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A Systematic Literature Review on How Artificial Intelligence (AI) is Revolutionizing Education 4.0

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Abstract

This paper assesses how artificial intelligence (AI) changes the education landscape, especially in Education 4.0. It also investigates how AI facilitates this change, improves educational methods, and identifies the main obstacles and future directions in its implementation. An educational transformation is underway to tackle the complex demands of today's learners to keep pace with the rapidly changing technological world. This transformation moves from conventional teaching methods towards embracing personalized learning experiences, AI-driven tutoring, streamlined administrative processes, and predictive analytics. Education 4.0 is a significant milestone where technology, particularly AI, is used to improve the educational journey. This article closely examines AI's function in education, emphasizing the benefits it provides on the learning experience and analyzing future trends in data-driven educational practices. The transition from traditional educational frameworks to Education 4.0 signifies a move away from rigid, uniform teaching methods in favor of more flexible and tailored educational approaches. Additionally, this study examines the idea of adaptive learning and how AI can modify teaching strategies instantly, taking into account feedback and the student's rate of progress. Lastly, it sheds light on the difficulties of broadly implementing AI in education.

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1. Introduction

In this technologically advanced world of ours, it's becoming increasingly essential to include artificial intelligence (AI) in education. Keeping up with the demands of students in the modern day requires schools to include cutting-edge technological tools into their curricula. The culmination of the current technological revolution is approaching rapidly, which combines digital, biological, and physical aspects, and this is causing significant changes in the education sector (Moraes et al., 2023; Verma et al., 2021; Mukul and Büyüközkan, 2023; Noh and Karim, 2021). Education 4.0 is at the forefront of this change, paving the way for a revolution in teaching methods where artificial intelligence (AI) is key. This change aims to develop personalized and adaptive learning experiences (Kim, 2022; Himmetoglu et al., 2020; Shahroom and Hussin, 2018). AI, which mimics human intelligence, has proven to be very effective in many different areas, especially during the COVID-19 pandemic, and has become a major global force (Vaishya et al., 2020). It is changing education by providing personalized learning methods that are not limited by the traditional, strict education systems (Talan, 2021). Historically bound by strict schedules and physical locations, traditional educational institutions are now changing to incorporate

technological advancements (Sadiku et al., 2021). AI can investigate huge volumes of data, which allows for more personalized educational experiences (Abdellatif et al., 2022; Roll and Wylie, 2016; Chen et al., 2020). AI could usher in a new era of personalized education where learning is continuous and accessible, supporting personal growth (Ahmad et al., 2022).

The history of education consists of several distinct periods. Education 1.0, based on a traditional teaching model, was the same for everyone, characterized by memorization and teacher-centered instruction. In Education 2.0, multimedia and technology began to be used in classrooms, resulting in more interactive and engaging learning experiences. Education 3.0 highlighted student-centered learning, promoting collaborative surroundings and the practice of online tools, which paved the way for today's digital education (Ramírez-Montoya, 2021; Chakraborty, 2023; Alda et al., 2020; Hariharasudan and Kot, 2018). In the current era of Education 4.0, the educational scene has been defined by the incorporation of technologies such as cloud computing, big data analytics, the Internet of Things (IoT), and artificial intelligence (AI) (González-Pérez and Ramírez-Montoya, 2022; Almeida and Simoes, 2019; Oliveira and De Souza, 2022; Gajek et al., 2022; Miranda et al., 2021). One area where AI has emerged as a game-changer is in the realm of education. According to many studies (Kwon, 2023; Chen et al., 2020; Lameras and Arnab, 2021; Levin et al., 2022; Qu et al., 2022; Huang, 2021), it is capable of personalizing learning experiences to match the specific requirements and preferences of every student.

The use of AI in education facilitates personalized learning paths and supports adaptive systems that respond to learners' progress, enhancing the proficiency and usefulness of the educational development (Rios-Campos et al., 2023; González and Bonilla, 2022; Ouyang and Jiao, 2021; Sanusi et al., 2022). Although AI technologies like expert systems (ES) and machine learning (ML) have been part of education for over 60 years, current developments, such as Synthesia, ChatGPT, Dall-E2, and Bard, are significantly disrupting the field. These tools can generate essays, create images, explain complex concepts, and solve math problems. The World Economic Forum (2024) highlights that generative AI's ability to mimic human reasoning and creativity raises questions about the relevance of current educational methods, especially in writing, grammar, and logic. Ideally, students would benefit from personalized support, inclusive learning opportunities, and strong teacher relationships to ensure proper supervision and acknowledgment of their achievements. Artificial intelligence's ability to sift through mountains of data and deliver insights that facilitate the development of individualised learning plans is driving its growing use in the arena of education. According to several studies (Tedreet al., 2021; Kolachalama, 2022; Cardona et al., 2023; Fiebrink, 2019; Combrink et al., 2023; Luan and Tsai, 2021; Malik et al., 2023), ML algorithms, which are a subfield of artificial intelligence, analyze learners' unique habits, interests, and abilities to tailor lessons and learning materials to meet the needs of individual students. According to Kim (2022), Alda et al. (2020), and Almeida and Simoes (2019), one of the distinguishing features of AI in Education 4.0 is its capacity to create adaptable learning environments. Based on students' progress and knowledge, these systems adapt the speed, subject matter, and delivery of classes in real time. This flexibility permits students to study at their own speed, getting help when they need it and moving on to more difficult topics when they're ready, creating a more comprehensive and relevant learning environment. Through encouraging interactive and hands-on learning, AI also plays a significant role in cultivating vital abilities for the 21st century. According to prior studies (Tan et al., 2022; Al-Ansi et al., 2023; Zhang and Wang, 2021; Dzyuba et al., 2022; San Lippo et al., 2022; Joo and Jeong, 2020; Fitria, 2023;), students can engage in immersive simulations through the use of VR and AR technologies powered by AI. This approach deepens understanding of various subjects and cultivates creativity, teamwork, and problem-solving abilities—skills critical for thriving in the modern, interconnected world. While AI in education offers great promise, its full potential can only be realized through careful implementation that ensures equitable access to quality education. The World Economic Forum's Education 4.0 Framework highlights eight essential changes needed to enhance education in the context of the Fourth Industrial Revolution. These include personalized,

accessible, problem-solving, collaborative learning, lifelong, student-centered education that nurtures global citizenship, innovation, technological fluency, and interpersonal skills. Research has shown the positive impact of AI-driven teaching systems on learner performance across different subjects, with AI-powered adaptive learning platforms helping to reduce achievement gaps for marginalized groups. By incorporating AI, the advancement of Education 4.0 can be accelerated, and students can be better equipped for the future.

This paper delves into the intricacies of Education 4.0 by investigating the effect of artificial intelligence (AI) in intelligent tutoring systems, personalized learning, the automation of administrative tasks, and predictive analytics. Additionally, by analyzing the accomplishments and emerging trends in AI integration within education, the current study adds to the ongoing conversation about effectively harnessing AI to improve the educational experience (see Figure 2). In order to fill the gap, the researcher addresses the following research questions:

a. How does Artificial Intelligence contribute to Education 4.0?
b. What success does Education 4.0 achieve with AI?
c. What trends will AI add to Education 4.0 in the future?

2. Research Methodology and Framework

In this research, the author employed a comprehensive methodology that included a literature review, bibliometric analysis, and keyword analysis to explore the integration of AI within the frameworks of "Education 4.0." This approach aimed to thoroughly examine AI's contributions to Education 4.0, focusing specifically on personalized learning, intelligent teaching systems, the automation of administrative tasks, and predictive analytics. Furthermore, this methodology facilitates understanding the achievements and future trends in AI integration within education.

2.1. Literature Review

One approach considered to be scientifically informative is the assembly, organization, analysis, merger, and interpretation of research findings of the literature on a specific subject (AlDhaen, 2022; Zhai et al., 2021; Chen et al., 2020). The author extensively reviewed books, websites, scholarly articles, conference proceedings, and other academic sources to gain insights into AI's theoretical foundations, practical applications, and emerging trends in education. The author thoroughly reviewed 97 publications, including four books, two websites, and three conference papers, focusing specifically on AI in education. Searches were performed across various electronic databases, like Springer, Elsevier, and Google Scholar, using relevant keywords related to AI and education within "Education 4.0". A total of 97 articles from 72 peer-reviewed journals (between 2016 and 2024) were included, with most (67.99%) coming from the computer science and social sciences fields (see Table 1).

The researcher followed PRISMA guidelines for a systematic literature review on AI in Education 4.0. The process began with identifying 651 papers from seven databases, with no automated software used. The author removed duplicates and excluded 185 papers after screening abstracts and titles. Access issues led to the elimination of 95 more papers. Again, the researcher removed another 110 full-text papers using ambiguous criteria and convenience selection, leaving few relevant AI publications. After a full-text review, 97 publications met the inclusion criteria and were analyzed (see Figure 1). This research explored AI's impact on Education 4.0, culminating in developing a conceptual framework highlighting AI's achievements, future directions, and contributions to the field (see Figure 2).

2.2. Bibliometric Analysis

After conducting a literature review, the author carried out a quantitative bibliometric analysis to evaluate the academic landscape. Metadata and citation data were collected from Springer, Elsevier, and Google Scholar sources. The researcher used network analysis techniques to map

the relationships between authors and keywords. This analysis yielded significant insights into collaborative research networks, publication patterns, and the influence of AI on education.

2.3. Keyword Analysis

The researcher also performed a keyword analysis to identify important terms and concepts that shape the role of AI in education. The primary focus areas included "personalized learning," "intelligent tutoring systems," "automation of administrative tasks," and "predictive analytics." This analysis uncovered key themes, emerging trends, and research interests at the intersection of AI and education. Additionally, it contextualized the findings within the broader academic conversation and highlighted potential avenues for future study.

2.4. Integration and Synthesis

The author established an inclusive understanding of the present state of AI integration in education by assimilating the findings from the literature review, bibliometric analysis, and keyword analysis. This triangulation of data sources facilitated the identification of research gaps, emerging trends, and possible future directions in the field. The methodological approach provided valued insights into the implications of AI for personalized learning, intelligent tutoring systems, administrative automation, and predictive analytics while also contributing to the ongoing dialogue in this area.

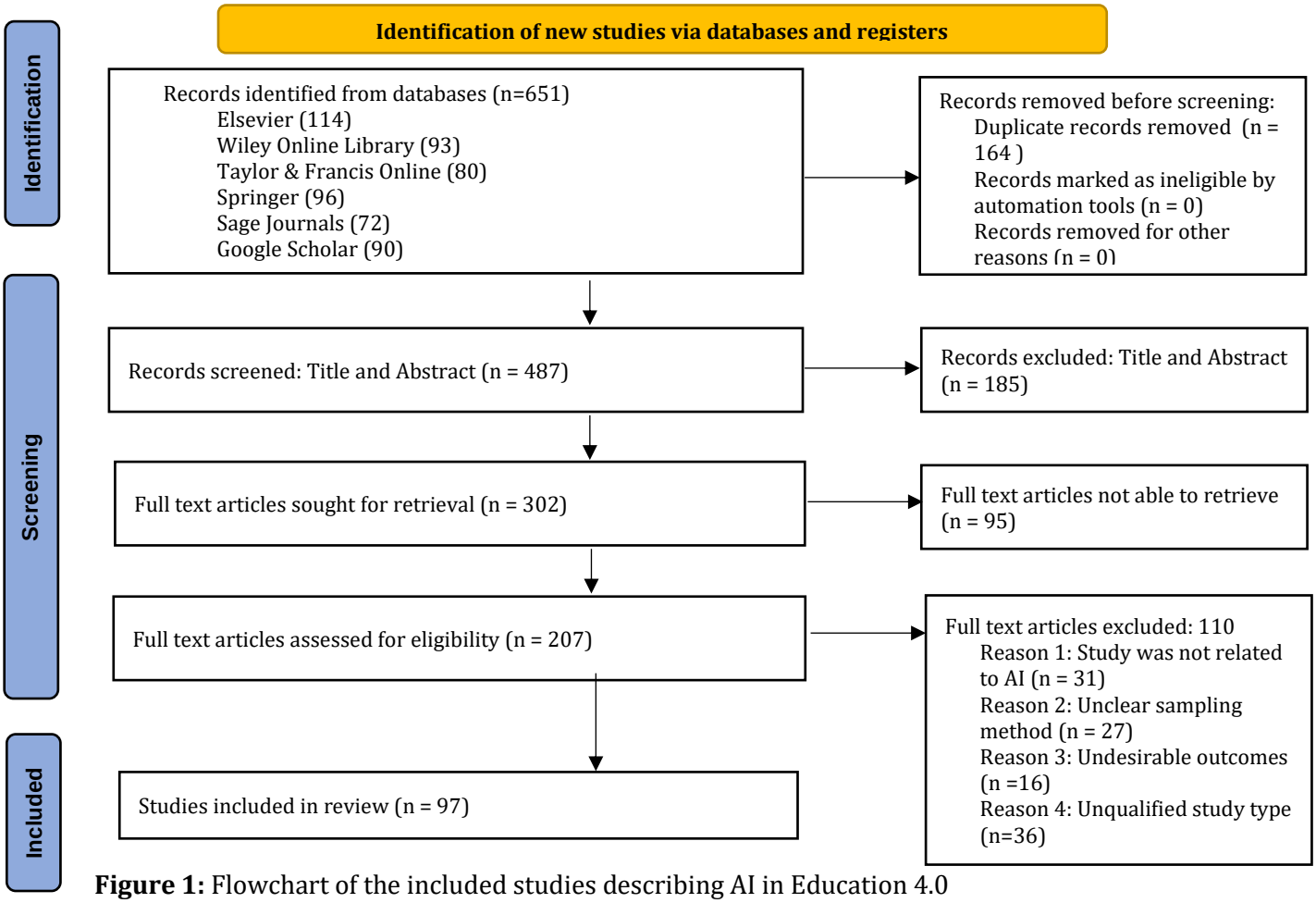

Figure 1: Flowchart of the included studies describing AI in Education 4.0
Source: *Author*

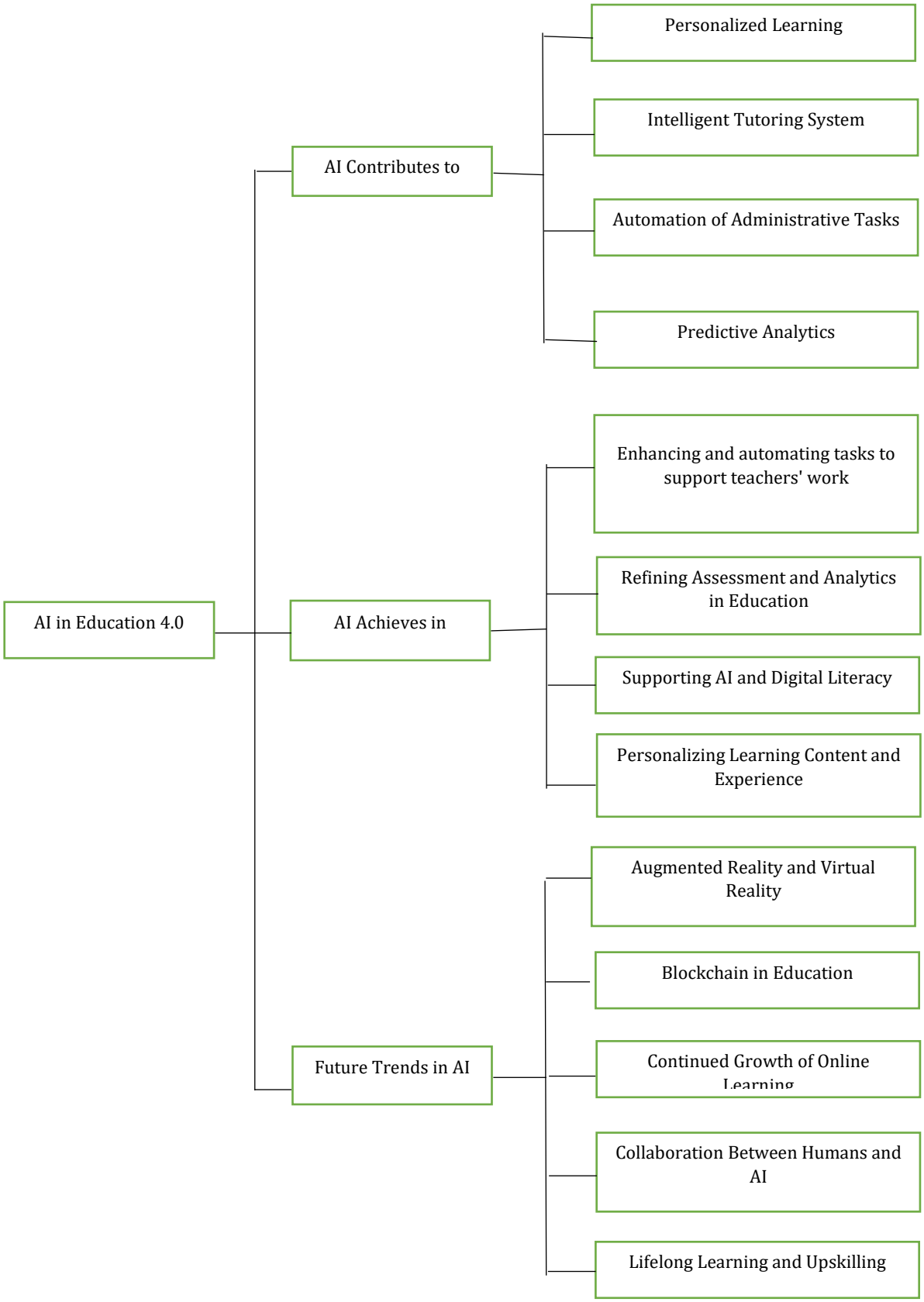

Figure 2: Conceptual framework of how AI is revolutionizing in Education 4.0
Source: *Author*

Table 1: Recent Large-Scale Review Research

SL. No.	Journal Name	Journal Category	No. of relevant articles	%
1	TechTrends	Computer Science and Social Sciences	2	2.06
2	Vietnam Journal of Education	Education, theory, and practice in education; expediting the integration of research.	1	1.03
3	European Journal of Dental Education	Dentistry and Social Sciences	1	1.03
4	International Journal for Educational Integrity	Social Sciences	1	1.03
5	Journal of Information Technology Education: Research	Computer Science and Social Sciences	1	1.03
6	Journal of Learning Analytics	Computer Science and Social Sciences	1	1.03
7	Edutracks	Education	2	2.06
8	NPJ Science of Learning	Neuroscience and Social Sciences	1	1.03
9	IEEE Transactions on Education	Engineering and Social Sciences	1	1.03
10	Journal of Visual Impairment & Blindness	Medicine	1	1.03
11	Operations Management Research	Business, Management and Accounting, Engineering, and Decision Sciences	1	1.03
12	Procedia Computer Science	Computer Science	1	1.03
13	Learning, Media and Technology	Engineering and Social Sciences	1	1.03
14	Frontiers in Education	Social Sciences	1	1.03
15	Frontiers in Psychology	Psychology	1	1.03
16	IEEE Access	Computer Science, Engineering, and Materials Science	2	2.06
17	Interactive Learning Environments	Computer Science and Social Sciences	1	1.03
18	Educational Psychology	Psychological aspects of education	1	1.03
19	Materials Today Proceedings	Materials Science	1	1.03
20	International Transactions on Artificial Intelligence	Artificial Intelligence	1	1.03
21	Environmental Science and Pollution Research International	Environmental Science and Medicine	1	1.03
22	International Journal of Educational Technology in Higher Education	Computer Science and Social Sciences	2	2.06
23	Journal of Research on Technology in Education	Computer Science and Social Sciences	2	2.06
24	Journal of Innovation in Educational and Cultural Research	Innovation Education	1	1.03
25	International Journal of Professional Business Review	Business, Management and Accounting, and Decision Sciences	1	1.03
26	The Journal of Defense Modeling and Simulation	Engineering and Mathematics	1	1.03
27	Journal of Business Research	Business, Management and Accounting	1	1.03
28	International Journal of Smart Technology and Learning,	Computer science & Medicine.	1	1.03
29	International Journal of Electrical Engineering Education	Electrical Engineering and Electronics	1	1.03
30	International Journal of Early Childhood Special Education	Psychology and Social Sciences	1	1.03
31	International Journal of Research in Education and Science (IJRES)	Social Sciences	1	1.03
32	Higher Education Pedagogies	Social Sciences	1	1.03
33	Research & Occasional Paper Series: CSHE.	Research	1	1.03
34	Learning and Instruction	Psychology and Social Sciences	1	1.03
35	Diabetes and Metabolic Syndrome: Clinical Research and Reviews	Medicine	1	1.03
36	Challenges	Planetary Health	1	1.03
37	Future Internet	Computer Science	1	1.03
38	British Journal of Educational Technology	Social Sciences	6	6.18
39	Education And Information Technologies	Social Sciences	4	4.12
40	Wireless Communications and Mobile Computing	Computer Science and Engineering	1	1.03
41	International Journal of Serious Games	Computer Science, Social Sciences, and Mathematics	1	1.03

42	Computers & Education: Artificial Intelligence	Computer Science and Social Sciences	3	3.09
43	Educational Technology Research and Development	Social Sciences	1	1.03
44	Virtual Economics	Economics, Business, Management and Accounting, Econometrics and Finance	1	1.03
45	Complexity	Computer Science and Multidisciplinary	1	1.03
46	International Journal of Environmental Research and Public Health	Environmental Science and Medicine	1	1.03
47	International Journal of Information and Communication Sciences	Communications Engineering	1	1.03
48	Sustainability	Computer Science, Energy, Environmental Science, and Social Sciences	4	4.12
49	Asia Pacific Education Review	Social Sciences	1	1.03
50	Humanities and Social Sciences Communications	Arts and Humanities, Economics, Business, Management and Accounting, Econometrics and Finance, Social Sciences, Psychology	1	1.03
51	Information Technologies and Learning Tools	ICT in teaching and learning, ICT in educational researches, ICT in management of education, computer-oriented learning tools	1	1.03
52	Applied Sciences	Chemical Engineering, Computer Science, Engineering, Materials Science, Mathematics, Physics and Astronomy	1	1.03
53	Social Sciences & Humanities Open	Decision Sciences, Psychology, Social Sciences	1	1.03
54	BMC Medical Education	Medicine, Social Sciences	1	1.03
55	International Journal of Emerging Technologies in Learning	Engineering, Social Sciences	8	8.25
56	International Journal of Engineering Trends and Technology	Engineering and Technology	1	1.03
57	Behaviour & Information Technology	Arts and Humanities, Computer Science, Psychology, Social Sciences	1	1.03
58	International Journal of Artificial Intelligence in Education	Computer Science and Social Sciences	1	1.03
59	International Journal of Scientific Advances (IJSCIA)	Science, Technology, Engineering, and Mathematics	1	1.03
60	International Journal of Research Publications	Sciences, Engineering and Technologies, Business,	1	1.03
61	Smart Learning Environments	Computer Science and Social Sciences	1	1.03
62	International Journal of Educational Research	Social Sciences	1	1.03
63	Societies (Basel, Switzerland)	Social sciences, Humanities	1	1.03
64	Business Horizons	Business, Management and Accounting	1	1.03
65	SRA Journal	Social sciences	1	1.03
66	Computers and Education Open,	Computers & Education	1	1.03
67	Big Data and Society	Computer Science, Decision Sciences, Social Sciences	1	1.03
68	Prospects	Social Sciences	1	1.03
69	International Journal of Education and Development Using Information and Communication Technology	Educational technology & Higher education.	1	1.03
70	Computers & Education	Computer Science and Social Sciences	1	1.03
71	AI	Artificial Intelligence (AIJ)	1	1.03
72	International Journal of Research and Analytical Reviews	Multidisciplinary	1	1.03

***Source**: Author*

3. Literature Review

3.1. Artificial Intelligence (AI)

The philosophers, who viewed human thought as symbolic manipulation, ascertained the roots of modern AI, which eventually directed to the growth of programmable digital computers in the 1940s. An electronic brain emerged because it was mathematically logical (Kaplan and Haenlein, 2019). "Artificial intelligence" was first coined in 1956 at a workshop at Dartmouth College, marking the beginning of intense interest and investment phases, occasionally interrupted by "AI winters" when expectations were unmet. Two primary AI approaches have since developed: the "symbolic" approach, which centers on expert systems and rule-based reasoning (Good Old-Fashioned AI), and the neural network-inspired AI, which mimics brain-like decision-making through data processing. AI indicates the computer systems that simulate human brain functions such as thinking, learning, communication, and decision-making (Zhai et al., 2021; Escotet, 2023). AI generally describes machine-based systems that predict, suggest, or make decisions impacting real or virtual environments according to human-defined goals. These systems interact with humans and their surroundings, performing tasks that require human-like intelligence and reasoning. Although definitions of AI may differ, they typically highlight intelligent programming, human-like reasoning, logical behavior, and humanoid responses (Fiok et al., 2022; Hassani et al., 2020; Lele and Lele, 2019).

3.2. Artificial Intelligence in Education

A review of existing literature is a critical component of any research project. Artificial intelligence (AI) has an insightful influence on higher and general education. For instance, AI assists higher education institutions in filtering emails, advertisements, apps, digital libraries, YouTube content, Google Scholar, and other research tools (García-Vélez et al., 2021). The effect of AI on teaching and learning is particularly evident in areas such as enrollment and curriculum design (Taneri, 2020). Jain and Jain (2019) found that AI can boost student learning, offering a promising outlook for AI's role in higher education. In a study, Chen et al. (2020) explored AI's technological aspects and its effects on education, while Khan (2021) discussed AI's significance in education, its challenges, and its potential to create adaptable learning environments. In his 2023 study, Khan focused on AI-integrated teaching and its educational objectives. AI can ensure mastery of any subject, personalize instruction according to students' preferences and abilities, and enable them to learn at their own pace (AlDhaen, 2022; Naz et al., 2021). In higher education, AI supports various functions such as resource planning, marketing, admissions, and course offerings (Crompton and Burke, 2023). It is also increasingly employed to design curricula, allocate resources, and manage student enrollment (Nemorin et al., 2023; Bali et al., 2022). AI facilitates tailored feedback, self-paced learning, and tailored course delivery, addressing challenges posed by large, impersonal lecture settings (Alam and Mohanty, 2023). Moreover, AI can support educators in handling time constraints, offering customized courses, and providing continuous personalized feedback, ultimately boosting student confidence and understanding (Pallathadka et al., 2021).

4. Results and Discussion

4.1. Contribution of AI to Education 4.0

4.1.1. Personalized Learning

AI systems evaluate student data to change customized instructional materials that align with individual learning styles and needs (Sanusi et al., 2022; Alam, 2021). These systems enrich the learning experience by providing feedback, adaptive assessments, and tailored learning ways, making education more efficient and effective. As online learning platforms expand and more student data becomes available, AI's role in personalized learning grows. AI algorithms process large volumes of data to create individualized learning plans, improving success rates, higher engagement, and better retention (Sanusi et al., 2022; Perić and Vitezić, 2021; Chassignol et al., 2018). By aligning learning with students' preferences and areas for growth, AI fortifies retention through personalized pathways and ongoing feedback.

First, AI-driven personalized learning enhances student achievement by transporting content that aligns with individual needs, allowing students to progress at their own pace (Hwang et al., 2020; Sanusi et al., 2022). Adaptive assessments modify the trouble of queries based on performance, targeting areas that need further attention (Sharifi et al., 2021; Chassignol et al., 2018). Second, AI recommender systems suggest customized learning materials based on student performance and behavior, exposing them to new topics they might not otherwise encounter. AI-powered learning analytics detect patterns in student data, guiding personalized teaching approaches (Hwang et al., 2020; Shrivastava, 2023). Finally, although AI holds transformative potential, its integration with traditional teaching methods can present challenges. Teachers must require training and support to effectively incorporate AI tools into the classroom (Jokhan et al., 2022). Despite these obstacles, the ability of AI to create tailored learning has the possible to transform education by contributing customized instruction and enhancing student engagement through advanced machine learning (ML) and natural language processing (NLP) (Fudge et al., 2022).

Case Studies: AI enhances Duolingo by offering personalized language instruction, adjusting the difficulty of exercises according to the learner's skill level, and showcasing its effectiveness in language education. Coursera leverages AI to recommend courses by analyzing a student's previous work, goals, and interests, creating a personalized learning journey. An AI-powered platform in a California primary school improved academic performance and student engagement by analyzing data to provide customized resources. This platform promoted equity, active participation, and inclusivity by adapting to various learning styles. This case study highlighted how AI can enhance achievement and engagement by delivering tailored recommendations.

4.1.2. Intelligent Tutoring Systems (ITS)

The goal of artificial intelligence (AI) in intelligent tutoring systems (ITS) is to facilitate individualized instruction and assessment. In order to assess student work and provide tailored comments, these systems use artificial intelligence methods including machine learning and natural language processing (Sunarya, 2022). A significant benefit of ITS is the ability to deliver immediate feedback, which can be challenging for instructors to provide in real time. ITS also adapts to each learner's style and pace, offering extra explanations or practice as required (Guo et al., 2021). Additionally, ITS tracks student improvement, enabling teachers to recognize areas where students may struggle and adjust lessons accordingly (Xia et al., 2022; Taub et al., 2021). Despite its advantages, challenges such as ensuring system reliability, minimizing bias, and offering sufficient training for educators and students remain. Nonetheless, ITS holds the possible to transform education by delivering personalized support (Xue and Wang, 2022; Pai et al., 2021).

Case Studies: A case study at a UK institution developed an AI-powered tutoring system for computer science students. This system utilizes machine learning and natural language processing to understand student queries, provide immediate feedback, and deliver personalized assistance. Students using the system performed better than those in traditional learning environments. The system's ability to provide accurate responses, create an engaging learning atmosphere, and offer quick feedback to address misunderstandings supported student progress. The system provided targeted support by analyzing student data, showcasing AI's potential to enhance learning outcomes and revolutionize education.

4.1.3. Automation of Administrative Tasks

Automation reduces manual errors, speeds up administrative tasks, and directs resources toward more critical activities. Berglind et al. (2022) emphasize that AI is revolutionizing administrative operations. Moreover, AI enables educators to devote more time to teaching by automating tasks like grading and scheduling.

First, AI can grade tests, quizzes, and assignments, saving teachers' time, ensuring consistency, and minimizing human errors. Second, managing student records can be lengthy, but AI systems streamline tasks like data entry, retrieval, and organization, making it easier for teachers to access the required information. Third, scheduling classes to accommodate both students and professors can be complex. AI algorithms can optimize this process by determining student preferences, teacher availability, and room assignments. Fourth, traditional methods of tracking attendance can be burdensome. AI-driven systems can automate attendance using facial recognition or other techniques, reducing teacher administrative work. Finally, AI can assist in automating communication between students, parents, and teachers. It can send automated notifications about homework deadlines, parent-teacher meetings, and important dates, ensuring precise and timely communication.

4.1.4. Predictive Analytics

Predictive analytics customs data, statistical models, and ML techniques to foresee the probability of future events based on past data. This method augments curriculum design, assists identify at-risk students, anticipates performance, and modernizes educational administrative tasks. Big data technologies are built to process large datasets, often in real-time, to extract valuable insights and identify patterns (Daniel, 2019; Bell et al., 2021; Allam et al., 2023). The big data analytics include statistical analysis, data mining, machine learning, and data visualization. Machine learning-driven AI is especially powerful in learning from and adapting to complex datasets. In education, AI can monitor student behavior and predict academic outcomes. Although it is still evolving, AI has shown auspicious results in tasks like evaluating student responses and investigating large, complex datasets.

Case Studies: One university applied predictive analytics to assess student performance across multiple courses. The analysis highlighted certain curriculum areas that were particularly difficult for students. In response, the university adjusted its resources and teaching methods for those courses, leading to notable improvements in student performance and understanding.

4.2. Achieving Success with AI in Education 4.0

In the context of Education 4.0, four key promises for AI have emerged:

4.2.1. Enhancing and Automating Tasks to Support Teachers' Work

The increasing demand for teachers and a lack of qualified educators ominously challenge cultivating student outcomes. By integrating AI to streamline administrative duties, teachers can devote more time to direct interactions with students. AI technologies, such as ML and computer-assisted instruction, assist in managing classroom activities and supporting teaching in areas like physical education and language (Yang et al., 2020; Jaiswal and Arun, 2021; Wang and Zheng, 2020; Zhang, 2021). These tools facilitate the quick distribution of resources and task assignments and address text-based challenges, pointedly boosting teacher efficiency (Gupta and Bhaskar, 2020; Jarke and Macgilchrist, 2021; Huang et al., 2021; Rapanta and Walton, 2016). By automating routine tasks, AI improves the learning environment, enabling a more human-centered method to teaching. Nevertheless, AI should function as a complement to, rather than a replacement for, teachers in their roles.

4.2.2. Enhancing Assessment and Analytics in Education

Assimilating AI into education can revolutionize analytics and evaluation by proposing teachers' valuable insights, from identifying learning trends to assessing unconventional exams. Research indicates that AI enhances grading efficiency, providing quicker, more accurate, and secure evaluations in mathematics and language (Fu et al., 2020; Alghamdi et al., 2020; Kumar and Boulanger, 2020). AI can deliver immediate feedback in online learning environments, although its application remains confined to specific subjects, such as language learning, and faces

challenges in real-world scenarios (Sun, 2021). Additionally, there is a lack of standardized measures for assessing the validity of grading systems across different contexts (Hu, 2021). AI also aids in forecasting student performance, particularly in online education, by analyzing participation in activities like discussion forums (Yu, 2021; Costa-Mendes et al., 2021; Akmese et al., 2021). Traditional socioeconomic variables could not mesh with AI models, which makes it difficult to choose the right data for predictions (Costa-Mendes et al., 2021). Teachers may use AI to help students improve by giving them immediate feedback, analyzing their strengths and areas for improvement, and designing lessons specifically for them.

4.2.3. Promoting AI and Digital Literacy

The widening digital skills gap presents a challenge to education systems, affecting students' employability and their ability to use technology ethically. Closing this gap is crucial for preparing a workforce ready for the demands of AI. AI can foster critical thinking, creativity, problem-solving skills, and digital literacy, aligning students with future job market needs. Kickmeier-Rust and Holzinger (2019) introduced the MAXMIN ant system for adaptive gaming, while Westera et al. (2020) used AI to build detailed student profiles through automated difficulty adjustments, emotion detection, and non-verbal cue analysis, which increased student engagement. However, these studies did not explore the impact of AI-driven environments on learning outcomes. A major challenge in this field is the absence of an effective evaluation strategy. Whether employing traditional or advanced methods, the integration of AI into education plays a crucial role in preparing students for the future workforce.

4.2.4. Customizing Learning Content and Experiences

Compared to their classmates in regular classes, pupils who received individual attention from tutors performed 98% better on standardized tests. But private lessons may be pricey, and AI offers a more economical substitute. According to Bellod et al. (2021), Aldeman et al. (2021), and McCarthy et al. (2016), intelligent tutoring systems are created to provide instructors with individualized recommendations for resources and tasks. Artificial intelligence systems, like the ones created by Luo (2018) and Standen et al. (2020), use multimodal data to gauge students' emotional states and guide teachers in adjusting their methods of instruction. Lampos et al. (2021) used AI to suggest good ways to communicate with students who have autism. According to Crowe et al. (2017), instructional software provided teachers with real-time feedback, which led them to modify their teaching approaches. Short experiment durations and small sample sizes hamper development in real-world implementations of these systems (Standen et al., 2020; Aldeman et al., 2021). Another obstacle to progress is the lack of agreed-upon standards for evaluation. The use of AI in the classroom has the ability to make lessons more tailored to the individual requirements of each student, including those with physical or neurological disabilities. This might lead to better results for all students.

4.3. Future Trends in AI in Education 4.0

Several trends are likely to shape the future of AI in education, as shown in Table 2.

Table 2: The impact of emerging technologies and AI on different aspects of education.

Trend in Education	Explanation	Title of Article	Journal	Author	Year
Augmented Reality (AR) and Virtual Reality (VR)	AR and VR transform education, while AI enhances these technologies by personalizing experiences to individual learning styles.	Virtual and augmented reality in dental education: The good, the bad and the better.	European Journal of Dental Education	Dzyuba et. al.	2022
		Analyzing augmented reality (AR) and virtual reality (VR) recent development in education.	Social Sciences & Humanities Open	Al-Ansi et.al	2023
Blockchain in Education	Blockchain technology can securely and transparently record and validate academic qualifications, making credentialing and certification more reliable and efficient.	Blockchain in education: a systematic review and practical case studies	IEEE Access	Ocheja et.al.	2022
		Blockchain-based applications in education: A systematic review.	Applied science	Alammary et. al.	2019
		Visualization of education blockchain data: trends and challenges.	Interactive Learning Environment	Ocheja et. al.	2023
		Adopting a Student Centric Education Blockchain System.	International Journal of Information *and* Communication Sciences	Iyer et. al.	2022
		Promises and challenges of blockchain in education.	Smart Learning Environments	Park	2021
Continued Growth of Online Learning	Blockchain technology enhances credentialing by securely storing and certifying academic records, ensuring greater dependability, transparency, and security.	Aims for cultivating students' key competencies based on artificial intelligence education in China	Education and Information Technologies	Huang	2021
		Prediction of sodium hazard of irrigation purpose using artificial neural network modelling.	Sustainability	Gautam et. al.	2023
		Evaluating the selection criteria of formwork system (fs) for rcc building construction	International Journal of Engineering Trends and Technology	Rane et. al.	2023
Collaboration Between Humans and AI	AI in education will likely boost human-machine cooperation, improving teaching and learning by automating routine tasks and offering valuable insights.	Literature review of the reciprocal value of artificial and human intelligence in early childhood education.	Journal of Research on Technology in Education	Crescenzi-Lanna	2023
		Impact of artificial intelligence on human loss in decision making, laziness and safety in education.	Humanities and Social Sciences Communications	Ahmad et. al.	2023
		Collaborative learning with block-based programming: investigating human-centered artificial intelligence in education.	Behaviour & Information Technology	Andersen at. al.	2022
		Reciprocal issues of artificial and human intelligence in education	Journal of Research on Technology in Education	Ifenthaler and Schumacher	2023
		Human-centered artificial intelligence in education: Seeing the invisible through the visible.	Computers & Education: Artificial Intelligence	Yang et. al.	2021

		Closing the loop – The human role in artificial intelligence for education.	Frontiers in Psychology	Ninaus and Sailer	2022
Lifelong Learning and Upskilling	AI in Education 4.0 will support upskilling and lifelong learning by offering personalized education tailored to individual needs, helping people adapt to an evolving labor market.	Human and artificial intelligence in education.	International Journal of Smart Technology and Learning	Spector	2023
		Curriculum implementation towards education 4.0.	International Journal of Research Publications	Palestina	2021
		Technological unemployment in the perspective of industry 4.0 development	Virtual Economics	Kuzior	2022
		Determining characteristics of teachers, students and educational managers in the 4.0 educational context.	Vietnam Journal of Education	Cuong and Le	2024
		Smart classroom teaching strategy to enhance higher order thinking skills (hots)—an agile approach for education 4.0.	Future Internet	Venkatraman et. al.	2022
		Transformation or evolution?: Education 4.0, teaching and learning in the digital age.	Higher Education Pedagogies	Bonfield et. al.	2020
		Opportunities to develop lifelong learning tendencies in practice-based teacher education: Getting ready for education 4.0.	Future Internet	Matsumoto-Royo et. al.	2021

***Source**: Author*

5. Challenges and Potential Avenues for Future Study

This section summarizes key challenges to AI in Education 4.0 identified in this review. These challenges can direct future research in the field.

5.1. Lack of Sufficient Educational Resources for Adaptive Learning

Personalized and adaptive learning platforms rely on similar teaching methods and resources. AI systems can recommend learning objects-standardized, reusable digital resources tailored for various contexts and educational goals. This promising potential of AI in educational system highlights the prerequisite for further study to completely explore and leverage AI's capabilities in personalized and adaptive learning.

5.2. Selecting Appropriate Data for AI Prediction Models

Emerging AI technologies may not be compatible with the structured student data traditionally used in models like linear regression. AI models must require more extensive, organized, and unstructured data, raising significant privacy concerns. It is essential to balance the effectiveness of AI with ethical constraints, especially since AI in education often involves young learners. Sharma et al. (2019) emphasized the need for additional research to determine which data suits AI models while addressing ethical considerations.

5.3. Lack of Connection between AI Technologies and Their Educational Application

New artificial intelligence systems aim to aid teachers in making decisions by providing them with useful data (learning analytics) and instructional tools (chatbots, robots) (Kim et al., 2022). However, this review reveals that many educators may not be familiar with these technologies, struggle to interpret learning analytics, or fully recognize AI's potential in education or its pedagogical implications. For instance, when should students engage with chatbots—before or after class? Future studies should investigate how educators incorporate AI into their teaching strategies.

5.4. Lack of Multidisciplinary AI Learning Technologies

The AI technologies currently used in education may not meet all learning needs due to the inherent complexity of learning processes. Although neural networks, computer vision, and natural language processing are essential AI subfields (Chiu et al., 2022; Chiu, 2021; Xia et al., 2022), most AI tools in education remain basic and specialized. The education sector lags in AI development (Bates et al., 2020; Nicolae and Nicolae, 2018), with many teachers relying on less effective technologies for teaching. Researchers should focus on developing more advanced, multidisciplinary AI tools for educational purposes.

5.5. Negative Perceptions of AI among Students and Teachers

There is some reluctance and uncertainty among educators and students when it comes to using AI in the classroom. According to Wang et al. (2020), students worry that AI will make their future jobs obsolete, while teachers typically struggle with low self-efficacy since they don't fully comprehend AI systems. These worries make people think negatively about AI in education, which prevents it from being used to improve education (Qin et al., 2020; Attwood et al., 2020). This emphasizes the critical need for more study, especially in areas outside of engineering such as K-12 education, the arts, and teacher professional development related to artificial intelligence (Xia et al., 2022).

5.6. Insufficient Educational Perspectives on AI in Education (AIEd) Research

This review emphasizes the educational perspective on AI in education. However, many AIEd researchers come from engineering backgrounds, which often leads to a focus on technological design and development. This approach tends to overlook educators' viewpoints. Given the interdisciplinary nature of AI, future research should adopt new methodologies that engage students, teachers, and educational scholars (Holstein et al., 2019).

5.7. Inadequate Methods for Evaluating AI in Education

Traditional evaluation methods for AI in education may be ineffective. Renz and Hilbig (2020) point out that most studies rely on existing techniques that are unsuitable for technologies involving large and unstructured datasets. Teachers and students often find AI systems, deemed successful in engineering-based research, difficult to use or demotivating. Consequently, there is a need to develop new evaluation approaches tailored explicitly to AI in education research.

6. Conclusions and Limitations

A review of 97 publications from 2016 to 2024, sourced from various academic outlets, examined the role of AI in Education 4.0. This new era shifts away from traditional teaching methods, utilizing AI to create adaptable, interactive, student-centered learning environments. AI enhances personalized learning by tailoring content to meet student needs and increasing engagement. Adaptive learning systems improve educational outcomes by adjusting the material based on students' progress. The advancements of AI in Education 4.0 aim for a seamless integration of human and artificial intelligence. This phase transcends mere technological usage, advocating for a balanced coexistence between humans and AI. It emphasizes the importance of nurturing uniquely human skills like creativity, complex problem-solving, critical thinking, and emotional intelligence. These human traits complement the capabilities of AI.

Augmented and virtual reality, blockchain, online education, and continuous professional development are some of the key technologies emphasized by Education 4.0. Instead than displacing humans, AI works hand in hand with them to amplify their strengths. The importance of mentoring, teamwork, and the cultivation of social skills—the "human" components of education—is growing. Teachers will be free to focus on students' development as whole people while AI takes care of mundane jobs and provides individualized lessons. This research delves at issues like as data privacy, the digital divide, and ethical problems, highlighting the significance of trust, justice, and openness in artificial intelligence. In order to keep Education 4.0 inclusive, it draws attention to obstacles faced by marginalized groups and requests that future research address these concerns. We must ensure that all students, regardless of their financial condition, have equal access to the educational advantages of AI.

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