthy winter wheat and having yellow rust disease based on a hierarchical self-organising classifier and hyperspectral reflectance data. The demonstrated application of this method contributed to a more effective application of fertilisers and fungicides according to specific plant's needs (Pantazi et al., 2017).

3. AIEd for Building Personalised Learning Pathways, Acquiring Knowledge and Developing Professional Competencies

Learning is a natural human ability that starts in personal experience, cognitive awareness, personal biases, opinions, cultural background and environment. Learning is an individualised experience that expands knowledge, mind perspectives and practical skills (Shemshack and Spector, 2020). A significant disadvantage of traditional teaching is that all students have to follow the same learning sequences, but not all of them have the same knowledge, preferences, learning goals and needs. Traditional learning resources encourage learners to follow a set of learning sequences to improve their academic performance. Fixed learning pathways are not appropriate for all students. The designers of modern educational courses pay special attention to the development of personalised learning pathways taking into account the needs, motivation, interests, behaviour patterns and abilities of each student (Elshani and Nuçi, 2021).

At the same time, the specificity of the teacher's personality in the context of the implementation of personalised student learning should be noted. While under the traditional approach, the educator is more likely to make decisions on various aspects of the learning process, personalised learning transforms their role into "coordinator" or even "mentor". At the same time, the educator should have a fluent grasp of the tools for the digitalisation of scientific disciplines, i.e., complete appropriate professional development courses in the field of IT (Elfeky, 2018).

Personalised learning is a systematic learning design that adapts learning to the personal strengths, preferences, needs and goals of an individual learner. It leads to a comprehensive learning experience by ensuring a wide choice of new disciplines and skills development (Walkington and Bernacki, 2020). Personalised learning assigns a specific role to teachers that is to give the student the opportunity to manage the learning process, to be responsible for setting and implementing educational goals that correspond to his personal interests and needs (Aberbach et al., 2021). Personalised learning systems and approaches motivate students to learn and improve academic performance (Zlatarov et al., 2021).

Personalised learning emphasises the importance of personal growth and the learning environment. A personalised learning environment includes a variety of services, learning tools and applications tailored to the individual students' needs. They use technologies such as Web 2.0 or Web 3.0 to develop cheaper training, enhance user experience, and create personalised student profiles. Adaptive systems can be customised to individual learners' needs, focusing more on specific topics, repeating learning materials that have not been mastered properly (Klašnja-Milićević and Ivanović, 2021).

The use of artificial intelligence offers students of different age groups, academic levels and socioeconomic backgrounds opportunities to enhance learning experiences and improve academic achievements. Artificial intelligence technologies play a pivotal role in the development of personalised learning pathways. AI allows the use of different teaching methods effective for each student, taking into account the strengths, weaknesses, talents and academic problems of each learner. Advanced analytics and machine learning present a potential for developing social and emotional learning skills. New technologies enable educators to develop personalised learning pathways and analyse both qualitative and quantitative data. Artificial intelligence, data, analytics and machine learning help educators to deliver educational programmes to students via an immersive virtual environment. This approach helps to ensure the quality of distance learning and effective teaching (Duggan, 2020).

In recent years, advances in artificial intelligence, machine learning and big data analytics have opened up new opportunities for personalised learning. *Personalised learning* is one of the innovations that help educators to customise learning and respond to new educational perspectives. The new paradigm influences the quality of education based on the characteristics and expectations of each student, such as personality, talent, and individual goals and backgrounds. Continuing education promotes the educational process, as well as help student to acquire new skills and competencies important for the future (Maghsudi et al., 2021). Personalised learning systems, automated assessment systems, facial recognition systems, chatbots (social networking sites) and predictive analytics tools that run on machine learning systems and algorithms are increasingly adopted in educational establishments to ensure effective teaching. Intelligent learning systems are one of the most widespread and valuable artificial intelligence applications for students and teachers to access a variety of learning materials depending on their individual learning needs (Akgun and Greenhow, 2021). Intelligent Learning Systems (ITS) are able to teach students using computing systems and provide immediate and personalised feedback (Kokku et al., 2018).

The introduction of artificial intelligence to improve the optimality of learning processes has been actualised strongly in the context of the coronavirus pandemic. Medical education was the domain most affected by such learning format adjustments. As noted by researchers from the University of the West Indies (Gaur et al., 2020), the COVID-19 pandemic has posed several challenges to premedical education, among which suspension of face-to-face teaching and lack of cadaveric dissections and hands-on/lab sessions. However, at the same time, it has provided an impetus for many innovative initiatives that include but are not limited to AI-based education. As a result, AI was confirmed to be a sound solution for adaptive learning due to its broad virtual simulation capabilities.

Each student has unique learning needs and the AIEd goal is to provide students with a personalised learning experience within the intelligent learning environment that facilitates knowledge acquisition and provides personalised feedback. AI can significantly automate and track the student's progress. AI helps educators to apply the most effective teaching methods, taking into account the learning contexts and academic achievements (Chaudhry and Kazim, 2022). For students, the AIEd opens up new opportunities to learn online and enrich their learning environments with adaptive learning materials and metacognitive cues. AIEd increases engagement and improves learning outcomes. For educators and school administration, AIEd helps to record academic achievements, develop personalised learning materials, provide reviews and analyse data. The use of

AIEd provides the most immediate benefits of automating simple tasks such as assessments, digital asset classification or scheduling. AIEd helps teachers to save time usually spent on routine tasks and devote more time to communicate with students. Student needs and curriculum are changing as educators identify which skills the world needs for the future. AI-based analytics is required to identify the key trends in the subject area and help the teacher to generate learning content. In addition, the AI solutions can be integrated with other IT initiatives such as smart technology and a managed IoT network ensuing effective learning solutions for students (Joshi, Rambola, and Churi, 2021). AI learning environment can improve LMS for both teachers and students with the help of expert systems, visual feedback and learning process based on visualization and immersive technologies (Zhang and Aslan, 2021). The quality of learning can be improved by developing new pedagogical approaches and introducing technological innovations. Personalised learning helps students to take responsibility for their personal, professional and academic development and use the acquired knowledge and skills at the workplace (Whalley et al., 2021).

The artificial intelligence tools help educators to build a complex educational environment. Learning can be more personalised and flexible, and education management more inclusive. New learning contexts can help students to develop knowledge and skills that are in demand in society (Pokrivčáková, 2019). Educational technologies interlinked to other forms of innovative pedagogical practices make personalised learning the cornerstone for the effective achievement of the set goals (Cheung et al., 2021). Figure 2 presents the possibilities of AIEd technologies for personalised approaches in education.

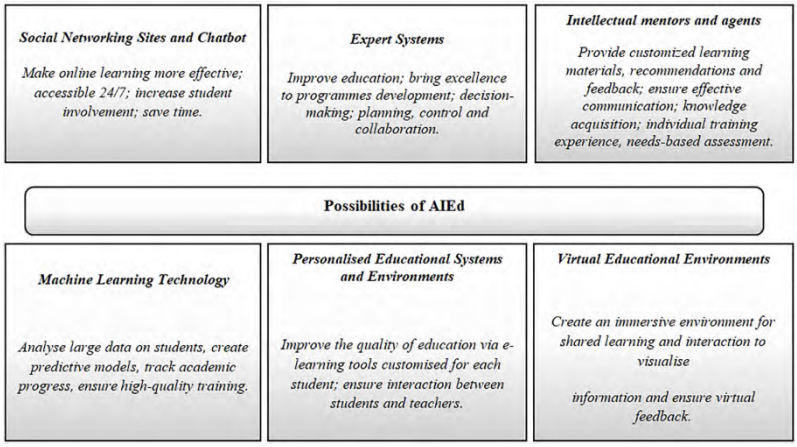

Figure 2: AIEd technologies in personalised approaches to learning

* Author's development

AIEd technologies are effective tools used for the students' competencies development. The new approaches help students to acquire skills and knowledge important for tomorrow's challenges. Students use and develop new competencies when they face unfamiliar or challenging situations. For example, Nanyang Technological University in Singapore has performed research on the application of virtual reality in medical education. Virtual reality technology helps to improve the understanding of medical subjects (Larchenko and Barynikova, 2021). Another research on digital education examined the problem of online gamification for the development of entrepreneurship skills. The developed special online game had a positive effect on the acquisition of entrepreneurial skills among students (Holmes et al., 2021).

The developments in natural language processing resulted in the deep and network learning progress, as well as the growth of technological capabilities for large data analysis. Today, AI can analyse the psychological characteristics, selecting an algorithm for raw data analysis, detection of stress, anxiety and depression using technology (Tapalova and Kuatbekov, 2021). Artificial intelligence in language learning resulted in the development of the Intelligent Computer-Assisted Language Learning (ICALL system). The system involves personalised teaching materials, machine translation tools, chatbots, platforms and applications for learning languages based on artificial intelligence, intelligent learning systems, adaptive and intelligent systems for collaborative learning, and intelligent virtual reality (Pokrivčáková, 2019).

However, the theoretical basis for determining AI as a digital tool in an educational environment is individual for each region or educational institution (Zhang, Basham, and Yang, 2020). Even though there are several publications describing the key features of AI implementation in education, this issue has not yet been sufficiently explored in the context of personalised student learning, which is taking on a more traditional form under today's global challenges.

4. The Case Study on the AIEd Implementation in Education

Artificial intelligence tools are popular in education offering opportunities for student-centred learning. The possibilities of using artificial intelligence to develop a personalised pathway in psychological disciplines including "Zoopsychology", "Cognitive and affective foundations of human behaviour", as well as special disciplines such as "Speech therapy", "Subject-practical training in children with impairments", The sample included 184 second-year students of the Institute of Pedagogy and Psychology at the Abay Kazakh National Pedagogical University and the Kuban State Technological University to collect the data. The vast majority of them were females (112), while the number of males was notably fewer (72). Research participants' mean age constituted 19.6 years. The selection of students was made with reference to their field of study. The scholars analysed the benefits of artificial intelligence in teaching university students. The training was carried out in a distance format for 3 months from September to November 2021. Following the instructions of the course moderator, students tested educational tools adapted to the educational content. All moderators (20 people) were IT instructors in the university under study. As concerns the ethical side of the research, all the ethical principles were met in the course of the investigation. Each person involved consented to personal data processing, while achievements made were agreed with the university administration.

In the course of the educational experiment, educational digital tools powered by artificial intelligence were used, such as Altitude Learning (2021). It is a professional learning platform that encourages students to self-study and helps teachers to meet the needs of every student in the entire learning cycle, from the course planning to assess student progress. With the support and guidance of a teacher or mentor, students gain independent learning experiences by completing assignments and interacting with peers in groups.

Gradescope (2021) is a platform that combines expertise with the latest machine learning and artificial intelligence technologies to help the teacher assess student progress. The platform is effective because it allows teachers to save time usually spent on academic reviews and assessments. Gradescope provides statistics and identifies classroom trends and student needs. Knewton's Alta (2021) is an artificial intelligence platform designed to improve learning and help teachers to assess assignments. KnewtonAlta is responsive learning software that provides a hands-on learning experience with detailed explanations and timely instructions. At Knewton Alta, students use the personalised pathway based on their individual achievements and needs. The platform monitors student progress and adapts it in real-time to maximize learning outcomes.

The other learning platform, Knowji (2021) is a research-based audiovisual application that tracks student progress. It reflects cognitive category typologies and structures academic knowledge. It helps to research the connection of gestalts with the basic level concepts, analyses quick reasoning based on figurative-schematic structures and explores clip thinking (mental and visual images), visual images (high-quality memorization, productive building of their logical relationship). The system develops the student's psychological portrait.

Knowji's vocabulary applications combine the best techniques to provide fun for students and effective learning at the same time. Duolingo (2021) is a chatbot platform integrated with artificial intelligence algorithms that allow educators to understand the user's context and respond to individual students' needs.

The interest of foreign researchers in machine learning algorithms (Mashing Learning, ML) was heated by the digitalization of education. Big data means digital traces that students generated on a daily basis in social networks. The research hypothesis state that there was a link between students' characteristics (for example, creativity or academic performance) and behaviour patterns in social networks.

During the learning process, the moderators of the training course structured the possibilities of AIEd technology in educational activities for students, teachers and educational institutions (Figure 3).

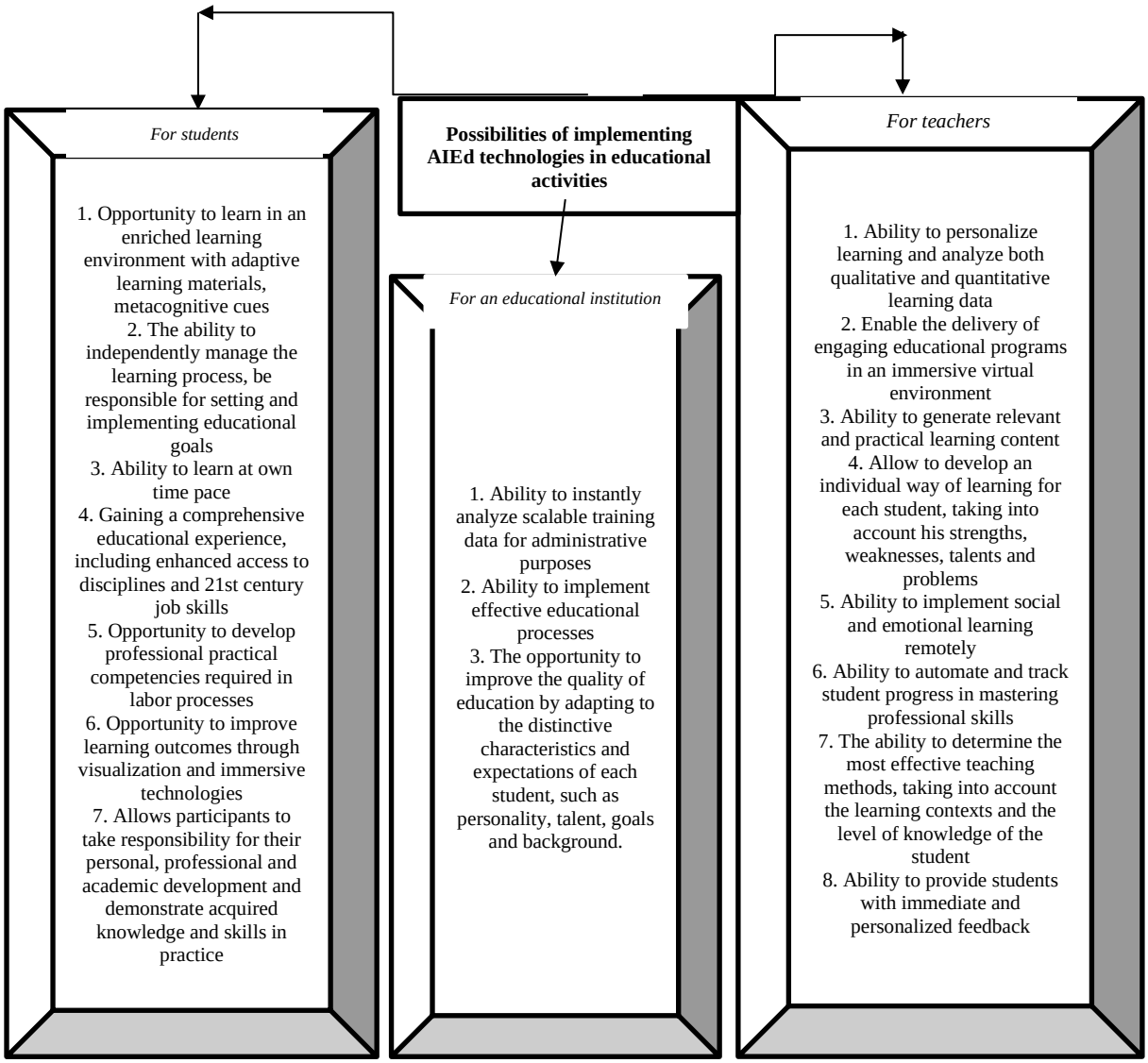

Figure 3: Possibilities of AIEd technology in educational activities for students, teachers and educational institutions

* Author's development

At the end of the training, in the online survey mode on the Zoom communication platform, students asked to answer the following question: "In your opinion, to what extent the possibilities of AIEd technologies in educational practices affect the implementation of the principles of personalized learning.
The results of the survey are presented in Table 1.

The training sessions provided students with personalised learning pathways and demonstrated that educational tools based on artificial intelligence were important for educational purposes. The digital tools turned out to be a valuable and rewarding educational experience for most students. The students identified key advantages for building personalized educational pathways based on artificial intelligence technologies (Figure 4).

Table 1: The results of the student survey

Innovative capabilities of AIEd technologies	**The degree of influence on the implementation of the principles of personalized learning**		
	No effect	Not significant	Significant
Opportunity to learn in an enriched learning environment with adaptive learning materials, metacognitive cues		14%	86%
The ability to independently manage the learning process, be responsible for setting and implementing educational goals		2%	98%
The opportunity to gain a comprehensive educational experience, including expanded access to disciplines and 21st century work skills		20%	80%
Opportunity to develop professional practical competencies required in labor processes		32%	68%
Ability to instantly analyze scalable training data		22%	78%
The ability of curricula to adapt to the distinctive characteristics and expectations of each student, such as personality, talent, goals and background			100%
Opportunity to learn in an exciting virtual environment with the effect of presence		14%	86%
The ability to generate relevant and practical learning content in an online environment		8%	92%
Ability to implement social and emotional learning remotely		12%	82%
Ability to automate and track learning progress		4%	96%
The ability to determine the most effective teaching methods, taking into account learning contexts and knowledge levels		2%	98%
Ability to receive immediate and personalized feedback and access to training 24/7			100%

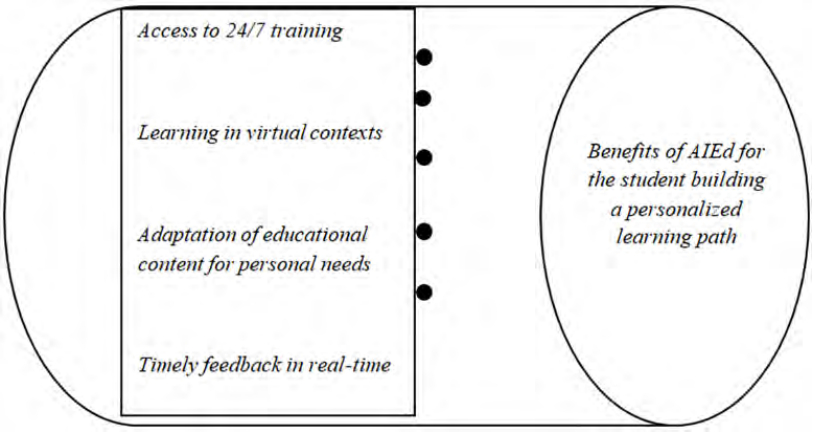

Figure 4: Benefits of AIEd for the student building personalized learning pathways

* Author's development

The majority of participants responded that the implementation of AIEd technologies in education increased their involvement and interest in learning, helped to adapt educational content to personal needs, accelerated the educational process and stimulated mental activity. Therefore, it provided an opportunity to learn disciplines in virtual contexts by providing access to training in 24/7 mode and ensured timely feedback.

On the other hand, the use of AI technology in personalised learning opens up broad professional development opportunities for educators, which may significantly impact the quality of education. Hence, for example, the research carried out on the basis of several universities in Russia proves the need for practical and dynamic training of teachers of the Russian Federation to work in the electronic information and educational environment (EIEE), which is continuously and intensively enriched with AI technologies. At the same time, it is shown that the use of new types of educational activities in the conditions of a digital educational environment

enriched with AI elements contributes to the innovative professional training of a modern educator (Vlasova et al., 2019).

5. The Social and Ethical Concerns AI May Pose to Humanity and Its Role in the Digitalisation of Education

The social and ethical concerns of artificial intelligence are apparent. Artificial intelligence is at the centre of controversy, for example, in the automation of workplaces and public services. The algorithms lead to bias and discrimination, inequality and disadvantages for individual users. The scholars admit that the main challenges connected with artificial intelligence include ignoring data protection and confidentiality, political and commercial micro-targeting, and the inability of technology corporations to control the economy. Numerous ethical frameworks and professional codes of conduct have been developed to try to reduce the potential dangers and risks of artificial intelligence in society (Williamson and Eynon, 2020). In the educational context, the ethical issues related to artificial intelligence include privacy, security, use of personal data, and the impact of virtual assistants on assessments. Potential social and ethical risks arise as artificial intelligence become more intelligent and sophisticated (Dignum, 2021). Several European Commission initiatives have addressed ethics as a means to protect people from the risks posed by new technologies and as a way to govern and regulate areas of innovation. The spread of references to "ethics" and "ethical principles/values" in legal and political discourse, as well as the growing importance of ethical expertise, ethical committees, ethical advisory groups and councils, ethical guidelines are called the phenomenon of "ethification" (Dijk and Casiraghi, 2020).

The scope of AI ethics covers immediate, topical issues such as data privacy and bias in existing AI systems, the impact of AI and robotics on the workplace, and concerns about techno replacing human capabilities. Ethical concerns about AI have sparked a huge number of national and international initiatives from non-governmental organizations, academic and industrial groups, professional organizations and governments. These initiatives vary greatly in their goals, amount of investment, and their commitment to developing an ethical framework. These initiatives have resulted in the publication of a large number of sets of ethical principles for robotics and AI (EPRS, 2020).

In European countries, artificial intelligence technologies are considered by citizens as a positive addition to the socio-economic life. The general trends in public perception obtained during a special Eurobarometer survey on the attitudes of citizens of the European Union (EU) towards the digitalization of their daily lives revealed the main concerns in digitalization trends: the risk of job cuts, the lack of special knowledge and skills for effective and thorough technology management, concerns about access and protection of their data and online information, privacy (European Commission, 2020).

In 2019, the European Commission published the Ethical Guidelines for Trusted AI to instruct the public on their expectations for the proper development and use of AI. The guiding principles included: strength and security, privacy and data governance, transparency, diversity, non-discrimination and fairness, social and environmental well-being, accountability (Mitchell et al., 2020). In 2021, the European Commission presented its proposal for a Law on Artificial Intelligence, called "the world's first regulation on AI". While many declarations have been made about the ethics of AI over the past few years, the novelty and complexity of AI, combined with concerns about stifling innovation, have limited the translation of these ethical principles into concrete regulatory measures (INQ LAW, 2021).

The European Commission provides a common framework for the development of AI in the EU, but Member States are also required to develop their own national strategies. For example, Finland was the first Member State to develop a national program on artificial intelligence (Ministry of Economic Affairs and Employment of Finland, 2018) aimed at promoting the good governance and efficient use of information, taking into account the principles of fair data management, including recommendations on the use of information and ethical values. . The UK National Artificial Intelligence (AI) Strategy 2021 is a vision of innovation and opportunity, underpinned by a system of trust that puts innovation and opportunity first. While strategy sends important signals for innovation, achieving ethical innovation is more challenging and will require a carefully crafted framework built with relevant expertise (Kazim et al., 2021). The focus of the Danish National Strategy for Artificial Intelligence is to ensure that the development and use of artificial intelligence is based on democratic values. The use of artificial intelligence should help analyze, understand and make decisions and complement people, and algorithms should ensure equality, being objective, based on facts and independent of personal

circumstances (Denmark, 2019). In Germany, with the aim of integrating AI into society in ethical, legal, cultural and institutional terms, the Strategy for Artificial Intelligence of the German Federal Government was adopted (Die Bundesregierung, 2020). France launched the AI for Humanity program in 2018, which is committed to supporting French talent, making better use of data, and setting an ethical framework for AI (AI For Humanity, 2018). Digital ethics is now a major issue in a global world where data, information and knowledge play such an important role in our daily lives and in our society. In 2019, the French National Committee for Digital Ethics (FNCDE) was created with the task of helping to organize reflections on digital ethics in France in close coordination with European and international institutions and initiatives (Kirchner, 2020). In May 2019, a group of experts led by the Ministry of Economic Affairs and Communications (MKM) and the Government Office submitted proposals to promote the implementation of artificial intelligence (AI) in Estonia, also known as the Estonian National AI Strategy. The Estonian National AI Strategy has been developed in the context of the European Union's coordinated action plan on artificial intelligence, synchronized with relevant activities at the EU level. The strategy takes into account the ethical implications of AI, and proposes practical economic incentives and pilot programs (OECD.AI, 2021).

Currently, there is no regulatory regime and no federal regulation of AI in North America. In the US, concerns about the possible misuse or unintended consequences of AI have spurred efforts to study and develop standards, such as the US National Institute of Standards and Technology (NIST) initiative, which includes workshops and discussions with the public and private sectors around the development of federal standards for reliable artificial intelligence systems (NCSL, 2022). Although Canada was the first country in the world to launch a national AI strategy in 2017, AI systems in Canada are governed by general privacy, technology and human rights laws and efforts are being made to develop a more flexible framework for regulating AI. In 2020, the Office of the Privacy Commissioner of Canada (OPC) released PIPEDA reform recommendations to help you reap the benefits of AI while respecting people's basic right to privacy (INQ LAW, 2021).

In the Middle East, the United Arab Emirates was the first country to develop a strategy for AI in 2017, with a focus on improving government performance and financial sustainability. The Dubai AI Ethics Guidelines have identified key principles that make AI systems fair, accountable, transparent and explicable. A self-assessment tool has also been developed to help AI technology developers assess the ethics of their system (EPRS, 2020).

Israel launched the National Department of Synchronization of Research Center Operations (IDSI or Israel Data Science Initiative) program in 2020. The goals of the program are to promote high-level research and create an ecosystem that will ensure the further development and competitiveness of industry, academia and the public sector in the field of high technologies. The program also aims to develop mission-critical applications for the Israeli security system and master the use of AI in industry, the service sector, and government ministries (Xinhua, 2020).

Asian countries have experience in complying with the EU General Data Protection Regulation (GDPR). The wide extraterritorial scope of the GDPR has prompted many countries to model their own legislation along similar lines (Harjani, 2021). In 2019, the Japanese Cabinet released a document titled "Social Principles for Human-Centered AI". The document includes the following principles: human focus, education, confidentiality, security, fair competition, fairness, accountability, transparency and innovation (Mitchell et al., 2020). In 2019, Singapore presented its AI Governance Model Framework at the World Economic Forum (WEF) in Davos. The two guiding principles of the system are: decisions made by AI must be "explainable, transparent and fair"; and AI systems must be human-centred (i.e., the development and deployment of AI must protect the interests of people, including their safety and well-being) (Choudhury, 2021). For 2021, the Chinese government has released a number of policy papers and public statements that seem to reinforce the country's AI governance regime. These initiatives show the emergence of three different approaches to managing AI, each championed by a different branch of the Chinese bureaucracy and at different levels of maturity: 1) rules for online algorithms with an emphasis on public opinion (Internet Information Service Algorithmic Recommendation Management Provisions; Guiding Opinions on Strengthening Overall Governance of Internet Information Service Algorithms); 2) tools for testing and certification of "reliable AI" systems (Trustworthy AI white paper; Trustworthy Facial Recognition Applications and Protections Plan); 3) establishing AI ethics principles and creating technical ethics councils in companies and research institutions (Guiding Opinions on Strengthening Ethical Governance of Science and Technology; Ethical Norms for New Generation Artificial Intelligence) (Sheehan, 2022).

AI will increasingly shape the global response to the world's most complex problems, especially in the field of social development. To minimize the risks associated with the implementation of AI systems in educational processes and maximize their benefits, human rights principles must be embedded in the development stages, from the earliest stages of conception to implementation and follow-up. In addition, it is important to put in place mechanisms that guarantee an adequate level of both technical and organizational transparency. For any educational project, it is necessary to ensure the use of high quality data and adherence to best practices for data protection and confidentiality. For AI tools to contribute to human progress, educational organizations must be active and inclusive in developing tools, policies and accountability mechanisms that protect human rights (Pizzi, Romanoff, and Engelhardt, 2020).

Active implementation of personalised learning is a challenge to the traditional system of any educational establishment (Murphy, 2019). Therefore, each higher education institution must develop personal adaptive student-instructor interaction program to ensure effective cooperation and use AI capabilities in modern conditions.

6. Conclusions

Personalised learning is a trend in the modern educational system related to the global digital transformations of all aspects of socio-economic life. The introduction of artificial intelligence technologies makes it possible to increase the efficiency and quality of education focused on the needs and demands of students. The use of social networking sites and chatbots in education allows teachers to make training more effective, accessible 24/7, increase student engagement, and save time. Expert systems improve the efficiency of education, ensure excellence in curriculum development, decision-making, planning, control and collaboration. Intelligent mentors and agents promote individualised learning pathways based on students needs, preferences and previous academic knowledge. Machine learning technologies allow teachers to analyse large amounts of student data, create predictive models, track educational progress and adjust learning to students needs and ensure high-quality learning. Personalised educational pathways improve the quality of e-learning and provide students with personalised learning materials and resources. Moreover, they facilitate interaction between students and educators. Virtual learning environments provide an immersive environment for collaborative learning, interaction, information visualisation and real-time virtual feedback.

The findings suggest that the key advantages of AIEd technologies allow educators to build personalised educational pathways to meet individual learners' needs. The majority of participants admitted that the implementation of AIEd technologies in education increased their involvement and interest in learning, helped them to adapt educational content to personal needs, accelerated the educational process and stimulated mental activity. Moreover, AIEd provided an opportunity to research psychological aspects in virtual contexts, accessed academic progress in 24/7 mode and ensured timely feedback. The educational paradigm proposed within the current study depicts the growing role of AI in socio-economic life, the social and ethical problems that AI can cause for humanity, as well as the role of AI in the digitalisation of education, especially personalised.

6.1 Research Limitations

The research is theoretical and descriptive by its nature. It lacked the quantitative data assessment related to the effectiveness of AIEd technologies in education. Future research is still needed. The research provides evidence for changes in the future. The recommendations may be pertinent to other universities on how to use the specifically designed programme based on AI-powered tools.

References

Aberbach, H., Jeghal, A., Sabri, A., Tairi, H. and Laaouina, L., 2021. A personalized learning approach based on learning speed. *Journal of Computer Science,* 17(3), pp. 242–250. https://doi.org/10.3844/jcssp.2021.242.250.

AI For Humanity, 2018. *AI for humanity: French Strategy for Artificial Intelligence.* Available at: <https://super-ai.diascreative.net/ai-for-humanity-french-strategy-for-artificial-intelligence> [accessed on 19 November 2021].

Akgun, S. and Greenhow, C., 2021. Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics,* in press. https://doi.org/10.1007/s43681-021-00096-7.

Altitude Learning, 2021. *Official web site.* Available at: <https://ausd.altitudelearning.com> [accessed on 19 November 2021].

Baker, R., 2021. Artificial intelligence in education: Bringing it all together. In: *OECD Digital Education Outlook 2021: Pushing the frontiers with AI, blockchain, and robots*. Paris: OECD. Available at: <https://www.upenn.edu/learninganalytics/ryanbaker/oecd-baker.pdf> [accessed on 19 November 2021].

Chaudhry, M. and Kazim, E., 2022. Artificial Intelligence in Education (Aied) a high-level academic and industry note 2021. *AI and Ethics,* 2(1), pp. 157-165. https://doi.org/10.1007/s43681-021-00074-z.

Cheung, S.K., Wang, F.L., Kwok, L.F. and Poulova, P., 2021. In search of the good practices of personalized learning. *Interactive Learning Environments,* 29(2), pp. 179–181. https://doi.org/10.1080/10494820.2021.1894830.

Choudhury, A.R., 2021. *A closer look at Singapore's AI governance framework: insights for other governments.* Global Government Forum. Available at: <https://www.globalgovernmentforum.com/singapores-ai-governance-framework-insights-governments/> [accessed on 19 November 2021].

Cox, A.M., 2021. Exploring the impact of Artificial Intelligence and robots on higher education through literature-based design fictions. *International Journal of Educational Technology in Higher Education,* 18(1), p. 3. https://doi.org/10.1186/s41239-020-00237-8.

Denmark, 2019. *National Strategy for Artificial Intelligence.* Ministry of Finance and Ministry of Industry, Business and Financial Affairs. Available at: <https://en.digst.dk/media/19337/305755_gb_version_final-a.pdf> [accessed on 19 November 2021].

Die Bundesregierung, 2020. *Artificial Intelligence Strategy of the German Federal Government.* The Federal Government. Available at: <https://www.ki-strategie-deutschland.de/files/downloads/Fortschreibung_KI-Strategie_engl.pdf> [accessed on 19 November 2021].

Dignum, V., 2021. The role and challenges of education for responsible AI. *London Review of Education,* 19(1), pp. 1–11. https://doi.org/10.14324/LRE.19.1.01.

Dijk, N. and Casiraghi, S., 2020. *The "ethification" of privacy and data protection in the EU. The case of Artificial Intelligence.* Privacy Hub Working Paper. Vol. 6, Nr. 22. Available at: <https://brusselsprivacyhub.eu/publications/BPH-Working-Paper-VOL6-N22.pdf> [accessed on 19 November 2021].

Duggan, S., 2020. *AI in education: Change at the speed of learning.* UNESCO IITE. Available at: <https://iite.unesco.org/wp-content/uploads/2020/11/Steven_Duggan_AI-in-Education_2020.pdf> [accessed on 19 November 2021].

Duolingo, 2021. *Official web site.* Available at: <https://www.duolingo.com/> [accessed on 19 November 2021].

Elfeky, A.I.M., 2018. The effect of personal learning environments on participants' higher order thinking skills and satisfaction. *Innovations in Education and Teaching International,* 56(4), pp. 505-516. https://doi.org/10.1080/14703297.2018.1534601

Elshani, L. and Nuçi, K.P., 2021. *Constructing a personalized learning path using genetic algorithms approach.* arXiv preprint arXiv:2104.11276.

EPRS, 2020. *The ethics of artificial intelligence: Issues and initiatives.* Scientific Foresight Unit (STOA), PE 634.452. https://doi.org/10.2861/6644

European Commission, 2020. *Special Eurobarometer 460: Attitudes towards the impact of digitisation and automation on daily life*. Available at: <https://www.europeansources.info/record/attitudes-towards-the-impact-of-digitalisation-on-daily-lives/> [accessed on 19 November 2021].

Fahimirad, M. and Kotamjani, S.S., 2018. A review on application of artificial intelligence in teaching and learning in educational contexts. *International Journal of Learning and Development,* 8(4), pp. 106-118. https://doi.org/10.5296/ijld.v8i4.14057

Flogie, A. and Aberšek, B., 2022. Artificial intelligence in education. In: *Active Learning: Theory and Practice*. IntechOpen, pp. 97-115. https://doi.org/10.5772/intechopen.96498

Gaur, U., Majumder, M.A.A., Sa, B., Sarkar, S., Williams, A. and Singh, K., 2020. Challenges and opportunities of preclinical medical education: COVID-19 crisis and beyond. *SN Comprehensive Clinical Medicine,* 2(11), pp. 1992-1997. https://doi.org/10.1007/s42399-020-00528-1

González-Calatayud, V., Prendes-Espinosa, P. and Roig-Vila, R., 2021. Artificial intelligence for student assessment: A systematic review. *Applied Sciences,* 11(12), p. 5467. https://doi.org/10.3390/app11125467.

Goodfellow, I., Bengio, Y. and Courville, A., 2016. *Deep learning.* Cambridge: MIT press.

Gradescope, 2021. *Official web site.* Available at: <https://www.gradescope.com> [accessed on 19 November 2021].

Harjani, M., 2021. *Is the EU's AI legislation a good fit for ASEAN?* East Asia Forum. Available at: <https://www.eastasiaforum.org/2021/07/14/is-the-eus-ai-legislation-a-good-fit-for-asean/> [accessed on 19 November 2021].

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S.B., Santos, O.C., Rodrigo, M.T., Cukurov, M., Bittencourt, I.I. and Koedinger, K.R., 2021. Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education,* in press. https://doi.org/10.1007/s40593-021-00239-1.

Huang, J., Saleh, S. and Liu, Y., 2021. A review on artificial intelligence in education. *Academic Journal of Interdisciplinary Studies,* 10(3), pp. 206–206. https://doi.org/10.36941/ajis-2021-0077.

INQ LAW, 2021. *Canada's AI Regulation Landscape: A Review of Four Federal and Provincial Initiatives*. Available at: <https://www.inq.law/post/canada-s-ai-regulation-landscape-a-review-of-four-federal-and-provincial-initiatives> [accessed on 19 November 2021].

Janiesch, C., Zschech, P. and Heinrich, K., 2021. Machine learning and deep learning. *Electronic Markets,* 31, pp. 685–695. https://doi.org/10.1007/s12525-021-00475-2.

Joshi, S., Rambola, R.K. and Churi, P., 2021. Evaluating artificial intelligence in education for next generation. In *Journal of Physics: Conference Series*. Bristol: IOP Publishing. Vol. 1714, No. 1, p. 012039. https://doi.org/10.1088/1742-6596/1714/1/012039.

Kaluarachchi, T., Reis, A. and Nanayakkara, S., 2021. A review of recent deep learning approaches in human-centered machine learning. *Sensors,* 21(7), p. 2514. https://doi.org/10.3390/s21072514.
Kaur, K., 2021. Role of artificial intelligence in education: Peninsula College Central Malaysia. *International Journal of Academic Research in Progressive Education and Development,* 10(2), pp. 1006–1016.
Kazim, E., Almeida, D., Kingsman, N., Kerrigan, C., Koshiyama, A., Lomas, E. and Hilliard, A., 2021. Innovation and opportunity: review of the UK's national AI strategy. *Discover Artificial Intelligence* 1(1), pp. 14. https://doi.org/10.1007/s44163-021-00014-0
Kirchner, C., 2020. *The French national committee for digital ethics.* AI regulation. Available at: <https://ai-regulation.com/the-french-national-committee-for-digital-ethics/> [accessed on 19 November 2021].
Klašnja-Milićević, A. and Ivanović, M., 2021. E-Learning personalization systems and sustainable education. *Sustainability,* 13(12), p. 6713. https://doi.org/10.3390/su13126713.
Knewton's Alta, 2021. *Official web site.* Available at: <https://www.knewton.com/> [accessed on 19 November 2021].
Knowji, 2021. *Official web site.* Available at: <https://www.knowji.com/> [accessed on 19 November 2021].
Kokku, R., Sundararajan, S., Dey, P., Sindhgatta, R., Nitta, S. and Sengupta, B., 2018. Augmenting classrooms with AI for personalized education. In: *2018 IEEE international conference on acoustics, speech and signal processing (ICASSP)*. Calgary: IEEE. pp. 6976–6980. https://doi.org/10.1109/ICASSP.2018.8461812.
Lam, T.C., Hoang, N., Low, B.K.H. and Jaillet, P., 2021. Model fusion for personalized learning. In: *International Conference on Machine Learning*. PMLR. pp. 5948–5958.
Larchenko, V. and Barynikova, O., 2021. New technologies in education. In: *E3S Web of Conferences*. Les Ulis: EDP Sciences. Vol. 273, p. 12145. https://doi.org/10.1051/e3sconf/202127312145
Liakos, K.G., Busato, P., Moshou, D., Pearson, S. and Bochtis, D., 2018. Machine learning in agriculture: A review. *Sensors*, 18(8), p. 2674. https://doi.org/10.3390/s18082674
Luckin, R. and Cukurova, M., 2019. Designing educational technologies in the age of AI: A learning sciences-driven approach. *British Journal of Educational Technology,* 50(6), pp. 2824–2838. https://doi.org/10.1111/bjet.12861.
Maghsudi, S., Lan, A., Xu, J. and van Der Schaar, M., 2021. Personalized education in the artificial intelligence era: What to expect next. *IEEE Signal Processing Magazine,* 38(3), pp. 37–50. https://doi.org/10.1109/MSP.2021.3055032.
Magomadov, V.S., 2020. The application of artificial intelligence and Big Data analytics in personalized learning. *Journal of Physics: Conference Series,* 1691, p. 012169. https://doi.org/10.1088/1742-6596/1691/1/012169
Ministry of Economic Affairs and Employment of Finland, 2018. *Work in the Age of Artificial Intelligence.* Available at: <https://www.google.com/search?client=safari&rls=en&q=work+in+the+age+of+artificial+intelligence&ie=UTF-8&oe=UTF-8> [accessed on 19 November 2021].
Mitchell, A.M., Dokei, T., Hickman, T. and Albagli, D., 2020. *Regulation of Artificial Intelligence in Europe and Japan.* White & Case Technology Newsflash. Available at: <https://www.mondaq.com/new-technology/1010204/regulation-of-artificial-intelligence-in-europe-and-japan> [accessed on 19 November 2021].
Murphy, R.F., 2019. Artificial intelligence applications to support K–1 2 teachers and teaching. *Rand Corporation,* 10, pp. 1-21.
NCSL, 2022. *Legislation Related to Artificial Intelligence.* Available at: <https://www.ncsl.org/research/telecommunications-and-information-technology/2020-legislation-related-to-artificial-intelligence.aspx> [accessed on 19 November 2021].
OECD.AI, 2021. *AI in Estonia.* Available at: <https://oecd.ai/en/dashboards/countries/Estonia> [accessed on 19 November 2021].
Ouyang, F. and Jiao, P., 2021. Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence,* 2, p. 100020. https://doi.org/10.1016/j.caeai.2021.100020
Owoc, M.L., Sawicka, A. and Weichbroth, P., 2019. Artificial intelligence technologies in education: Benefits, challenges and strategies of implementation. In: *IFIP International Workshop on Artificial Intelligence for Knowledge Management*. Cham: Springer. pp. 37–58. https://doi.org/10.1007/978-3-030-85001-2_4
Pantazi, X.E., Moshou, D., Oberti, R., West, J., Mouazen, A.M. and Bochtis, D., 2017. Detection of biotic and abiotic stresses in crops by using hierarchical self organizing classifiers. *Precision Agriculture,* 18(3), pp. 383-393. https://doi.org/10.1007/s11119-017-9507-8
Pedro, F., Subosa, M., Rivas, A. and Valverde, P., 2019. *Artificial intelligence in education: Challenges and opportunities for sustainable development.* United Nations Educational, Scientific and Cultural Organization (UNESCO).
Pizzi, M., Romanoff, M. and Engelhardt, T., 2020. AI for humanitarian action: Human rights and ethics. *International Review of the Red Cross,* 102 (913), pp. 145–180. https://doi.org/10.1017/S1816383121000011
Pokrivčáková, S., 2019. Preparing teachers for the application of AI-powered technologies in foreign language education. *Journal of Language and Cultural Education,* 7(3), pp. 135–153. https://doi.org/10.2478/jolace-2019-0025.
Roh, Y., Heo, G. and Whang, S.E., 2019. A survey on data collection for machine learning: A big data-AI integration perspective. *IEEE Transactions on Knowledge and Data Engineering,* 33(4), pp. 1328–1347. https://doi.org/10.1109/TKDE.2019.2946162.
Sarker, I.H., 2021. Machine learning: Algorithms, real-world applications and research directions. *SN Computer Science,* 2(3), p. 160. https://doi.org/10.1007/s42979-021-00592-x.
Sheehan, M., 2022. *China's New AI Governance Initiatives Shouldn't Be Ignored.* Carnegie. Available at: <https://carnegieendowment.org/2022/01/04/china-s-new-ai-governance-initiatives-shouldn-t-be-ignored-pub-86127> [accessed on 19 November 2021].

Shemshack, A. and Spector, J.M., 2020. A systematic literature review of personalized learning terms. *Smart Learning Environments,* 7(1), p. 33. https://doi.org/10.1186/s40561-020-00140-9.

Shestak, V., Gura, D., Khudyakova, N., Shaikh, Z.A. and Bokov, Y., 2020. Chatbot design issues: building intelligence with the Cartesian paradigm. *Evolutionary Intelligence,* in press. https://doi.org/10.1007/s12065-020-00358-z

Tapalova, O. and Kuatbekov, A., 2021. The use of digital media resources educating the education managers. pedagogy and psychology. *Pedagogy and Psychology,* 47(2), pp. 129–137.

Tedre, M., Toivonen, T., Kahila, J., Vartiainen, H., Valtonen, T., Jormanainen, I. and Pears, A., 2021. Teaching machine learning in K–12 classroom: Pedagogical and technological trajectories for artificial intelligence education. *IEEE Access,* 9, pp. 110558–110572. https://doi.org/10.1109/ACCESS.2021.3097962.

Tetzlaff, L., Schmiedek, F. and Brod, G., 2021. Developing personalized education: A dynamic framework. *Educational Psychology Review,* 33(3), pp. 863–882. https://doi.org/10.1007/s10648-020-09570-w.

Tuomi, I., 2018. *The impact of artificial intelligence on learning, teaching, and education.* Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/12297.

Vlasova, E.Z., Avksentieva, E.Y., Goncharova, S.V. and Aksyutin, P.A., 2019. Artificial intelligence-The space for the new possibilities to train teachers. *Scientific Bulletin,* 40(9), pp. 17-23.

Walkington, C. and Bernacki, M.L., 2020. Appraising research on personalized learning: Definitions, theoretical alignment, advancements, and future directions. *Journal of Research on Technology in Education,* 52(3), pp. 235–252. https://doi.org/10.1080/15391523.2020.1747757.

Whalley, B., France, D., Park, J., Mauchline, A. and Welsh, K., 2021. Towards flexible personalized learning and the future educational system in the fourth industrial revolution in the wake of Covid-19. *Higher Education Pedagogies,* 6(1), pp. 79–99. https://doi.org/10.1080/23752696.2021.1883458.

Williamson, B. and Eynon, R., 2020. Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology,* 45(3), pp. 223–235. https://doi.org/10.1080/17439884.2020.1798995.

Xinhua, 2020. *Israel launches national AI plan at cost of 1.63 bln USD.* Available at: <http://www.xinhuanet.com/english/2020-12/23/c_139613874.htm> [accessed on 19 November 2021].

Zawacki-Richter, O., Marín, V.I., Bond, M. and Gouverneur, F., 2019. Systematic review of research on artificial intelligence applications in higher education–where are the educators? *International Journal of Educational Technology in Higher Education,* 16(1), p. 39. https://doi.org/10.1186/s41239-019-0171-0.

Zhang, D., Mishra, S., Brynjolfsson, E., Etchemendy, J., Ganguli, D., Grosz, B., Lyons, T., Manyika, J., Niebles, J.C., Sellitto, M., Shoham, Y., Clark, J. and Perrault, R., 2021. *The AI Index 2021 Annual Report*. Stanford: AI Index Steering Committee, Human-Centered AI Institute, Stanford University. Available at: <https://aiindex.stanford.edu/wp-content/uploads/2021/11/2021-AI-Index-Report_Master.pdf> [accessed on 19 November 2021].

Zhang, K. and Aslan, A.B., 2021. AI technologies for education: Recent research & future directions. *Computers and Education: Artificial Intelligence,* 2, p. 100025. https://doi.org/10.1016/j.caeai.2021.100025.

Zhang, L., Basham, J.D. and Yang, S., 2020. Understanding the implementation of personalized learning: A research synthesis. *Educational Research Review,* 31, p. 100339. https://doi.org/10.1016/j.edurev.2020.100339

Zlatarov, P., Ivanova, E., Ivanova, G. and Doncheva, J., 2021. Design and development of a web-based student screening module as part of a personalized learning system. *TEM Journal,* 10(3), pp. 1454–1460. https://doi.org/10.18421/TEM103-58.