*Research article*

# Research on performance evaluation of higher vocational education informatization based on data envelopment analysis

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**Abstract:** This article highlights the multifaceted role of AI in modern education and offers insights into innovative ways to revolutionize educational practices through AI technologies. Since this article provides comprehension of the scope and depth of AI's impact on the education sphere, it appeals to a diverse readership, encompassing educators, policymakers, researchers, and the general public. This article explores key issues within the domain of AI in education, including personalized learning, AI-driven assessments, data analytics, and the integration of AI into learning management systems. The article highlights promises, potentials, and challenges accompanying this technological advancement. The authors emphasize the need for a balanced and informed approach to using AI to enhance the education system.

educational technology

# 1.  Introduction

Education plays an integral role in driving social progress, and the challenges it faces remain at the forefront of the agenda for policymakers, educators, and researchers globally. Being recognized as a cornerstone of development, education catalyzes fostering informed citizens, innovative thinkers, and skilled professionals. However, it is a considerable challenge to ensure accessibility and high quality of education. Substandard educational systems can impede students' capacity to gain requisite knowledge and skills. Moreover, numerous geographic regions contend with a lack of suitably qualified educators [19]. Furthermore, the quality of teacher training and their professional development differ significantly, which influences the efficacy of educational work.

Innovations have been introduced into the educational process to mitigate the detrimental effects caused by these challenges. One prominent challenge that innovations have sought to address is the issue of accessibility and quality in education. The accessibility of quality education remains a global concern since socio-economic disparities often deprive students of opportunities for equal study. Innovations such as online learning platforms, Massive Open Online Courses (MOOCs), and digital educational resources have significantly expanded access to education. Moreover, these innovations aim to enhance the quality of education by providing engaging, interactive, and personalized learning experiences; it would prevent low-quality education systems from hindering students' capacity to acquire essential knowledge and skills. However, according to UNESCO, there are no indications of a system-wide adoption of AI-based applications for teaching and learning or system management, even though the educational technology industry has yet to cease production of new developments [22].

Innovations also addressed such a challenge as the shortage of qualified teachers in many regions. Online teacher training programs, professional development courses, and virtual mentoring initiatives have helped bridge the gap in educator availability. Furthermore, innovative teaching methods, which may include AI-powered tutoring and virtual classrooms, lighten teachers' workload by providing additional support and resources for students. Innovations are also instrumental in ensuring the relevance of educational content in an era of rapid technological evolution. The flexibility of digital curricula allows for timely updates to meet the needs of the job market and society, developing a more dynamic and responsive education environment. As these innovations continue to evolve, they hold the potential to transform education into a more equal, efficient, and dynamic system better equipped to meet the diverse needs of learners in the 21st century.

Educators rely on AI-powered services in their daily lives, including home voice assistants, grammar correction, sentence completion, and essay writing tools, as well as automated travel planning accessible through their phones. Educators understand that AI-powered services, such as speech recognition, can enhance the support provided to students with disabilities, multilingual learners, and other groups who could benefit from more adaptivity and personalization in digital learning tools. Teachers explore how AI can assist them in preparing and improving lessons or identifying, selecting, and adapting instructional materials for use in their classes [23].

However, the introduction of AI innovations in education entails numerous challenges, including ethical considerations, privacy concerns, and the need for comprehensive teacher training for

utilizing these tools. However, the overall trajectory of incorporating innovations into the educational process is undoubtedly promising since it offers a means to address the longstanding issues in the education environment.

## 2. Methods

The methodology of this article is designed to provide a comprehensive analysis of various AI-driven technologies in the field of education. A comprehensive research framework was developed to achieve this aim. The authors provided a comparative assessment of various AI-driven technologies, considering their historical development and current state. This analysis encompassed assessing fundamental principles, functionalities, and real-world applications of each technology within the education environment. The authors also delve into their historical evolution. Furthermore, the analysis sought to highlight the benefits, challenges, and ethical considerations associated with the adoption of these technologies over time. To provide real-world context, the authors analyze case studies and examples showcasing the implementation of AI-driven technologies and their impact on education. They were drawn from academic institutions, ed-tech companies, and research projects, offering practical insights into the transformative potential of AI in education across different time periods

## 3. Results

### 3.1. The historical development of Artificial Intelligence in education

The first initiatives aimed at AI integration into education can be traced back to the 1960s. During this period, advancements were noticed in the capabilities of computers, characterized by increased storage capacity, enhanced processing speed, cost-effectiveness, and improved accessibility [2]. Furthermore, notable progress was achieved in machine learning algorithms, accompanied by a heightened capacity to discern the most suitable algorithm for specific problem-solving activities. The concept of computer-assisted learning (CAL) was still under development in the 1960s. The availability of technologies was limited, but researchers were eager to find new ways to use computers for education.

One of the earliest examples of computer-based learning systems was the Programmed Logic for Automatic Teaching Operations (PLATO) system developed in 1960 by Donald Bitzer and his team at the University of Illinois. It was a significant innovation at the time since it allowed students to work with instructional materials using a computer terminal. It could adapt to the pace and abilities of each student, providing targeted feedback and additional instruction when needed. This personalized learning approach was a groundbreaking concept in the 1960s. Many more ideas and technologies used in PLATO were later adopted and elaborated in subsequent educational software and online learning systems.

The 1970s and 1980s were marked by the invention of Intelligent Tutoring Systems (ITS). ITSs aimed to personalize learning by adapting instruction to individual student needs. Notable ITS projects included "Socratic" by Gordon Pask and "SAIL" (Stanford Artificial Intelligence Laboratory) developed by Bruce Sherwood. These systems used rule-based approaches to provide detailed feedback to students.

AI was at the center of attention in education in the 1990s and 2000s; researchers were engaged in developing intelligent tutoring systems and personalized learning environments. The aim was to

develop computerized systems to monitor learners' performance, identify their strengths and weaknesses, and provide support and personalized feedback. These intelligent systems were expected to improve student learning outcomes, increase the efficiency of the learning process, and reduce the costs involved in delivering high-quality education. Educational software of that time involved interactive content, simulations, and multimedia elements to engage learners.

The development and use of Learning Management Systems (LMS) have significantly transformed the learning process, both in traditional educational settings and in corporate training environments. LMS platforms serve as centralized repositories for learning materials. In educational institutions, this includes course content, assignments, and resources [16]. As for corporate training environments, LMS platforms encompass training modules, appropriate materials, and onboarding resources. Many platforms include tools for discussion forums, chat, and messaging, allowing learners to collaborate and communicate with instructors and peers. Another great thing was that learners could access the LMS from any place with an internet connection, which provided greater flexibility in the learning process.

Machine learning algorithms and artificial neural networks began to play a more prominent role in education in the 2000s-2010s. These technologies allowed for data-driven personalization of content and learning experiences. These systems included personalized learning algorithms, recommendation engines, and the development of chatbots that promoted more dynamic interactions between students and AI systems. The use of data analytics and machine learning algorithms also made it possible for educators to predict student outcomes, identify patterns of learning, and personalize the learning experience for individual students. Adaptive learning platforms, such as Knewton and DreamBox, started to gain popularity.

They begin with an initial assessment to create a learner profile, outlining strengths, weaknesses, and optimal learning paths. Based on this profile, they deliver content adapted to the student's level of understanding. These platforms provided real-time feedback, allowing students to monitor their progress and receive explanations, hints, and correct answers. Continuous progress tracking records data on the effectiveness of materials and areas where students need more practice. The platforms adjust the sequence of topics and activities based on the student's demonstrated proficiency; students get additional support for mastering complicated concepts and advanced content. Gamification elements keep students engaged and motivated. Teachers and parents can access the platform to monitor student progress and provide targeted assistance. Data analytics are central to adaptive learning platforms since they ensure constant improvement and refinement for a more personalized learning experience. In summary, these adaptive learning platforms rely on technologies and data analysis to provide tailored learning experiences and make education more engaging, effective, and personalized for learners of all ages.

Massive Open Online Courses (MOOCs) were conceived at that time to reshape the educational environment. These online platforms revolutionized access to various courses and educational materials. Prominent platforms like Coursera and edX harnessed AI to perform automated grading, offer personalized content recommendations, and identify students encountering challenges in their learning. MOOCs have transformed education by providing accessible, convenient, and diverse learning opportunities [20]. They offer the following benefits:

- MOOCs are accessible to anyone with an internet connection, making education available to a global audience.
- Learners can access course materials and participate at their convenience, allowing for flexible scheduling.

- Learners can choose from a diverse range of courses, spanning various subjects, making it easy to explore different topics.
- Many MOOCs are affordable or even free, making high-quality education accessible to a wide audience.
- MOOCs feature interactive elements, including video lectures, quizzes, assignments, and discussion forums.
- Automated grading of quizzes and assignments provides instant feedback.
- Certificates or digital badges are often awarded upon course completion, which can be valuable for career advancement.

Currently, AI in education continues to evolve, driven by advances in neural networks, natural language processing, and other AI technologies. Chatbots and virtual assistants, underpinned by the principles of artificial intelligence and bolstered by advancements in natural language processing and machine learning, have achieved pervasive adoption within the realm of educational institutions. This marked proliferation of AI-driven conversational agents has ushered in a transformative era for student support and question resolution mechanisms.

These tools provide students with immediate assistance, addressing queries and responding to questions swiftly and efficiently [8]. These tools apply natural language processing. Since they overcome traditional communication barriers, students are able to interact with them conversationally and intuitively. AI-driven chatbots and virtual assistants marked a turning point in a paradigm shift in educational support systems, offering students a seamless, round-the-clock resource for information and guidance. This not only enhances the accessibility of assistance but also aligns with the contemporary learning environment's demands for immediacy and responsiveness.

Table 1 summarizing the main innovations in AI for learning across distinct chronological periods offers a valuable insight into the progressive integration of artificial intelligence in the field of education. From the early roots of computer-based tutoring systems in the 1960s to the contemporary developments in advanced adaptive AI, this chronicle of innovations reflects the dynamic evolution of educational technology. It underscores the pioneering spirit that gave rise to intelligent tutoring systems, paved the way for personalized learning environments, and ultimately brought forth the highly sophisticated AI systems we have today. The table serves as a testament to the relentless quest for enhancing the quality of education and reshaping the learning experience through AI-driven solutions, reaffirming the vital role of technological progress in the realm of learning.

In summary, the trajectory of AI technology within the realm of education has traversed a notable evolutionary path since its nascent stage, marked by the advent of computer-based tutoring systems in the 1960s. This pioneering phase laid the foundation for a journey characterized by progressive innovation and continual refinement. In the contemporary educational landscape, AI in education has reached unprecedented heights with the development of advanced adaptive AI systems. These systems, powered by machine learning algorithms and vast datasets, offer finely tuned, individualized learning pathways, ensuring that each student's educational journey is optimized to maximize their potential.

AI evolution in education holds profound promise for enhancing education quality and transforming the learning process. It aligns with the imperative to address longstanding challenges in the field, from improving accessibility to fostering personalized, data-informed learning experiences.

As AI technology continues to develop and adapt to the dynamic demands of education, its role in shaping the future of learning remains crucial and ever more promising.

**Table 1.** Chronology of AI innovations in education.

| Period | Main Innovations in AI for Learning |
|---|---|
| 1950s -1960s | - Early computer-assisted learning (CAL) systems<br>- Pioneering projects like IBM's "Tutoring System" |
| 1970s -1980s | - Emergence of Intelligent Tutoring Systems (ITS)<br>- Rule-based AI for personalized instruction |
| 1990s | - Multimedia in education software<br>- Development of Learning Management Systems (LMS) |
| 2000s -2010s | - Introduction of machine learning and adaptive learning<br>- Growth of Massive Open Online Courses (MOOCs)<br>- Data analytics and predictive modeling for learner support |
| 2010s -Present | - AI-driven chatbots and virtual assistants<br>- Adoption of gamification elements for engagement<br>- Expansion of AI-driven content recommendations and assessments |

*Source: compiled by the authors*

### 3.2. The role of Artificial Intelligence in personalized learning

In the present era, AI integration in education has opened up a vast array of possibilities that have the potential to transform and enhance the educational landscape. AI-driven technologies are revolutionizing the way we teach, learn, and administer educational processes. These innovations are offering educators, students, and institutions a plethora of opportunities for improving educational outcomes and experiences. One of the most prominent and promising aspects of artificial intelligence in education is its capacity for personalized learning. AI-driven systems can analyze vast amounts of data to create tailored learning experiences for each student. This personalization ensures that students receive instruction that aligns with their individual abilities, interests, and learning styles.

One of great examples is MATHia. It is an intelligent tutoring system developed by Carnegie Learning, Inc. that utilizes artificial intelligence and educational data analytics to provide personalized learning experiences in mathematics [4]. It is designed to assist students in improving their mathematical proficiency through adaptive instruction and tailored feedback. MATHia's underlying AI engine accumulates extensive data on each student's interactions, performance, and progress. This data is processed to extract valuable insights into a student's learning patterns and preferences. These insights can inform educators, students, and parents about the student's strengths, weaknesses, and areas that need improvement.

The following case is an example of successful integration. Cabell County Schools, situated in Huntington, the second-largest city in West Virginia, embarked on a transformative journey in mathematics education under the guidance of Lisa Burris, the Academic Math Specialist responsible for the district's middle schools. The primary goal of this initiative was to shift the traditional, teacher-centered approach to a more student-centered educational model. Such paradigm shifts in education are inherently challenging, necessitating the implementation of the right professional learning resources and strategies. To facilitate this transition, Cabell County Schools opted to

collaborate with Carnegie Learning, a well-established education technology company known for its evidence-based approach to mathematics education. The impact of the collaboration between Cabell County Schools and Carnegie Learning is reflected in the outcomes presented in Table 2. These results serve as compelling evidence of the effectiveness of personalized learning services in driving positive change in mathematics education within the district.

**Table 2.** Results of Cabell County Schools' Partnership with Carnegie Learning.

| Year | Number of Participants | Overall Rating for Academy | Overall Rating for Facilitator | How Likely to Recommend to a Colleague | Agreeing that they will be able to incorporate what they learned into their daily work |
|---|---|---|---|---|---|
| 2019 | 71 | 9.6/10 | 9.7/10 | 9.5/10 | 100% |
| 2020 | 54 | 9.7/10 | 9.8/10 | 9.7/10 | 96.3% |
| 2021 | 36 | 9.8/10 | 9.9/10 | 9.7/10 | 97.2% |
| 2022 | 32 | 9.9/10 | 9.9/10 | 9.9/10 | 100% |
| 2019-2022 | 191 | 9.7/10 | 9.8/10 | 9.7/10 | 98% |

*Source: [3]*

AI also plays an important role in the development of the online education sector. Coursera, a pioneering online learning platform, has strategically adopted AI as a potent tool to revolutionize and personalize the learning journey for its extensive user base, comprising millions of learners globally. Founded in 2012 by Andrew Ng and Daphne Koller, Coursera has emerged as one of the leading providers of massive open online courses (MOOCs) worldwide, granting access to top-quality education from world-renowned universities and institutions.

The platform introduced several new content offerings and AI-powered platform innovations [24]. Coursera has implemented a novel AI-driven chatbot tool named Coursera Coach, leveraging artificial intelligence to elevate the educational experience. Fueled by ChatGPT, this intelligent coach possesses the capacity to address inquiries by analyzing and succinctly summarizing Coursera's extensive curriculum. The AI coach excels at simplifying complex concepts, rendering them more accessible for learners. Notably, it exhibits multilingual proficiency and caters to diverse educational levels, thereby fostering a globally inclusive and captivating learning environment.

In addition to its chatbot application, Coursera harnesses AI across various dimensions. Coursera employs AI to aid clients in the creation of their own courses, introducing a suite of AI-powered features capable of autonomously generating course content. This includes comprehensive structures, readings, assignments, and glossaries, empowering course authors to significantly reduce both time and expenditure associated with content production. This multifaceted utilization of AI serves to enhance the quality and cost-effectiveness of training content development.

Furthermore, Coursera's AI efforts extend into the realm of personalized learning experiences. The platform's AI algorithms analyze user data, including their course completion history, learning preferences, and skills assessments. This comprehensive analysis facilitates personalized learning pathways that align with each user's specific educational objectives, ensuring they encounter courses and materials that meet their needs precisely. Coursera's integration of AI strategically enables the

development of superior training material and mitigates linguistic obstacles with machine translation. This ultimately enhances the overall learning experience by promoting a tailored and interactive dimension.

As mentioned above, AI can play a key role in the realm of language acquisition. To illustrate this, we shall examine a noteworthy exemplar of an influential language-learning platform, namely, Duolingo. Founded in 2011, Duolingo has rapidly gained popularity and is considered one of the leading language-learning applications globally. The platform offers courses in a multitude of languages, making it accessible to a diverse user base. Duolingo's success can be attributed, in large part, to its innovative use of AI to adapt the difficulty of lessons and exercises to individual learners' progress.

The Duolingo language-learning platform initiates the learning journey with an AI-driven placement test, which serves the purpose of ascertaining the initial proficiency level of each user in the language they aspire to study. For instance, in the case of an individual registering to learn French, their educational background, such as four years of prior instruction in high school, influences their starting point within Duolingo's language lessons. In contrast, a user with no prior exposure to the French language will commence at a different point. The AI-driven placement test continuously adapts during its administration, contingent upon the user's accuracy in answering preceding questions. In a mere span of five minutes, this diagnostic assessment effectively gauges each user's baseline comprehension of the language, facilitating the platform in determining the optimal starting point for the individual's language course [12].

This dynamic adaptability not only enhances the overall user experience but also mitigates the likelihood of learners with some pre-existing knowledge disengaging from the platform due to an overly elementary starting point, thereby contributing to a more constructive and engaging language-learning process.

## 3.3. Artificial Intelligence as a teaching partner

AI extends its benefits not only to students but also to educators. Project Topeka constituted a rigorous two-year research pilot initiative conducted by Digital Promise, in collaboration with the Bill & Melinda Gates Foundation. The principal objective of this endeavor was to assess a spectrum of tools and methodologies designed to enhance writing proficiency among educators and students by fostering increased engagement in writing practice and facilitating constructive feedback. Commencing in February 2020 and concluding in June 2022, Digital Promise provided extensive support to middle school English language arts instructors nationwide, enabling them to employ the tools and resources within the Project Topeka framework to impart instruction in argumentative writing [6].

The research involved the comprehensive evaluation of an AI-equipped platform that facilitated middle school students in the creation, submission, and revision of argumentative essays in response to pre-determined writing prompts. Upon each submission, the students received AI-generated mastery-based scores ranging from 1 to 4, meticulously aligned with four distinct writing domains: Claim & Focus, Support & Evidence, Organization, and Language & Style [7]. Moreover, the AI system provided dimension-aligned comments that furnished both observations and constructive recommendations for essay enhancement, all of which were instantaneously generated upon students' submissions.

To establish a comparative analysis between the AI-generated scores and feedback and the assessments rendered by human instructors, a dedicated in-person gathering was convened, comprising 16 middle school writing teachers who had employed the AI-powered platform in their classrooms during the 2021–22 academic year. These educators underwent a calibration process aimed at ensuring a shared, reliable understanding and application of the project's rubric, which guided the scoring and feedback provision. Each teacher was assigned a set of 10 random essays (distinct from those of their own students) to evaluate and provide feedback on. This collaborative effort yielded a total of 160 essays, all assessed by teachers, thus enabling a direct and comprehensive comparison between the AI-generated scores and feedback and the evaluations conducted by human educators on the same essays.

The research findings indicate that, on average, human teachers assigned lower scores to essays when compared to the AI-generated scores, and these differences were statistically significant in all dimensions, except for Claim & Focus. Specifically, in terms of the cumulative score encompassing all four dimensions (with a minimum score of 4 and a maximum of 16), the average score provided by teachers for the 160 essays under consideration was 7.6. In contrast, the AI system yielded an average score of 8.8 for the same set of essays, underscoring the disparities in scoring between human instructors and the AI across the evaluated dimensions (Figure 1).
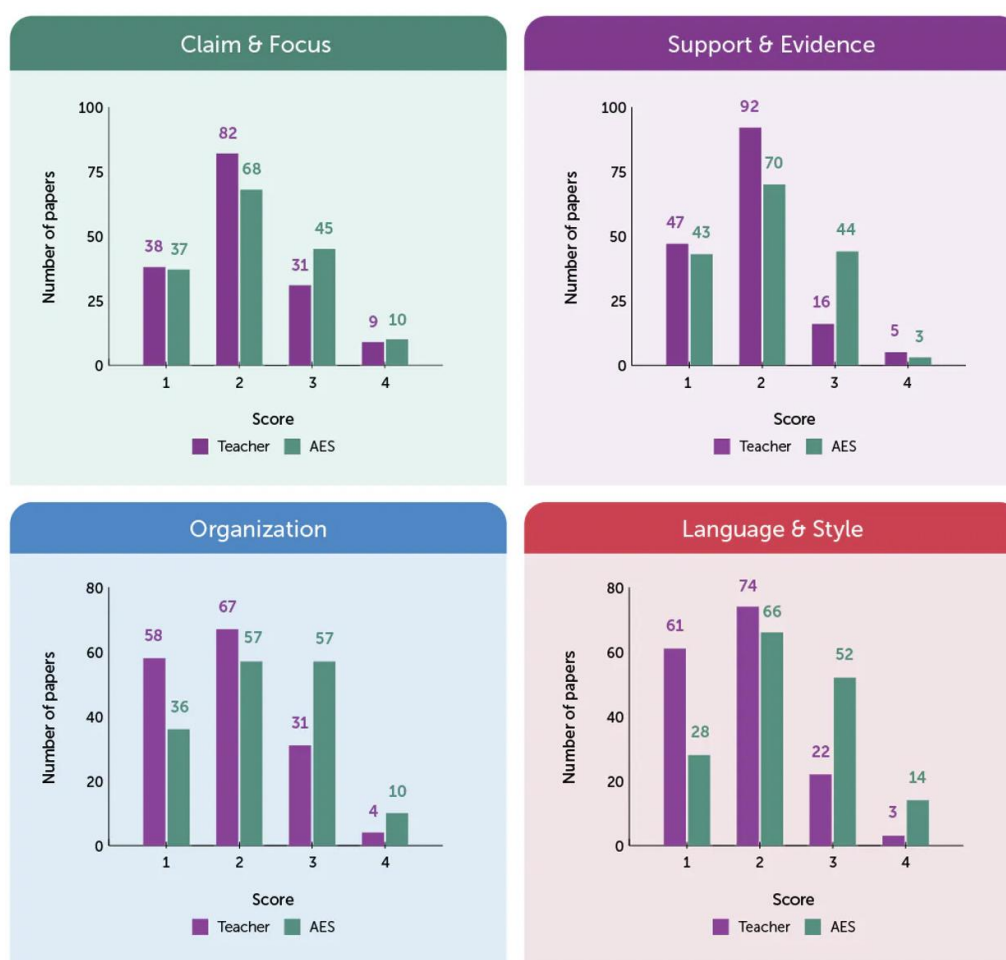


**Figure 1.** Teacher and AI scores in four dimensions of argumentative writing (n = 160 essays). *Source: [13]*

Tasks that were previously characterized by tedium, repetition, and time-intensive requirements, often leading to heightened stress levels and reduced productivity among teachers, are now amenable to automation. This automation serves to expand teachers' capacity and provides them with the flexibility to adapt their daily routines in accordance with specific pedagogical requirements. Findings from the research indicate nuanced differences in the assessment approaches of teachers and AI systems. Nevertheless, researchers maintain the belief that by training AI systems to adopt a more comprehensive perspective similar to that of teachers when evaluating essays and by refining the language used in feedback to align with students' developmental and contextual needs, AI has the genuine potential to support educators in the grading process.

Indeed, such educational assistants already exist. NoRedInk, an AI-based educational tool, was born from Jeff Scheur's eight-year experience as a high school English teacher who had graded 15,000 papers. The challenge was managing large class sizes and providing meaningful feedback. Recognizing that students often struggled to understand and apply his comments, Scheur embarked on a solution. He hired an engineer through Craigslist and developed a website, named "NoRedInk" by his students [17]. NoRedInk offers a range of features and tools designed to improve students' writing and grammar proficiency. It employs a personalized learning approach, leveraging adaptive algorithms to tailor lessons and exercises to individual students' skill levels and learning needs. The platform covers various aspects of writing and grammar, including sentence structure, punctuation, subject-verb agreement, and other language mechanics. In just nine weeks of its public release, NoRedInk gained traction, with 15,000 students and teachers actively using the platform, highlighting the demand for AI-driven solutions in education.

Numerous AI-based programs have been developed to facilitate the assessment and grading of students' assignments by educators. Notably, several of the most widely recognized AI-based grading solutions are outlined in Table 3.

**Table 3.** AI-based programs for assisting teachers.

| AI-Based Program | Description |
|---|---|
| Gradescope | Is a cloud-based platform that facilitates the grading of paper-based assignments, essays, and online quizzes. It employs AI to automate the grading process, saving teachers considerable time. |
| Formative AI | Is another cloud-based platform that assists teachers in grading students' work. It utilizes AI to offer real-time feedback on student performance, aiding educators in identifying areas where additional support may be required. |
| Rubric | Is an AI-powered grading tool specifically designed for assessing essays and written assignments. It employs AI to identify key concepts and skills within student writing, providing teachers with valuable feedback to enhance student writing. |
| PlagScan | Is an AI-powered plagiarism detection tool. It aids in detecting instances of plagiarism in student work, ensuring academic integrity. |
| Grammarly | Is an AI-powered grammar and spelling checker. It assists in identifying and correcting grammar, spelling, and punctuation errors in student work, promoting language accuracy. |

*Source: compiled by the authors*

By leveraging AI, educators can streamline assessment processes, save time, and provide more effective support to students. As AI technology continues to advance, its role in enhancing the efficiency and precision of educational assessment is expected to grow, ultimately benefiting both teachers and learners.

### 3.4. The era of chatbots and virtual assitants

AI-powered chatbots, or virtual assistants, have evolved into versatile tools that are becoming ubiquitous in various aspects of our lives, from customer support to healthcare and education. These intelligent conversational agents are designed to simulate human-like interactions, providing a natural and user-friendly way to access information and services. AI chatbots have witnessed remarkable advancements in natural language processing and machine learning, enabling them to understand and respond to human queries with unprecedented accuracy and context awareness. Chatbots are no longer confined to rigid scripts; they adapt to individual users' needs and preferences, offering a highly personalized experience. In customer service, they are available around the clock, reducing response times and enhancing customer satisfaction.

Moreover, the educational sector has embraced AI chatbots to provide students with instant answers to questions, guidance on coursework, and support in navigating administrative processes. This technology is helping institutions offer more accessible and responsive learning environments [18]. In healthcare, chatbots are being utilized for telemedicine and health-related queries, making healthcare services more accessible and efficient. The article published by Georgia State University (GSU) highlights a pioneering experiment that demonstrates the positive impact of AI-powered chatbots on student performance in higher education. The experiment conducted at GSU focused on the use of a classroom chatbot, specifically the AI chatbot named "Pounce." Pounce was designed to provide students with instant support and answers to their academic and administrative questions.

This innovative approach was implemented in one of the university's largest courses, Political Science 1101, and the study, led by Lindsay Page, the Annenberg Associate Professor of Education Policy at Brown University, utilized a randomized controlled trial to assess its impact. The study's findings revealed that students who received the PolsPounce messages experienced notable improvements in their academic performance. Specifically, the results indicated that [9]:

- Students who received messages from the chatbot achieved grades of B or higher at a rate 16 percent higher than students who did not receive these messages. This signifies a substantial positive impact on students' final grades.
- First-generation students in the control group had an average final grade of 64, whereas those who received chatbot messages earned final grades that were, on average, 11 points higher. This demonstrates that the chatbot had a particularly beneficial effect on the academic performance of first-generation students.
- Among students who were not in their first year of college, those who received chatbot messages displayed a higher likelihood of passing the course and a reduced likelihood of dropping their other Georgia State classes. Moreover, they achieved higher fall term grade point averages, with an increase of 0.28 points on average.
- The study also highlighted that students who had lower academic performance in high school, but received chatbot messages, were more likely to attend supplemental instruction, achieve grades of

B or higher in the class, and complete more credits for the semester. This suggests that the chatbot played a critical role in supporting and empowering academically struggling students.

These results underscore the significance of integrating AI technologies into higher education to provide students with personalized support and foster improved outcomes. Renick, the founding executive director of the National Institute for Student Success, emphasized that while the advantages of the chatbot intervention extend to students from diverse demographic backgrounds, a consistent pattern has emerged. The students who derive the most substantial benefits from the chatbot intervention are those who encounter the greatest academic challenges. Specifically, individuals belonging to demographic groups characterized by low income, being the first in their families to pursue a college education, or coming from underrepresented minority backgrounds have exhibited significant improvements in response to this technology.

Renick's insight underscores the critical role of the chatbot as a support mechanism for students who may lack a robust support system at home or familiarity with the resources available to them in a college environment. The chatbot serves as a readily accessible and available resource, providing continuous assistance 24/7. Consequently, it becomes an invaluable tool in bridging the support gap for students facing significant academic and social challenges, ultimately contributing to their academic success and progression in higher education.

The role of AI-powered chatbots in the field of education is becoming progressively valuable, contributing to enhancements in students' learning experiences and outcomes. The developments of some of them are summarized in Table 4.

**Table 4.** The valuable role of AI chatbots in education.

| AI-chatbot | Description | Impact on study process |
|---|---|---|
| ChatGPT | A large language model chatbot that can generate text, translate languages, write different kinds of creative content, and answer your questions in an informative way. | Can be used by students to generate study materials, such as summaries of key concepts, practice questions, and essays; can also be used to answer questions about the course material and to provide feedback on student work. |
| Bard | A large language model chatbot that can generate text, translate languages, write different kinds of creative content, and answer your questions in an informative way, even if they are open-ended, challenging, or strange. | Can be used by students to generate study materials, answer questions about the course material, and provide feedback on student work; can also be used for more creative tasks, such as generating ideas for research papers or writing creative pieces. |
| Copy.AI | An AI-powered copywriting tool that can generate different creative text formats of text content, like poems, code, scripts, musical pieces, email, letters, etc. | Can be used by students to generate creative content for assignments, such as poems, stories, and scripts; can also be used to generate marketing materials for student clubs and organizations. |

*Source: compiled by the authors*

Presently, ChatGPT boasts an expansive user base exceeding 100 million individuals, and its website witnesses an impressive volume of nearly 1.5 billion visitors on a monthly basis [10]. This extraordinary growth attracted widespread attention due to its capacity to generate text across a spectrum of complexity, leveraging natural language processing, a subfield of machine learning. Unsurprisingly, educators and students alike have been exploring the potential applications of this AI chatbot within the realm of education.

To gain insights into the extent of ChatGPT's utilization for academic purposes, The Stanford Daily conducted a survey involving approximately 4,497 respondents. This survey aimed to discern the prevalence of students using ChatGPT for assignments and examinations, shedding light on the tool's integration into the academic landscape. Here are the findings based on student responses [5]: 17% of respondents said they used ChatGPT during their fall quarter assignments and exams. Out of those 17%, here is what the students have to say:

- 59.2% of students said they used AI mainly for brainstorming, forming ideas, and outlining.
- 29.1% agreed that they answered multiple-choice questions using ChatGPT.
- 7.3% said they submitted ChatGPT responses as answers but with some edits.
- 5.5% claimed that they submitted answers directly from ChatGPT without edits.

AI chatbots present a plethora of opportunities for augmenting the educational process, encompassing the provision of immediate assistance, tailored guidance, and enhanced accessibility. Nevertheless, these advantages are accompanied by notable challenges that demand attention, including the imperative to address privacy-related apprehensions, mitigate the risk of excessive reliance on AI, and uphold responsible practices in content generation. Additional details and insights can be found in Table 5.

**Table 5.** The opportunities and disadvantages of AI chatbots.

| Opportunities in study process | Disadvantages in study process |
|---|---|
| 1. Instant support: AI chatbots provide immediate answers to academic queries, helping students with assignments, research, and coursework. | 1. Limited understanding: Chatbots may struggle to comprehend complex or highly specialized academic topics and may not provide in-depth explanations. |
| 2. Accessibility: Chatbots offer 24/7 support, making educational resources and assistance available at any time, enhancing accessibility and flexibility. | 2. Overreliance: Students may become overly dependent on chatbots, potentially reducing their problem-solving and critical thinking skills. |
| 3. Content generation: Some chatbots, like Copy.AI, assist with content creation, streamlining the writing process for essays, reports, and research papers. | 3. Risk of plagiarism: Overreliance on chatbots for content generation may lead to unintentional plagiarism if not used responsibly. |
| 4. Personalized guidance: AI chatbots can provide personalized recommendations and assistance tailored to the individual needs and learning style of students. | 4. Privacy concerns: The use of chatbots in education may raise concerns about student data privacy and security, requiring robust measures. |

*Source: compiled by the authors*

AI chatbots are not mere tools; they represent a significant stride towards a more interconnected, accessible, and efficient future, offering solutions to tasks and challenges that once seemed insurmountable. Their journey is ongoing, and their contributions to diverse fields will continue to grow and reshape the way we work, learn, and communicate.

## 4. Discussion

AI has emerged as a transformative force in various sectors, and its application in education leads to reshaping the way we teach and learn. The integration of AI technologies in education can enhance the education system significantly. However, offering benefits and opportunities, AI still presents particular challenges and considerations. One of the primary advantages of AI in education is the ability to make education more accessible and personalized. AI-driven platforms, such as virtual tutors and chatbots, provide students with 24/7 support, immediate answers to queries, and accessibility to educational resources. This personalized assistance considers individual learning needs and styles, helping students at their own pace and on their schedule.

AI presents a transformative paradigm in the realm of education, offering the potential to customize learning experiences for individual students. By leveraging AI, educators can comprehensively analyze the distinct learning styles, strengths, and areas of improvement of each student. This analysis forms the bedrock upon which personalized lesson plans and recommended resources are constructed, precisely addressing the unique needs of each learner. Such personalized learning environments empower students to progress at their own pace, resulting in tangible enhancements in their academic performance.

AI's pivotal role in education extends across various dimensions, empowering teachers with an array of tools and capabilities [21]. These include the automation of assignment grading, provision of constructive feedback, and tailoring of learning experiences. AI-driven adaptive learning systems dynamically adapt the complexity of educational materials based on each student's performance, ensuring a balance between challenge and comprehension without overwhelming the learner. Furthermore, AI finds purpose in the domain of special needs education, offering tailored support to students with specific requirements. For instance, AI systems can significantly benefit students with conditions like dyslexia by rendering textual content in auditory formats and highlighting crucial keywords, thereby rendering learning more accessible and effective.

In the context of language acquisition, AI becomes a catalyst for progress. It delivers personalized learning experiences, extending targeted support for learners seeking to acquire a new language. AI-powered tools, for instance, provide audio renditions of textual content and emphasize essential vocabulary, simplifying the language acquisition process. AI enriches the learning experience through the incorporation of gamification and immersive learning techniques [14]. AI-driven systems have the capacity to create interactive educational games, transforming learning into an engaging and enjoyable endeavor that facilitates the acquisition of new concepts and skills.

Beyond instructional support, AI serves as a liberating force for educators by automating routine administrative tasks. This encompasses functions such as grading, attendance management, and scheduling, relieving educators from the burden of administrative minutiae and affording them the time and capacity to focus on more substantive aspects of teaching and student engagement. This, in turn, enhances overall operational efficiency. AI, underpinned by the analytical power of data,

empowers educators to foresee and identify students at risk of underperformance or disengagement. Teachers can provide targeted support even before problems are aggravated, which helps students to improve their outcomes. Therefore, all learners receive the requisite assistance to excel in their educational pursuits. AI's introduction into the education environment also gives rise to a series of noteworthy concerns.

While AI offers substantial enhancements to the educational experience, an over-reliance on automated systems may erode the central role of human educators. The harmonization of AI-driven tools with human instructional capabilities is imperative to ensure that the quality and integrity of education remain uncompromised. The interpersonal dynamics and nuanced relationships that human educators foster, including mentorship, empathy, and rapport-building, present a considerable challenge for AI to replicate adequately. An unwarranted reliance on AI-driven education runs the risk of eroding these essential human connections that form the bedrock of effective educational interaction between educators and students.

Furthermore, the ethical use of AI-generated content constitutes a pressing concern. The capacity of AI to autonomously generate educational material begets questions pertaining to content quality, accuracy, and ethical integrity. The ethical use of AI-generated content in education is a critical issue in the educational discourse. As AI-powered tools become increasingly adept at generating educational materials, it is essential to ensure that these resources align with rigorous ethical guidelines to promote the highest standards of learning and integrity.

One key ethical consideration pertains to the accuracy and quality of AI-generated content. Educational institutions must be diligent in evaluating and curating the content produced by AI to ensure it meets the requisite standards for academic rigor. Furthermore, they must make certain that AI-generated materials are up-to-date and free from inaccuracies that could mislead students [1]. Rigorous oversight, review processes, and quality assurance mechanisms are necessary to maintain the credibility of AI-generated content. Another vital ethical dimension is the acknowledgment and proper attribution of AI-generated content. Students and educators should be informed about the involvement of AI in creating the learning materials they utilize. However, as Dr. Jeremy Van Hof [25], director of instructional technology and development at Michigan State University's Eli Broad College of Business, noted, it is important that teachers know that the technology exists, that it is free, and that students are likely to use it.

It is essential to acknowledge that overreliance on AI-powered tools in educational settings has the potential to impact the depth and authenticity of students' acquired knowledge. After all, true knowledge encompasses not only the ability to access information, but also the ability to critically engage with it, analyze it, and synthesize it.

AI-powered tools often provide quick answers through algorithms and pre-programmed data. While this can benefit certain tasks, it may discourage students from exploring the complexities of a subject. Overreliance on such tools may promote surface-level learning, where students prioritize quick answers over comprehensive understanding rather than fostering a thorough grasp of concepts through in-depth exploration and critical thinking. Relying solely on AI tools for information retrieval could also impede the development of critical research skills. Effective learning requires not only the acquisition of knowledge but also the ability to identify reliable sources, cross-reference information, and critically evaluate the credibility of data. Excessive dependence on AI may reduce the emphasis on these essential research skills and hinder students' abilities.

Educators have a crucial role in guiding students to view AI tools as supplements rather than substitutes for traditional learning methods. Encouraging critical inquiry, fostering independent exploration, promoting critical thinking, creativity, and problem-solving skills are crucial tactics. This approach ensures that students can benefit from AI's strengths while maintaining the room for human-centric traits.

Traditional educational settings involve dynamic interaction between educators and students. This includes mentorship, personalized guidance, and the cultivation of interpersonal skills. The active implementation of AI may unintentionally disrupt this vital human connection, as automated systems lack the capacity for genuine emotional engagement, empathy, and the nuanced understanding brought by human educators to the learning process. Collaborative learning, group discussions, and the camaraderie fostered in face-to-face interactions all significantly contribute to a comprehensive educational experience. The potential diminishment of these interpersonal dynamics in favor of AI-driven efficiency raises concerns regarding the broader impact on students' social skills, emotional intelligence, and overall well-being.

Mitigating this challenge requires a considerate approach to AI integration that acknowledges the indispensable role of human educators. Educators can utilize AI as a tool to improve their teaching methods, obtaining valuable insights and automating routine tasks. Nevertheless, it is crucial to maintain a balance that preserves the interpersonal aspects of education.

As AI continues to revolutionize education, these concerns necessitate ongoing attention, thoughtful policy development, and conscientious implementation, aiming to harness AI technologies to their fullest potential while effectively mitigating potential risks and challenges. Notwithstanding the challenges, the artificial Intelligence (AI) market is poised for sustained growth. Projections indicate that the global market for AI in education is expected to attain a value of $3.68 billion by the year 2023 [11]. Furthermore, the anticipated trajectory suggests substantial expansion in the global AI in education market, with a projected Compound Annual Growth Rate (CAGR) of 36.6% during the period spanning from 2022 to 2030. This growth is expected to culminate in the market reaching a valuation of $25.772 million by the year 2030 [15].

## 5. Conclusions

The role of artificial intelligence in education stands as a transformative and dynamic frontier since it enhances the education system and promotes innovations in teaching methods and learning management. AI technologies integrated into education have marked a new era of possibilities, facilitating personalized learning experiences, streamlining administrative tasks, and ultimately enhancing the educational process for students across the globe. This comprehensive exploration of AI's influence on education has underscored its multifaceted impact and the significant promise it holds for the future.

It is possible to trace significant milestones in the historical development of AI that shaped its contemporary role. The earliest endeavors to integrate AI into education date back to the 1960s when computers began to emerge as educational tools. These early computer-assisted learning (CAL) systems paved the way for the exploration of AI's potential in education. The 1980s were marked by the advent of intelligent tutoring systems, which laid the foundation for personalized learning environments that catered to individual student needs. The 2000s saw the proliferation of advanced adaptive AI systems, heralding the era of customized education. AI's evolution in education

continues to accelerate, and AI-powered chatbots and virtual assistants become ubiquitous in educational institutions.

AI's influence on teaching methods is profound, as it empowers educators with a suite of tools and capabilities that range from personalized lesson planning to automated grading and feedback provision. Adaptive AI-driven learning systems provide detailed instruction and address students' learning styles and needs. These innovations increase instructional efficiency and provide educators with valuable insights into student progress, allowing for timely intervention and support. By offering personalized learning experiences, AI caters to students with varying levels of proficiency and specific requirements, such as those with disabilities or students learning a new language. This adaptability promotes inclusivity and facilitates accessibility.

As the educational landscape continues to evolve in response to AI innovations, the simultaneous advancement and mitigation of these challenges is essential. Ethical guidelines, adequate teacher training, and a commitment to accessibility and inclusivity must underpin the integration of AI in education. Furthermore, the dynamic role of educators, as guides, mentors, and facilitators, becomes paramount in an environment where AI augments rather than supplants human teaching. In conclusion, the role of Artificial Intelligence in the education system is one of immense promise and transformative potential. The innovations in teaching methods and learning management brought about by AI herald an era of personalized, adaptive, and data-driven education. However, the responsible use of AI, with due consideration for ethical, privacy, and fairness concerns, is vital to ensure that the advantages it brings are harnessed for the betterment of the education system, educators, and students.

**Use of AI tools declaration**

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

**Conflict of interest**

The authors declare there is no conflict of interest in this article.

**Ethics declaration**

The author declared that the ethics committee approval was waived for the study.

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