Review Article

Unleashing the Power of AI: Revolutionising Indian Classrooms with AI-Driven Pedagogical Breakthroughs

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Abstract

Artificial intelligence (AI) is revolutionising education by enhancing accessibility, customisation, and engagement. AI applications, such as virtual tutoring, automation, and adaptive learning, are gaining ground in various domains of education. Forecasts about AI's journey in education indicate that nearly all educational sectors, from school education to various technical, professional, and non-technical higher education fields, will progressively rely more on AI technologies and tools. The growth of AI technology over time and how it can be utilised in the education sector, ranging from cutting-edge methods of instruction to effective instructional strategies and universal access to education, are addressed briefly in this article. Further, it explores AI's many potential application-related impacts on Indian education. It has been suggested that challenges such as socio-religious taboos, knowledge gaps, digital divide, shortage of specialists, and inadequate training initiatives must be addressed to incorporate AI technologies ethically in Indian education effectively.

Keywords: Artificial Intelligence, AI Educational Application, Teaching and Learning, AI in Indian Education

Introduction

Technology remains a powerful catalyst, enhancing quality of life by fostering socio-economic creativity and innovation. It has reshaped education by increasing accessibility, customisation, and engagement. The OECD *Skills Outlook 2021* underscores its role in developing 21st century competencies, while the Internet has broadened access to online education (Fernández-Batanero et al., 2022). Moreover, technology enables educators to tailor instruction to individual needs, revolutionising learning by boosting student engagement and unlocking new educational opportunities (Haleem et al., 2022).

Artificial intelligence (AI) has become a global focal point due to its transformative impact on daily life. Alan Turing's pivotal 1950 question, "Can machines think?" (Turing, 2009, p. 23), laid AI's foundations. AI involves creating systems with human-like intellectual capabilities, such as reasoning and learning from experience (Moradi et al., 2022). The 21st century has witnessed AI's rapid advancements across society, driven by increased information accessibility and computational power (Liu et al., 2018). Intelligent Automation (IA), one of AI's most significant applications, is reshaping industries like manufacturing, healthcare, and finance by boosting productivity and lowering costs (Coombs et al., 2020; Yoshida et al., 2022). In healthcare, AI-driven

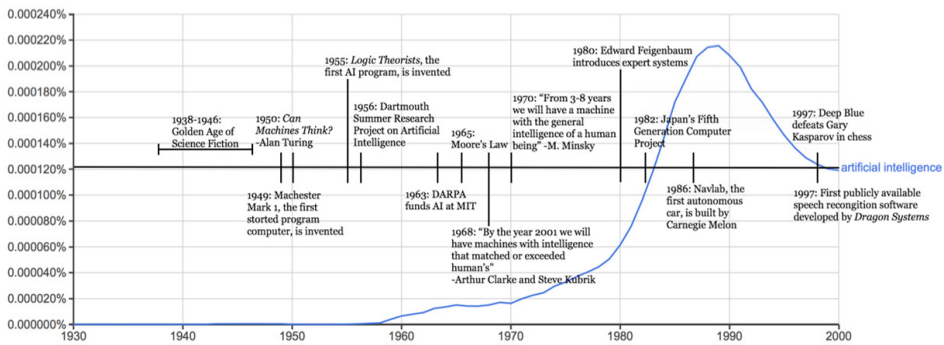
diagnostics enhance patient outcomes and reduce expenses (Dastjerdi et al., 2023). Further, conversational AI systems, such as Siri and Alexa, are revolutionising human-tech interaction through Natural Language Processing (NLP) and Machine Learning (ML) (Khurana et al., 2023). Meanwhile, modern Generative AI tools like ChatGPT streamline information retrieval, minimising the need for human intervention (Ray, 2023). Education, also evolving with AI, is no exception, particularly in areas like intelligent tutoring, adaptive learning, assessment design, and learning analytics (Brusilovsky, 2024). AI innovations like ChatGPT are shaping a new educational paradigm where AI tutors rival human capabilities (Bill Gates on AI Revolution, 2023). The present article will explore the evolution of AI technology and its diverse applications in education, from innovative teaching methods to personalised learning strategies and broadening access to education. It will also explore the potential implications of AI on the Indian education system, highlighting its transformative role in shaping the future of learning.

AI: A Historical Overview

AI has a long history, evolving continuously as an interdisciplinary field involving informatics, logic, cognition, systems science, and biology (Hsiao-Wuen Hon, 2019). The development of AI began in 1943 with the proposal of an artificial neuron model, marking the start of Artificial Neural Network research (Kandpal and Mehta, 2019). Science fiction also contributed to the concept of intelligent robots, with early depictions like the Tin Woodsman in The Wonderful Wizard of Oz (Lowne Cathy, 2023) and Maria from Metropolis (Pfeiffer Lee, 2023)

By the 1950s, philosophers, scientists, and mathematicians began investigating AI. The pivotal Dartmouth Conference in 1956, organised by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon, formally introduced the idea of creating machines that could reason and solve problems (Dick, 2019). Meanwhile, AI faced challenges in the 1960s due to hardware limitations and algorithmic flaws, leading to a temporary decline (Margeret, 1996). However, research on the Back-propagation algorithm in the 1970s spurred advancements as computer performance improved (Chakravarthy, 2019). By the 1980s, Back-propagation neural networks gained widespread recognition, and algorithms based on neural networks began advancing rapidly (Hinton and Salakhhutdinov, 2006). These developments laid the foundation for ML algorithms, which allowed computers to learn from data, eventually leading to the rise of deep learning. The timeline in Figure 1 illustrates the critical developments in AI between 1930 and 2000.

Figure-1: Artificial Intelligence Timeline



Note. From History of AI, by Rockwell Anyoha (2017)
https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/

By the 1990s and 2000s, many significant AI milestones had been achieved, such as advancements in voice recognition and Natural Language Processing (NLP). A significant breakthrough came in 1997 when IBM's Deep Blue defeated world chess champion Garry Kasparov, marking a pivotal moment in AI decision-making (Anyoha Rockwell, 2017). In 2006, the proposal of Deep Learning (Deng and Yu, 2014) propelled AI further, with the exponential growth of mobile internet fuelling more applications in the early 21st century. The 2016 victory of AlphaGo over the World Go champion (Silver et al., 2016) intensified discussions on AI's societal impact. Today, innovations in Deep Learning, Big Data, NLP, and Data Science continue to advance rapidly, with companies like Google, Facebook, IBM, and Amazon driving the development of cutting-edge AI technologies.

The Educational Possibilities of AI: From Teaching to Governance

Educators worldwide are rethinking the purpose of education as AI rapidly integrates into our lives, professions, and classrooms. AI has the potential to accelerate the transformation of education systems toward inclusive learning, equipping young people to thrive and shape a better future (World Economic Forum, 2023). It can further address significant challenges, innovate teaching practices, and expedite progress toward SDG 4 (UNESCO, 2023). *Beijing Consensus on AI and Education* urges countries to develop policies and strategies to promote educational innovation through AI (UNESCO, 2019).

AI impacts education in three key areas:

(a) learning by supporting personalised learning systems,

(b) teaching by automating feedback and assessment, and

(c) administration by providing data-driven insights to decision-makers (Baker et al., 2019).

Thus, AI can be applied across the following beneficial spectrum of education.

Offering an environment for personalised learning

Personalised learning adapts instruction to meet each learner's capabilities, needs, interests, and learning styles (Mötteli et al., 2023). This approach tailors the speed and methods of teaching to optimise learning for individuals (Bailey L. W, 2019). AI can be crucial in customising education by adapting instruction to learners' preferences, adjusting difficulty levels, and providing targeted feedback to enhance progress (Huang andYu, 2023). Further, AI can evaluate learners' backgrounds, identify strengths and weaknesses, and suggest relevant courses. Examples include the MOOC *Buddy* robot, which offers personalised learning resources (Holotescu et al., 2007), and Knewton's adaptive platform, *Alta*, which helps fill knowledge gaps (Schroer, 2022). Other AI-powered platforms like *GradeSlam, Duolingo, Cerego, Dreambox, SMART Learning Suite*, and *ALEKS* also deliver personalised learning experiences.

Setting up an intelligent Automated Grading System

An automated grading system employs AI techniques such as pattern recognition, ML, and NLP to evaluate student work based on predetermined criteria (Zhu et al., 2020). This system can assess student responses, check for accuracy and completeness, and assign grades according to guidelines set by educators or institutions. Research indicates that when thoughtful feedback is provided, student submissions can

improve by 96 per cent (Haldeman et al., 2018). *Gradescope* is an AI-based tool that uses a configurable rubric to deliver precise feedback and grading.

Round-the-clock smart Virtual Tutoring service

Recent advancements in AI technology have led entrepreneurs to develop online "virtual tutors" with AI capabilities (Alam, 2023). These platforms can provide tailored and responsive instruction across various disciplines and academic levels (H. Mohamed and Lamia, 2018). They offer a convenient option for students lacking access to in person instruction or those seeking to learn at their own pace, as they are accessible from anywhere with an internet connection. A notable example is Jill *Watson*, a teaching assistant at Georgia Institute of Technology, who impressed students with her quick and accurate responses, only to reveal she was an AI program from IBM (Watson et al., 2016). Virtual tutors can be utilised in various educational contexts, including blended learning, remote learning, and e-learning, particularly in fields with scarce expertise. Examples of AI-based virtual tutoring services include Duolingo for language learning, Amira for dyslexia assessments and progress reports, and platforms like EdTech Foundry, Thinkster Math, iTalk2Learn, and Querium.

Delivering Timely, Intelligent Feedback

Intelligent feedback systems can help educators and students evaluate essays and provide corrections, promoting academic integrity by checking for plagiarism. Using ML and NLP, Grammarly is an AI-powered tool that enhances writing clarity, boldness, and error-freeness (Grammarly Spotlight, 2019). Turnitin also offers plagiarism detection and feedback on originality and citation validity, while Quill provides insights on vocabulary, syntax, and sentence structure. Overall, AI feedback systems can improve the quality of written work by minimising errors and plagiarism and delivering immediate feedback to enhance student learning (Biswas and Bhattacharya, 2023).

Generating Automated Smart Academic Content

AI can also streamline the development of classroom activities and formative assessments, alleviating the time educators spend on these tasks (Bahrini et al., 2023). Smartest Learning is an AI-supported platform that simplifies content generation for educators. Additionally, tools like *Lumen5* convert text into engaging videos, while OpenAI's Chat GPT-3 generates high-quality text on various topics, including articles and product descriptions. Other AI content generators include Eduaide.AI, Magicschool AI, Jasper, Copy Smith, and Article Forge, while ExamSoft, Gamma AI and ClassPoint serve as AI-enhanced test preparation tools.

From Augmented Reality (AR)/Virtual Reality (VR) to Extended Reality (XR)

Several studies have documented the positive learning outcomes of integrating AR and VR technology across various disciplines (Ting-Chia Hsu, 2017). AI-powered AR/VR technology can create hyper-immersive environments that facilitate experiential learning, promoting interaction similar to in-person engagement (Gandedkar et al., 2021).

Extended Reality (XR), which merges physical and digital worlds, includes virtual, augmented, and mixed reality. AI-based XR technologies enable object recognition, gesture recognition, emotion recognition, and predictive analysis (Cunha et al., 2023). For example, *Labster* offers an AI-based virtual lab

where students practice laboratory skills through over 300 virtual science simulations. zSpace combines AR and VR to provide personalised learning experiences, while VirtualSpeech uses immersive VR simulations to help students improve their public speaking skills (Marr Bernard, 2021).

Gamification fuelled by AI

Gamification in education enhances engagement by integrating game elements into learning environments (Dichev and Dicheva, 2017). AI-powered gamification can ensure more engaging and personalised experiences for users. For instance, Brainly is an AI-driven platform that promotes student collaboration on assignments, while Kahoot! customises learning through discussions, polls, and quizzes, allowing students to compete for points. *Classcraft* personalises the educational experience and provides immediate feedback using AI. Other notable AI-based gamification platforms include Quizizz, Teachable Machine, and Minecraft Education.

Automating Tasks to Lighten the Workload

The educational process comprises many manual responsibilities. AI can automate routine tasks like grading and lesson organisation, freeing educators' time and allowing students to enhance their curiosity and skills (Pillai et al., 2023). This is achievable with AI-driven grading tools, scheduling tools, virtual assistants, content development tools, etc. With the help of Zapier, one can automate tasks by connecting 4000+ applications.

Ensuring Universal Access to Education

Education is crucial for seizing opportunities and enhancing living standards. Unfortunately, many learners still lack access to quality education. However, AI advancements can help address some barriers to education accessibility(Singh et al., 2024). AI can promote universal access by delivering personalised educational experiences and customising learning materials to meet individual needs (Kabudi, 2022). This is especially beneficial for students in remote areas or those with limitations. Additionally, AI can break language barriers using translation technologies to convert instructional materials into various languages, enabling students to learn in their mother tongue (Y. A. Mohamed et al., 2024). Popular AI-based translation tools like Gemini, DeepL, and Anuvadini utilise advanced NLP algorithms and neural machine translation for accurate translations. AI-driven content creation tools can enable teachers to quickly develop high-quality instructional materials, which is particularly helpful in regions with a shortage of skilled educators (Celik et al., 2022). Moreover, AI-powered chatbots can provide immediate support and guidance to learners lacking access to traditional services like school counsellors, offering emotional support and academic advice (Kavitha et al., 2024).

AI technology can also significantly benefit learners with special needs. For instance, CoWriter aids students with dyslexia by utilising predictive text technology for spelling and grammar assistance. AI-powered computer vision tools can assist visually impaired learners by recognising and describing objects and text in real-time. EmoReact provides emotional support to learners with behavioural challenges by detecting emotional changes through facial recognition. Similarly, Brain Power's AI tool helps students on the autism spectrum practice social interactions and develop essential skills through gamified activities. In conclusion, AI

can potentially transform education, enhancing access, equity, and inclusivity for all learners.

The Potential Possibilities of Artificial Intelligence in Revolutionising Indian Classrooms

According to a recent report from the United Nations Population Fund India (2022), India has surpassed China to become the world's most populous nation, with 1.4286 billion people. Notably, 26 per cent of the population is aged between 10 and 24, making India a particularly young country. This youthful demographic represents a significant asset for the nation, providing India with a competitive edge on the global stage (Hameed and Mathur, 2020). To harness this potential, offering superior education that integrates modern technological advancements is essential.

In today's age of globalisation, learners must be digital natives to adapt to rapid changes, advance in their careers, and commit to innovation and sustainable development (Bagur et al., 2020). Breakthrough technologies can enhance educational experiences, sharpen skills, and improve living standards and societal well-being (Afshari et al., 2009). By effectively utilising 21st-century technological innovations, educational institutions can transform the learning process. The COVID-19 pandemic has further accelerated this shift, pushing online and technology use beyond traditional classroom and book-based learning (Joshi et al., 2021).

The recent National Education Policy (NEP) 2020 in India aligns with the 2030 Agenda for Sustainable Development, focusing on inclusive and equitable quality education, as outlined in SDG Goal 4. Aiming to transform India into a "Vibrant Knowledge Society," the NEP (2020) emphasises the importance of digitisation and modern technology in education. Significant steps have been taken to strengthen ICT infrastructure through initiatives like NRF, SWAYAM, SWAYAM PRABHA, and NETF (Singh Dhillon et al., 2022). The Indian government has launched the National Educational Alliance for Technology (NEAT) to support AI in education and provide customised learning opportunities, particularly for economically and socially disadvantaged groups. The NITI Aayog's discussion paper on Responsible AI (2021) highlights education as a sector with high potential for AI to address societal needs, enhance personalised learning, and reduce dropout rates (Kasinathan, 2020). The government launched NEAT 3.0 in January 2022 with backing from NEP 2020 to constitute a bridge between ed-tech companies, educational institutions, and learners. This was crucial to providing superior educational opportunities nationwide, particularly in TIER 2 and TIER 3 towns and villages. The government further acknowledged the potential of technology and the rapidity with which it may reach tiny towns and villages with a qualified instructor at their fingertips. In the Union Budget for 23–24, the education sector received its highest-ever allocation of INR 1.12 lakh crore, mainly emphasising upskilling young people and advancing digitalisation. Meanwhile, to make it possible for the Indian education system to be a part of the global education system, the Ministry of Education has placed a promising emphasis on introducing ML, AI, and 3-D visuals in the education system of India. Furthermore, AI has emerged as a critical component of development and innovation across sectors; it is essential for young people to learn its fundamental concepts early. UNESCO's (2022) report, "State of the Education Report for India 2022: HERE, THERE, EVERYWHERE," also recommends increasing AI utilisation

in Indian schools to accelerate progress toward achieving SDG 4.

Data from the education ministry's online portal revealed that 12,53,019 students in India were not attending school in the 2022–2023 academic year, including 6,97,121 male students, 5,55,854 female students, and 44 transgender students (HT Correspondent, 2023). Among these, 3,22,488 were secondary-level students, and 9,30,531 were in elementary education. According to a 2019 UNESCO report, three-fourths of Indian children with disabilities under five do not attend any educational institution, with 27 per cent having never been enrolled and 12 per cent having dropped out (Ramachand Mythili et al., 2019). AI can be the critical component of the universal learning objective that India has always promoted. The Andhra Pradesh government and Microsoft AI have successfully piloted a project to identify and manage dropouts in Visakhapatnam (Rao, 2018). The AI-enabled device can make predictions through reaction recognition, performance and reasons analysis of the student's performance and potential causes leading to dropping out of school (Bhaduri, 2020). By leveraging AI tools, education can be made more accessible to students who need specific monitoring and support, such as those who are deaf, hard of hearing, or speak a different dialect.

Due to the diverse levels and types of intelligence and abilities, educators have been striving for a long time to develop a curriculum, course, or teach a skill that appeals to all involved learners. Personalising education for every learner is a huge process that takes a lot of time and effort, which is unattainable, especially in a country like India, where diversity is the primary challenge. However, AI is a technology that can eliminate these obstacles. Aside from aiding teachers and students in designing educational programmes that specifically cater to their needs, AI can also provide an analysis of the strategy's overall effectiveness. AI can adapt to an individual's skill level, desired learning objectives, and each learner's learning rate to optimise learning. AI-driven technologies can further evaluate pupils' schoolwork, pinpoint their growth gaps, and suggest programmes, providing various opportunities for individualised learning (Sayed et al., 2023). This can boost student motivation and significantly lower dropout rates.

According to the UNESCO 2021 State of the Education Report for India (2021), "No Teacher, No Class," the nation has approximately 1.2 lakh single-teacher schools, 89 per cent of which reside in rural regions. As per the report, India needs an extra 11.16 lakh teachers to compensate for the present shortage. The education system would undoubtedly benefit from the additional assistance offered by AI, considering the condition of most schools in rural parts of India. AI has the dynamic potential to enhance online education in India (Fauvel et al., 2018), which is expected to reach US$ 1.96 billion by the end of 2022, and 47 per cent of learning management tools will be AI-enabled by 2024, along with an anticipated annual growth rate of artificial intelligence in education by 40.3 per cent between 2019-25 (Pawar, 2022).

AI can assist educators with administrative tasks, including grading papers, scheduling parental-teacher meetings, and providing learner feedback. This frees up their time so they can focus more on the innovative aspects of instruction. The Eagle 5.0, a kind of Humanoid robot, a Collaborative Learning Model (CLM), was first implemented in Indian schools by Indus International in Hyderabad and Bengaluru (Collaborative Learning Model — Indus Bangalore, 2022). Based on this framework, educators would

share daily duties with robot assistants who accompany them while they teach in classrooms.

Assessment and grading tasks that took educators days to prepare and complete are now possible concurrently by AI. During the inspected assessment while taking exams, an AI-driven system can accomplish this by streaming audio and video and recognising faces and pictures as much as a person can. As a result, it can detect and comprehend examinees' movements, interpret the response script, and accurately grade students' work based on their merits and performance. Additionally, an AI-enabled tool could simplify the laborious tasks associated with administering school and competitive exams since it can recognise images, faces, movements, and directions. With knowledge and careful management, this one-time investment can save significantly more annually over the present examination system. In a survey conducted by Analytics Insight (Artificial Intelligence: A Technology Bridging the Education Gap, 2022), 46 per cent of the respondents believed that AI could predict school dropout rates in India, 65.9 per cent of participants believed that AI could enhance the efficiency of individualised education, 31.7 per cent of participants believed that the models of AI could enhance personalised and about 34.1 per cent of the participant's believed that the educational apps of AI help in covering the syllabus in their homes

Before AI can effectively integrate into the Indian educational system, several challenges must be addressed. A primary obstacle is the lack of expertise and understanding of AI technology among learners and educators. Many educators in India are not adequately trained to teach AI, and numerous students are unfamiliar with the concepts (Kim et al., 2021). Effective implementation of AI in education requires a solid grasp of the field. Additionally, many villages still lack sufficient access to electricity, making deploying AI technologies costly and challenging. This contributes to a significant digital divide, where students in urban areas have far greater access to technological resources than their rural counterparts. However, the IT ministry's recent announcement of a nearly $30 billion investment to ensure that the last-mile 5G network reaches every village in India offers hope for bridging this divide and realising a "Rural Digital India."

AI integration into the Indian educational system necessitates significant infrastructure and resource expenditures, including fast internet access, innovative technology and software, and skilled staff. As per the report of the Ministry of Education, Govt of India- UDISE+ 2019-20, only one-fourth of teachers in India were reportedly trained to deal with the technology-oriented teaching-learning process, and only 22.28 per cent of all management schools in India had internet facilities. Moreover, only 38.54 per cent of all management schools, of which only 30.03 per cent of government, 62.97 per cent of government-aided, and 59.88 per cent of private schools had computer facilities. The incapacity of several educational institutions in India to invest in these essentials could also slow down the successful integration of AI into the classroom.

Concerns have been raised about AI exacerbating existing biases, the digital divide, and educational inequalities. To avoid such issues, AI research and implementation must adhere to ethical guidelines (Williams et al., 2023). Additionally, there is no standard framework for teaching AI in academic institutions, requiring a unified curriculum and clear guidelines to equip learners with the

skills needed for future job markets. Meanwhile, the digital divide poses a significant challenge, as unequal access to technology creates disparities in learning opportunities. Students from marginalised communities may lack the necessary resources, such as internet connectivity and digital devices, further widening the educational gap in AI learning (Asrani, 2022). Other challenges include socio-religious taboos, student knowledge gaps, a lack of emotional engagement, and a shortage of qualified professionals and training programs. Furthermore, AI's use in education raises concerns about privacy and security and an over reliance on AI tools (Wu et al., 2023), highlighting the need for stringent measures to safeguard student data. Addressing these issues is crucial for AI to transform Indian education effectively.

Conclusion

Although the future of AI in education is not yet fully established, it is predicted that almost all fields of education, including school education and technical, professional and non-technical fields of higher education, will be more reliant on technologies and tools in the future to foster a well-rounded learning environment for learners as well as educators. New and innovative AI tools are being created every day, and it is anticipated that these tools will assist students in clearly outlining their potential career routes and working towards their objectives. Undoubtedly, AI is well-suited to revolutionise and restructure the Indian educational system. If implemented effectively, the proficiency of educators and the most effective AI technology endures the power to overhaul India's educational system completely.

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