

# 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.semanticscholar.org/paper/6624236a5ab39d57d2463fca646e15973a5a6a55>) 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 As AI capabilities expand, any definition may quickly become outdated.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.semanticscholar.org/paper/147fde8bd3c092aeb9372c85cedb460d9f22a2ee).

#### 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 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.

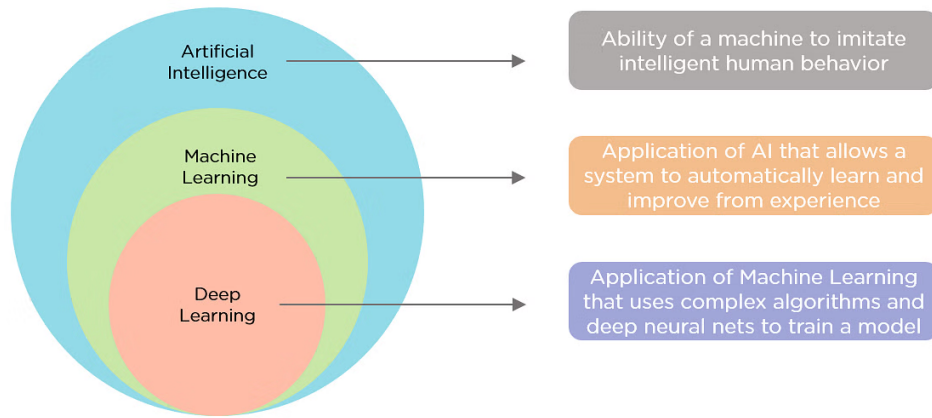


Figure 1: AI vs Machine Learning vs Deep Learning

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.

The development of large pre-trained language models using neural networks and vast amounts of text data has led to significant advancements in NLP capabilities in recent years.

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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.

### **2.3.6 Summary**



## 3 The Growing Influence of AI in Education

### 3.1 Record-Breaking User Growth

ChatGPT achieved unprecedented user growth, becoming the fastest-growing consumer application in history [?]. It surpassed 1 million users within just 5 days of launch and skyrocketed to 100 million monthly active users by January 2023, only two months after its debut [?] [?] [?]. For comparison, TikTok took 9 months and Instagram about 2.5 years to reach the 100 million user milestone [?]. As of August 2023, ChatGPT boasts over 180.5 million users, an 80.5

### 3.2 Global Reach and Demographics

ChatGPT has a global presence, with users spanning 161 countries [?]. However, it remains banned in several nations, including China, Russia, Iran, and Venezuela [?] [?]. The United States accounts for the largest share of users at 46.75

### 3.3 News coverage and public attention

The impact of AI on education has garnered significant media attention, with numerous articles discussing the potential benefits, risks, and implications for students and teachers [?] [?] [?]. Headlines have highlighted both the revolutionary potential of AI to transform learning and the challenges it poses for academic honesty and traditional educational practices. The topic has sparked widespread public debate about the appropriate role and regulation of AI tools in schools [?] [?].

### 3.4 Fear of Widespread Cheating and Plagiarism

One of the primary concerns surrounding ChatGPT's launch was its potential to facilitate cheating and plagiarism among students [?] [?] [?]. With its ability to generate high-quality, human-like text based on prompts, educators feared that students would use ChatGPT to complete assignments, essays, and exams without putting in the necessary effort or learning [?] [?]. A recent survey revealed that nearly half of students were likely to use AI tools like ChatGPT, while 60

Most cheating statistics are derived from surveys in which students are asked about their recent cheating behavior. However, to accurately interpret these statistics, it is crucial to understand what students consider to be cheating. A Pew Research Center survey of U.S. teens, conducted between September 26 and October 23, 2023, revealed an interesting discrepancy in students' perceptions of AI usage. While approximately 60

### 3.5 Bans and Restrictions in Schools

In response to the potential for widespread cheating, several large public school districts, including New York City, Los Angeles, Seattle, and Baltimore, swiftly banned access to ChatGPT on school devices and networks [?] [?]. These bans aimed to prevent students from misusing the tool and to uphold academic integrity standards [?]. However, the effectiveness of such bans remains questionable, as students can still access ChatGPT on personal devices outside of school networks [?]. The bans also sparked debates about the role of AI in education and the need for schools to adapt to emerging technologies [?] [?]. Recent research from Stanford University suggests these cheating fears may have been overblown, as overall cheating rates in high schools have not significantly increased despite the growing use of AI tools [?].

### 3.6 Emergence of AI Detection Tools

In response of the cheating concerns, various AI detection tools have been developed to help identify content that has been partially or wholly generated by AI [?]. These tools are intended for use by educators, publishers, recruiters, and others who want to ensure the originality and authenticity of written content. Examples are Originality.ai [?], copyleaks.com [?], quillbot.com [?], gptzero.me [?], or a French tool compilatio.net [?]. However, the effectiveness and reliability of these tools have been the subject of much debate [?] [?] [?].

### 3.6.1 How AI Detection Tools Work

AI detection tools rely on machine learning (ML) and natural language processing (NLP) techniques to analyze and classify text as either human-written or AI-generated [?] [?]. They are often built using language models similar to those used in the AI writing tools they aim to detect [?]. These tools work by examining various linguistic patterns, sentence structures, and other characteristics of the text [?] [?]. They compare the input text to large datasets of known AI-generated and human-written content to determine the likelihood that the text was created by an AI [?] [?]. Some common techniques used by AI detection tools include [?] [?]:

- Perplexity: Measuring how well a language model predicts the next word in a sequence
- Burstiness: Analyzing variations in sentence structure and length
- Semantic techniques: Topic modeling, sentiment analysis, and consistency assessment

### 3.6.2 Challenges and Limitations

Despite the development of various AI detection tools, their effectiveness and reliability remain questionable [?] [?] [?]. Several studies have shown that these tools often struggle to accurately classify text, particularly as AI text generators become more advanced [?] [?]. Some key challenges and limitations include:

- High rates of false positives and false negatives [?] [?] [?]
- Difficulty keeping pace with rapidly evolving AI technologies [?] [?]
- Inconsistent performance across different AI models and generators [?]
- Reduced effectiveness when faced with obfuscation techniques like manual editing or machine paraphrasing [?]

Additionally, the results provided by AI detection tools can be difficult for average users to interpret, with some tools providing complex statistical information or highlighting text without clear explanations [?].

### 3.6.3 An arm race

As AI detection tools become more prevalent, users and students are employing various strategies to evade these tools when using AI-generated content for schoolwork or other purposes. This has led to an ongoing battle, often referred to as an "arms race," between AI generators and detectors.

Some of the techniques used to bypass AI detection include manual editing and paraphrasing, where users take the AI-generated text and manually rephrase sentences, change word choices, and introduce minor grammatical errors to make the writing seem more human-like and less perfect [?] [?].

Another approach is the multilingual method, where users have AI tools like ChatGPT generate the text in a different language, then translate it back to English themselves, which can help obscure AI patterns [?].

Users also instruct AI models to mimic specific writing styles, such as a "struggling B-level student" or a "lazy student rushing to proofread a paper," complete with intentional errors and imperfections expected from those archetypes [?] [?].

Some even resort to using "AI-detection-bypass" tools, which are AI-powered tools specifically designed to rephrase AI-generated text in ways that are harder for detectors to identify. Examples of such tools include Hix AI, Nova, Conch AI, Undetectable AI, and Stealthwriter [?] [?] [?].

Some users even exploit technical loopholes, such as replacing certain letters in their text with visually similar Unicode characters, which can trick AI detectors [?].

Others believe that text from more sophisticated models like GPT-4 is harder for current detectors to identify compared to GPT-3.5 or other models [?].

However, many users also express doubts about the effectiveness and longevity of these methods. Students are compiling evidence of false positives from detectors (e.g., flagging historical texts as AI-generated) to undermine their reliability and persuade schools not to trust the tools [?] [?].

### 3.6.4 Implications and Future Directions

The development of AI detection tools has significant implications for academia and beyond. Educators are grappling with how to adapt courses and assessments to the AI era while maintaining academic integrity [?] [?]. Publishers and content creators are also exploring ways to ensure the originality of their content [?]. However, the current limitations of AI detection tools suggest that they should be used with caution and not relied upon as the sole means of identifying AI-generated content [?] [?] [?]. Experts emphasize the importance of combining automated detection with human review and other methods to ensure the accuracy and fairness of the results [?] [?]. As AI text generators continue to advance, it is clear that AI detection tools will need to evolve in tandem to remain effective [?] [?] [?]. This ongoing "arms race" between AI generators and detectors is likely to shape the future of academic integrity and content authenticity in significant ways. Educators, institutions, and policymakers will need to stay informed about the latest developments in AI technology and adapt their practices accordingly to ensure the integrity of the educational process in the face of these rapidly evolving tools.

## 3.7 Government initiatives and policies

### 3.7.1 Investing in AI Infrastructure and Partnerships

Governments around the world are increasingly recognizing the potential of AI to transform education and are investing in initiatives to support AI research, development, and deployment in academic institutions. In the United States, the National Science Foundation (NSF) is leading efforts to create a national network of AI research centers by facilitating partnerships between government agencies and academic institutions [?]. These collaborations aim to increase access to AI resources for academia and support national AI goals. The UK government has also announced a £2 million investment in new classroom technology, including AI tools, to reduce teachers' workloads and enhance education [?] [?]. This funding will be used by Oak National Academy to develop and expand AI-powered teacher support tools, such as lesson planners and quiz builders [?] [?]. In 2018, the French government launched a national strategy for artificial intelligence (AI) called "AI for Humanity." This strategy aims to position France as a global leader in AI research, development, and innovation [?] [?]. The strategy is divided into two phases:

1. Phase 1 (2018-2022): Focused on strengthening France's research capabilities in AI, with an investment of €1.5 billion [?] [?] [?].
2. Phase 2 (2021-2025): Aims to diffuse AI technologies throughout the economy and support the development of trustworthy, frugal, and generative AI. This phase has a budget of €1.5 billion as part of the France 2030 plan [?] [?].

The French government has supported the creation and development of a network of interdisciplinary AI institutes, the establishment of chairs of excellence, and doctoral programs [?] [?]. It has also deployed the Jean Zay supercomputer to support AI research [?].

### 3.7.2 Developing Frameworks and Guidelines

Governments and international organizations are developing frameworks and guidelines to ensure the safe, ethical, and effective use of AI in education. For example, the Australian Government Department of Education has released the inaugural Australian Framework for Generative Artificial Intelligence in Schools, to be implemented from Term 1 2024 [?]. The framework prioritizes privacy, security, safety, teaching and learning outcomes, human and social wellbeing, transparency, fairness, and accountability [?]. UNESCO has also developed policy guidance for leveraging AI in education, emphasizing the need to harness the benefits of AI while mitigating risks [?]. The guidance covers various aspects, including promoting inclusive and equitable use of AI, developing ethical guidelines, fostering local AI innovations, and building an evidence base through pilot testing and evaluation [?]. As part of its broader national strategy for artificial intelligence (AI), the French government has recognized the importance of integrating AI into the education system. The strategy aims to position France as a global leader in AI research, development, and innovation, with education playing a crucial role [?] [?]. In March 2024, the Commission on Artificial Intelligence submitted a report to the President of the Republic containing 25 recommendations to help France capitalize on the AI technological revolution

[?] [?] [?]. These recommendations were based on extensive consultations and aim to guide public authorities in making decisions to position France at the forefront of AI, including in the field of education.

### **3.8 Conclusion (TODO)**

## **4 Benefits of AI in education**

### **4.1 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.

### **4.2 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.

### **4.3 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.

### **4.4 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.

## **5 Challenges and limitations of AI in education**

### **5.1 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.

### **5.2 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.

### **5.3 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.

## **6 Evolving roles of teachers and assessment methods**

### **6.1 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.

### **6.2 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.

### **6.3 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.

## **7 Future perspectives**

### **7.1 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.

### **7.2 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.

### **7.3 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.

### **7.4 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.



## 8 Conclusion

### 8.1 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.

### 8.2 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.

### 8.3 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

[\[1\]](#)

### References

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