# The impact of AI on education

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**Abstract**

The goal of this report is to provide a comprehensive overview of the impact of artificial intelligence (AI) on education, exploring the benefits, challenges, and future implications of integrating AI technologies into learning and teaching processes. The report aims to cover various aspects, from personalized learning and accessibility to the evolving roles of teachers and the development of creativity and critical thinking skills in the AI era.

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# 1 Introduction

# 2 The Building Blocks of AI in Education: Language, Speech, and Conversation

## 2.1 Defining Artificial Intelligence

### 2.1.1 Challenges of defining AI

Artificial Intelligence (AI) has become a buzzword in recent years, with its applications spanning across various domains, including education. However, defining AI is not a straightforward task due to several challenges. Firstly, there is a lack of a universally accepted definition of AI across different fields and contexts(https://www.semanticscholar.org/paper/6f18cf33eb6e22b1fd665bd24ddf1e9c0509a420)(https://www.semanticsch The concept of AI is complex and multifaceted, making it challenging to arrive at a precise, all-encompassing definition. Secondly, the rapidly evolving nature of AI technologies makes it difficult to establish a fixed definition(https://www.semanticscholar.org/paper/6624236a5ab39d57d2463fca646e15973a5a6a55) (https://www.semanticscholar.org/paper/147fde8bd3c092aeb9372c85cedb460d9f22a2ee). As AI capabilities expand, any definition may quickly become outdated. For instance, a simple linear regression, which is a statistical method used to model the relationship between a dependent variable and one or more independent variables, would be considered as AI by some, while others would argue that it is just statistics. However, one could argue that all artificial intelligence techniques are essentially based on statistics. Even the latest revolutionary AIs work by "predicting the next word" based on patterns in large datasets. Lastly, various fields, such as computer science, philosophy, and law, approach AI from different perspectives and with different goals in mind, leading to a range of definitions that may not always align(https://www.semanticscholar.org/paper/d45e5a95b3442afd3028e87edd060fcbacd128dc) (https://www.semanti

### 2.1.2 Common definitions

Despite the challenges in defining AI, there are some common definitions that are widely used. For example, Wikipedia defines AI as "intelligence demonstrated by machines", as opposed to the natural intelligence displayed by animals including humans. Similarly, the Oxford English Dictionary defines AI as "The capacity of computers or other machines to exhibit or simulate intelligent behaviour." However, these definitions are themselves based on the concept of intelligence, which is also not a trivial task to define.

Interestingly, what is hard for humans is often easy for computers, and vice versa. For instance, it is hard for us to make complex computations quickly, but simple for computers. On the other hand, it is trivial for us to recognize animals, stop signs, talk, and drive, but these tasks are incredibly challenging for computers to perform accurately and consistently. In practice, what is considered as artificial intelligence is often what has been challenging or seen as impossible for computers in the past. As computers become more capable of performing tasks that were once thought to be the exclusive domain of human intelligence, the definition of AI continues to evolve and expand.

## 2.2 Fields of AI

The Artificial Intelligence landscape is vast and encompasses a wide range of subfields and techniques. Nearly all the recent breakthroughs in AI can be attributed to the subfield called Machine Learning.

### 2.2.1 Introduction of Machine learning (ML)

Machine Learning (ML) is a special type of AI programming that allows computers to learn from data, rather than being explicitly programmed with rules. To illustrate this concept, let's consider the task of distinguishing between pictures of cats and dogs. It would be incredibly difficult, if not impossible, to write down all the rules that would account for all the possible variations in size, color, shape, and behavior.

This is where Machine Learning comes in. Instead of trying to write down all these rules, we can provide the computer with a large collection of labeled pictures (i.e., pictures that have been identified as either a cat or a dog). The computer then uses statistical techniques to find patterns and

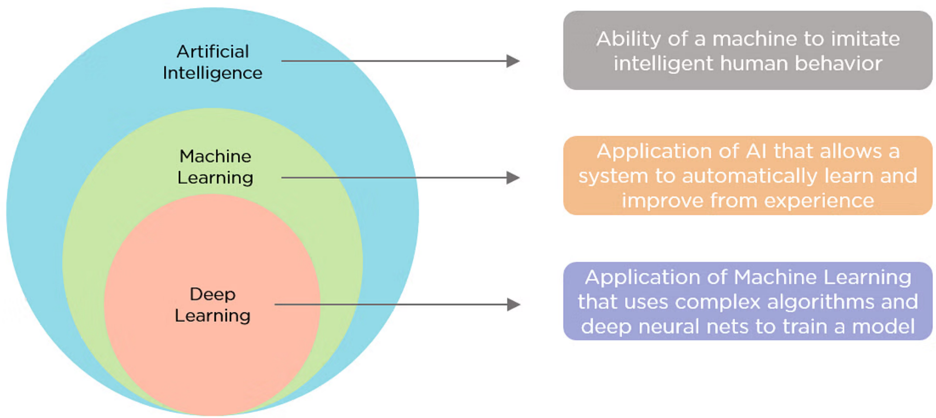


Figure 1: AI vs Machine Learning vs Deep Learning

relationships within these pictures. For example, it might learn that dogs usually have longer noses than cats, or that cats have pointy ears while dogs' ears are more rounded.

Once the computer has learned these patterns, it can then use them to correctly identify cats and dogs in new pictures that it hasn't seen before. In essence, Machine Learning is like giving the computer a set of examples to learn from, rather than a set of rules to follow. This makes it a powerful tool for solving complex problems that would be too difficult for traditional programming. And the best part is, the more data the computer has to learn from, the better it becomes at making accurate predictions.

Machine Learning has a wide range of applications across various domains, including image and speech recognition, natural language processing (NLP), recommendation systems, fraud detection, predictive maintenance, autonomous vehicles, healthcare, and many more.

### 2.2.2 Deep Learning

Nearly all the recent breakthroughs in Machine Learning can be attributed to the field of Deep Learning. Deep Learning uses layers of artificial "neurons" in a way that is similar to how the human brain learns. This approach is very flexible but requires a lot of data and computer power.

Thanks to Deep Learning, computers are now able to perform tasks that were previously thought to be too difficult for them, such as recognizing speech or understanding natural language. Deep Learning has revolutionized the field of AI and has opened up new possibilities for solving complex problems.

## 2.3 The technologies we will focus on in this report

We will not focus on AIs able to distinguish between cats and dogs, or systems that predict the price of Bitcoin. Instead, we will focus on AI technologies that can "understand" and produce human language, and allow engaging conversations between computers and humans.

### 2.3.1 Natural Language Processing (NLP)

Natural Language Processing (NLP) is an interdisciplinary subfield of computer science and information retrieval concerned with giving computers the ability to understand, interpret, and manipulate human language . The goal is a computer capable of "understanding" the contents of documents, including the contextual nuances of the language within them.

Up until the 1980s, most NLP systems were based on complex sets of hand-written rules. In the late 1980s, there was a revolution in NLP with the introduction of machine learning algorithms for language processing, due to increasing computational power. In the 2010s, representation learning and deep neural network-style machine learning methods became widespread in NLP, due to their achieving state-of-the-art results in many natural language tasks.

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### 2.3.2 Large Language Models (LLM)

Large Language Models (LLMs) are deep learning models trained on massive amounts of text data to understand and generate human language. They can perform a wide range of NLP tasks without requiring task-specific training data. There are a large number of LLMs available, both open-source and closed-source. Open-source models like Llama (developed by Meta), the "Mistral" models developed by the French company Mistral, and many more are available to researchers, companies, and the community. Closed-source models are developed by companies like OpenAI (GPT-3, GPT-4), Anthropic (Claude), and Google (Gemini). LLMs range in size from millions to hundreds of billions of parameters. Larger models generally have better performance but require more computational resources. State-of-the-art LLMs exhibit impressive language understanding and generation capabilities across many benchmarks and real-world applications. However, LLMs have a limited context window, typically a few pages of text, limiting their ability to process very long documents or maintain long-term memory. LLMs have various applications, such as chatbots and conversational AI (like ChatGPT) that engage in open-ended dialogue, text generation, summarization, translation, creative writing assistance, knowledge retrieval, and question answering from large knowledge bases. However, LLMs have some limitations in the education context. Training and running large LLMs is hugely energy-intensive, raising environmental concerns. Smaller models are more efficient and can even run on phones. LLMs excel at pattern matching and information retrieval but struggle with tasks requiring logical reasoning, causal understanding, and domain expertise. They can also generate plausible but factually incorrect statements (known as "hallucinations"), which is problematic for educational applications where accuracy is critical.

### 2.3.3 Vision

More and more LLMs come with vision capabilities, allowing them to handle not just text but also images and even videos. LLMs can perform general-purpose vision tasks such as answering questions about image content, recognizing objects, scenes, and visual concepts, generating detailed, contextual captions and descriptions for images, visual grounding and reasoning (e.g., locating objects mentioned in a query), providing visual explanations and differentiating between similar images/classes, and enabling open-ended visual task instructions via natural language.

Some examples of vision-capable models include GPT-4 (OpenAI), the Claude 3 family of models (Anthropic), and Grok 1.5 Vision (xAI).

### 2.3.4 Speech Recognition and Synthesis

Speech recognition involves converting spoken language into written text. Previous models were not well-suited for human conversation, requiring exaggerated voice clarity and only recognizing one language at a time. Whisper, an open-source speech recognition model by OpenAI, significantly improved performance, understanding technical vocabulary and multiple languages in one conversation.

Speech synthesis has also advanced, with new models capable of simulating emotions and allowing interruptions, enabling more natural human-like conversations.

Combining speech recognition, NLP, and speech synthesis enables real-life conversations with AI, which are faster and more engaging than typing. Example applications include PI.ai, which helps users better understand their emotions without simulating affection, reducing the risk of emotional dependence (although the AI may sometimes be overly supportive), and ChatGPT voice, which allows fluid conversations, such as practicing job interviews with the AI simulating an employer role.

However, the current process of converting voice to text, processing, and converting back to voice removes emotional nuances like irony, humor, and doubt. State-of-the-art solutions are being developed to address this issue.

### 2.3.5 Building on LLMs

Beyond chatbots in web browsers, LLMs can be integrated into a wide range of tasks. LLMs are steerable and can act as teachers, experts, or take on various roles. They enable automation and integration with other systems and workflows. For instance, LLMs can be integrated into customer service, and other examples are yet to be explored.

Retrieval-Augmented Generation (RAG) combines LLMs with external knowledge retrieval to enhance their factual accuracy and knowledge coverage.

## 2.4 The Growing Influence of AI in Education

### 2.4.1 Rapid adoption of AI tools by students

Students are increasingly using AI tools like language models and writing assistants to support their learning and complete assignments. This trend highlights the need for educators to adapt their teaching methods and assessment strategies to account for the presence of AI.

### 2.4.2 Integration of AI solutions by learning platforms

Learning management systems and educational platforms are integrating AI solutions to offer personalized learning experiences, automate grading, and provide intelligent feedback to students. This integration enables more efficient and effective learning processes.

### 2.4.3 Government initiatives and policies

Governments around the world are recognizing the potential of AI in education and implementing initiatives and policies to support its adoption. These efforts include funding research, developing guidelines for responsible AI use, and promoting digital literacy among students and educators.

# 3 Benefits of AI in education

## 3.1 Personalized learning

AI enables personalized learning experiences by adapting content, pacing, and feedback to individual student needs and preferences. This approach can lead to improved learning outcomes and increased student engagement.

## 3.2 Increased accessibility to knowledge and education

AI technologies can make education more accessible by providing intelligent tutoring systems, automated translation of learning materials, and voice-based interaction for students with disabilities. This increased accessibility can help bridge educational gaps and promote lifelong learning.

## 3.3 Student engagement and motivation

AI-powered learning tools can create interactive and engaging learning experiences that motivate students to actively participate in their education. Gamification, adaptive challenges, and immediate feedback can enhance student motivation and retention.

## 3.4 Administrative efficiency and teacher support

AI can automate administrative tasks, such as grading and record-keeping, freeing up teachers' time to focus on more high-value activities like lesson planning and student mentoring. AI-powered tools can also provide teachers with insights into student performance and learning patterns, enabling data-driven decision-making.

# 4 Challenges and limitations of AI in education

## 4.1 Ensuring AI Serves as an assistant, not a substitute

It is crucial to ensure that AI is used as an assistive tool to enhance teaching and learning, rather than a substitute for human educators. AI should complement and support the role of teachers, not replace them entirely.

## 4.2 Risks of over-reliance on AI for learning

Over-reliance on AI tools for learning can lead to students developing a shallow understanding of concepts and lacking critical thinking skills. It is essential to strike a balance between AI-assisted learning and traditional teaching methods that foster deep learning and problem-solving abilities.

## 4.3 Inequalities in access to AI technologies

The adoption of AI in education may exacerbate existing inequalities, as not all students and schools have equal access to the necessary technology and infrastructure. Efforts must be made to ensure equitable access to AI tools and resources to prevent widening educational gaps.

# 5 Evolving roles of teachers and assessment methods

## 5.1 Adapting courses and exams to the AI era

With the increasing presence of AI in education, teachers need to adapt their courses and assessment methods to account for the capabilities of AI tools. This may involve designing assignments that require higher-order thinking skills and creativity, which are less easily replicated by AI.

## 5.2 AI as a complementary tool for teachers

AI should be viewed as a complementary tool that can assist teachers in their roles, rather than a threat to their jobs. Teachers can leverage AI to personalize instruction, provide targeted feedback, and identify areas where students need additional support.

## 5.3 Importance of teacher training and professional development

To effectively integrate AI in education, it is crucial to provide teachers with adequate training and professional development opportunities. This will enable them to understand the capabilities and limitations of AI, and to effectively use AI tools to enhance their teaching practices.

# 6 Future perspectives

## 6.1 Developing creativity and critical thinking in the AI era

As AI becomes more prevalent in education, it is essential to focus on developing students' creativity and critical thinking skills. These skills will be crucial in a future where many tasks can be automated by AI, and where the ability to innovate and solve complex problems will be highly valued.

## 6.2 AI and lifelong learning

AI has the potential to support lifelong learning by providing personalized learning experiences that adapt to an individual's changing needs and interests over time. This can enable continuous skill development and help people stay relevant in a rapidly evolving job market.

### 6.3 Potential for AI to bridge educational gaps in developing countries and underserved communities

AI-powered education tools can help bridge educational gaps in developing countries and underserved communities by providing access to high-quality learning resources and personalized instruction. This can contribute to achieving the United Nations' Sustainable Development Goal 4, which aims to ensure inclusive and equitable quality education for all.

### 6.4 Future scenarios for education in the AI era

As AI continues to advance, we can envision future scenarios where education is highly personalized, adaptive, and accessible to all. AI-powered virtual tutors, immersive learning environments, and intelligent assessment systems may become commonplace, transforming the way we learn and acquire knowledge.

## 7 Conclusion

### 7.1 Synthesis of key points

This report has explored the growing influence of AI in education, focusing on key technologies such as NLP, LLMs, vision, speech recognition, and synthesis. We have examined the benefits of AI in education, including personalized learning, increased accessibility, student engagement, and administrative efficiency. However, we have also highlighted challenges and limitations, such as the risk of over-reliance on AI, inequalities in access, and the need to ensure AI serves as an assistant rather than a substitute for human educators.

### 7.2 Recommendations for responsible integration of AI in education

To responsibly integrate AI in education, we recommend the following:

1. Develop guidelines and standards for the ethical use of AI in education, ensuring transparency, fairness, and accountability.
2. Provide teachers with training and professional development opportunities to effectively use AI tools and adapt their teaching practices.
3. Ensure equitable access to AI technologies and resources to prevent widening educational gaps.
4. Foster collaboration between educators, researchers, and technology developers to create AI solutions that meet the needs of diverse learners and educational contexts.
5. Emphasize the development of creativity, critical thinking, and problem-solving skills in students to prepare them for a future shaped by AI.

### 7.3 Call to action for collaboration among educators, policymakers, and technology developers

To fully realize the potential of AI in education, it is essential for educators, policymakers, and technology developers to collaborate and work towards a shared vision. By combining expertise from different domains, we can create AI solutions that are pedagogically sound, ethically responsible, and technologically advanced. This collaboration will be crucial in shaping the future of education in the AI era and ensuring that all learners can benefit from the transformative power of artificial intelligence.

## Annex : Doing exams with AI

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## References

[1] Albert Einstein. Zur Elektrodynamik bewegter K"orper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921, 1905.