



AI In Education: A Matrix

Tılfarlıođlu, Filiz Yalçın^a, Gökdemir Ahmet Nejdet^b

^a Gaziantep University, Foreign Languages Education Department & Professor, Türkiye, email: fyalcin@gantep.edu.tr

^b Gaziantep University, Foreign Languages Education Department & Student, Türkiye, email: nejdet.1925@gmail.com

APA Citation:

Yalçın, F.T., Nejdet, A.G., (2021). AI in education: A Matrix. *Journal of Language and Linguistic Studies*, 22(1), 14-32; 2026.

Abstract

During the 21st century, Artificial Intelligence (AI) has rapidly occurred as a noteworthy technology, bringing far-reaching and transformative applications in education, and has become a decisive focus for educators, researchers, and policymakers. This article begins with a conceptual introduction to the technology, attempting to establish a clear understanding of its nature and functionality in the context of teaching and learning. Generally, the definition of AI is the imitation of human cognitive processes by automated devices. The educational applications of AI focus on a variety of specific areas, including adaptive learning, machine learning, intelligent tutoring systems. With the rapid and enormous advancements in technology, AI has quickly become widely used worldwide in many areas. Education has also been thoroughly and profoundly affected by the evolving AI. In this paper, the objective is to present the readers a look at the current literature on how AI is used in educational contexts. Various aspects of AI, including main opportunities and challenges, have been presented.

Keywords: artificial intelligence; evolving technology; education technologies; intelligent tutoring systems.

1. Introduction

This article aims to provide a detailed overview of AI's origins, development, opportunities, application areas, and challenges, exploring its role in education. It aims to provide both a conceptual foundation and, by providing concrete examples of AI's impact on today's learning environments, to integrate theoretical considerations with practical applications. Considering not only its advantages but also its ethical and pedagogical concerns, it is going to offer comprehensive understanding of the potential and limitations of the implementation of AI in educational context for educators, researchers, and policymakers.

In this era of the 4th Industrial Revolution, almost every human activity has become tightly connected to the application of information technologies (IT) as a support in various tasks. IT is considered as not only an instrument, but also a mandatory element. The developments that provide great support in human life have brought about a strong dependence on information technologies (Rahmatullah et al., 2022). On top of that, because in the digital age technology has a vital role more than ever, the majority of people of the day are educated in terms of technological tools. The increase in literacy, combined with new technological developments, has contributed to the spread of educational technology. Generations such as millennials and Gen-Z have unique features affecting their age. They demand active participation in education. Consequently, technology has become a part of contemporary education and it is required to be integrated into educational settings (Hashim, 2018).

It is no longer a choice but a compulsion for contemporary educational facilities that are at the top university level to utilise IT in their instruction. This is owing to the fact that such education demands

solid management which guarantees openness, responsibility, productivity and potency. Today, how important information and communication technology (ICT) has become is increasingly understood because it is among the cornerstones of the development of human civilization. The seriousness of the management approach ensures that the use of ICT is the basic element in education (Rahmatullah et al., 2022). Remarkable breakthroughs in the field of big data and AI have created significant impacts on many social areas such as resources management, administration of public affairs, research and schooling (Luan et al., 2020). AI, an algorithm-based technology that can make predictions, diagnoses, recommendations, and judgments, has recently gained popularity in education thanks to its ability to foster education in different environments. Artificial intelligence refers to sophisticated computing systems characterised by adaptive behavioural patterns, encompassing mechanisms and elements that enable human-like mental and operational traits. This improves supercomputer's human interaction capability. Artificial intelligence denotes the capacity of a software application to acquire knowledge and perform cognitive processes. Artificial intelligence includes anything that involves a program that performs tasks that people usually associate with intelligence (Mitchell, 2019).

2. Literature review

The field of AI is with a deep history and is continually advancing and expanding. It concentrates on algorithms or technologies which adapt themselves to their environments and respond to increase their probability of achievement (Shabbir & Anwer, 2018). For more than 20 years, computers have been used in educational settings. The earliest computer-based education methods included computer-based training (CBT) and computer-assisted instruction (CAI). In these techniques, instruction was not tailored to student needs. Instead, student progress was predetermined, with decisions like, "If question 21 is answered correctly, move on to question 54; otherwise, move on to question 32." Students' abilities were not considered. Both CBT and CAI can address student needs, but they cannot offer the personalised attention provided by a human instructor. To provide such attention, a computer-aided learning system must be designed to suit both the subject matter and the students. This has fostered research on intelligent tutoring systems (ITSs). They enable greater versatility in material display, allowing them to respond more effectively to individual pupil demands. They acquire "intelligence" through enabling pedagogical decisions regarding teaching methods and the collection of student data. This allows the system to monitor its interactions with the student, increasing its adaptability.

The field focuses on researching, creating, and evaluating software solutions that enhance learning processes. Various long-term goals are proposed, including understanding student responses, analysing their impact on learning ability, identifying gaps in a student's knowledge, providing tips to help students better grasp the material, and ultimately, enabling them to mimic teacher behaviour. It is suggested that tutors be developed for individual students or groups based on factors such as gender, achievement level, and duration of instruction. Another goal is to use AI methods to inform teaching and learning while contributing to educational theory. Almost every term in the previous definition of "intelligent teacher" requires AI techniques; these include the ability to understand complex student responses, support student learning, identify when and why students are struggling, and offer guidance. The primary issues (or goals) of AI studies include reasoning, knowledge, planning, learning, vision, natural language processing, and the ability to navigate and control objects. In order to evaluate collaborative activity, give a detailed understanding of how individuals learn, and create novel representations and reasoning about cognitive insights, artificial intelligence approaches are crucial. Artificial intelligence in education (AIED) has been used in complex areas such as physics, programming, essay writing, and reading. Many tutors learn each pupil's competences and shortcomings across various subjects, their abilities, and emotional states. How effective are intelligent tutors? Numerous tutors have proven highly effective in classrooms. Researchers have examined students' abilities in experiments, at the end of classes, and on large-scale standardised tests and found significant improvements in comprehension and learning.

Intelligent online tutors are successful examples of AI, but researchers want to support learning across different activities and domains by moving from one domain to another. To effectively guide and assist anyone, experienced instructors are going to review educational tasks and mirror emerging trends among students. Predictions about an individual's skills or affective condition, derived from student illustrations, reveal their knowledge, feelings, and actions. What was the time and the means by which the information was acquired? Which method was the most effective for the pupil? Analysing particular forms of educational data and using data extraction and machine learning approaches from artificial intelligence for better comprehension of pupils and their learning processes is vital.

3. Method

The descriptive study approach is used in this article to provide the readers with an overview of how AI is utilised in educational settings. The study has a purpose of describing a brief history, opportunities and practical applications, challenges and ethical considerations of the mentioned utilisation.

3.1. Data collection and analysis

A comprehensive investigation of the recent literature was the means by which data was collected for this article. This process involved locating relevant sources about the broad subject of AI and education. The selection criteria mainly focused on historical context, applications, and ethics with regard to AI. The data that was collected was analysed with a thematic content analysis approach. The information was categorised and organised into separate themes.

4. Results and discussion

4.1 Opportunities and practical applications

The chapter 4.1.1 examines the enriching possibilities of AI in education. It highlights AI's capability to personalise learning by customising educational processes to specific demands of pupils, thus adapting to different learning styles and abilities. Additionally, AI can help teachers by carrying out administrative duties like attendance and grading, freeing them up to concentrate more on instruction and pupil participation. Another option is to use AI-powered analytics to identify learning disabilities, predict student performance, and make educational decisions. These potentials position AI as a key ally in creating more effective, inclusive, and successful educational institutions. In light of the previous discussion of AI's potential, the following chapter 4.1.2 provides concrete examples of current uses of AI in education. Examples of practical applications include intelligent tutoring systems that provide personalised feedback, software that supports language learning, chatbots that provide instant academic assistance, and adaptive applications which modify the level of complexity of the content depending on pupils' progress. The section also discusses administrative uses of AI, such as improving resource allocation and predicting student enrolment trends. This chapter explains, through real-world examples, how theoretical possibilities translate into practical results in classrooms and educational institutions. The chapter 4.1.3 explores classic AI applications, as well as emerging technologies that combine AI, VR, and AR. Previously unimaginable digital educational practices can now be realised with the help of these technologies. For instance, pupils may carry out scientific experiments in virtual laboratories and see historical locations using virtual reality, and develop language skills in virtual cultural environments. Augmented reality enhances the physical classroom environment by adding digital layers, supporting interactive and multifaceted learning. Such tools, especially paired with AI, can provide individualised recommendations and customise students' experiences according to their developmental stage, resulting in a highly efficient and captivating atmosphere for learning

4.1.1 Opportunities

The field of study known as AI in Education (AIED) emerged concurrently alongside the first AI studies. It combines use-inspired basic and pure applied research. AIED systems incorporate learner models, domain expertise, teaching expertise, and user interfaces. The learner model drives personalisation in instruction by representing knowledge, misconceptions, interests, and objectives. It must depict the components that power the system, like evaluating the behaviour of the students and creating their own initiatives. This constitutes precisely the foundation of AIED applications since it allows the program to "fully engage" with the student, while the student model allows the system to better understand the student and guide educational customization. The learner model is closely intertwined with two other crucial components: domain expertise and teaching expertise. Indeed, AIED systems require a strong connection between the representations used in these elements; all three elements must work together to ensure effective instruction. AIED systems must cope with uncertain, inconsistent, and complex data about learners. For example, learners can make both errors and accurate yet unknowing predictions. AIED systems are developed so that the model does not change monotonically with the learner's development. The fourth element in the traditional perspective on AIED systems is the user interface. This encompasses various AIED research areas, such as perception, interface design, and intelligent interactive environments. Many AIED researchers focus on developing interfaces that make learning more effective by making interactions genuine, engaging, and efficient. For instance, a fundamental aspect of AIED studies is the pursuit of natural language interfaces that require speech understanding in certain situations, along with natural language understanding and production. AIED's recent work has significantly contributed to the development of interface tools, including avatars that generate identity based on language, facial expressions, and elements such as race and gender. Furthermore, significant efforts have been made to design interfaces that understand students' emotional and motivational states. The picture encompasses many different types of interfaces, including simulations and gaming environments. There have been some significant recent trends in the vast and varied corpus of AIED research. The development of some systems based on cognitive theories has been a significant one, and significant strides have been made in the development of instruments that facilitate the expansion of earlier systems' constituent parts. Examples include the commonly used cognitive tutors that thousands of students use on a daily basis. Constraint-based tutors can be mentioned, as well. Interestingly, the learner model is depicted in the graphic as more than just an AIED system component. As an open learner model, it can be directly linked to an interface.

AI is the capacity of computer systems to mimic human mental functions such as acquiring knowledge and figuring out solutions. The advent of easily accessible AI applications like ChatGPT has made it more crucial than ever to think about how AI could impact and enhance education. Three major groups can be made to classify the effects of AI on educational settings: "Guidance," "Teacher," and "Student" to make weighing its advantages and disadvantages easier. New techniques with a more defined focus can be developed by classifying previous AI attempts in education. As AI advances and becomes more widespread, it is clear that having a proper organisational structure will help make better informed decisions about the future of AI use and educational processes.

AI programs that help teachers and students make decisions are loosely referred to as "Guidance" AI. Some examples of such programs are Teacher Recommendation System, Identifying At-Risk Students and Giving Intervention, and Informative Actionable Feedback. A recommendation system for online instructors and students has been developed with the support of AI (Chen et al., 2021). During remote individual sessions, such tools are crucial for correctly matching faculty members and students. Students and teachers should be carefully matched to minimise programming errors and communicative problems. Previous student feedback and evaluations may be deceptive and untrustworthy, reducing the effectiveness of the recommendation system. To develop recommendations, AI predicted which teachers and students were compatible with each other based on data on the academic backgrounds of instructors and students, and used this information to recommend specific professors to certain students. One study

by Hlosta et al. (2021) used AI to predict children who might not receive intervention. It applied predictive learning analytics (PLA) for estimating pupil performance. The estimations employed were utilised to determine those pupils more likely to be in failure, allowing teachers to reach out and intervene. Students who received support were more likely to succeed. The study also found that intervention benefited disadvantaged students who were financially struggling or belonged to a minority group (Hlosta et al., 2021). The study claims that AI can minimise educational disparities and enhance access. However, it is emphasised that this needs to be supported with more replication. AI has also been utilised to assist pupils in determining things to do to increase their academic success. Scholars have created a software which predicts academic success using information compiled by a learning management system (Afzaal et al., 2021). These predictions have been used to automatically generate practical feedback that students can take to boost their educational achievement, including reviewing instructional materials or completing homework. When applied, this method creates input through a method known as counterfactual explanations to determine the decisions that will have the most impact on the AI's predictions. Such activities serve as feedback for students to benefit from. This process promotes self-regulation and personalised learning, leading to increased productivity.

"Student" educational AI is the term used to describe the integration of AI and instructional concepts to improve the effectiveness of instruction, as for example by transforming education to be a better experience or serving as a readily available and customised tutor. Learning analytics, game-based learning, and intelligent tutoring systems are a few instances of "learning AI." STEM education is the main topic of the online course ALEKS. ALEKS presents pupils with a variety of "topics" and then administers progress tests to measure their achievement. Progress tests can be considered significant for allowing to determine how well a pupil retains acquired knowledge. However, according to student feedback, ALEKS users tend to prefer to acquire new knowledge based on progress tests. Scholars also found that following a progress test, pupils are more unlikely to respond to a query due to "assessment fatigue" (Adams et al., 2021). For enhancing progress tests, scholars employed AI technology to identify themes less remembered and ought to be added to the check. Later, scholars utilised these estimations to improve the themes that the progress checks would assess to increase learning gains. They described learning gain as themes that were retained in the progress test. Adams et al. (2021) reported a 9% increase in learning gains for two groups of approximately 150,000 students between 2019 and 2020. This increase is thought to be related to the COVID-19 pandemic. As stated by the Entertainment Software Association, 65 percent of people living in the USA spend no less than sixty minutes playing digital games each week (Pierre-Louis, 2023). Taking advantage of the rising popularity of digital games, teachers may incorporate gamification into their lessons for a collaborative education environment. According to Kirchner-Krath et al. (2021), educational games use medals, scores, stories, tasks, and more to direct pupils throughout instructional exercises, give prompt feedback, and divide learning material into smaller assignments. To boost student interest and engagement, educational games can incorporate features like plots, in-game awards, or captivating graphics. AI can adjust gameplay to the player's learning level and gather information for learning analytics by allowing human-like interactions with non-player characters. One such is the game-based learning platform Crystal Island, which has a microbiological theme and requires students to identify a sickness that affects people on an island. According to Rowe et al. (2009), the narrative objectives, the student's present interactions, and their game progress can all influence this story. For instance, the AI can anticipate the student's objectives and reinterpret the narrative in light of the information the student has gathered, such as character dialogue or hints (Dever et al., 2021). This suggests that students can use easily accessible adaptive support to self-regulate their learning when needed (Goslen et al., 2022).

"Teacher" AI is the term for AI tools that support teachers in their instruction. In this instance, AI serves as a supplement to the instructor by, for example, increasing the number of hours used on instruction through handling unnecessary duties or widening the range of flexible teaching techniques available to

teachers. AI-enabled novel teaching methods and automated grading are some of the examples. Automatic essay evaluation systems use artificial intelligence techniques to score essays. In this process, machine learning method is used to evaluate texts without needing human intervention. Natural language processing method is also used during the process of evaluation. AI software tries to understand which essays are of higher quality by examining trends in essays that have been previously evaluated by humans. Although an AI model cannot fully grasp the reasons behind the quality of an essay and may ignore the subtle details and the setting, it may predict accurate scores based on statistical data from essays that have received high scores in the past. Automatic essay graders can be further developed through utilising item response theory for averaging across numerous raters (Aomi et al., 2021). Teachers who use automatic scoring systems can save time spent on manual scoring and focus on interaction with their pupils. Future essay graders can improve the ability of theirs for offering personalised feedback by making it easier to analyse essays and free responses. Inq-ITS examines students' responses and engagement levels in an online lab environment with AI support. Pupils' progress through the experiment is tracked simultaneously, allowing for predictions on when assistance is required (Dickler et al., 2021). On condition that a pupil is struggling with a particular issue or notion, the AI is capable of identifying it and notifying the instructor for assistance. This type of technological innovations allows educators to efficiently recognise and guide pupils who are struggling, ensuring that the entire class progresses without falling behind.

Classifying AI-based teaching strategies can promote development that is both safe and efficient. In relation to AI in education, the groups "Student," "Teacher," and "Guidance" were proposed. "Student" includes methods supporting learning, "Teacher" includes methods supporting instructor instruction, and "Guidance" refers to methods that support academic management. These organisations may provide a basis for grasping AI's applications in education, which can help advance the field.

4.1.2 Practical applications

AI's implementation in education has many potential advantages. For instance, AI has the potential to customise every pupil's educational journey, allowing them to progress at their own pace and in alignment with their individual needs and abilities. This could lead to increased pupil participation and improved educational results. Personalised learning is an educational approach tailored to the unique needs, strengths, shortcomings, and interests of every individual (Samad et al., 2022). Personalised learning employs technological resources to organise courses in line with the levels and learning speeds of students (Zarei et al., 2022). AI greatly contributes to personalised learning by examining data and identifying patterns in pupils' learning behaviours, choices and success (Samad, 2022). It can then utilise the data for providing personalised learning experiences for every pupil (Samudrala et al., 2022). As an instance, AI may provide suitable educational materials, identify themes requiring reinforcement, and modify the complexity of activities. A crucial advantage of personalised learning is how it ensures every pupil gets the assistance and direction necessary to fully realise their capabilities. Personalised learning can assist pupils who are facing difficulties in developing their skills, and at the same time also providing challenges for those who are more competent, allowing them to thrive at their own pace (Gningue et al., 2022). When students have personalised learning experiences, they are more motivated in learning, resulting in increased achievement (Al-Abboodi et al., 2021). AI-powered educational applications may customise the educational process according to pupils (Ibrahim et al., 2022). As an instance, AI has the capability to analyse pupils' previous achievements to determine the subjects they are struggling with and offer focused assistance in these domains (Alarabi & Wardat, 2021). AI may adjust to the pupil's success rate, either decelerating or accelerating the educational experience as needed (Mohammed Al-Bahrani et al., 2020). In addition, AI has the capability to deliver specific suggestions regarding pupil achievement and recommend areas for enhancement, thereby fostering a more individualised and impactful educational journey. Personalised learning with AI continues to be effectively implemented

across diverse instructional sectors, including K-12 institutions, colleges and universities, and business education (Mohammed, Samad, & Omar, 2022). As an instance, a math software powered with AI by Carnegie Learning showed 30% improvement in students' mathematics achievement. Duolingo's AI-driven application offers personalised learning opportunities specific to students' proficiency levels, preferences, and study methods (Al-Bahrani et al., 2022). While the advantages of personalised learning through AI are promising, there are certain issues that must be addressed. A significant concern is the necessity for reliable and precise data to feed AI systems (Wu et al., 2022). Making sure the data is consistent and correct is crucial because the quality of the data might impact how accurate a personalised learning experience is. The requirement that educators receive training in order to successfully incorporate AI-based personalised learning is also an issue (Zahmatkesh et al., 2022). Educators should be informed about AI tools' utilisation and the analysis and application of data provided by algorithms. Personalised learning supported by AI has the capacity to transform students' learning processes and their ability to fully realise their potential. Personalised learning can increase academic achievement, reduce dropout rates, and increase engagement by providing appropriate support for each individual. AI may offer a personalised and efficient learning experience by providing specific feedback and suggestions for progress (Jarrah et al., 2022). The advantages of AI-supported personalised learning in education are considerable and propitious, despite certain drawbacks.

Moreover, teachers and students may focus on more important work by using AI to automate repetitive tasks like data analysis, grading, and administrative work. By automating grading and evaluation processes, AI can save educators time and effort while providing instant feedback to students (AlAli et al., 2023). AI systems review pupil projects and deliver recommendations according to set frameworks, which allows pupils to obtain instant information about what they have achieved (M Al-Bahrani et al., 2018; Li et al., 2022). Automated writing assessment systems are an example of AI-based automated assessments (Stoica & Wardat, 2021). These systems analyse student writing using machine learning strategies for providing rapid feedback and scoring.

Also, AI can enhance pupil participation through providing dynamic and captivating learning chances. Chatbots and virtual assistants, as an instance, may enhance the educational experience, making it more engaging and interactive, while adaptive learning technologies may maintain pupil curiosity by delivering content tailored to their comprehension. Chatbots are software that interact and communicate with humans via written or voice interfaces (Sreenivasu et al., 2023). Lately, the use of chatbots in education has increased, providing personalised assistance for pupils, carrying out administration-related processes, creating innovative chances for participation (Yeruva et al., 2022). A significant advantage of chatbots in the realm of instruction is their ability to offer tailored assistance to pupils. These robots serve as digital mentors, offering immediate responses to pupils, addressing their enquiries, and steering them through the educational journey (Sridhar et al., 2022). In addition, they may make personal suggestions for teaching materials, identify where development is needed, and monitor pupil growth, which can provide a customised educational journey. One more advantage of employing chatbots in educational settings is their ability to streamline administrative duties (Mohammed Al-Bahrani et al., 2022). Chatbots have the capability to handle repetitive tasks like launching applications, taking down notes, and responding to common enquiries, thereby enabling educators to dedicate more time to critical matters such as instruction and mentorship (Gningue et al., 2022). This automated process may as well be beneficial by reducing failures in administration and discrepancies, making operations more efficient and accurate. Chatbots may as well offer novel ways to increase interaction in education (Patil et al., 2022). Chatbots, together with conversational interfaces, can improve learning processes by encouraging engaged participation and promoting pupil motivation. Chatbots have the potential of offering gamified learning by organizing activities and offering rewards and motivation to achieve learning goals (Stoica & Wardat, 2022). A number of instructional establishments and organisations have incorporated chatbots into their educational processes (Yeruva et al., 2023). As an instance,

Georgia State University has launched the chatbot “Pounce,” which answers students’ enquiries and provides assistance with regard to instructional and administration-related stuff. In addition, the University of Adelaide in Australia has developed a chatbot called “MyUni,” which supports students with administrative issues such as registration, programs, and course information (Mohammed Al-Bahrani, 2019; Yeruva, Durga et al., 2022). In addition, Duolingo’s chatbot allows students to improve their spoken language skills and receive feedback.

A platform introduced by Google in 2023 called NotebookLM is among the noteworthy innovations of AIED. The educational and research capabilities of Google NotebookLM are characterised by its reliance on a retrieval-augmented generation (RAG) architecture, which ensures that all generated outputs are derived from user-provided source materials. This design effectively mitigates the risk of AI-generated misinformation and hallucinations, thereby fostering greater reliability and transparency within academic environments (Tozuka et al., 2024). By anchoring responses in specific lecture notes, research articles, and transcripts, the platform facilitates a more relevant and contextualised learning experience than traditional large language models. Several practical applications of this technology are identified across the higher education landscape. As a research companion, the tool can be utilised to streamline literature reviews by summarising extensive texts, clustering similar concepts, and identifying overarching themes. Academic integrity is further reinforced through citation-aware question-answering, which allows for the precise tracing of ideas back to their original sources. In the context of curriculum development, the platform is employed to perform rapid content audits, ensuring that intended learning outcomes are pedagogically aligned with assessment tasks and instructional activities. For instructional purposes, NotebookLM is used to generate personalised study aids, including summaries, flashcards, and timelines tailored to individual student needs. An interactive podcast feature enables the conversion of complex scientific papers into conversational audio dialogues, which supports auditory learners and promotes deeper conceptual understanding. Furthermore, the platform is applied in teaching delivery to manage high-volume Q&A settings, functioning as a real-time tutor that maintains consistency with course-specific terminology. Through these multimodal outputs, diverse learning preferences are accommodated while cognitive load is reduced, ultimately promoting self-regulated learning and generative AI literacy (Hu, 2024). While the pedagogical benefits are significant, several drawbacks and institutional risks are identified in relation to the integration of Google NotebookLM. Concerns regarding copyright and intellectual property are raised, particularly as the platform enables the public sharing of notebooks (The Verge, 2025). If a notebook contains copyrighted journal articles or book chapters, public distribution may violate legal standards and service terms unless specific licensing agreements are in place. Financial and scalability issues are also highlighted as potential barriers to adoption. The introduction of a premium “Pro” version suggests that access to expanded features may be limited for financially disadvantaged groups. This can pose as a risk to educational equity, potentially widening the digital divide for students and institutions with limited financial resources. Furthermore, there are technical limitations and the risk of overreliance on automated outputs. Although the retrieval-augmented generation (RAG) architecture minimises hallucinations, the accuracy of the AI remains dependent on the quality of the uploaded documents. Users may develop a false sense of comprehensiveness, potentially overlooking critical knowledge gaps that exist beyond the curated source material. Therefore, educator oversight is essential to ensure pedagogical accuracy and to mitigate the effects of any biases present in the original documents. Finally, institutional governance and long-term sustainability are also issues to be handled. Data privacy must be evaluated to ensure compliance with local protection laws, particularly when sensitive student information is involved. Additionally, because the developer company has a history of discontinued services, this creates uncertainty regarding the long-term availability of the platform. The withdrawal of service support could significantly disrupt established teaching and research workflows. Consequently, integrating Google NotebookLM into higher education requires to be grounded in robust pedagogical

principles and empirical evidence. For AI to be both sustainable and transformative, institutional policies must be established to address data governance, accessibility, and intellectual property proactively.

Artificial intelligence tools, which cover a wide range from adaptive learning platforms that customise lessons according to student needs to intelligent tutoring systems that provide instant feedback, have changed the educational environment. In addition, AI-based solutions enhance the review of extensive instructional information, allowing teachers to access precious information on pupil achievement, study patterns, teaching efficiency (George and Wooden, 2023). Artificial intelligence-supported virtual reality (VR) and augmented reality (AR) apps present experiential educational opportunities which go beyond the limits of traditional classroom experiences.

Artificial intelligence is often seen as a powerful tool capable of transforming education (Chen et al., 2020; Pedro et al., 2019; Alam, 2021). Educators can leverage AI tools for improving the instructional experience and student performance, simplifying administration-related processes, and creating engaging educational settings. The potential to offer students individualised learning experiences is among the most important advantages of incorporating AI into education. Traditional standardised education approaches frequently struggle in adapting to the diverse learning preferences and speeds of each pupil (Lopez and Schroeder, 2008; Mustafa, 2015). Yet, AI-based adaptive education platforms can analyse large data sets regarding pupil progress and choices for tailoring education to the specific needs of each student (Gligorea et al., 2023). These systems can dynamically adjust the content, pace, and difficulty of learning materials based on immediate feedback, ensuring that students receive support and challenges appropriate to their ability levels. Personalised educational opportunities increase pupil participation, motivation, and success because pupils enjoy a sense of confidence and aid throughout the process of education (Song et al., 2012; Zakaria et al., 2024). Additionally, personalised learning may aid in reducing inequalities in success and foster equality through ensuring that every pupil receives effective, customised education (Patrick et al., 2016; Pape & Vander Ark, 2021). AI-powered chatbots, for instance, may imitate human teachers by conducting engaging conversations, answering questions, and providing quick responses. Additionally, AI-powered instructional simulations and games give students fun, interactive opportunities to use what they've learned in real-world situations. Teachers can devote more time and effort to instructing and guiding pupils by using AI to automate administrative duties. AI-powered solutions automate mundane administrative tasks like grading, designing and planning lessons, freeing up instructors to create captivating educational opportunities, provide personalised assistance toward pupils, and collaborate with coworkers. AI also helps teachers examine data on pupils using machine learning to find recurring themes and opportunities for improvement. This methodology helps teachers better choose educational approaches, actions, materials, helping them achieve better teaching and learning outcomes.

4.1.3 Virtual reality and augmented reality: A dimensional transition

VR and AR have lately become prominent technologies. They make it possible for individuals to access the digital world. The chance of combining the digital and real worlds enhances creativity and interaction opportunities by enabling the transfer or transformation of information. Creators have the ability to merge their virtual creations with real life, while players can bring the game universe from their computer monitors to the real world, and more information can be transmitted quickly in physical offices. Cinematographer Morton Heilig developed virtual reality (VR) in 1950 to provide audiences with a cinematic experience. Virtual reality (VR) can be defined as an electronically designed environment that is used through tools that enable interaction. VR display equipment falls into three main categories: spatial projector, head-mounted device (HMD), and hand-held devices. HMD is a device that allows users to interact with their environment. This immersion measures users' perception of their "reality" within the electronically generated environment.

Yet, augmented reality is a type of virtual reality which adds virtual elements to the real world. Instead of allowing users to see their real surroundings, virtual reality presents a totally virtual environment. This demonstrates that augmented reality technology enhances the real world rather than completely replacing it. Therefore, augmented reality can be considered a balance between fully virtual and fully real environments. Like virtual objects in VR, users must connect with augmented items through calibrated and programmed tools, ensuring that these objects appear compatible with the real surroundings. These tools are called human-computer interaction (HCI). This encompasses the ways people interact with virtual or augmented objects, such as a contemporary keyboard featuring physical keys, a screen, or voice detection.

The development of engaging educational settings via VR and AR technology is another fascinating possibility that AIED may offer. With these immersive technologies, students could be taken to historical locations, virtual worlds, or scientific simulations, enabling them to engage with and explore ideas in ways that aren't feasible in a conventional educational setting. As an instance, pupils in biology classes can utilise AR technology for projecting visual representations of bodily components over real objects, which allows visualising in a three-dimensional manner. Likewise, scholars studying past incidents can utilise VR for experiencing vivid recreations of significant locations or occurrences and develop better comprehension of the setting and importance of historical happenings (Yin, 2022; AlGerafi et al., 2023; Gandedkar et al., 2021).

The abilities needed by 21st-century citizens differ from those of previous centuries. Cognitive (non-routine problem solving, systems thinking, and critical thinking), interpersonal (active listening, presentation, and conflict resolution), and intrapersonal (generally grouped under adaptability and self-management/self-development personal qualities) skills are all examples of 21st century skills. For instance, two AI methods—dialogue systems and inquiry learning— can enhance instruction for 21st century abilities. In the future, in addition to offering instructors and developers real-time data to improve their teaching strategies, intelligent tutors may offer many of the advantages of a human tutor. Implementing robust discussion and communication methods is a critical step in teaching 21st-century skills. Teachers can understand the intonation and stress students use when speaking and use this to provide ongoing interaction and feedback. The interaction and feedback capabilities of intelligent tutoring systems are still limited. Systems capable of simulating authentic interactions exist. Yet, further investigation is required for better interpreting students' speech, intonation, gestures, expressions of the face and reacting appropriately. Teachers' dialogue modules ought to guide students while prompting appropriate questions to help them acquire information. The ability for computers and students to engage in deeper dialogue overcomes some limitations in human-computer communication and contributes to the development of constructivist teaching methods.

The 21st-century workforce requires both "hard" skills (traditional fields such as history, mathematics, and physics) and "soft" skills (collaboration, reasoning, disciplined thinking, creativity, social skills, metacognitive abilities, computer literacy, and the ability to evaluate and analyse information). Furthermore, navigating the contemporary information economy demands a strong tolerance for ambiguity, an eagerness for accepting strategic opportunities, and the capacity to develop innovative answers for questions which defy clear definition. Individuals living in a knowledge-based society must be able to quickly grasp innovations, frequently experiment with various problem-solving methods, and build effective teams. Individuals must address both knowledge-related challenges and opportunities. Instructors must rapidly revise their teaching methods and content to utilise current information within an area with rapid technological advancements. Let's take an example from the rapid development and unpredictable movements of the internet. The internet first emerged in the mid-1990s. As of 2015, 37.3 percent of the world's population was using the internet. Internet-related services and applications are present in nearly every aspect of modern life. How can education prepare children for this rapidly changing, profound culture? Over the past 25 years, the internet has become a crucial part of nearly all

social activities, affecting many aspects of human life. At the very least, students should be taught how to search the internet, how to obtain information from it, how to evaluate the data they obtain, how to use it responsibly, and how to present well-researched information. One solution is to strengthen and develop students' skills. Students need to be more creative, dynamic, and prone to group work; they also need to understand learning methods. Critical thinking, creativity, teamwork, higher-order thinking, and motivation are among these essential qualities.

Eventually, it is anticipated that AI technology will enhance learning experiences for students, enabling them to reflect on their own education. Education professionals leveraging AI technologies will be able to analyse large data sets of teaching behaviours, encompassing elements such as learning, emotion, motivation, and social interaction. In the coming years, intelligent online teaching is expected to become more prevalent in internet-based learning. Within five years, young people will likely spend more time in virtual environments, learning advanced teaching skills through educational games and simulations. While users may not fully grasp the workings of the adaptation algorithm, the algorithm is influencing personal search rankings behind the scenes, as seen in partnerships with Google. Algorithms exist to help increase search efficiency. Students will experience a similar phenomenon in the educational materials they use; this process involves intelligence. Intelligent instructors can provide many of the same advantages as human instructors while also providing immediate insights for educators and creators who are willing to enhance their methodologies.

4.2 Challenges and ethical considerations

Benefits of AIED are significant; however, the challenges and ethical issues surrounding its use must also be considered. This section addresses issues such as data protection, algorithmic fairness, technology addiction, and student access to AI resources. This raises questions about the role of teachers in AI-enabled classrooms: Should teachers act more as facilitators while AI performs mundane tasks, or does AI risk undermining the emotional dimension of teaching? This section highlights the importance of transparency, responsiveness, and responsible design in implementing AI systems in education.

Although integrating AI into education has a lot of potential, there are a number of issues that must be resolved for it to be used successfully. Guaranteeing every pupil, without regard to socioeconomic status and geographic location, fair accessibility to AI-powered tools and resources is one of the main obstacles to incorporating AI into educational settings. Pupils from under-represented groups or disadvantaged areas might not have the devices, hardware, and web connection needed for accessing such digital environments. People who have medical conditions might face challenges when using AI technologies that are not tailored to their needs, leading to digital inequality (Chiu et al., 2023; Božić, 2023; Johansson et al., 2021). Instructors, legislators, and software manufacturers need to focus on inclusiveness for all pupils to solve access difficulties. In the process, pricing, accessibility, alignment with assistance technology should be considered, along with ensuring the necessary instruction and guidance for teachers and pupils to efficiently use the technologies.

AIED requires the gathering, preservation, examination of pupil information, which poses serious issues regarding data confidentiality and safety (Pedro et al., 2019; McCardle, 2002;). Education organisations and companies ought to confront intricate legislative and moral issues when collecting, using, and disseminating personal pupil data whilst also adhering to information safeguarding laws like the Family Educational Rights and Privacy Act (FERPA) in the US (Rights and the Law, 2014). Creating inclusive AI solutions that are usable by all students must be a top priority for educators, legislators, and tech developers in order to solve accessibility concerns. Furthermore, the spread of AI tools introduces a potential for information leaks, unauthorised entries, as well as malevolent actors exploiting pupil information.

Biases by AI, with a potential to reinforce disparities and undermine efficiency of AI tools, also pose as a challenge to AI's integration into educational settings. Biases in AI systems can arise from data biases

used in the training process, choices in algorithm design, and societal biases inherent in the information utilised for training these systems. To illustrate, if AI systems learn from outdated info that shows current gaps in education or resource access, they might unintentionally continue biases by strengthening current disparities. Furthermore, opaque or poorly accountable algorithmic decision-making processes can obscure prejudices and complicate not only the detection but also the correction of segregations by algorithms (Akgun & Greenhow, 2022; Borenstein & Howard, 2021). For reducing bias, teachers and tech creators should consider values such as equity, responsibility, openness when designing and executing AI. That encompasses analysing instructional information for detecting as well as reducing prejudices, carrying out equity-focused machine learning algorithms, and regularly auditing and evaluating AI applications for guaranteeing that marginalised communities are not negatively affected (Bogina et al., 2021; Xivuri and Twinomurizi, 2023).

Complicated moral issues regarding legitimacy, accuracy, and equity in school evaluation processes arise from using AI for assessing pupil achievement. Privacy and security of student information play a vital role in the implementation of AI into educational settings. Academic establishments and tech suppliers are required to comply with rigorous data safeguarding protocols and moral principles to ensure the confidentiality of pupils and avert unlawful access, utilisation, or sharing of delicate private information. Effective data encryption, access controls, and security measures must be established for safeguarding pupil information against malicious online attacks and illicit hacking. In addition, clear information management rules and processes, as well as informed consent and control mechanisms, are essential for making sure of an understanding among pupils as well as their households regarding the methods of data collection, storage, and utilisation. Tackling the prejudices is crucial for guaranteeing justice, equality, as well as inclusion in AI-based educational settings. These prejudices may sustain current disparities as well as promote discriminatory practices, leading to inequitable outcomes and further deepening gaps in education (Agarwal et al., 2023; Zajko, 2021). For reducing prejudices, teachers and tech creators should employ a multifaceted method which includes algorithmic equality principles, algorithms aware of prejudices, as well as diverse instructional information. The strategy involves thoroughly assessing instructional information for detecting as well as reducing prejudices, enriching the data to represent various groups of pupils, and applying equity measurements as well as assessment methods for not only examining but also reducing biases within AI systems (Kordzadeh and Ghasemaghaei, 2022; Michael et al., 2023).

In addition, clarity as well as responsibility serve as necessities to ensure the fairness, reliability, and accountability of AI systems. Clarity around the creation and execution of AI, and tools to explain and audit algorithmic decisions are needed for not only recognising but also eliminating prejudice and unfairness. Clarity and responsibility constitute the key to legitimate utilisation of AI in educational settings. Education stakeholders need to provide open and honest information about how AI technology is used in educational settings, including the purpose of the AI, the origins of information and systems used, as well as the probable impact on students' educational journeys and achievements. All of that necessitates establishing ethical principles and standards for the use of AI in education, as well as open and candid communication with children, parents, teachers, and other stakeholders to obtain informed consent and feedback. It is also imperative to implement accountability mechanisms and effective methods to handle problems, concerns, as well as requests concerning AIED to make sure the accountability of AI tools for not only the choices they make but also the results they achieve. This process involves defining specific categories of authority as well as responsibility over creation, execution, review of AI tools, also implementing not only auditing but also evaluation processes for monitoring AI systems' adherence to moral rules along with laws. Although AI technologies can improve educational evaluations' effectiveness, impartiality, and dependability, if they are not applied sensibly and ethically, they also carry the risk of prejudice, discrimination, and privacy violations.

The significance of AIED research is becoming more widely acknowledged. The Grand Challenges that have been identified reflect this. According to a challenge, "A teacher for every learner," computers can revolutionise instruction by improving learning outcomes for everyone and changing how individuals gain new knowledge over the course of their existence. It is the challenge "to provide learning environments that approach the effectiveness of one teacher for every learner." The National Academy of Engineering has identified fourteen key challenges in engineering. Advanced Personalised Learning is among them. This concept encompasses effective online individualised tutoring platforms, along with recommendation programs which assist students in selecting the most relevant information from a variety of options. It also highlights the potential for analysing data from digital learning activities in education. This acknowledges the interaction with learning systems engineering by combining the human brain and neuroscience with healthcare examination technologies. The UK Computing Research Committee has identified nine Grand Challenges to the field of Computing Research. Learning for Life is among them. It aims to develop technologies that enable each student to learn at their own pace and to encourage collaboration between students and appropriate teachers. This challenge highlights the importance of effectiveness at the individual, group, and societal levels. Unlike previous significant challenges, this one encompasses a broader scope than the individual student. Memories for Life is another UK Grand Challenge that acknowledges that our memories shape who we are. Because our augmented memories serve as essential for lifelong learning, augmented cognition is associated with a comprehensive perspective of AIED. The most recent example of such innovative statements is the Microsoft Being Human, Human-Computer Interaction in the year 2020. This study explores different aspects of learning, encompassing both formal educational settings and learning through new mobile and continuously accessible interaction tools. The rich and detailed data generated from learners' digital traces is considered crucial. This could transform assessment methods and provide families with a more comprehensive perspective on their children's development. Learning is recognised as playing a critical role in lifelong health needs, particularly as individuals age and face challenges to their health and well-being. Developing technology can provide useful information on those as well as similar components of life, yet individuals must be empowered for using this data effectively. Even though the concept is addressed within the context of Human-Computer Interaction, it presents many challenges related to AI and AIED. This situation highlights the fundamental characteristics of AIED. Overall, approximately half of these Grand Challenges are strongly linked to AIED research.

5. Conclusions

One of the most striking technologies to emerge in the 21st century is artificial intelligence, often defined as the imitation of human intelligence by machines. In education, AI refers to systems which can take over tasks once performed by educators, such as language understanding, personalised instruction, learning analytics, automated assessment, and student support services. The role of AIED is gaining further importance and complexity while it keeps evolving.

Since its inception in the mid-20th century, artificial intelligence has undergone significant development. AI began with theoretical ideas, initially involving rule-based systems and specialized software. Today, it has evolved into a useful tool integrated into real-world learning environments through deep learning and natural language processing models. In recent years, large-scale language models and adaptive learning platforms have enabled teachers and students to provide instant feedback and personalised learning experiences in diverse learning situations.

AI in education offers a very promising opportunity. By tailoring information to every pupil's needs, AI can improve learning outcomes and provide personalised instruction. It can also alleviate teacher burdens by automating administrative and grading processes. It provides continuous guidance and feedback to students, providing support through chatbots and intelligent systems. AI-based analytics can

be used to help teachers identify learning gaps and increase the effectiveness of their interventions, creating a more inclusive as well as flexible instructional setting.

Yet, the increasing utilisation of AIED raises crucial ethical questions, as well. Ensuring that AI technologies be equitable and prevent worsening current disparities, issues like information confidentiality alongside biases in algorithms require careful consideration. Furthermore, consideration should be given to how accountability and transparency should be maintained in AI-enabled systems, and to what extent educational decisions should be influenced or determined by algorithms.

In summary, AI can transform education; however, its utilisation must be guided by pedagogical goals, ethical responsibilities, and inclusiveness. To effectively implement AI, it is essential that educators, researchers, policymakers, and technology experts collaborate to enhance, rather than disrupt, human-centred teaching and learning. However, unless these conditions are met, AI will not be a truly creative, successful, and equitable educational tool.

The road ahead of AIED looks promising with prospects for advancement as well as development. AI can revolutionise the landscape of education, enabling it to be further personalised, effective, and successful. Within years to come, stronger AI tools understanding and responding to feelings, providing further complex responses, also generating personalised lesson plans according to individual students may be expected.

To sum up, there are many chances to improve student results, learning experiences, and educational equity and inclusion through the utilisation of AIED. For guaranteeing appropriate and fair applications of AI technology in educational settings, it also presents important obstacles and moral dilemmas that need to be properly handled. Educational stakeholders may fully utilise AI for serving various demands as well as goals of every student and advance fair global accessibility to top-notch learning environments by carefully and proactively addressing these issues and ethical concerns.

Acknowledgements (Optional)

I wholeheartedly express my thanks and appreciation for Res. Asst. Dilber Yaren Polat for all the help during the formatting and organising process of this article.

References

1. Adams, C., Pente, P., Lemermeyer, G., & Rockwell, G. (2021). Artificial intelligence ethics guidelines for K-12 education: A review of the global landscape. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 24–28). Cham: Springer.
2. Afzaal, M., Nouri, J., Zia, A., Papapetrou, U. F., Wu, Y., Li, X., & Weegar, R. (2021). Generation of automatic data-driven feedback to students using explainable machine learning. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 31–35). Cham: Springer.
3. Agarwal, R., Bjarnadottir, M., Rhue, L., Dugas, M., Crowley, K., Clark, J., & Gao, G. (2023). Addressing algorithmic bias and the perpetuation of health inequities: An AI bias aware framework. *Health Policy and Technology*, 12(1), Article 100702.
4. Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, 2(3), 431–440.
5. Al-Abboodi, H., Fan, H., Mahmood, I. A., & Al-Bahrani, M. (2021). Experimental investigation and numerical simulation for corrosion rate of amorphous/nano-crystalline coating influenced by temperatures. *Nanomaterials*, 11(12), 3298.
6. AlAli, R., Wardat, Y., & Al-Qahtani, M. (2023). SWOM strategy and influence of its using on developing mathematical thinking skills and on metacognitive thinking among gifted tenth-grade students. *EURASIA Journal of Mathematics, Science and Technology Education*, 19(3), em2238.

7. Alam, A. (2021, November). Possibilities and apprehensions in the landscape of artificial intelligence in education. In 2021 International Conference on Computational Intelligence and Computing Applications (ICCICA) (pp. 1–8). New York, NY: IEEE.
8. Alarabi, K., & Wardat, Y. (2021). UAE-based teachers' hindsight judgments on physics education during the COVID-19 pandemic. *Psychology and Education Journal*, 58(3), 2497–2511.
9. Al-Bahrani, M., Gombos, Z. J., & Cree, A. (2018). The mechanical properties of functionalised MWCNT infused epoxy resin: A theoretical and experimental study. *Int. J. Mech. Mechatronics Eng*, 18, 76–86.
10. Al-Bahrani, M., Alhakeem, M. R. H., & Cree, A. (2020). Damage sensing and mechanical properties of a laminate composite material containing MWCNTs during low-velocity impact. *Journal of Petroleum Research and Studies*, 10(4), 147–164.
11. Al-Bahrani, M., Bouaissi, A., & Cree, A. (2022). The fabrication and testing of a self-sensing MWCNT nanocomposite sensor for oil leak detection. *International Journal of Low-Carbon Technologies*, 17, 622–629.
12. AlGerafi, M. A., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. *Electronics*, 12(18), Article 3953.
13. Aomi, I., Tsutsumi, E., Uto, M., & Ueno, M. (2021). Integration of automated essay scoring models using item response theory. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 46–50). Cham: Springer.
14. Beck, J., Stern, M., & Haugsjaa, E. (1996). Applications of AI in Education. *XRDS: Crossroads, The ACM Magazine for Students*, 3(1), 11–15.
15. Bogina, V., Hartman, A., Kuflik, T., & Shulner-Tal, A. (2021). Educating software and AI stakeholders about algorithmic fairness, accountability, transparency and ethics. *International Journal of Artificial Intelligence in Education*, 1–26.
16. Borenstein, J., & Howard, A. (2021). Emerging challenges in AI and the need for AI ethics education. *AI and Ethics*, 1, 61–65.
17. Božić, V. (2023). Artificial intelligence as the reason and the solution of digital divide. *Language Education and Technology*, 3(2).
18. Chen, J., Li, H., Ding, W., & Liu, Z. (2021). An educational system for personalized teacher recommendation in K-12 online classrooms. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 78–82). Cham: Springer.
19. Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264–75278.
20. Chiu, T. K., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 4, 100118.
21. Dever, D. A., Cloude, E. B., & Azevedo, R. (2021). Examining learners' reflections over time during game-based learning. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 105–109). Cham: Springer.
22. Dickler, R., Hirshfield, L., Ishii, R., & Uti, N. (2021). Examining the use of a teacher alerting dashboard during remote learning. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 110–115). Cham: Springer.
23. Eden, C. A., Chisom, O. N., & Adeniyi, I. S. (2024). Integrating AI in education: Opportunities, challenges, and ethical considerations. *Magna Scientia Advanced Research and Reviews*, 10(2), 006–013.
24. Gandedkar, N. H., Wong, M. T., & Darendeliler, M. A. (2021, June). Role of virtual reality (VR), augmented reality (AR) and artificial intelligence (AI) in tertiary education and research of

- orthodontics: An insight. In *Seminars in Orthodontics* (Vol. 27, No. 2, pp. 69–77). Philadelphia, PA: WB Saunders.
25. George, B., & Wooden, O. (2023). Managing the strategic transformation of higher education through artificial intelligence. *Administrative Sciences*, 13(9), 196.
 26. Gligorea, I., Cioca, M., Oancea, R., Gorski, A. T., Gorski, H., & Tudorache, P. (2023). Adaptive learning using artificial intelligence in e-learning: A literature review. *Education Sciences*, 13(12), 1216.
 27. Gningue, S. M., Peach, R., Jarrah, A. M., & Wardat, Y. (2022). The Relationship between Teacher Leadership and School Climate: Findings from a Teacher-Leadership Project. *Educational Sciences*, 12(749).
 28. Goslen, A., Carpenter, D., Rowe, J. P., Henderson, N., Azevedo, R., & Lester, J. (2022). Leveraging student goal setting for real-time plan recognition in game-based learning. In M. M. Rodrigo, N. Matsuda, A. I. Cristea, & V. Dimitrova (Eds.), *Artificial intelligence in education* (Vol. 13355, pp. 250–255). Cham: Springer.
 29. Hashim, H. (2018). Application of technology in the digital era education. *International Journal of Research in Counseling and Education*, 2(1), 1–5.
 30. Harry, A. (2023). Role of AI in education. *Interdisciplinary Journal & Hummanity (INJURITY)*, 2(3).
 31. Hlosta, M., Herodotou, C., Bayer, V., & Fernandez, M. (2021). Impact of predictive learning analytics on course awarding gap of disadvantaged students in STEM. In I. Roll, D. McNamara, S. Sosnovsky, R. Luckin, & V. Dimitrova (Eds.), *Artificial Intelligence in Education* (Vol. 12749, pp. 182–186). Cham: Springer.
 32. Hu, C.-W. (2024, April 3). NotebookLM launches new features to help students study. The Keyword.
 33. Ibrahim, H. K., Al-Awkally, N. A. M., Samad, A., Zaib, W., & Hamza, M. (2022). Covid-19 pandemic and its impact on psychological distress, malignancy and chronic diseases: A scoping review. *Eduvest-Journal Of Universal Studies*, 2(5), 1017–1021.
 34. Jarrah, A. M., Almassri, H., Johnson, J. D., & Wardat, Y. (2022). Assessing the impact of digital games-based learning on students' performance in learning fractions using (ABACUS) software application. *EURASIA Journal of Mathematics, Science and Technology Education*, 18(10), em2159.
 35. Johansson, S., Gulliksen, J., & Gustavsson, C. (2021). Disability digital divide: the use of the internet, smartphones, computers and tablets among people with disabilities in Sweden. *Universal Access in the Information Society*, 20(1), 105–120.
 36. Kay, J. (2012). AI and education: Grand challenges. *IEEE Intelligent Systems*, 27(5), 66–69.
 37. Kirchner-Krath, J., Schürmann, L., & von Kortzfleisch, H. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games, and game-based learning. *Computers in Human Behavior*, 125, 106963.
 38. Kordzadeh, N., & Ghasemaghaei, M. (2022). Algorithmic bias: review, synthesis, and future research directions. *European Journal of Information Systems*, 31(3), 388–409.
 39. Li, J., Chen, J., Yuan, Z., Xu, L., Zhang, Y., & Al-Bahrani, M. (2022). Multi-objective risk-constrained optimal performance of hydrogen-based multi energy systems for future sustainable societies. *Sustainable Cities and Society*, 87, 104176.
 40. Limna, P., Jakwatanatham, S., Siripipattanakul, S., Kaewpuang, P., & Sriboonruang, P. (2022). A review of artificial intelligence (AI) in education during the digital era. *Advance Knowledge for Executives*, 1(1), 1–9.
 41. Lopez, D. M., & Schroeder, L. (2008). Designing strategies that meet the variety of learning styles of students. Online Submission. Retrieved from <https://eric.ed.gov>

42. Luan, H., Geczy, P., Lai, H., Gobert, J., Yang, S. J., Ogata, H., ... Tsai, C. C. (2020). Challenges and future directions of big data and artificial intelligence in education. *Frontiers in Psychology*, 11, 580820.
43. McCardle, J. R. (2002). The challenge of integrating ai & smart technology in design education. *International Journal of Technology and Design Education*, 12, 59–76.
44. Michael, F., Melissa, C., & Shuzhou, Y. (2023). Biases in scholarly recommender systems: impact, prevalence, and mitigation. *ACM Transactions on Recommender Systems*, 1(1), 1–25.
45. Mitchell, M. (2019). *Artificial Intelligence: A Guide for Thinking Humans*. London, UK: Penguin.
46. Mohammed, A. A., Samad, A., & Omar, O. A. (2022). *Escherichia coli* spp, *Staph albus* and *Klebseilla* spp were affected by some Antibiotics for Urinary Tract Infections in Bani Waleed City. *Brilliance: Research of Artificial Intelligence*, 2(2), 66–70.
47. Mustafa, M. B. (2015). One size does not fit all: Students' perceptions about Edmodo at Al Ain University of Science & Technology. *Journal of Studies in Social Sciences*, 13(2).
48. Nguyen, N. D. (2023). Exploring the role of AI in education. *London Journal of Social Sciences*, (6), 84–95.
49. Pape, B., & Vander Ark, T. (2021). Policies and practices that meet learners where they are [4 in a series]. *Making Learning Personal for All*. Washington, DC: Digital Promise Global.
50. Patil, S. M., Raut, C. M., Pande, A. P., Yeruva, A. R., & Morwani, H. (2022). An efficient approach for object detection using deep learning. *Journal of Pharmaceutical Negative Results*, 563–572.
51. Patrick, S., Worthen, M., Frost, D., & Gentz, S. (2016). Promising state policies for personalized learning. Vienna, VA: International Association for K-12 Online Learning.
52. Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). *Artificial intelligence in education: Challenges and opportunities for sustainable development*. Paris, France: UNESCO.
53. Pierre-Louis, S. (2023, July 6). Essential Facts. Entertainment Software Association. Retrieved from <https://www.theesa.com/>
54. Rahmatullah, A. S., Mulyasa, E., Syahrani, S., Pongpalilu, F., & Putri, R. E. (2022). Digital era 4.0: The contribution to education and student psychology. *Linguistics and Culture Review*, 6, 89–107.
55. Reyna, J. (2025a). The potential of Google NotebookLM for teaching and learning. Paper presented at eLearn 2025, Bangkok, Thailand.
56. Rowe, J., Mott, B., McQuiggan, S., Robison, J., Lee, S., & Lester, J. (2009, July). Crystal Island: A narrative-centered learning environment for eighth grade microbiology. In *Workshop on Intelligent Educational Games at the 14th International Conference on Artificial Intelligence in Education* (pp. 11–20). Brighton, UK.
57. Samad, A. (2022). Antibiotics resistance in poultry and its solution. *Devotion Journal of Community Service*, 3(10), 999–1020.
58. Samad, A., Hamza, M., Muazzam, A., Ahmad, H., Ahmer, A., Tariq, S., ... Akram, W. (2022). Policy of control and prevention of infectious bursal disease at poultry farm. *African Journal of Biological, Chemical and Physical Sciences*, 1(1), 1–7.
59. Samad, A., Hamza, M., Muazzam, A., Ahmer, A., Tariq, S., Ahmad, S., & Mumtaz, M. T. (2022). Current perspectives on the strategic future of the poultry industry after the COVID-19 outbreak. *Brilliance: Research of Artificial Intelligence*, 2(3), 90–96.
60. Shabbir, J., & Anwer, T. (2018). Artificial intelligence and its role in near future. *arXiv Preprint*, arXiv:1804.01396.
61. Song, Y., Wong, L. H., & Looi, C. K. (2012). Fostering personalized learning in science inquiry supported by mobile technologies. *Educational Technology Research and Development*, 60, 679–701.

62. Sreenivasu, S. V. N., Sathesh Kumar, T., Bin Hussain, O., Yeruva, A. R., Kabat, S. R., & Chaturvedi, A. (2023). Cloud based electric vehicle's temperature monitoring system using IOT. *Cybernetics and Systems*, 1–16.
63. Sridhar, K., Yeruva, A. R., Renjith, P. N., Dixit, A., Jamshed, A., & Rastogi, R. (2022). Enhanced machine learning algorithms: Lightweight ensemble classification of normal versus leukemic cells. *Journal of Pharmaceutical Negative Results*, 496–505.
64. Stoica, G., & Wardat, Y. (2021). An inequality can change everything... *Am. Math. Mon.*, 128(9), 810.
65. The Verge. (2025, June 3). Google's NotebookLM now lets you share your notebook and AI podcasts - publicly. *The Verge*.
66. Tozuka, R., Johno, H., Amakawa, A., et al. (2024). Application of NotebookLM, a large language model with retrieval-augmented generation, for lung cancer staging (arXiv:2410.10869). *arXiv*.
67. Woolf, B. P. (2015). AI and Education: Celebrating 30 years of marriage. In *AIED Workshops* (Vol. 4, pp. 38–47). Cham: Springer.
68. Wu, X., Fan, H., Wang, W., Zhang, M., Al-Bahrani, M., & Ma, L. (2022). Photochemical synthesis of bimetallic CuNiS x quantum dots onto gC 3 N 4 as a cocatalyst for high hydrogen evolution. *New Journal of Chemistry*, 46(31), 15095–15101.
69. Xivuri, K., & Twinomurizi, H. (2023). How AI developers can assure algorithmic fairness. *Discover Artificial Intelligence*, 3(1), 27.
70. Yeruva, A. R., Choudhari, P., Shrivastava, A., Verma, D., Shaw, S., & Rana, A. (2022). Covid-19 disease detection using chest X-ray images by means of CNN. In *2022 2nd International Conference on Technological Advancements in Computational Sciences (ICTACS)* (pp. 625–631). New York, NY: IEEE.
71. Yin, J.-H., Chng, C.-B., Wong, P.-M., Ho, N., Chua, M., & Chui, C.-K. (2020). VR and AR in human performance research—An NUS experience. *Virtual Reality & Intelligent Hardware*, 2(5), 381–393.
72. Yin, W. (2022). An artificial intelligent virtual reality interactive model for distance education. *Journal of Mathematics*, 2022, 1–7.
73. Zahmatkesh, S., Rezakhani, Y., Arabi, A., Hasan, M., Ahmad, Z., Wang, C., ... Ghodrati, I. (2022). An approach to removing COD and BOD based on polycarbonate mixed matrix membranes that contain hydrous manganese oxide and silver nanoparticles: A novel application of artificial neural network based simulation in MATLAB. *Chemosphere*, 308, 136304.
74. Zajko, M. (2021). Conservative AI and social inequality: conceptualizing alternatives to bias through social theory. *AI & SOCIETY*, 36(3), 1047–1056.
75. Zakaria, N., Lim, G. F., Jalil, N. A., Anuar, N. N. A. N., & Aziz, A. A. (2024). The implementation of personalised learning to teach English in Malaysian low-enrolment schools. In *SHS Web of Conferences* (Vol. 182, p. 01011). Les Ulis, France: EDP Sciences.
76. Zarei, M., Taghizadeh, M., Moayedi, S., Naseri, A., Al-Bahrani, M., & Khordehbinan, M. W. (2022). Evaluation of fracture behavior of warm mix asphalt (WMA) modified with hospital waste pyrolysis carbon black (HWPCB) under freeze-thaw damage (FTD) at low and intermediate temperatures. *Construction and Building Materials*, 356.

Eğitimde yapay zeka: Matrix metaforu

Özet

Yapay Zeka (YZ), 21. yüzyılda hızla önemli bir teknoloji olarak ortaya çıkmış, eğitimde geniş kapsamlı ve dönüştürücü uygulamalar sunmuş ve eğitimciler, araştırmacılar ve politika yapıcılar için belirleyici bir odak noktası haline gelmiştir. Bu makale, teknolojinin kavramsal bir tanıtımıyla başlar ve öğretim

ve öğrenim bağlamında teknolojinin doğası ve işlevselliđi hakkında net bir anlayış oluşturmaya çalışır. YZ genellikle makineler tarafından insan bilişsel süreçlerinin simülasyonu olarak tanımlanır ve eğitim alanındaki uygulamaları doğal dil işleme, uyarlanabilir öğrenme, makine öğrenimi ve akıllı öğretim sistemleri gibi çeşitli özel alanlara odaklanır. Teknolojideki hızlı ve muazzam ilerlemelerle birlikte, YZ kısa sürede dünya çapında birçok alanda yaygın olarak kullanılmaya başlanmıştır. Eğitim de gelişen YZ'den kapsamlı ve derin bir şekilde etkilenmiştir. Bu makale, okuyuculara eğitimde YZ kullanımıyla ilgili mevcut literatürü sunmayı amaçlamaktadır. YZ'nin ana fırsatlar ve zorluklar gibi çeşitli yönleri sunulmuştur.

Anahtar sözcükler: yapay zeka; gelişen teknoloji; eğitim teknolojileri; akıllı öğretim sistemleri.

AUTHOR BIODATA

Insert here author biodata.