



MINISTÈRE  
DE L'ÉDUCATION  
NATIONALE,  
DE L'ENSEIGNEMENT  
SUPÉRIEUR  
ET DE LA RECHERCHE

*Liberté  
Égalité  
Fraternité*

# Artificial intelligence and education

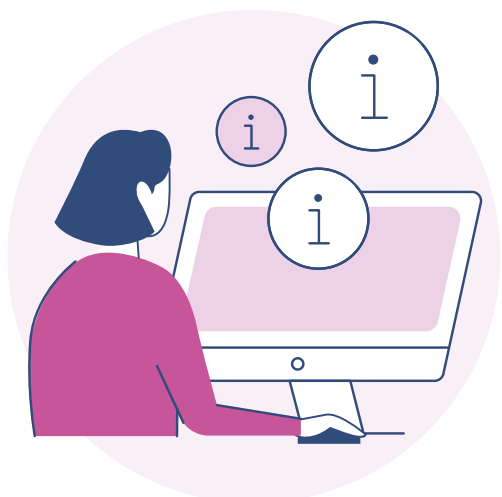
Research contributions  
and challenges  
for public policies

January 2025



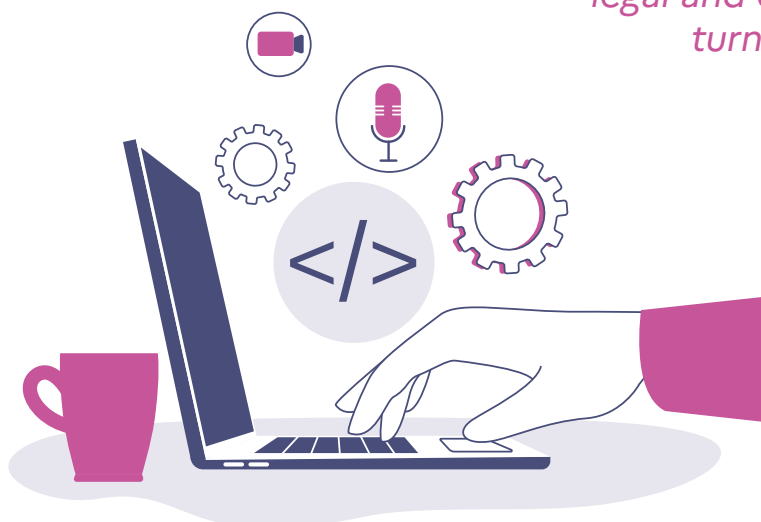
## État des lieux sur les apports de la recherche et les lignes directrices des institutions internationales sur l'intelligence artificielle et l'éducation :

définitions et approches, politiques publiques, enjeux juridiques et éthiques, applications, tournant des IA génératives.



### ***Current situation on the Research Contributions Guidelines of international institutions on artificial intelligence and education:***

*definitions and proposals, public policies, legal and ethical issues, applications, turning point of Generative AI.*



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# Abstract

This document, produced by the Digital Directorate for Education (Ministry of National Education, Higher Education and Research), offers an inventory (January 2025) of the contributions of research and the guidelines of international institutions on the artificial intelligence (AI) and education: diversity of definitions and approaches, issues for public policies, legal and ethical issues, fields of application, avenues for training and teaching, perspectives with the turning point of generative AI and large language models.

## Résumé

*Ce document, réalisé par la Direction du numérique pour l'éducation / ministère de l'Éducation nationale, de l'Enseignement supérieur et de la Recherche propose un état des lieux (janvier 2025) sur les apports de la recherche et les lignes directrices des institutions internationales sur l'intelligence artificielle (IA) et l'éducation : diversité des définitions et des approches, enjeux pour les politiques publiques, enjeux juridiques et éthiques, domaines d'application, pistes de travail pour former et enseigner, perspectives avec le tournant actuel des systèmes d'IA générative et des grands modèles de langage.*

## Resumo

*Este documento, producido por el Departamento de Educación Digital (Ministerio de Educación Nacional, Enseñanza Superior e Investigación), ofrece un inventario (Enero de 2025) de las contribuciones de la investigación y las directrices de las instituciones internacionales sobre la inteligencia artificial (IA) y la educación: diversidad de definiciones y enfoques, cuestiones para las políticas públicas, cuestiones jurídicas y éticas, campos de aplicación, vías de formación y enseñanza, perspectivas con el giro actual de las IA generativas y los grandes modelos de lenguaje.*

# Introduction

**Reality is never “what we might believe it to be”:  
it is always what we ought to have thought.**

Gaston Bachelard, *The Formation of the Scientific Mind* (1938)

We are very pleased to present the 2025 edition of the trilingual brochure, “*Artificial Intelligence and Education: Research contributions and the challenges for public policy*” proposed by the Directorate of Digital Education (DNE) at the French Ministry of Education, Higher Education and Research (MENESR). With the rapid growth of artificial intelligence technologies since 2022, this third edition is again coming at a time of acceleration in this area, marked by rapid and sometimes unpredictable changes that require researchers to accept to work, make proposals and advance within a “grey area” of huge uncertainty. Indeed, just like the web revolution in the 1990s-2000s, AI is a new industrial revolution taking place over a very short period of time, where not only does the intensity of the speed of change change rapidly but the direction these changes take is also highly volatile, as evidenced by the recent and indispensable debate in terms of learning organisation, pedagogical design and assessment.

Against this backdrop, this 2025 edition highlights decisive public policy issues in light of recent research contributions and the key innovation and education questions to be explored for the future of education systems and democratic societies. Beyond technological issues, AI already comes within the sphere of the digital humanities and should be even more anchored in these digital humanities which alone enable an on-going dialogue between the arts and science on the systemic implications for the transformation of, access to and transmission of, knowledge, both in the way knowledge is produced and disseminated. A necessary insight from the sciences, therefore, in their plurality, but always with the indispensable critical awareness of the challenges, perspectives and limits. This process involves accepting to work in this “grey area” where the difficulty comes from the uncertainties and the many explorations to be discovered and to overcome the “epistemological obstacles” that require us to know against our previous knowledge, as Gaston Bachelard said, and who, together with Edgard Morin, helps us continue this complex quest for intelligibility and innovation.

We warmly thank the teams in the digital thematic groups (#GTnum) and other partners in our watch, applied research and innovation actions, including Pacal Plantard (University of Rennes 2), Georges-Louis Baron (Paris Cité University), Colin de la Higuera (University of Nantes, UNESCO Chair Relia), Vanda Luengo (Sorbonne University), Margarida Romero (Côte d’Azur University), Pierre-Yves Oudeyer (Inria) and Didier Roy (Inria), for their work and contributions to the work carried out by the Ministry. We respectfully greet our European colleagues in Ireland, Italy, Luxembourg and Slovenia and those in the DELTA group with whom we regularly work on AI in education (including the AI4T project).

This edition is dedicated in particular to Anne Boyer for all her work on AI, her pioneering and demanding contributions to education and whose commitment and vision continue to inspire us.

Since not all questions are covered in this publication, we follow Sisyphus’s path and believe that often, when reading the articles, new questions will emerge and will need to be explored, studied and shared.

Finally, we hope that this new edition will continue to be useful to stakeholders in the education world, accompanying them in the advent of a new agency\*, at a time when the technological acceleration in AI demands that the need for critical thinking and action informed by the different perspectives of researchers and practitioners - teachers, trainers, school heads and inspectors - be further reinforced to ensure we always remain within a framework in which digital AI applications are at the service of humans.

**Elie Allouche and Axel Jean,**

Support Office for Digital Innovation and Applied Research  
and the DNE-TN2 CREIA and P2IA team  
DNE – MENESR - France, January 2025

\* Source: “The ability of human beings to act intentionally on themselves, on others and on their environment.”  
According to Jézégou, A. (2022). Agency. In *Dictionnaire des concepts de la professionnalisation* (Vol. 2, p. 41-44). From Boeck Supérieur.  
<https://doi.org/10.3917/dbu.jorro.2022.01.0041>

# Takeaways

## 10 markers on AI and education

<https://edunumrech.hypotheses.org/12695>



### 01. Definition

Artificial intelligence: a domain that has studied [since the 1950s] the mechanisms of intelligence by modelling them with algorithms and experimenting with machines (Inria, 2020).



### 02. Applications

Adaptive learning systems, conversational agents, mentoring, detection and remediation of learning difficulties, processing and producing knowledge, administrative practices.



### 03. Legal and ethical aspects

Compliance with the AI Act and GDPR framework. Points of vigilance: human control, identification and correction of bias, fairness, inclusion, respect for the dignity of individuals, justification of choices, transparency and explainability.



### 04. Literacy

AI literacy: Understanding and ability to interact effectively with AI: technical know-how, ethical and societal implications (Zhang *et al.*, 2023).



### 05. Generative AI

Technologies trained on massive data sets and generating new content (text, image, audio, video) randomly from an instruction/prompt (Gozalo-Brizuela & Garrido-Merchan, 2023).



### 06. ChatGPT type conversational agents

Conversational agent open to the public in November 2022 (word prediction by the "Transformer" neural network architecture 2017). Performance close to human interactions.



### 07. Explore and experiment

Explanation of AI operating principles, challenges and application options for students, educating for a critical mindset, vigilance on personal data protection/GDPR compliance.



### 08. Prompt

Quality of the response strongly dependent on that of the prompt. To write a prompt, specify in particular: context, level, need, objectives, constraints, audience, style, format, keywords, examples.



### 09. Educational Engineering

Potential of generative AI for the design of learning sequences: explanation, reflective approach, distancing, problematisation. Contributions of AI: structuring, reflection, creativity.



### 10. Prospective

Need for training, impacts on teaching and learning, skills and professions, production and dissemination of information and knowledge, user experience and work environments. Emergence of autonomous AI agents.

(Allouche, 2024)

# 1 Artificial intelligence (AI): manifold definitions and approaches

## 1.1 Origins and founding acts

Going back to its origins, as a new scientific discipline, AI was “based on the conjecture that all **cognitive functions** – especially learning, reasoning, computation, perception, memorization, and even scientific discovery or artistic creativity – can be described with such precision that it would be **possible to programme a computer to reproduce them.**” Source: (Ganascia, 2022)

“In addition to an important paper on morphogenesis in 1952, [Turing’s] two most famous papers in the world of computing are ‘On Computable Numbers, With an Application to the Entscheidungsproblem’ (1937), where he laid the foundations of **Turing machines** and computability theory, and ‘Computing Machinery and Intelligence’ (1950), where he posited the **question of whether machines could exhibit intelligent behaviour** and proposed the **Turing test.**” (Le Blanc, 2014)

“One classical definition specifies that **AI is research** that develops technologies that can do things that would require intelligence if done by humans (Minsky, 1969). This approach originates from **Turing**, who proposed that if a **simulation of an intelligent human** cannot be distinguished from a real person, questions about intelligence become irrelevant (Turing, 1950). Many cognitive scientists and some AI researchers and philosophers have adopted a stronger view, arguing that research on AI can reveal how the human mind works (Gardner, 1985).” (Holmes et al., 2022)

“If its history needs a beginning, let’s start with the **Dartmouth Conference**, where the term ‘artificial intelligence’ was first coined. It was held during the summer of **1956** at Dartmouth College near Hanover, New Hampshire, by AI’s two pioneers: **Marvin Minsky and John McCarthy.**” (Le Cun et al., 2019)

“Surprisingly, the term recently used to describe these astounding computing abilities is artificial intelligence (AI). The return of this term – **coined by John McCarthy in 1956** – to the front stage is an interesting enigma in the history of science and technology. Specifically, the majority of close observers state that it is only in the field of machine learning methods, and in particular in deep learning, that observable progress in calculated prediction is currently taking place. Yet these techniques have not always been considered to fall within AI. (...)

The origins of **neural networks** are found in the pioneering history of computer science and early cybernetics. Even though the term was coined later, cybernetics can effectively be considered ‘connectionist’ and still refers to the goal of mathematically modelling a neural network, set by neurophysiologist **Warren McCulloch** and logician **Walter Pitts in 1943**. To this day, that seminal article continues to be quoted as the starting point of the connectionist journey, even in current citations in deep learning articles.” (Cardon et al., 2018)

## Milestones in the history of AI

1943	McCulloch and Pitt publish their article on <b>artificial neurons</b> .
1950	<b>Turing</b> publishes his article "Computing Machinery and Intelligence" based on the Turing test.
1956	The term "artificial intelligence" is used for the first time at a <b>conference held at Dartmouth College</b> .
1957	Invention of <b>Perceptron</b> (first machine learning model based on an artificial neural network) by <b>Frank Rosenblatt</b> .
1958	<b>John McCarthy</b> invents the programming language LISP.
1964-1966	<b>ELIZA</b> , one of the first ever <b>chatbots</b> , is developed by Joseph Weizenbaum. It gives rise to the "Eliza effect", the tendency to unintentionally project human traits into sequences of computergenerated symbols.
1972-1981	The <b>MYCIN expert system</b> is developed, helping physicians to diagnose infectious diseases.
1974	Paul Werbos develops the first backpropagation algorithm, a key component in <b>deep learning</b> .
1997	<b>Deep Blue</b> , the chess computer developed by IBM, beats chess world champion Garry Kasparov.
2011	IBM's <b>Watson</b> wins the TV game "Jeopardy!" against two former human champions.
2012	The AlexNet <b>convolutional neural network</b> wins the ImageNet competition, marking the beginning of the deep learning era.
2016	<b>AlphaGo</b> , an AI program developed by Google DeepMind, beats world Go champion Lee Sedol. Google develops its voice assistant.
2017	Article on <b>Transformers</b> published by (Vaswani et al.) [Google Research].
2018	Google develops its <b>BERT language model</b> , improving performance in automatic natural language processing.
2019	Pluribus developed by Facebook AI makes a breakthrough in the field of poker.
2022	OpenAI launches <b>ChatGPT</b> to the public.
2023	Rapid development of <b>generative AI systems</b> and <b>large multimodal models</b> (text, image, sound, video).
2024	<b>Nobel Prize in Physics</b> awarded to <b>John Hopfield</b> and <b>Geoffrey Hinton</b> and <b>Nobel Prize in Chemistry</b> awarded to <b>Demis Hassabis</b> and <b>John Jumper</b> for their work on AI.

## 1.2 Human decisions, modelling and automation of cognitive tasks

“The term ‘artificial intelligence’, coined in the 1950s, refers to the **field of research that studies the mechanisms of intelligence** by modelling them using algorithms and experimenting them with machines. These mechanisms include, for example, the ability to automatically find solutions to problems, which can then implement planning, prediction, control, memorisation or learning functions. By extension, the term ‘artificial intelligence’ is often used to refer to **algorithms** [set of rules followed by calculations for problem-solving] **that simulate or share characteristics with certain human intelligence capabilities.**” (Inria & Class’Code, 2020)



AI is defined as “**machine-based** systems that can, given a set of human-defined objectives, **make predictions, recommendations, or decisions** that influence real or virtual environments. AI systems interact with us and act on our environment, either directly or indirectly. Often, they appear to operate autonomously, and can adapt their behaviour by learning about the context.” Source: (UNICEF, 2021) and cited by (Holmes & Tuomi, 2022)

It is also a “**theoretical and practical interdisciplinary field** that combines digital, mathematical, statistical and algorithmic technologies.” (*Grand lexique français de l’Intelligence artificielle*, 2021)

“Since the 1950s, AI has been an abundant field of research combining applied mathematics and psychology. Techniques have evolved, several definitions have been proposed, but the central idea is to **push back the boundaries of human actions that can be automated**. Sometimes we talk about decision-making, sometimes about decision support, but the fact is that **AI has the ambition to model certain mental faculties of human beings**. Nowadays, with the multiplication of massive data sets, the refinement of analysis methods and the visibility of certain projects that stimulate collective imagination such as self-driving cars, the potential applications of AI in different knowledge areas are on the rise.” (Romero *et al.*, 2023)

## 1.3 Types of AI

There are several types of AI:

### Defined by their technology

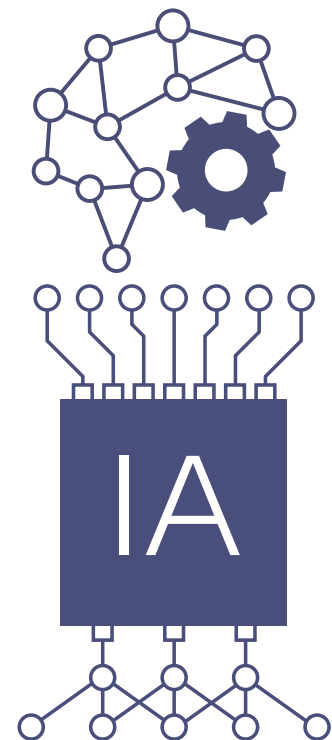
"The other is knowledge-based or symbolic AI. **Data-driven AI** might have great potential in education, depending on the intentions of the system, but **knowledge-based AI** still underpins most existing AIED systems. A third conceptual model, **hybrid AI** that combines data-driven and knowledge-based approaches with human cognition." Source (Holmes et al., 2022)

### Defined by their scope

"**Weak AI differs from strong AI** in terms of the scope of application of these computer programs. Weak AI is a type of artificial intelligence that focuses on a specific task, while strong AI or AGI (artificial general intelligence) can be applied to any problem. All existing AI systems are currently considered weak artificial intelligence systems." (*Grand lexique français de l'Intelligence artificielle*, 2021)

"**Complete or strong artificial intelligence** [General AI]: Artificial intelligence that has the ability to mimic human functions (learning, understanding, reasoning, decision-making, having a conscience, feeling emotions, etc.). **To date, strong artificial intelligence does not exist: it is a concept.**

**Weak artificial intelligence:** This is artificial intelligence as we know it today: it's a 'learning' algorithm that adapts its parameters to learn data and is not equipped with mental or cognitive functions, but can perform a specific task efficiently, sometimes more efficiently than humans." (Inria & Class'Code, 2020)



### Classic AI and machine learning

**Classical AI:** "Much early or 'classical AI', variously known as '**symbolic AI**', 'rule-based AI', or 'good-old-fashioned AI' ('GOFAI'), involves writing sequences of IF... THEN... and other rules of conditional logic, steps that the computer will take to complete a task. Over decades, rule-based AI '**expert systems**' were developed for a diverse range of applications, such as medical diagnostics, credit ratings, and manufacturing. Expert systems are based on an approach known as 'knowledge engineering', which involves eliciting and modelling the knowledge of experts in a specific domain, a resource-intensive task that is not without complications. (...)

**Machine learning:** Many recent AI advances – including natural language processing, facial recognition, and self-driving cars – have been made possible by advances in machine-learning-based computational approaches. Rather than using rules, **machine learning (ML) analyses large amounts of data to identify patterns and build a model** which is then used to predict future values. It is in this sense that the algorithms, rather than being pre-programmed, are said to be 'learning'.

There are **three main ML approaches**:

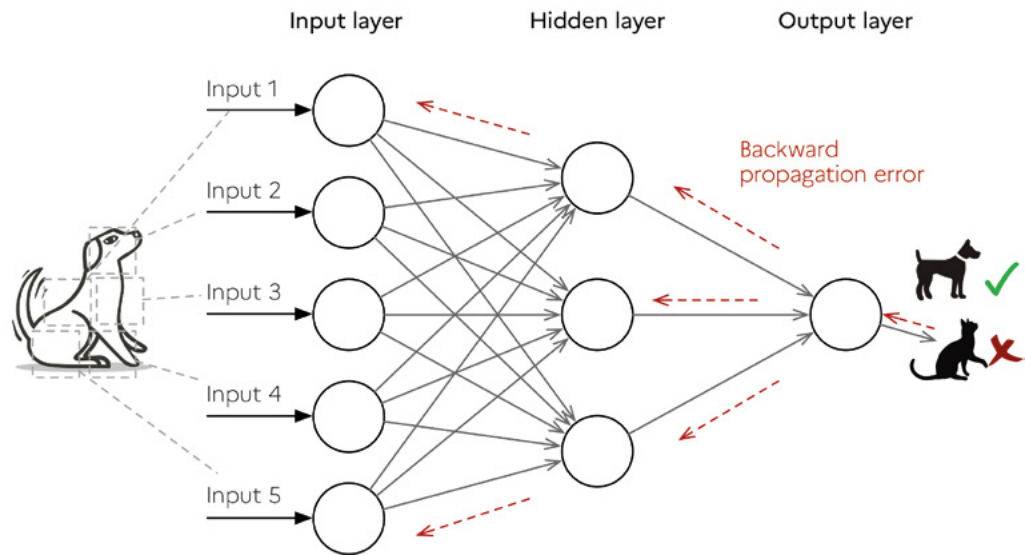
- **supervised,**
  - **unsupervised,**
  - **and reinforcement.**
- 
- **Supervised learning** involves data that has already been labelled – such as many thousands of photographs of people that have been labelled by humans. The supervised learning links the data to the labels, to build a model that can be applied to similar data – for example, to automatically identify people in new photographs. In unsupervised learning, the AI is provided with even larger amounts of data, but this time the data has not been categorized or labelled.
  
  - **The unsupervised learning** aims to uncover hidden patterns in the data, clusters that can be used to classify new data. For example, it may automatically identify letters and numbers in handwriting by looking for patterns in thousands of examples. In both supervised and unsupervised learning, the model derived from the data is fixed, and if the data changes, the analysis has to be undertaken again.
  
  - However, the third ML approach, **reinforcement learning**, involves continuously improving the model based on feedback – in other words, this is machine learning in the sense that the learning is ongoing. The AI is provided with some initial data from which it derives a model, which is assessed as correct or incorrect and rewarded or punished accordingly. (...)

**An artificial neural network (ANN)** is an AI approach that is inspired by the structure of biological neural networks (i.e. animal brains). ANNs each comprise three types of interconnected layers of artificial neurons: an input layer, one or more hidden intermediary computational layers, and an output layer that delivers the result (...)

**Deep learning refers to ANNs that comprise multiple intermediary layers.** It is this approach that has led to many of the recent remarkable applications of AI (for example, in natural language processing, speech recognition, computer vision, image creation, drug discovery, and genomics)."

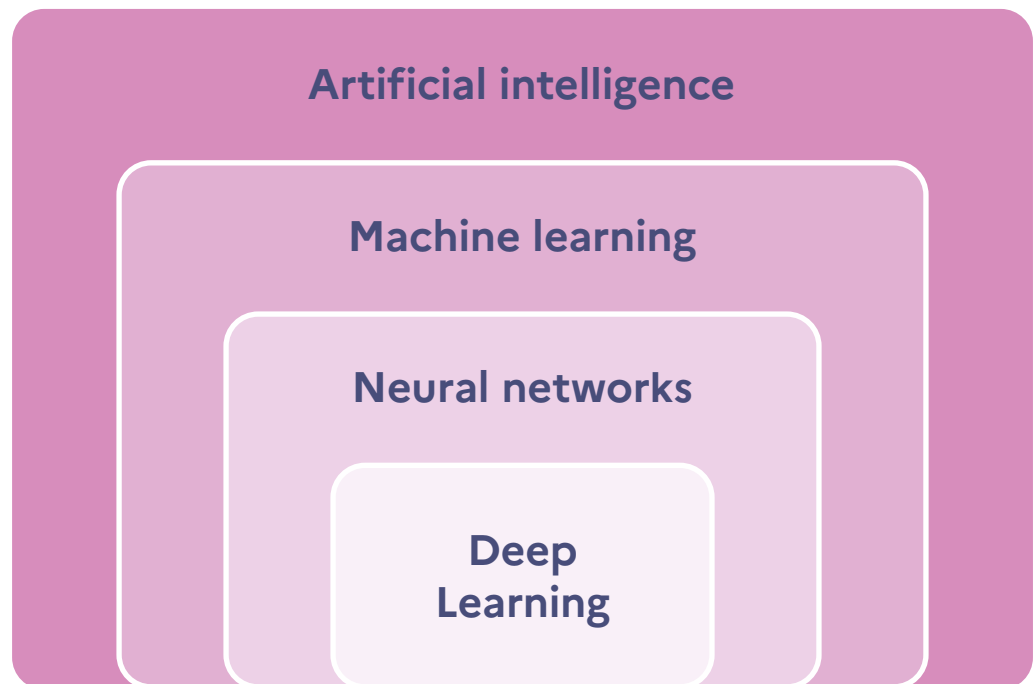
(UNESCO, 2021)

## Working of a neural network



(Cardon et al., 2018) Related to the work of the Nobel Laureates in Physics 2024.

## IA, machine learning, neural networks and deep learning



(UNESCO, 2021)

## The future of AI according to Yann LeCun

According to Yann LeCun, **human intelligence has four characteristics:**

- Understanding the physical world
- Persistent memory (remembering and finding things)
- Reasoning
- Planning

So, even if we can be impressed by the volume of data processed by LLMs, we learn and process more data through our sensory perceptions, observations and interactions with the real world, than through language. What is learnt by humans and most animals in their early years has nothing to do with language. He mentions the **“Moravec paradox”** whereby that which is easiest for humans is often the hardest for machines, and vice versa.

To move towards strong AI, it is therefore necessary for AI technologies to embed and simulate an understanding of the physical world. A **“world model”** embedded into an AI would enable:

“(1) missing information about the state of the world not provided by perception [to be estimated], and (2) plausible future states of the world [to be predicted]. The world model may predict natural evolutions of the world or predict future world states resulting from a sequence of actions proposed by the actor module.”

From (LeCun, 2022, LeCun et al., 2022 and Lex Fridman, 2024)

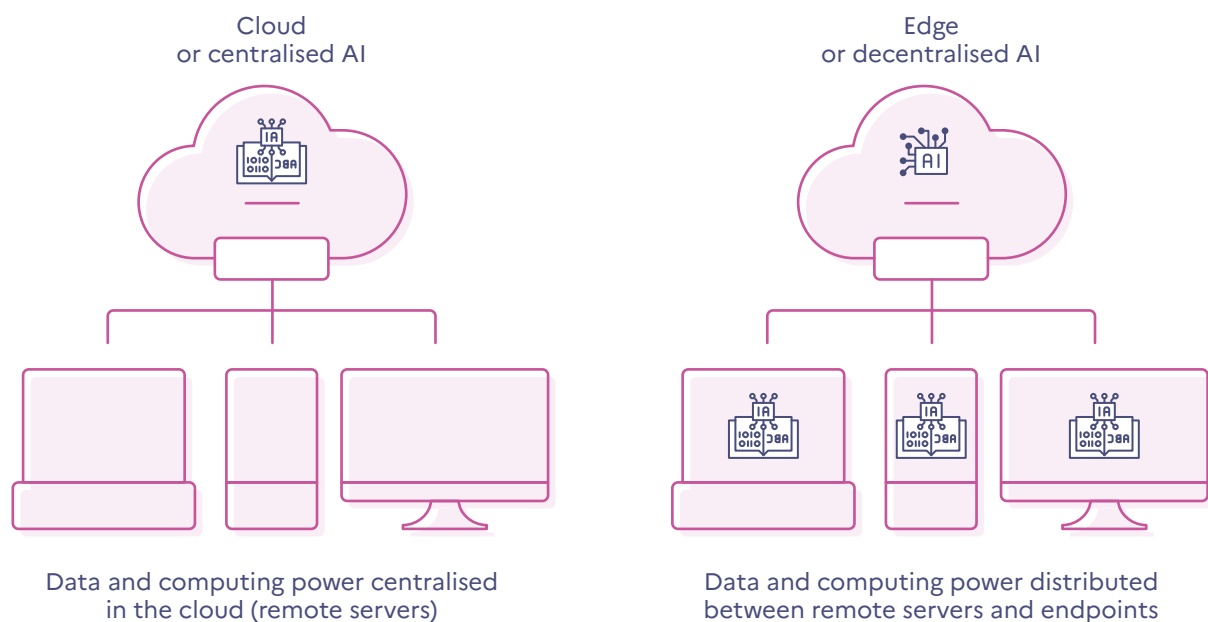
### What is Edge AI?

“AI at the edge is the use of AI in real-world devices. Edge AI refers to the practice of doing AI computations near the users at the edge of the network instead of centralised locations like a cloud service provider’s data centre or a company’s own private data warehouse.”

(Singh & Gill, 2023)

This work is part of the national AI strategy.

### Edge AI



# 2. What are the challenges for public policies?

## 2.1 The Beijing Consensus

The Beijing Consensus “recommend[s] that governments and other stakeholders in UNESCO’s Member States:

- **Plan AI in education policies** (...) to achieve SDG 4 [Sustainable Development Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all];
- **Support the development of new models;**
- **Envisage the use of pertinent data**, where appropriate, to encourage
- evidence-based policy planning;
- Ensure AI technologies are used to **empower and not replace teachers** and develop programs designed to build skills to enable teachers to work alongside AI systems;
- Prepare the next generation of workers by **equipping them with the most pertinent values and skills needed for living and working** in the age of AI;
- Promote a **fair and inclusive** use of AI.”

(UNESCO, 2019)



## 2.2 UNESCO and OECD recommendations and forecasts

### Recommendations for policy makers

#### 1. A system-wide vision and strategic priorities

- Define a system-wide vision of AI and education policies:
  - Ensuring the inclusive and equitable use of AI in education;
  - Leveraging AI to enhance education and learning;
  - Promoting the development of skills for life in the age of AI, including teaching how AI works and its implications for humanity;
  - Safeguarding the transparent and auditable use of education data.
- Assessing system-wide readiness and choose strategic priorities.

#### 2. Overarching principle for AI and education policies

- Adopt a humanistic approach as an overarching principle for AI and education policies.

#### 3. Interdisciplinary planning and inter-sectoral governance

- Mobilize interdisciplinary and multi-stakeholder expertise to inform policy planning and build the capacities of policy-makers.
- Set up inter-sectoral governance and coordination mechanisms.

#### 4. Policies and regulations for equitable, inclusive, and ethical use of AI

- Set out cross-cutting strategic objectives, and plan regulations and programmes, to ensure the equitable and inclusive use of AI in education.

#### 5. Master plans for using AI in education management, teaching, learning, and assessment

- Leverage AI to boost and upgrade education management and delivery.
- Cultivate learner-centred use of AI to enhance learning and assessment.
- Ensure that AI is used to empower teachers.
- Plan the use of AI to support lifelong learning across ages, locations and backgrounds.
- Develop values and skills for life and work in the AI era.

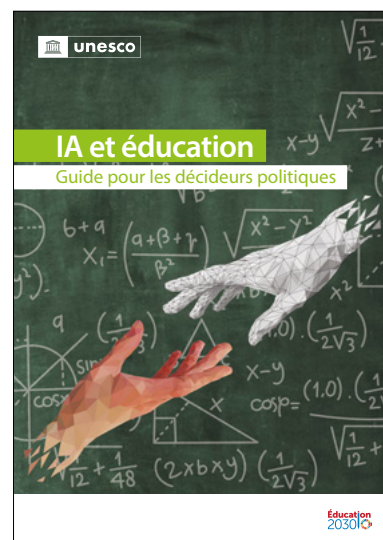
#### 6. Pilot testing, monitoring and evaluation, and building an evidence base

- Build a trusted evidence base to support the use of AI in education.
- Strengthen research and evaluation in the field of AI and education.

#### 7. Fostering local AI innovations for education

- Promote the local development of AI technologies for education.

Source: (UNESCO, 2021) (Extracts)



## AI and inclusive education

“AI-powered institutional tools present **promising opportunities for enhancing equity and inclusion in education systems**. The application of AI in higher education admissions, for example, uses algorithms and data analytics to **streamline the admissions process**, potentially reducing biases and improving fairness in candidate selection. Similarly, AI tools designed to **identify students at risk of leaving education** can provide crucial insights, allowing for timely school interventions. Additionally, AI can **facilitate data-based decision making**, enabling more efficient and targeted distribution of resources to areas of greater need.”

Source: (OCDE *et al.*, 2024)

## The new challenges of generative AI

“The implications of GenAI for assessment go far beyond the immediate concerns about learners cheating on written assignments. We must contend with the fact that **GenAI can produce relatively well-organized papers and essays and impressive works of art**, and can pass some knowledge-based exams in certain subject areas. **We therefore need to rethink what exactly should be learned and to what ends**, and how learning is to be assessed and validated. (...)”

The most fundamental perspective of the long-term implications of GenAI for education and research is still about the **complementary relationship between human agency and machines**. One of the key questions is whether humans can possibly cede basic levels of thinking and skill-acquisition processes to AI and rather concentrate on higher-order thinking skills based on the outputs provided by AI. The emergence of various GenAI chatbots demand that countries carefully consider – and publicly deliberate – the appropriate age threshold for independent conversations with GenAI platforms. **The minimum threshold should be 13 years of age**. Countries will also need to decide if self-reporting age remains an appropriate means of age verification.”

(Miao & Holmes, 2023)

“Generative AI models that generate text, image, video, and audio (e.g., music, speech) content are advancing at breakneck speed. This poses **endless possibilities, demonstrated across a growing array of domains**. However, the technology also poses numerous challenges and risks to individuals, companies, economies, societies, and policymaking around the globe, ranging **from near-term labour-market disruption and disinformation** to potential long-term challenges in controlling machine actions. The future trajectories of generative AI are difficult to predict, but governments must explore them to have a hand in shaping them.”

(Lorenz *et al.*, 2023)

## 2.3 A national strategy

“Following the report ‘Giving meaning to artificial intelligence: towards a national and European strategy’ (2018) and as part of the France 2030 plan, the Government launched a **national strategy for artificial intelligence (SNIA)** in 2018. This strategy aims to position France as one of the European and global leaders in artificial intelligence (AI).

The national strategy for artificial intelligence aims to safeguard and strengthen France’s economic, technological and political sovereignty and put AI at the service of the economy and society. It is linked to the mastering sovereign and secure digital technologies component of the France 2030 plan.”

(French Government - The Directorate General of Enterprises, 2023)

### “The France 2030 plan”

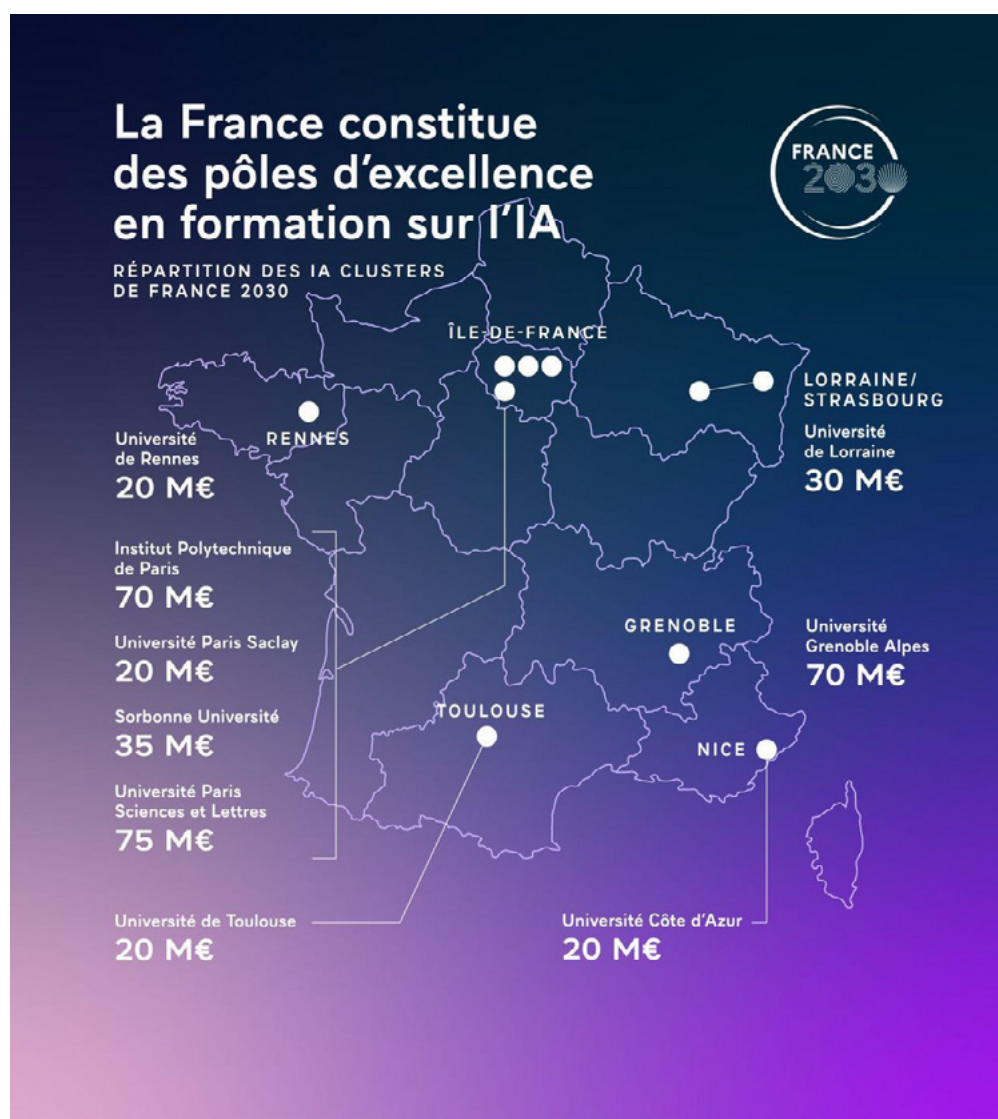
#### The P2IAs

“AI Innovation Partnerships (P2IAs) enable the development of innovative **digital educational services that integrate AI for learning the basics of maths and French, as well as languages**. The P2IA for cycle 2 (CP-CE1-CE2) has been deployed, that for cycle 3 (CM1-CM2-6<sup>e</sup>) is in progress and the P2IA for cycle 4 (5<sup>e</sup>-4<sup>e</sup>-3<sup>e</sup>) is forthcoming. Finally, another P2IA will soon be dedicated to tools integrating generative AI to support teachers in their daily activities (class preparation, assessment, correction, etc.)”

#### The “Digital Commons for Generative AI” call for projects

“In order to encourage the development of generative AI in the French economy and to master the entire value chain of this technology, France 2030 launched the ‘Digital Commons for Generative AI’ call for projects in 2023. This scheme, associated with the National AI Strategy, aims to develop and make accessible the fundamental technological building blocks of generative AI: massive databases that enhance national heritage, ‘foundation’ models, systems for deploying, assessing and controlling generative AI models.”

## Centres of excellence in AI training



Source: (French Government, 2024)

### “The recommendations of the Artificial Intelligence Commission

1. Create the conditions for collective appropriation of AI and its challenges by launching a **plan to raise awareness and train** the nation.
2. Massively invest in **digital businesses** and business transformation to support the **French AI ecosystem** and make it one of the world's leaders.
3. Make France and Europe a **major hub for computing power**, in the short and medium term.
4. Transform our **approach to personal data to continue to protect** while facilitating innovation to serve our needs.

5. Ensure the influence of **French culture** by enabling **access to cultural content** while respecting **intellectual property rights**.

6. Assume the principle of **experimentation** in **public AI research** to strengthen its attractiveness.

7. Structure a coherent and concrete **diplomatic initiative** aimed at founding a **global governance of AI.**"

(Artificial Intelligence Commission, 2024)



## 2.4 Actions and output of digital theme groups (#GTnum)

The Directorate of Digital Education implements and supports **research groups**, the digital theme groups, bringing together researchers and education practitioners, who contribute to the production of **open access knowledge** on digital technology in education. Each GTnum is supported for three years by research laboratories in partnership with academic territories.

### GTnum work programmes on generative AI

#### — Generative AI and large language models in education: GTnum #GenIAL



“The approach is based on three levels: the **educational context** in terms of pedagogical actions, but also educational standards and forms, the **educational contract** that is developed in a relational and normative framework between teaching staff and learners, and finally the **mechanisms and processes** that govern activity in the school. Our goals are thus to be able to **assess the transformative potential of these generative AIs and large language models in schools, and more broadly in teaching.**”

— **Generative AI and schools in the Grand-Est region: GTnum #IA2GE**

“The theme group we have set up aims to **study the uses (and non-uses) of primary and secondary teachers and students in the Grand-Est region** in light of the contributions of current scientific knowledge to pedagogical, didactic, learning and educational phenomena. Our goal is to **identify obstacles, conflicts and levers** in the context of generative AI uses to produce practical resources relating to pedagogical, educational and training engineering, as well as the **prospective approach** to developing future tools to support teachers.”

Laboratoire	interuniversitaire
des sciences de l'éducation	
et de la communication   LISEC   EA 2310	
Université de Strasbourg	



(DNE-TN2, 2024a, 2024b)

Which countries have integrated AI into their educational program?



**Table 4. K-12 AI curricula, endorsed and implemented by governments**

Country/Region	Curriculum Title	Curriculum Developer	Educational Levels		
			Primary	Middle	High
<b>Armenia</b>	Curriculum of ICT	Government		✓	✓
<b>Austria</b>	Data Science and Artificial Intelligence	Federal Ministry of Education, Science and Research			✓
<b>Belgium</b>	IT Repository	Fédération Wallonie-Bruxelles			✓
<b>China</b>	AI curriculum embedded in the Information Science and Technology	Ministry of Education of the People's Republic of China	✓	✓	✓
<b>India</b>	Atal Tinker Labs AI modules	Atal Tinker Labs, Atal Innovation Mission, NITI Aayog		✓	✓
<b>Republic of Korea</b>	AI Mathematics under the Mathematics Subject Group for High Schools	Korea Foundation for the Advancement of Science and Creativity			✓
	AI Basics under Technology Home Economics Subject Group	Korea Foundation for the Advancement of Science and Creativity			✓
<b>Kuwait</b>	Standards curriculum	Curricula technical guidance experts and teachers	✓	✓	
<b>Portugal</b>	Information and Communication Technologies	State school teachers of ICT and Mathematics	✓	✓	✓
<b>Qatar</b>	Computing and Information Technology	Binary Logic, Ministry of Education and Higher Education	✓	✓	✓
	Computing and Information Technology (High Tech Track)	Binary Logic, Ministry of Education and Higher Education			✓
<b>Serbia</b>	Informatics and programming – Grade 8	Ministry of Education		✓	
	Modern technologies in gymnasiums – Grade 3 and 4	Ministry of Education		✓	
<b>United Arab Emirates</b>	AI curriculum embedded under the Technology Subject Framework	Ministry of Education	✓	✓	✓

Source: (UNESCO, 2023)

**Table 5. Governmental K-12 AI curricula in development**

Country/Region	Curriculum Title	Curriculum Developer	Educational Levels		
			Primary	Middle	High
Germany	1. Identifying and Formulating Algorithms [Algorithmen erkennen und formulieren]	Standing Conference of the Ministers of Education and Cultural Affairs of the Länder	✓	✓	✓
Jordan	2. Digital Skills	National Center for Curriculum Development	✓	✓	
Bulgaria	3. Computer Modelling, Information Technology and Informatics	Expert groups (academia, teachers, education experts)	✓	✓	✓
Saudi Arabia	4. Digital Skills	Binary Logic and Tatweer Co.	✓	✓	✓
Serbia	5. Technique and Technology	Ministry of Education working group	✓		
	6. AI in gymnasiums	Ministry of Education working group		✓	
	7. AI in all high schools	Ministry of Education working group		✓	

(UNESCO, 2023)

## 2.5 Innovation, AI and prospects for Europe



“With the world now on the **cusp of another digital revolution**, triggered by the spread of artificial intelligence (AI), a window has opened for Europe to redress its failings in innovation and productivity and to restore its manufacturing potential.(...) AI – and particularly generative AI – is an evolving technology in which EU companies still have an opportunity to carve out a leading position in selected segments. Europe holds a strong position in autonomous robotics, hosting around 22% of worldwide activity, and in AI services, hosting around 17% of activity. But innovative digital companies are generally failing to scale up in Europe and attract finance, reflected in a **huge gap in later-stage financing between the EU and the US**. In fact, there is no EU company with a market capitalisation over EUR 100 billion that has been set up from scratch in the last fifty years,

while in the US all six companies with a valuation above EUR 1 trillion have been created over this period. (...)

**Although technology is crucial to protect Europe’s social model, AI could also undermine it without a strong focus on skills.** Unlike previous waves of computerisation, **the jobs of higher-skilled workers are likely to be more exposed.** Providing workers with adequate skills and training to make use of AI can nevertheless help to make the benefits of AI more inclusive. In one recent study, access to AI assistance was found to increase productivity for all workers, but less experienced or low-skilled staff benefited the most. While Europe should strive to match the US in innovative potential, it should aim to exceed it in **providing opportunities for education and lifelong learning** – ensuring that the benefits of AI are widely shared and any negative impacts on social inclusion are minimised.”

(Draghi, 2024)

## 2.6 AI and environmental impact

“Every time we query an AI model – be it via our phone, a chat interface, or a smart speaker – this request has to run through **physical hardware** to provide us with an answer. As AI models get bigger in size and complexity, they also require more powerful hardware to run them. One common hardware component for AI systems is the GPU (**graphical processing unit**), and an individual AI model may require multiple GPUs. These GPUs are often on servers within data centers located across different regions of the world and connected via the Web. On average, 40-50% of the energy used by a data center is used for powering the computing equipment, with a further 30%-40% dedicated to **cooling the equipment**. Energy is also used for **manufacturing the hardware** (e.g., GPUs), as well as other elements of data center infrastructure (e.g., storage, networking, etc.) – although the exact amount used by companies such as Nvidia, who have considerable market shares on GPU design, remains unknown.

There is currently **little transparency on the energy demands of specific AI applications**, although a recent estimate has put the **amount of energy used for a ChatGPT query to be anywhere between 6-10 times more than a traditional Web search** (0.3 Wh vs. 2.9 Wh). At a macro level, AI is estimated to use 10%-20% of data center electricity today, but as new generations of AI-enabled servers consume more power, this percentage is set to increase at an average of 70% in coming years and double by 2030.”

(Luccioni *et al.*, 2024)

**“AI increases the risks but also the opportunities digital technology can offer the environment.** In the broad digital domain, artificial intelligence (AI) occupies a specific place, particularly so-called ‘generative’ AI, capable of generating new content (texts, audio, photos, videos, etc.) from data.

In terms of opportunities, **AI can directly contribute to reducing the environmental footprint through systems created specifically for their ecological utility.** For example, AI helps measure and manage air quality by predicting the concentration of particulate matter in a particular location several hours in advance and recommending that travel be adapted accordingly. AI can also indirectly contribute to reducing the environmental footprint by improving the energy efficiency of all activities. This resource use optimisation takes multiple forms in many sectors: traffic flow management, heating in buildings, waste management, etc.

**But, on the other hand, the consumption of electricity, rare metals, water and soil sealing attributable to AI is growing sharply,** although it remains marginal compared to total consumption. AI therefore aggravates the environmental footprint of digital technology, both through its three hardware components (terminals, networks, data centres) and in all stages of the lifecycle (manufacturing, distribution, use and end of life).”

(Tatot & Vermot Desroches, 2024)



# 3. What are the legal and ethical considerations?

## 3.1 AI and personal data protection

The first recommendations from the CNIL:  
For the use of AI that protects personal data

“These CNIL recommendations are intended to **support AI ecosystem players in their efforts to comply with personal data protection legislation**. They provide concrete answers, illustrated by examples, to the legal and technical challenges related to the application of the GDPR to AI. The points discussed in these initial recommendations enable the following in particular:

- determine the appropriate legal regime;
- define a purpose;
- determine the legal qualification of the actors;
- establish a legal base;
- perform tests and checks in case of reuse of data;
- perform an impact analysis if necessary;
- take data protection into account when designing the system;
- take data protection into account when collecting and handling data.”

(CNIL, 2024)

## 3.2 A European AI Act (AI Act)

“What does the AI Act provide for?”

The European AI Act is the world’s first general legislation on artificial intelligence. It aims to provide a framework for the development, placing on the market and use of artificial intelligence (AI) systems, which may pose risks to health, safety or fundamental rights.

## Four Levels of Risk

The AI Act follows a risk-based approach by classifying AI systems into four levels:

- **Unacceptable risk:** the AI Act prohibits a limited set of practices that are deemed contrary to the values and fundamental rights of the EU.  
Examples: social scoring, exploitation of people's vulnerability, use of subliminal techniques, use for law enforcement of real-time remote biometric identification in publicly accessible spaces, predictive policing targeting individuals, recognition of emotions in the workplace and in educational institutions.
- **High risk:** The AI Act defines AI systems as high-risk where they may affect the safety of individuals or their fundamental rights, which justifies their development being subject to enhanced requirements (conformity assessments, technical documentation, risk management mechanisms). These systems are listed in annex I for systems embedded in products that are already subject to market surveillance (medical devices, toys, vehicles, etc.) and in annex III for systems used in eight specific areas.  
Examples: biometric systems, systems used in recruitment, or for law enforcement purposes.
- **Specific transparency risk:** the AI Act imposes specific transparency obligations on AI systems, in particular where there is a clear risk of manipulation.  
Examples: use of chatbots or systems generating content.
- **Minimal risk:** for all other AI systems, the AI Act does not include a specific obligation. These are the vast majority of AI systems currently in use in the EU or likely to be used in the EU according to the European Commission.

### High-risk AI systems in education and vocational training

- a) AI systems intended to be used to determine access or admission or to assign natural persons to educational and vocational training institutions at all levels;
- b) AI systems intended to be used to evaluate learning outcomes, including when those outcomes are used to steer the learning process of natural persons in educational and vocational training institutions at all levels;
- c) AI systems intended to be used for the purpose of assessing the appropriate level of education that an individual will receive or will be able to access, in the context of or within educational and vocational training institutions at all levels;
- d) AI systems intended to be used for monitoring and detecting prohibited behaviour of students during tests in the context of or within educational and vocational training institutions at all levels.

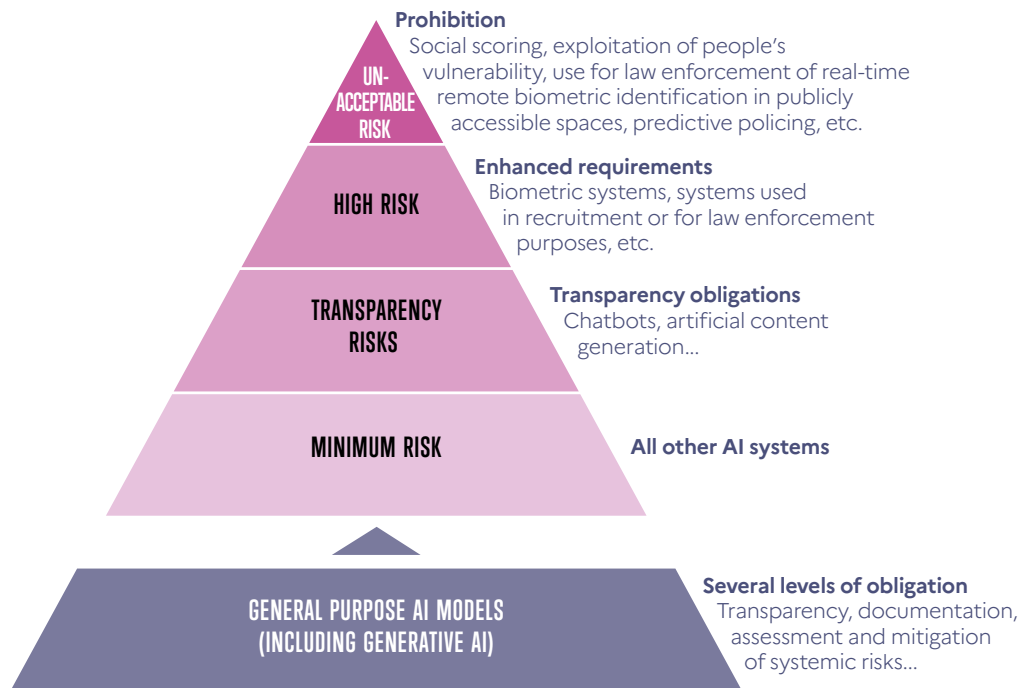
Source: [https://eur-lex.europa.eu/legal-content/FR/TXT/HTML/?uri=OJ:L\\_202401689#anx\\_III](https://eur-lex.europa.eu/legal-content/FR/TXT/HTML/?uri=OJ:L_202401689#anx_III)

## General-purpose AI models

Moreover, the AI Act also provides a framework for a new category of so-called general-purpose AI models, in particular in the **field of generative AI**. These models are defined by their ability to serve a large number of tasks (such as large language models, or LLMs, like the ones provided by Mistral AI or OpenAI companies), making them difficult to classify them in the previous categories.

For this category, the AI Act provides for several levels of obligations, ranging from minimum **transparency and documentation measures** (article 53) to an in-depth assessment and the implementation of **systemic risk mitigation measures** that some of these models might entail, in particular because of their power.”

### Regulation IA - Risk-based approach



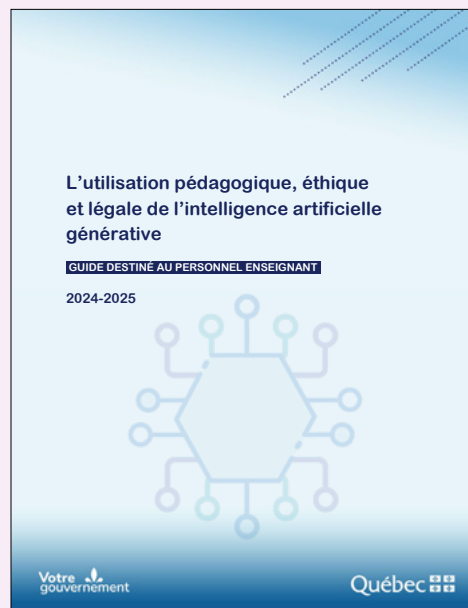
(CNIL, 2024)

### Towards an AI use framework in education

From these legal and ethical frameworks arise practical implementation questions for teaching and learning with AI. As in other countries, the French ministry is undertaking a series of consultations at the beginning of 2025 to establish an adaptable usage framework.

(DNE-TN2, 2025).

Example of a guide for teachers in the French-speaking world: (Directorate for the Development of Digital Culture - Sub-Ministry of Digital Technology and Information, 2024)



## 3.3 Guidelines from international institutions

“AI systems are not magic. **Humans design, train and guide AI**, whether they are the people that set AI policies and strategies, the software programmers who build AI systems, those that collect and tag the data used by them, or the individuals who interact with them. This means that **all stakeholders in the AI technology development ecosystem need to understand the key challenges** that require them to contribute to the responsible use of AI. This can include **knowing why and how an AI system was designed, by whom and for what purpose.**”

(UNICEF, 2021)

“Regarding the ethical use of AI and data in teaching, learning and assessment, the European Commission recommends four key considerations to be addressed:

- **human action and human control:** capacity for action of education actors (teachers, learners, heads of institutions);
- **fairness:** impartiality, inclusion, non-discrimination and fair distribution of rights and responsibilities;
- **human-centred:** consideration for people, their identity, integrity and dignity;
- **justification of decisions, transparency and explainability:** use of knowledge, facts and data to justify collective decisions in the school environment, through participatory and collaborative decision-making models.”

Source: (Directorate General for Education, Youth, Sport and Culture & European Commission, 2022)

## 3.4 The diversity of ethical issues identified by research

“The ethical and critical issues raised by AI in education are manifold and of diverse origin: use of big data, which can have an impact on the respect of privacy of students and school staff, production by private companies rather than school authorities, research in computer science or sciences, technology, engineering and mathematics rather than educational sciences, cognitive bias due to lack of diversity within design teams.”

Source: (Collin & Marceau, 2021)

## 3.5 The explainability issue

“In the field of education, there are two categories of user who need to take ownership of the digital environment: students and teachers. **It is crucial that teachers take ownership of CBLEs (computer-based learning environments) to promote the wider use of these tools in teaching.** It is therefore necessary to design systems that teachers can adapt to meet their needs. To do so, **teachers must be able to understand the decisions or recommendations made by the AI system concerning their students,** trust the system and, in some way, ‘become one’ with it so as to explain the combined behaviour of the system as implemented. This calls for an explicit representation of knowledge and decision-making processes. The issue of explainability must be taken into account from the design stage.”

(Association Française pour l’Intelligence Artificielle (AFIA), 2022)

# 4. What are the areas of application?

## 4.1 Categorisation and taxonomy

### Categorisation proposed by the European Commission

Teaching	Student-focused aid	Teacher-focused aid	Institution-focused aid
<ul style="list-style-type: none"> <li>• Computer-based environment for human learning</li> <li>• Dialogue-based tutoring systems</li> <li>• Language-learning applications</li> </ul>	<ul style="list-style-type: none"> <li>• Exploratory learning environments</li> <li>• Automatic formative assessment</li> <li>• AI-powered collaborative learning</li> </ul>	<ul style="list-style-type: none"> <li>• Summative assessment of writing, grading</li> <li>• Keyword detection in learner forums</li> <li>• AI teaching assistants</li> <li>• Educational resource recommendation</li> </ul>	<ul style="list-style-type: none"> <li>• Exploration of educational data for resource allocation</li> <li>• Diagnosis of learning difficulties</li> <li>• Orientation services</li> </ul>

Source: (European Commission. Directorate-General for Education, Youth, Sport and Culture, 2022)

### Further categorisation from the digital theme groups:

- Adaptive and personalised systems (recommendation and selection of content, resources), adaptive assessment and automatic correction.
- Chatbots and intelligent teaching systems, e.g. for teaching the investigative approach and scientific approach (Cisel & Baron, 2019).
- Early anticipation, prediction and prevention of school dropout.
- Detection and remediation of learning disabilities.
- Use of knowledge produced by research using AI (image analysis, annotation, classification, automatic summary/synthesis, processing of big data on textual or image corpora).
- Administrative uses.

Source: (DNE-TN2, 2021) (DNE-TN2, 2022) (Lepage Alexandre, 2022) (Romero et al., 2021)

Taxonomy based on the literature review by (Holmes et al., 2022)

## Student-focused AIED

Intelligent Tutoring Systems (ITS)
AI-assisted Apps (e.g., maths, text-to-speech, language learning)
AI-assisted Simulations (e.g., games-based learning, VR, AR)
AI to Support Learners with Disabilities
Automatic Essay Writing (AEW)
Chatbots
Automatic Formative Assessment (AFA)
Learning Network Orchestrators
Dialogue-based Tutoring Systems (DBTS)
Exploratory Learning Environments (ELE)
AI-assisted Lifelong Learning Assistant

## Teacher-focused AIED

Plagiarism detection
Smart Curation of Learning Materials
Classroom Monitoring
Automatic Summative Assessment
AI Teaching Assistant (including assessment assistant)
Classroom Orchestration

## Institution-focused AIED

Admissions (e.g., student selection)
Course-planning, Scheduling, Timetabling
School Security
Identifying Dropouts and Students at risk
e-Proctoring

Source: (Holmes et al., 2022)

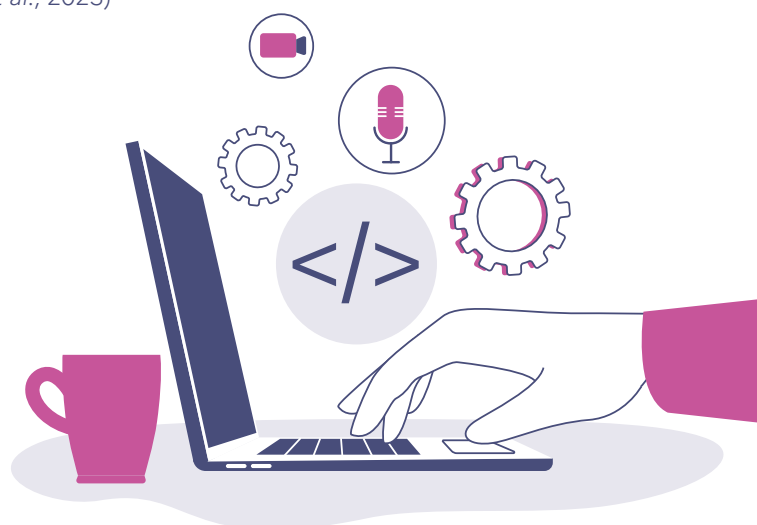
## 4.2 How does it contribute to the learning experience?

“Artificial intelligence (AI) has a large and increasing role in education. One important case is of **personalised teaching systems** which are already well established, with **growing evidence of their effectiveness for improving learning** (VanLehn, 2011; Kulik & Fletcher, 2016; Steenbergen-Hu & Cooper, 2014, 2013; Ma, Adesope, Nesbit, & Liu, 2014; du Boulay, 2016). AI in education (AIED) systems may also make **diverse and sophisticated use of AI to create the interface that is so important for the learning experience**. For example, the interface may use **natural language processing and generation, speech interfaces, avatars, video analysis of the learner** to judge their attention and emotion.”

(Khosravi *et al.*, 2022)

“By using **algorithms, learning can be adaptive**. By analysing the student’s learning traces, such as results from questionnaires or software usage data, the system can modify how it functions to adapt to the user, including in the areas of **content selection and difficulty level**. It is beginning to be possible to analyse learner behaviour using sensors, external ones like a camera, and more intrusive ones, such as a brain-computer interface. The principle of adaptation is at the heart of digital pedagogy, and is most often encountered in a context where **gamification objectives** are also pursued; the learner then enters into an educational game with the machine, sometimes in collaboration with other learners (Giraudon *et al.*, 2020). The KidLearn project (...) offers a learning activity whose multiple variants involving the addition or subtraction of integers or decimals have been designed and implemented by teachers. Variants are organised in the form of a graph of increasing difficulty, respecting the concept of the zone of proximal development (Vygotsky, 1978). This concept is based on the idea that AI and education : research contributions and challenges for public policies – DNE – 2024 27 between an exercise that is too difficult and offputting and an exercise that is too easy and boring, there is an optimal zone that maximises learning progress, measured here by observing the student’s performance throughout the game. It is these elements that are integrated into the algorithm, which will automatically adapt to the learner (Oudeyer *et al.*, 2020).”

(Romero *et al.*, 2023)



### Example of adaptive teaching for reading and French language

"Lalilo is developing a teaching assistant for CP, CE1 and CE2 teachers to **help them modify how they teach reading based on each student's level**, using artificial intelligence technologies. The assistant is an online platform, with a student interface and a teacher interface. It is co-developed with school teachers: the platform is continuously improved, taking into account teacher feedback. (...)

**An adaptive learning algorithm:** The goal of Lalilo, to help children learn to read at their own pace, is based on a predetermined learning progression, divided into lessons. Each lesson contains several 'learning outcomes', which each contain a wide range of questions. For example, the '[a] vowel' lesson contains two learning outcomes: 'recognise the grapheme [a]' and 'decode the phoneme [a]'. (...) The adaptive learning system allows a child to choose the most suitable exercise at any given time based on their progress and the exercises completed."

(Gelin, 2022)

[Lalilo is one of the award-winning projects from the Artificial Intelligence Innovation Partnership (P2IA) supported by the French Ministry of National Education and Youth.]

## 4.3 AI and knowledge production: the example of digital humanities

"...Corpus linguistics and semantics have developed significantly thanks to AI analyses on knowledge representation and machine learning. Likewise, many developments have opened up **opportunities in the area of literary studies**. At the start of the millennium, under the pressure of publishers (not scientists), the term *Humanities Computing*, which referred to research at the fringes of humanities in the 'Anglo-Saxon' sense, **i.e. cultural sciences**, became *Digital Humanities*. This name change meant that humanities were no longer merely instrumented by computers, but were becoming digital. We spoke about a '**computational turning point**' to describe this fundamental evolution. The subsequent change was very successful. In every country, multiple research teams working in the field of classical humanities, whether in history, archaeology or literature, refreshed their approaches in collaboration with computer scientists."

(Ganascia, 2022)

# 5. What solutions exist for being trained on and teaching AI?

## 5.1 CREIA, an AI-in-education practice community

“Launched in November 2023 by the Directorate of Digital Education (DNE), the **Community for Educational Reflection on Artificial Intelligence (CREIA)** aims to put innovation and artificial intelligence (AI) at the heart of teaching practices and reflections. Since 30 August 2024, this community **addresses all members of the educational community**.

CREIA is characterised by **collaborative work** and a **resource** pooling approach. It promotes the exchange of ideas and experiences within a network of more than one hundred trainers from DRANE and national education operators.

It aims to integrate innovation and artificial intelligence into the heart of teaching and training actions.”

(DNE-TN2, 2024)



m@gistère

## 5.2 AI literacy skills framework

### Frameworks of competences in AI for teachers and students (UNESCO)

#### AI competency framework for teachers: aspects and progression levels

Aspects	Progression		
	Acquire	Deepen	Create
1. Human-centred mindset	Human agency	Human accountability	Social responsibility
2. AI Ethics	Ethical principles	Safe and responsible use	Co-creating ethical rules
3. AI foundations and applications	Basic AI techniques and applications	Application skills	Creating with AI
4. AI Pedagogy	AI-assisted teaching	AI-pedagogy integration	AI-enhanced pedagogical transformation
5. AI for Professional development	AI enabling lifelong professional learning	AI to enhance organisational learning	AI to support professional transformation

#### AI Competency Framework for Students

Competencies	Progression		
	Understand	Apply	Create
Human-centred mindset	Human agency	Human accountability	Citizenship in the era of AI
Ethics of AI	Embodied ethics	Safe and responsible use	Ethics by design
AI techniques and applications	AI foundations	Application skills	Creating AI tools
AI system design	Problem scoping	Architecture design	Iteration and feedback loops

(Miao & Cukurova, 2024; Miao & Shiohira, 2024)

## Competency framework proposed by (Long et Magerko, 2020)

### 1. Recognizing AI

Distinguish between technological artefacts that use and do not use AI.

### 2. Understanding intelligence

Critically analyse and discuss features that make an entity “intelligent”.  
Discuss differences between human, animal, and machine intelligence.

### 3. Interdisciplinarity

Recognize that there are many ways to think about and develop “intelligent” machines.  
Identify a variety of technologies that use AI, including technology spanning cognitive systems, robotics and ML.

### 4. General vs narrow AI

Distinguish between general and narrow AI.

### 5. AI strengths and weaknesses

Identify problem types that AI does/does not excel at.  
Determine when it is appropriate to use AI and when to leverage human skills.

### 6. Imagine future AI

Imagine possible future applications of AI and consider the effects of such applications on the world.

### 7. Representations

Understand what a knowledge representation is and describe some examples of knowledge representations.

### 8. Decision-making

Recognize and describe examples of how computers reason and make decisions.

### 9. ML steps

Understand the steps involved in machine learning and the practices and challenges that each step entails.

### 10. Human role in AI

Recognize that humans play an important role in programming, choosing models, and fine-tuning AI systems.

### 11. Data literacy

Understand basic data literacy concepts.

### 12. Learning from data

Recognize that computers often learn from data (including one’s own data).

### 13. Critically interpreting data

Understand that data requires interpretation. Describe how the training examples provided in an initial dataset can affect the results of an algorithm.

### 14. Action and reaction

Understand that some AI systems have the ability to physically act on the world.  
This action can be directed by higher-level reasoning (e.g. walking along a planned path) or reactive impulses (e.g. jumping backwards to avoid a sensed obstacle).

### 15. Sensors

Understand what sensors are and that computers perceive the world using sensors. Identify sensors on a variety of devices. Recognize that different sensors support different types of representation and reasoning about the world.

### 16. Ethics

Identify and describe different perspectives on the key ethical issues surrounding AI: privacy, employment, misinformation, "singularity", 11 decision-making, diversity, bias, transparency and accountability.

### 17. Programmability

Understand that agents are programmable.

Source: (Long et Magerko, 2020), cited by (UNESCO, 2022)

## 5.3 A major issue: citizenship, critical thinking, IME and AI training

"AI concerns all citizens, firstly because it is increasingly present in all sectors of society and secondly because **it is necessary to understand it in order to take part in the ethical debates** it generates. **It is normal to question the relevance of entrusting algorithms with tasks that lead to crucial decisions**, for example in matters of justice, hiring, or other situations with strong human consequences. (...) The **MOOC [‘artificial intelligence with intelligence’ from Inria] adopts a fun and experiential approach to teaching.**"

(Romero *et al.*, 2023)

"Media and information literacy [MIL] has often been legitimised by its role in promoting citizenship. It increases the power of civic action and promotes the ethical use of media and information, for better participation in social affairs (...). (...) The changes brought about by [generative] AI require workers to acquire new digital skills through continuous training and lifelong learning. Inadequate critical thinking, civic and creative skills can be a barrier to keeping people poor or marginalised."

(Frau-Meigs, 2024)

## Response produced by DeepSeek v3 (03/01/25)

### Prompt

A pathway proposal must be produced for a trainer on digital education. In the context of school education in France, propose, in table format, an induction training module of approximately three hours on artificial intelligence to teach and learn for teachers (primary and secondary education).

This module should present for example, and without being limited to the origins of AI, the basic definitions, the challenges in the area of education (for teachers and management staff), the legal and ethical issues and examples of application in a school setting.

The order of the contents can be changed and must be proposed in the reply. Several options for presenting the content can be submitted. The trainer will then make a choice adapted to the needs of the teachers based on their level of knowledge of the subject. The content must incorporate the latest technological developments and the state of research on the subject.

### Response

Here is a suggested training path for a digital trainer in education, structured in the form of a table. This three-hour module is designed to introduce primary and secondary school teachers to artificial intelligence (AI) in an educational context. It is modular and adaptable according to the level of knowledge of the participants.

#### Training module: AI induction to teach and learn

Duration	Theme	Detailed content	Format	Organization options
0h00 - 0h15	<b>Introduction What is AI all about?</b>	<ul style="list-style-type: none"> <li>• Presentation of the course goals.</li> <li>• Definition of AI: machine learning, deep learning, neural networks.</li> <li>• Historical origins of AI (from the 1950s to the present day).</li> <li>• Current state of research and recent developments (GPT, generative models, etc.).</li> </ul>	Interactive presentation with visual support (slides, short videos).	<p><b>Option 1:</b> Start with definitions and origins.</p> <p><b>Option 2:</b> Start with a hands-on demonstration to arouse interest.</p>
0h15 - 0h45	<b>AI issues in education</b>	<ul style="list-style-type: none"> <li>• Impacts on teaching and learning methods.</li> <li>• Personalise educational paths with AI.</li> <li>• Role of AI in assessment and feedback.</li> <li>• Concrete examples: writing support tools, intelligent tutors, educational data analysis.</li> </ul>	Presentation + discussions with participants.	<p><b>Option 1:</b> Deepening educational issues.</p> <p><b>Option 2:</b> Include a discussion on fears and opportunities.</p>
0h45 - 1h15	<b>AI school applications</b>	<ul style="list-style-type: none"> <li>• Presentation of tools and platforms using AI: <ul style="list-style-type: none"> <li>– ChatGPT and other conversational assistants;</li> <li>– adaptive platforms (e.g.: Khan Academy, Lalilo);</li> <li>– plagiarism detection tools;</li> <li>– applications for students with specific needs (e.g.: DYS disorders).</li> </ul> </li> <li>• Practical demonstration of a tool.</li> </ul>	Demonstration + practical workshop (handling a tool).	<p><b>Option 1:</b> Focus on adaptive tools.</p> <p><b>Option 2:</b> Focus on conversational assistants.</p>

Duration	Theme	Detailed content	Format	Organization options
1h15 - 1h45	<b>Legal and ethical challenges of AI</b>	<ul style="list-style-type: none"> <li>• Personal Data Protection (GDPR).</li> <li>• Algorithmic bias and fairness issues.</li> <li>• Transparency and accountability of AI systems.</li> <li>• Impact on students' autonomy and creativity.</li> <li>• Debate: setting a framework for the use of AI in the classroom?</li> </ul>	Presentation + group debate.	<p><b>Option 1:</b> Deepen the legal aspects.</p> <p><b>Option 2:</b> Focus on ethical issues.</p>
1h45 - 2h15	<b>Integrating AI into teaching practice</b>	<ul style="list-style-type: none"> <li>• Learning scenarios using AI: <ul style="list-style-type: none"> <li>– creating course materials;</li> <li>– aid in pedagogical differentiation;</li> <li>– use of AI for interdisciplinary projects;</li> <li>– experience sharing between participants.</li> </ul> </li> </ul>	Working in small groups + presentation.	<p><b>Option 1:</b> Offer turnkey scenarios.</p> <p><b>Option 2:</b> Let the participants devise their own scenarios.</p>
2h15 - 2h45	<b>AI limitations and perspectives in education</b>	<ul style="list-style-type: none"> <li>• The current technological limitations of AI.</li> <li>• The skills to be developed by teachers and students.</li> <li>• Future prospects: AI and the metaverse, augmented reality, etc.</li> <li>• Open discussion about fears and opportunities.</li> </ul>	Presentation + open discussion.	<p><b>Option 1:</b> Stress the limits.</p> <p><b>Option 2:</b> Explore future prospects.</p>
2h45 - 3h00	<b>Conclusion and assessment</b>	<ul style="list-style-type: none"> <li>• Summary of key points.</li> <li>• Course assessment (questionnaire or questions around the table).</li> <li>• Resources to go further (articles, books, e-learning courses).</li> </ul>	Discussions + questionnaire.	<p><b>Option 1:</b> Written assessment.</p> <p><b>Option 2:</b> Oral assessment by going round the table.</p>

#### Overall organization options:

##### 1. Progressive path:

- Definitions and origins → Educational challenges → Practical applications → Legal and ethical aspects → Educational integration → Perspectives.  
*Suitable for beginners.*

##### 2. Practical path:

- Tool demonstration → School applications → Educational integration → Educational and ethical issues → Perspectives.  
*Suitable for teachers already aware of AI.*

##### 3. Reflective path:

- Ethical and legal issues → Limits and perspectives → School applications → Educational integration.  
*Suitable for teachers interested in the critical aspects of AI.*

#### Additional Resources:

- **Videos:** YouTube channels such as "Science étonnante" or "Heureka".
- **Articles:** Recent publications on AI in education (e.g. UNESCO reports, research articles).
- **Tools:** List of free or accessible AI tools for teachers (e.g.: ChatGPT, Canva AI, Quizizz).

This module is designed to be flexible and tailored to the needs of teachers, while incorporating the latest technological developments and current issues of AI in education. The trainer can adapt the organization according to the profile of the participants and their expectations.

## Response from Le Chat de Mistral (06/01/25)

### Prompt

A pathway proposal must be produced for a trainer on digital education. In the context of school education in France, propose, in table format, an induction training module of approximately three hours on artificial intelligence to teach and learn for teachers (primary and secondary education).

This module should present for example, and without being limited to the origins of AI, the basic definitions, the challenges in the area of education (for teachers and management staff), the legal and ethical issues and examples of application in a school setting.

The order of the contents can be changed and must be proposed in the reply. Several options for presenting the content can be submitted. The trainer will then make a choice adapted to the needs of the teachers based on their level of knowledge of the subject. The content must incorporate the latest technological developments and the state of research on the subject.

### Response

Here is a suggested pathway for a three-hour Artificial Intelligence (AI) training module for primary and secondary school teachers. This module incorporates the latest technological developments and the state of research on the subject.

#### Option 1: Linear layout

Duration	Content	Description
0:15	<b>Introduction</b>	Introduction of the trainer and the goals of the module. Questions around the table to find out what participants' expectations and level of knowledge are.
0:30	<b>Origins and Definitions of AI</b>	History of AI, basic definitions and key concepts (machine learning, deep learning, etc.).
0:30	<b>Challenges in the field of education</b>	Impact of AI on teaching methods, learning personalisation, and AI-based EdTech tools.
0:30	<b>Legal and Ethical Issues</b>	Data privacy issues, algorithmic biases and applicable regulations. Discussion on the ethics of using AI in education.
0:30	<b>School Applications</b>	Real-world examples of using AI in schools: virtual assistants, school support platforms and administrative management tools.
0:15	<b>Conclusion and Q&amp;A</b>	Summary of key points, open discussion and answers to questions from participants.

#### Option 2: Thematic layout

Duration	Content	Description
0:15	<b>Introduction</b>	Introduction of the trainer and the goals of the module. Questions around the table to find out what participants' expectations and level of knowledge are.
0:45	<b>Theme 1: AI Basics</b>	Origins of AI, basic definitions and key concepts. Discussion of recent advances in AI and machine learning.
0:45	<b>Theme 2: AI in Education</b>	Educational challenges, EdTech tools and concrete applications. Case study on integrating AI into schools.
0:45	<b>Theme 3: Legal and Ethical Issues</b>	Data confidentiality, algorithmic bias and regulations. Debate on the ethical implications of using AI in education.
0:15	<b>Conclusion and Q&amp;A</b>	Summary of key points, open discussion and answers to questions from participants.

### Option 3: Interactive layout

Duration	Content	Description
0:15	<b>Introduction</b>	Introduction of the trainer and the goals of the module. Questions around the table to find out what participants' expectations and level of knowledge are.
0:30	<b>Workshop 1: Discovering AI</b>	Interactive activities to understand the basics of AI. Using online tools to experiment with simple algorithms.
0:30	<b>Workshop 2: AI and Education</b>	Presentation of EdTech tools and discussion of how they are integrated into teaching practices. Case studies and feedback.
0:30	<b>Workshop 3: Ethical and Legal Issues</b>	Role-play and discussions on the ethical and legal issues of AI. Analysis of real scenarios and proposed solutions.
0:30	<b>Workshop 4: Practical Applications</b>	Demonstrations of concrete applications of AI in schools. Discussion of best practices and challenges to be taken up.
0:15	<b>Conclusion and Q&amp;A</b>	Summary of key points, open discussion and answers to questions from participants.

These layout options can be adapted to the specific needs of teachers and their level of AI knowledge.

## 5.4 AI training and school dropout prevention

“La **Scientothèque** is a non-profit organisation located within the Experimentarium, the physics museum at the Université Libre de Bruxelles (Belgium). Since it opened, in 2001, its main mission has been to contribute to the reduction of social inequalities. Two realities prompted the establishment of the organisation: on the one hand, the increased risk of school dropouts and the difficulty of accessing higher education for young people from disadvantaged backgrounds (Coslin, 2012) and, on the other hand, the low takeup of scientific studies among girls and women. It has also been shown that it is harder to attract girls to projects of a scientific or technological nature (Blanchard, 2021). (...) A selection of activities was offered to two groups of 10-12-year-olds during the **2020-2021 school year at weekly after-school sessions** at the Institut des Ursulines, a school in Koekelberg, Belgium. The project, funded by the Brussels-Capitale region, aimed to reduce the school dropout rate among pupils from more deprived neighbourhoods. In the sessions, the students were able, through **a fun and collaborative approach**, to learn about the history of machines, explore the basics of biological intelligence, understand the meaning of the word ‘algorithm’, observe and program Thymio robots, get started with programming on the Scratch platform, and discuss the consequences of AI on society.”

(Romero *et al.*, 2023)

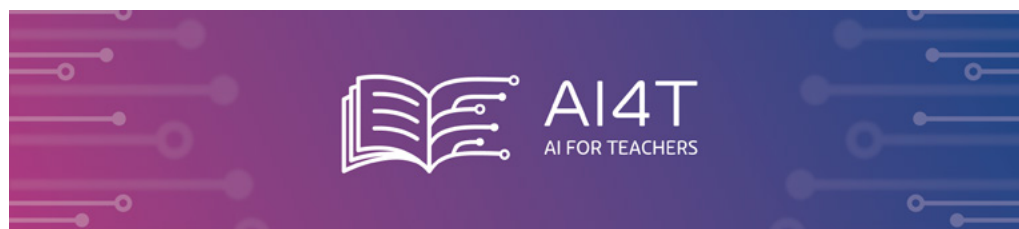
## 5.5 The European “AI4T” project: the “Artificial Intelligence for and by teachers” MOOC

### Training teachers and supervisory staff in artificial intelligence and its contribution to education:

<https://eduscol.education.fr/2643/intelligence-artificielle-et-education-les-ressources-de-formation-du-projet-europeen-ai4t>

This course **aims to help teachers and the wider educational community gain a general understanding of AI** – its uses, technologies and limitations – and to guide them towards an informed use of AI-based tools in the context of education.

Each module contains texts, videos, activities, quizzes and access to the forum for participants to share their experiences and interact with the teaching team and other participants. The course takes about two or three hours to complete.



This MOOC was developed and tested with teachers and school heads as part of the **European AI4T project, bringing together five countries: France, Italy, Ireland, Luxembourg and Slovenia.**



The content was developed in conjunction with the five education ministries involved in the project, in particular the MENJ (Directorate of Digital Education) and the French Ministry of Education (Directorate of Digital Education). The project was coordinated by France Éducation International.

Access to the MOOC in French via the FUN platform: <https://www.fun-mooc.fr/fr/cours/intelligence-artificielle-pour-et-par-les-enseignants-ai4t/>



The MOOC is accompanied by an AI4T (Open TextBook) via the UNESCO RELIA Chair: <https://chaireunescorelia.univ-nantes.fr/2023/11/16/le-manuel-ouvert-ai4t-en-route-pour-la-deuxieme-edition/>

<https://pressbooks.pub/iapourlesenseignants>



# 6 The tipping point of generative AI systems and large language models

## 6.1 The development of generative AI

### Presentation

"Before 2014, deep learning models were primarily descriptive, focusing on the summary or patterns and relationships between existing data. These models were designed to explain data and prediction patterns based on the information supplied. However, (Goodfellow *et al.*, 2014) introduced the **Generative Adversarial Network (GAN)**, opening a new era of generative artificial intelligence (GAI). Unlike their descriptive counterparts, generative models, such as GANs, are designed to learn the underlying probability distribution of data. Their main purpose is **to generate new data samples that match as close as possible the patterns observed in the training data**. The development of GANs marked a significant breakaway from traditional deep learning methods, opening up exciting possibilities for generative artificial intelligence. Generative artificial intelligence has since gained huge attention due to its **transformative impact** in various areas of life. It offers seamless solutions to complex problems, enabling the creation of synthetic data, artistic content and realistic images. This paradigm shift in AI technology has profoundly influenced the perception, implementation and use of artificial intelligence, sparking innovation and new application possibilities across industries. (...) The innovative work of Vaswani *et al.* '**Attention Is All You Need**' [2017] by the Google Brain team introduced a **transformer model** capable of analysing data sets at scale. [This model] was initially developed for natural language processing (NLP), but was then adapted to other areas of machine learning, such as computer vision. (...) The solution offered a new way of handling tasks such as translation, content generation and emotion analysis."

(Bengesi *et al.*, 2023)

"During the last two years there has been a **plethora of large generative models** such as ChatGPT or Stable Diffusion that have been published. Concretely, these models are able to perform tasks such as being a general question and answering system or automatically creating artistic images that are **revolutionizing several sectors**. Consequently, the implications that these generative models have in the industry and society are enormous, as several job positions maybe transformed. For example, Generative AI is capable of transforming effectively and creatively texts to images, like the DALLE-2model; text to 3D images, like the Dreamfusion model; images to text, like the Flamingo model; texts to video, like the Phenaki model; texts to audio, 38 Carnet Hypothèses 'Education, digital technology and research' like

the AudioLM model; texts to other texts, like ChatGPT; texts to code, like the Codex model; texts to scientific texts, like the Galactica model or even create algorithms like AlphaTensor.”



**Generative AI** refers to AI technologies that are trained on big data (entire content of Wikipedia, Github, social media, Google images, etc.) and which can generate new content (text, image, audio, video) randomly from prompts entered by users.

Generative AI models (deep neural networks, transformers and other models, such as generative adversarial networks (GANs), which have been increasing in number, especially since 2022) can be broken down according to the following taxonomy:

- Text to image (e.g. DALL-E 2 from OpenAI);
- Text to 3D representation (e.g. Dreamfusion from Google Research);
- Image to text (e.g. Flamingo from Deepmind);
- Text to video (e.g. Phenaki from Google Research);
- Text to audio (e.g. Jukebox from OpenAI);
- Text to text (e.g. ChatGPT from OpenAI);
- Text to code (e.g. Codex from OpenAI);
- Text to scientific formula (e.g. Galactica from Meta AI);
- Other models.

Source: (Gozalo-Brizuela & Garrido-Merchan, 2023)

## Foundation models

“A Foundation Model, as named by Stanford University, is a large-scale model based on a deep neural network architecture, trained on enormous quantities of unlabelled data (usually through self-supervised learning). Large Language Models (LLM) are special examples of foundation models that are trained on a corpus of texts. Foundation models open up **fresh perspectives and introduce a new paradigm in language processing, but also in multimodal signal processing** (sound, image, video, etc.). These models that are pre-trained on large corpora can be optimised for a new application using small quantities of additional data specific to that task.”

(CNPEN, 2023)

## 6.2 Large language models and the new generation of chatbots

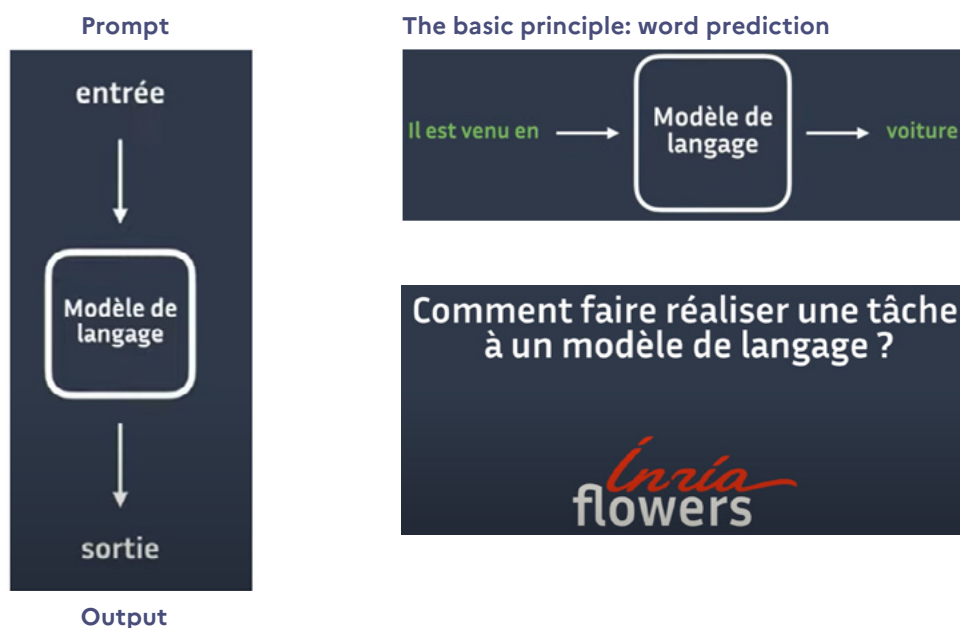
### How do large language models work?

The concept of large language models (LLM) is **nothing new**: this type of algorithm is already used on a daily basis in **message assistants**. They work by **predicting the next word** from a prompt entered by the user. The **training phase** allows internal parameters to be adjusted using text data from the web (unverified). A huge amount of data and parameters can improve prediction performance. However, we still can't say that an algorithm "understands" or has a "personality": **responses are generated from statistical regularities**. In addition, these models can generate "**hallucinations**" by inventing false information, which requires extra attention from the user. Currently, the most powerful language models are owned by large companies, which tend to keep any information on their training data to a minimum.

Source: (Inria Flowers, 2023a)

See also (Inria Flowers, 2023b) on prompting: "instructing a language model to perform a certain task (...) by explaining this task to them using phrases in natural language." Two methods are presented: "explain the task in natural language, and give examples of how to complete the task."

### Operation of a large language model and prompting



Source: (Inria Flowers, 2023)

Access all Inria Flowers videos:

[https://developmentalsystems.org/chatgpt\\_5\\_minutes/en/](https://developmentalsystems.org/chatgpt_5_minutes/en/)

Note: these videos are part of the AI4T project (see page 43).

## The “turning point of ChatGPT”: origins and technology foundation

In this category of generative AI models, the application ChatGPT, which OpenAI launched publicly on 30 November 2022, represents a **new generation of chatbots**, “agents that converse with a user to carry out research, find an answer to a question or even practise a given discipline” (CSEN & DNE-TN2, 2022). Due to the performance shown, it is clearly a **“qualitative leap forward”** in automatic language processing (ALP) – or **Natural Language Processing (NLP)** technologies (Boisson & DNE-TN2, 2023).

This **“chatbot prototype (...), a language model refined using supervised learning and reinforcement learning techniques”** (“ChatGPT”, 2023), based on generative artificial intelligence, capable of generating on-demand texts or computer code from questions in natural language, is a **proprietary application** developed from an optimisation of the GPT 3.5 algorithmic model.

“GPT-3 is larger than GPT-2, with 175 billion parameters. To get a more accurate picture of the size of this algorithm, Wikipedia’s data, which includes around 6 million articles, represents only 0.06% of the data trained by GPT-3.”

(Boa Sorte *et al.*, 2021)

**The technologies underpinning ChatGPT** can be summarised as follows:

- it is a **“large language model... a type of AI that uses deep learning (a form of machine learning) to process and generate natural language texts (...)** [These models are] trained on **massive amounts of text data, allowing them to learn the nuances and complexities of human language”** (Source: Susnjak, 2022);
- its name is a contraction of “chat” and “GPT” [Generative Pre-trained Transformer], which is a “predictive language translation model” (transformation of data represented in one form into data represented in another form);
- its **transformer-based** algorithm (Vaswani *et al.*, 2017) is a neural network architecture model that uses the **self-attention mechanism to establish relationships between words and determine the meaning of a word according to the context**, focusing on the most relevant words, thus allowing a credible approach to natural language;
- it works according **to a word prediction model**, based on the prompts given by the user in natural language, combining in its training phase learning by reinforcement and supervised learning from human feedback;
- it is therefore important to remember that, like any AI technology, texts are generated and **reinforced by human agency and efforts** (from the people who design the algorithm to those who identify or verify data or interact with the program).

The technology foundation of ChatGPT is the result of **“a combination of two models: a language model** (its references ended in 2021), GPT, a giant text prediction model and encyclopaedic model, and a conversational model (refined based on user feedback), InstructGPT, an ‘improved’ version of GPT-3 from the labelling of generated texts.”

It is also the result of **“a series of strata from linguistic and informatics research:**

- **semantic statistics**, with the concept of ‘popup window’ (the meaning comes from the relative position of the words with each other);
- **word vectorisation** (word embedding) allowing the characterisation of a word within contextual spaces in relation to neighbouring words;

- **neural networks** to recognise precise syntactic and semantic relationships between words and manage language transfers (responses to user prompts can thus be based on a multilingual semantic space);
- **transformer models** (2017) based on the attention mechanism and modelling syntactic formulas;
- the development of **large language models**, starting in 2018 with BERT (Google), then GPT-2 and 3 (OpenAI)."

Source: (Langlais, 2023)

On 14 March 2023, OpenAI announced the upgrade of its model with the launch of **GTP-4** (fee-based service or available in the new version of the Bing search engine): "a large-scale **multimodal model** that can accept image and text inputs and produce text outputs. Although less capable than humans in many real-world scenarios, GPT-4 exhibits human-level performance across a variety of professional and academic criteria, including passing a simulated bar examination with a score achieved by around 10% of top candidates." (OpenAI, 2023)

In May 2024, the **GPT-4o** model ("omnimodel") was made public, incorporating a real-time voice interaction mode that can adapt to the emotional signals of the interlocutor.

### Examples of large language models (November 2024) in France and abroad

Name of the model	Entity	Year created	Geographical origin	Link
BLOOM BigScience Project	Hugging Face	2022	France/USA	<a href="https://huggingface.co/bigscience/bloom">https://huggingface.co/bigscience/bloom</a>
ChatGPT GPT-4o	Open AI	2024	The United States	<a href="https://chatgpt.com/">https://chatgpt.com/</a>
Claude 3	Anthropic	2024	The United States	<a href="https://claude.ai/">https://claude.ai/</a>
Gemini	Google	2023	The United States	<a href="https://gemini.google.com/app">https://gemini.google.com/app</a>
Le Chat	Mistral	2024	France	<a href="https://chat.mistral.ai/chat">https://chat.mistral.ai/chat</a>
Llama 2	Meta	2024	The United States	<a href="https://www.llama.com/">https://www.llama.com/</a>
Moshi	Kyutai	2024	France	<a href="https://moshi-ai.com/fr">https://moshi-ai.com/fr</a>
Perplexity	Perplexity	2022	The United States	<a href="https://www.perplexity.ai/">https://www.perplexity.ai/</a>

## OSI open source criteria for recent foundation models

Model	Licence	Access to the weight of the model	Free redistribution and modification	No restriction on commercial uses	No restrictions on unethical uses	Open source in the sense of OSI
BigScience Bloom	Bloom	✓	✓	✓	✗	✗
Google Gemini	Google Generative AI Terms of Use	✗	✗	✗	✗	✗
Meta Llama2	Llama2	✓	✓	✗	✗	✗
Microsoft Orca2	Microsoft Research	✓	✗	✗	✗	✗
OpenAI GPT-4	OpenAI Terms of Use	✗	✗	✗	✗	✗
TII Falcon	Falcon	✓	✓	✗	✗	✗
Anthropic Claude	Anthropic terms of use	✗	✗	✗	✗	✗
Mixtral 8x7B	Apache 2.0	✓	✓	✓	✓	✓
Mistral Large	Mistral Terms of Use	✗	✗	✗	✗	✗

(Center of expertise for digital platform regulation, 2024)

Access the “AIG model opening comparator”:

<https://www.peren.gouv.fr/compare-os-iag>

## The challenge of aligning LLMs

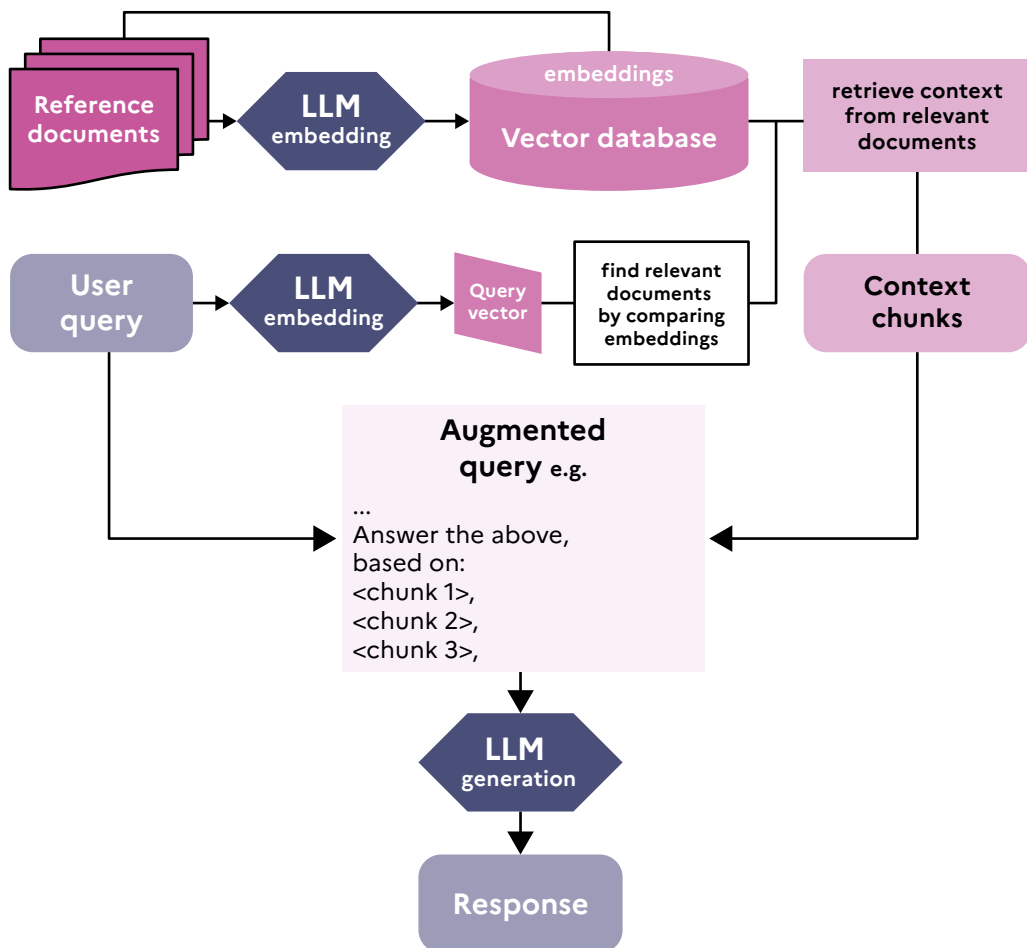
“Over the past decades, the pretraining of **LLMs through self-supervised learning** has seen significant advancements. These improvements have been driven by the development of larger decoder-only Transformers, the utilization of trillions of tokens, and the parallelization of computations across multiple GPUs. Following the pretraining phase, instruction tuning was employed to guide LLMs in responding to human queries. Despite these advancements, a critical issue remains unresolved: **LLMs can generate undesired responses**, such as providing instructions on how to commit illegal activities. To mitigate this risk, it is essential to **align LLMs with human values**. **Reinforcement Learning from Human Feedback (RLHF)** has emerged as a groundbreaking technique for aligning LLMs. This approach has led to the development of powerful models such as GPT-4, Claude, and Gemini.”

(Wang *et al.*, 2024)

## RAG (Retrieval-Augmented Generation)

"A common issue is the **generation of incorrect information, or 'hallucinations'** [Zhang *et al.*, 2023b], specially when queries extend beyond the model's training data or necessitate up-to-date information. These shortcomings underscore the impracticality of deploying LLMs as **black-box** solutions in real-world production environments without additional safeguards. One promising approach to mitigate these limitations is **Retrieval-Augmented Generation (RAG)**, which **integrates external data** retrieval into the generative process, thereby enhancing the model's ability to provide accurate and relevant responses. RAG, introduced by Lewis *et al.* [Lewis *et al.*, 2020] in mid-2020, stands as a paradigm within the realm of LLMs, enhancing generative tasks. Specifically, RAG involves an **initial retrieval step where the LLMs query an external data source to obtain relevant information** before proceeding to answer questions or generate text. This process not only informs the subsequent generation phase but also ensures that the responses are grounded in retrieved evidence, thereby significantly enhancing the accuracy and relevance of the output."

(Gao *et al.*, 2024)



Source: [https://en.wikipedia.org/wiki/Retrieval-augmented\\_generation](https://en.wikipedia.org/wiki/Retrieval-augmented_generation) Turtlecrown, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons





## A French LLM and a digital commons for education: OpenLLM France and the LUCIE project

The “OpenLLM France” consortium is one of the winners of the **“Digital Commons for Generative AI” call for projects launched by BPIfrance (public investment bank) as part of the France 2030 plan**. “The OpenLLM France Consortium brings together 17 players who have come together following on the creation of the OpenLLM France community, which today brings together an **ecosystem of nearly 200 entities** (public research laboratories, potential data suppliers, specialised tech players, use case suppliers, etc.)”

The consortium has developed LUCIE, “the first truly OpenSource sovereign LLM model, with a 1st use case focused on education”.



**A family of open, streamlined and high-performance multimodal LLMs to offer transparency and control**

 <b>RELIABILITY &amp; SECURITY</b> Pre-trained LLMs on clean data, connected to secure knowledge bases, which can be self-hosted.	 <b>OPEN SOURCE &amp; SOVEREIGNTY</b> Model architecture, learning data and auditable weights. Ready for assessment and certification.	 <b>PERFORMANCE &amp; MULTIMODALITY</b> Voice support. Enhancements to achieve the best performance on appropriate benchmarks.	 <b>EFFICIENCY</b> Environmentally responsible LLMs, all below 15B settings, capable of performing advanced specialised tasks.
Gather “clean” data in French. Enable secure business knowledge to be injected to make the responses generated more reliable.	Make sure that the models are valid from an ethical and regulatory standpoint (copyright, DPR, AI Act).	Characterise and popularise a methodology and benchmarks adapted to the industrial application context, sensitive and in French.	Reduce training and indifferrence costs. Minimise environmental impact

Source: <https://www.openllm-france.fr>

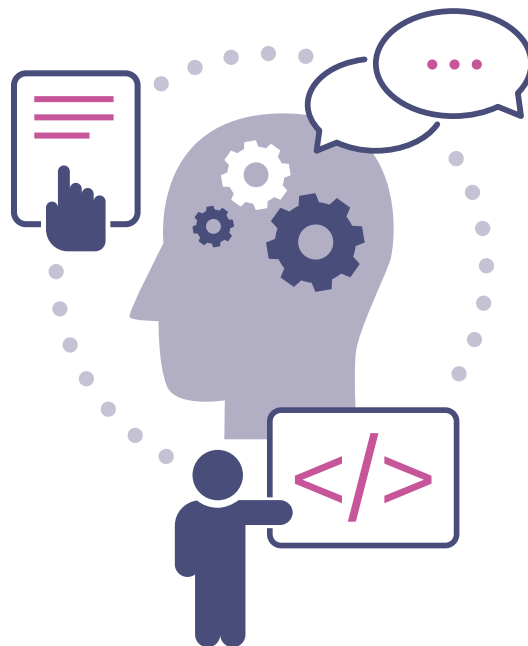
Access to the Lucie model: <https://huggingface.co/spaces/Tonic/Lucie-7B>

## 6.3 Prospects for teaching/learning and training

### What are the educational opportunities?

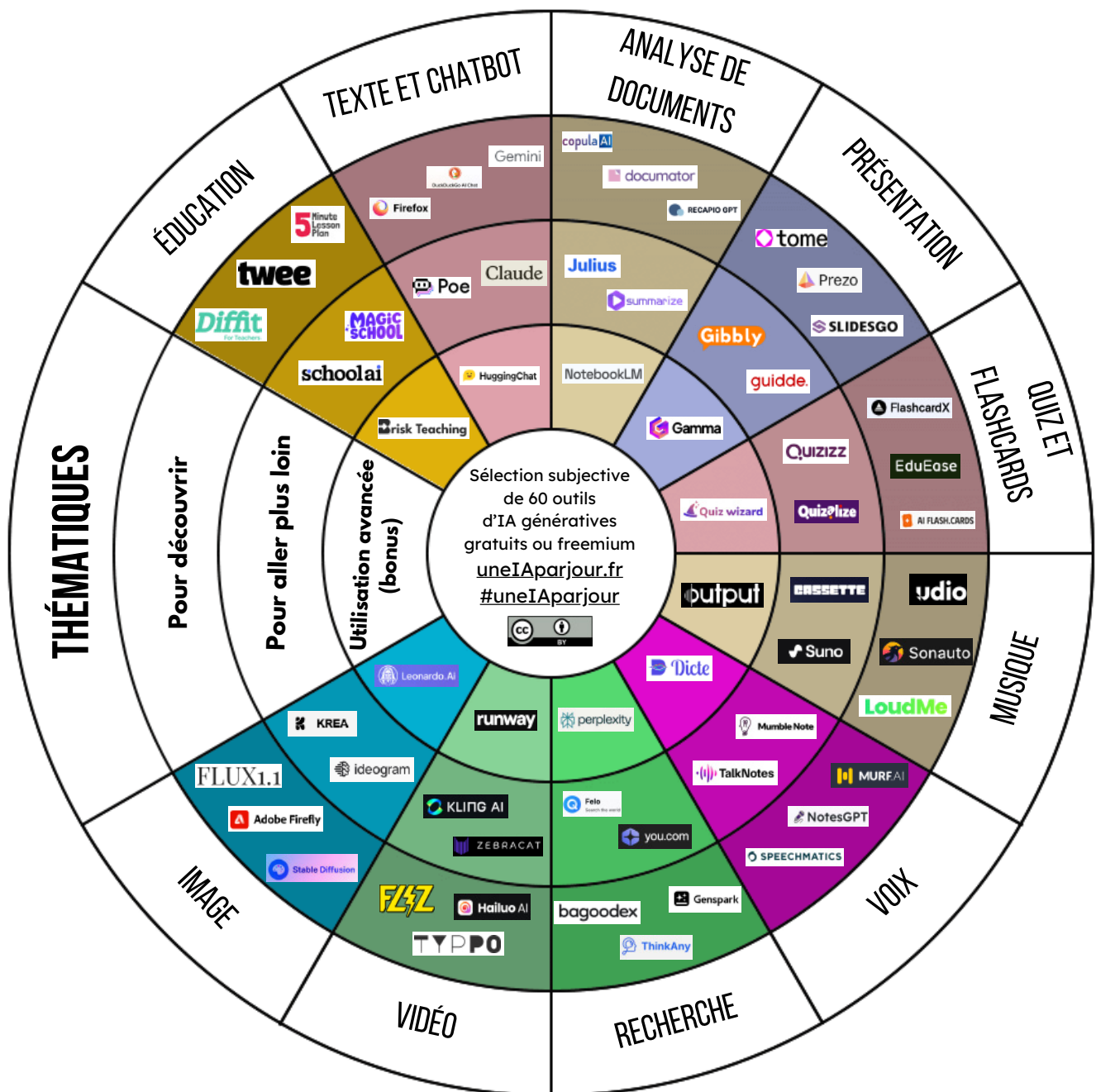
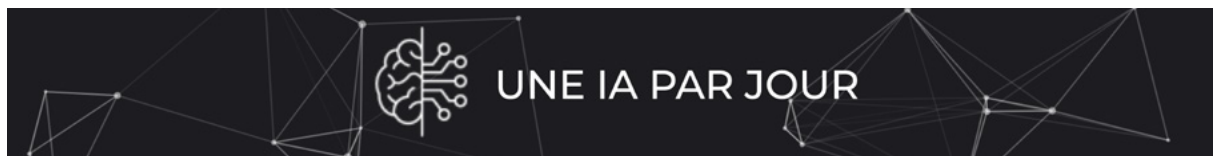
This type of application offers several educational opportunities that are currently being actively explored and shared by the teacher community:

- **pedagogical engineering aid** (design of teaching and learning materials, see proposed matrix below);
- **creativity aid** by proposing, based on the prompts and questions entered, an initial draft or code;
- **assistance with learning foreign languages** through the conversational followup function;
- **assistance** with initiating or optimising a writing-based task;
- a **new challenge** for media and information literacy (MIL) and a framework for teaching critical thinking, which requires teachers and their students to systematically check the content and relevance of the answers provided.



## AI and education watch: the “Une IA par jour” website

<https://www.uneiaparjour.fr>



(Formet, 2023)

## Prompting and pedagogical engineering: example of a matrix for an instruction sheet

Information	Educational situation	Complete field
Identity Context Discipline/learning area	I am a teacher of [...] in [type of institution]	
Framework of action Constraints Difficulties	The school or students has/have [profile], have to deal with [difficulty]	
Outcomes Objectives Target audience/level Actions targeted	I teach students of [ level, age] – I want to help them improve in or teach them [subject, knowledge, skill]	
Question Request	I want to build [sequence], produce [resource, learning situation] for/with my students.	
Style Format Keywords Steps	I would like the answer in the form of a [list/table...], to produce a visual, a diagram, in a language adapted to [level], using the following keywords: ... <i>Complete with an example of the expected result if necessary.</i> <i>If necessary, detail the steps to follow to improve the result (chain-of-thought prompting).</i>	

(Allouche, 2023b)

### The perspectives of large language models for people with disabilities

“To empower learners with disabilities, large language models can be used in combination with speech-to-text or text-to-speech solutions to help people with visual impairment. In combination with the previously mentioned group and remote tutoring opportunities, language models can be used **to develop inclusive learning strategies** with adequate support in tasks such as adaptive writing, translating, and highlighting of important content in various formats. However, it is important to note that the use of large language models **should be accompanied by the help of professionals** such as speech therapists, educators, and other specialists that can adapt the technology to the specific needs of the learner’s disabilities.”

(Kasneci et al., 2023)

## Bloom's Taxonomy Revisited

"Use this table as a reference for evaluating and considering changes to aligned course activities (or, where possible, learning outcomes) that emphasize distinctive human skills and/or integrate generative AI (GenAI) tools as a supplement to the learning process.

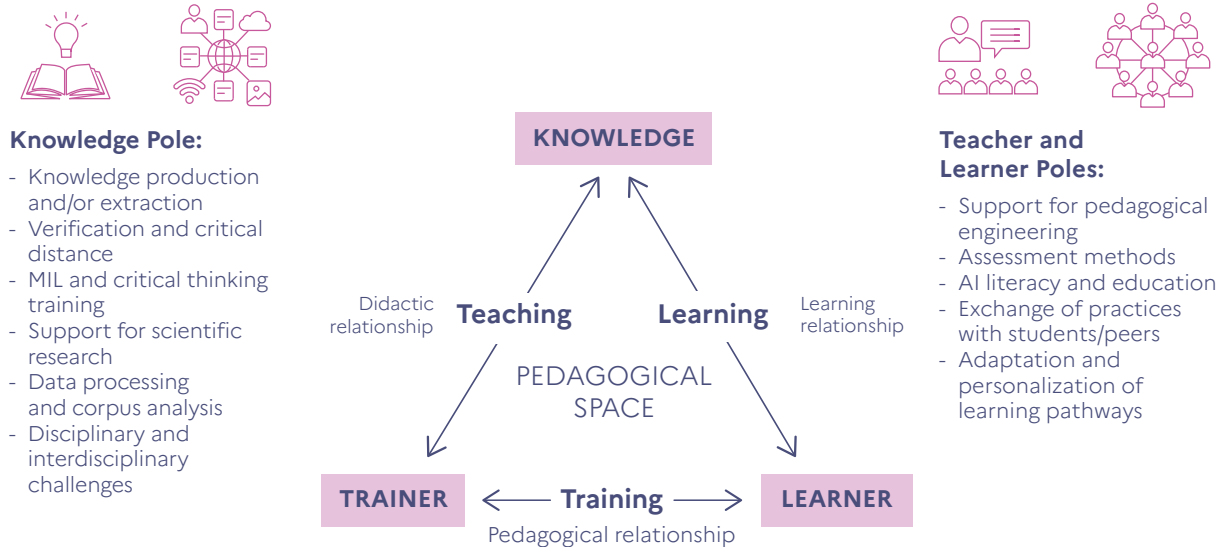
All course activities and assessments will benefit from ongoing review given the evolving capabilities of GenAI tools."

	Distinctive Human Skills	How GenAI Can Supplement Learning*
<b>CREATE</b>	Engage in both creative and cognitive processes that leverage human lived experiences, social-emotional interactions, intuition, reflection, and judgment to formulate original solutions	Support brainstorming processes; suggest a range of alternatives; enumerate potential drawbacks and advantages; describe successful real-world cases; create a tangible deliverable based on human inputs
<b>EVALUATE</b>	Engage in metacognitive reflection; holistically appraise ethical consequences of other courses of action; identify significance or situate within a full historical or disciplinary context	Identify pros and cons of various courses of action; develop and check against evaluation rubrics
<b>ANALYZE</b>	Critically think and reason within the cognitive and affective domains; justify analysis in depth and with clarity	Compare and contrast data, infer trends and themes in a narrowly-defined context; compute; predict; interpret and relate to real-world problems, decisions, and choices
<b>APPLY</b>	Operate, implement, conduct, execute, experiment, and test in the real world; apply human creativity and imagination to idea and solution development	Make use of a process, model, or method to solve a quantitative or qualitative inquiry; assist students in determining where they went wrong while solving a problem
<b>UNDERSTAND</b>	Contextualize answers within emotional, moral, or ethical considerations; select relevant information; explain significance	Accurately describe a concept in different words; recognize a related example; translate to another language
<b>REMEMBER</b>	Recall information in situations where technology is not readily accessible	Retrieve factual information; list possible answers; define a term; construct a basic chronology or timeline

\* AI capabilities derived with reference to an analysis of the MAGE framework, based on ChatGPT 4 as of October 2023. See Zaphir, L., Lodge, J. M., Liseck, J., McGrath, D., & Khosravi, H. (2024). How critically can an AI think? A framework for evaluating the quality of thinking of generative artificial intelligence. arXiv preprint arXiv:2406.14769.

(Oregon State University, 2024)

## An open research question: Where does generative AI fit in the learning triangle? (J. Houssaye)



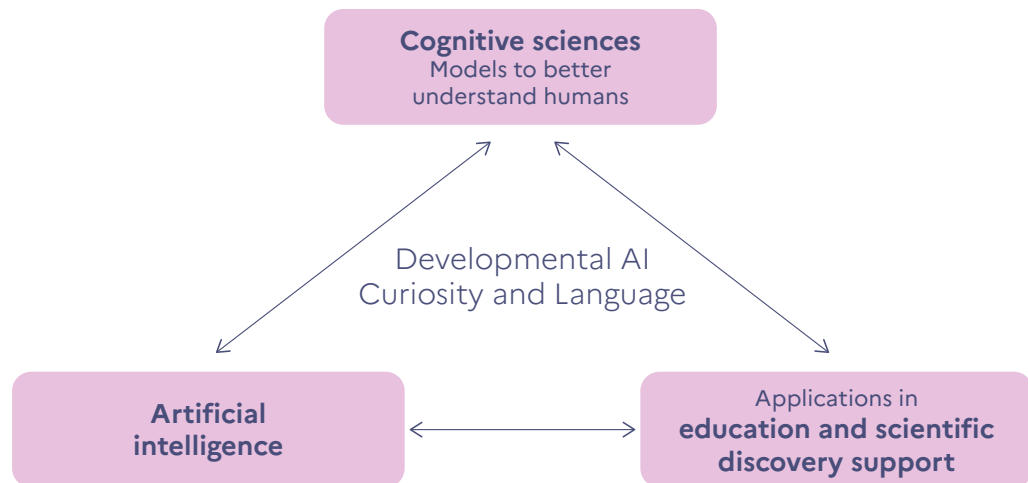
Source: Florent Dal Pos (EGLEFOR) CC BY-SA 4.0 (IID - Institut intelligence et données, ULaval, 2024) completed by (DNE-TN2, 2024)

## Conversational agents, curiosity and metacognition

“**Epistemic curiosity** – the desire to actively seek information for its inherent pleasure – is a complex phenomenon extensively studied across various domains. Several researchers in psychology, neuroscience, and computer science have repeatedly highlighted its foundational role in cognitive development and in fostering lifelong learning. Further, epistemic curiosity is considered **key for cultivating a flexible mindset capable of adapting to the world’s uncertainties**. These insights have spurred significant interest in the educational field, recognizing curiosity as essential for helping individuals be active and in control of their learning. These properties are crucial for addressing some of today’s major educational challenges, namely offering students individualized support to suit their competencies and motivations, and helping them become able to learn autonomously and independently in their dynamic and uncertain environments.”

(Abdelghani, 2024)

## AI curiosity and education



(Pierre-Yves Oudeyer, 2024)

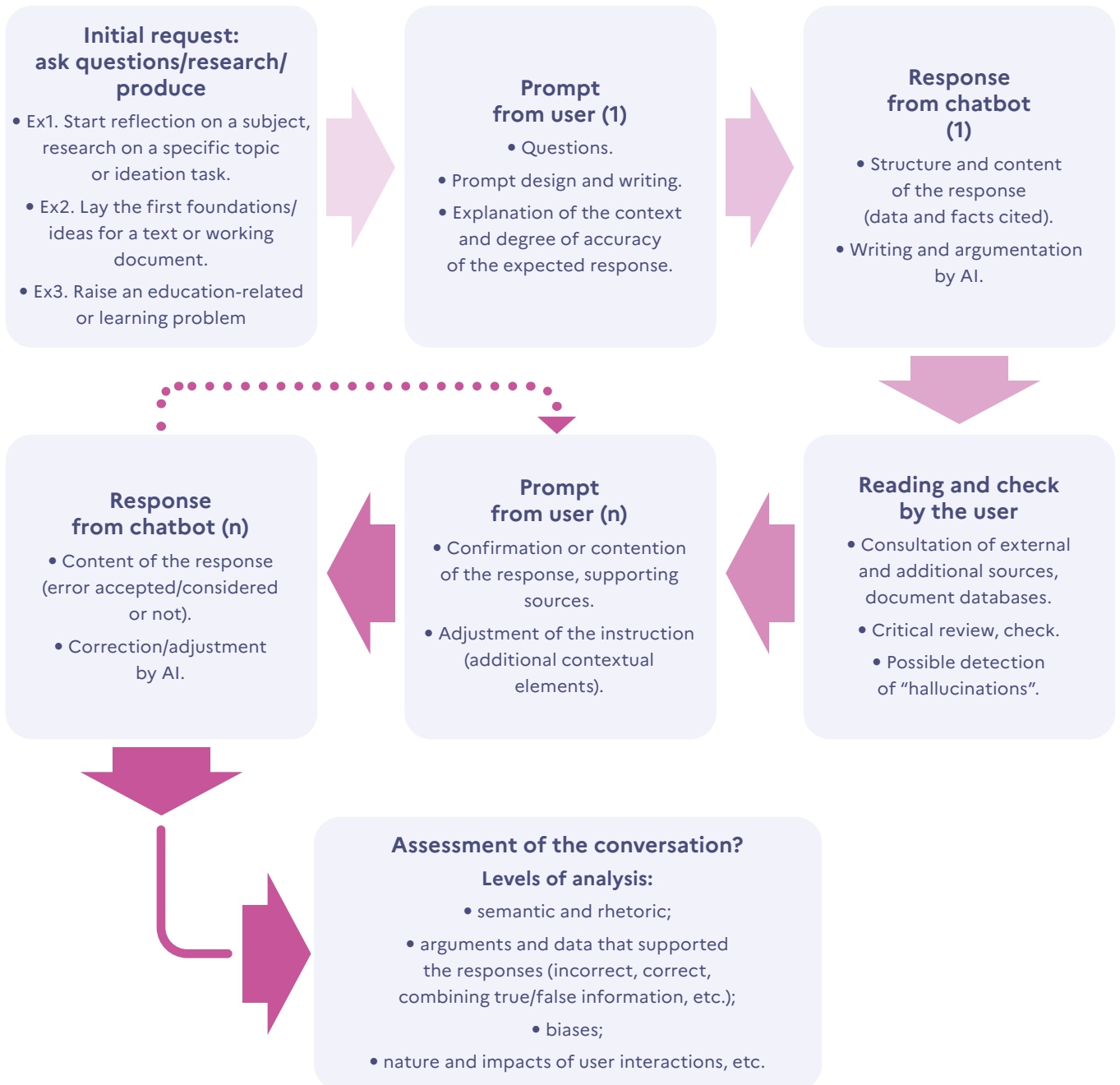
“Students’ ability to ask curious questions is a crucial skill that improves their learning processes. To train this skill, **previous research has used a conversational agent that propose specific cues to prompt children’s curiosity during learning.** Despite showing pedagogical efficiency, this method is still limited since it relies on generating the said prompts by hand for each educational resource, which can be a very long and costly process. **In this context, we leverage the advances in the natural language processing field and explore using a large language model (GPT-3) to automate the generation of this agent’s curiosity-prompting cues** to help children ask more and deeper questions. We then used this study to investigate a different curiosity-prompting behavior for the agent. The study was conducted with 75 students aged between 9 and 10. They either interacted with a hand-crafted conversational agent that proposes ‘closed’ manually-extracted cues leading to predefined questions, a GPT-3-driven one that proposes the same type of cues, or a GPT-3- driven one that proposes ‘open’ cues that can lead to several possible questions. Results showed a similar question-asking performance between children who had the two ‘closed’ agents, but a significantly better one for participants with the ‘open’ agent. Our first results suggest the **validity of using GPT-3 to facilitate the implementation of curiosity-stimulating learning technologies.** In a second step, we also show that GPT-3 can be efficient in proposing the relevant open cues that leave children with more autonomy to express their curiosity.”

(Abdelghani et al., 2023)

## What limits and areas for consideration (ethical, educational and scientific dimensions)?

Several tests were performed to evaluate the performance and limitations of ChatGPT (GPT 3.5) (Allouche, 2023a). The diagram below proposes a **model of a critical user journey**, integrating prompts that can be simple or complex, ranging from a simple request for information to problem solving.

### Modelling of a critical user journey with a chatbot



(Allouche, 2023a) updated

Following these tests, several limitations and points of caution may be identified (bearing in mind that, under GDPR, the application cannot be used in a school setting, only individual uses are permitted under the private contract system):

- for the time being, the responses provided are **not based on real-time data** via a web connection (subject to verification, this is data gathered from the web, prior to 2022);
- they contain **biases** due to the nature of the data processed, even if filters are applied to limit the most obvious biases;
- **factual errors** and possible “hallucinations” require in almost every instance verification of the content by the user, which can be both a constraint and an asset in an educational context for developing critical thinking and creating a healthy distance with the content generated;
- the risk of producing and disseminating truncated, incorrect or unverifiable data or information;
- this kind of technology, owing to its performance and high volume of data processed (without transparency on the nature of said data), inevitably raises the questions of referencing (can we refer to the answers produced when they are not systematically sourced or reproducible?), the authorship of the content (who does it belong to, can the authorship of a work be attributed to an AI engine?) (Stokel-Walker, 2023) or **copyright** (do the responses generated from this big data respect copyright when applicable? e.g. on a scientific or literary work that is not copyright-free);
- the **absence of sources** – or the potentially incorrect nature of those cited – constitutes a major problem for use in an academic context (education, research, documentation), unless the user expressly requests this, and provided that the user checks the references cited one by one;
- “until 2023, the answers given were not based on real-time data across a web connection; now, even if the training data dates back to year n-1, **the request may require real-time information extraction or checking on the web**, or by a user implementing a document”.

In response to this problem, other complementary or competing applications, such as Microsoft’s AI Copilot assistant (integrating GPT-4) or Perplexity (<https://www.perplexity.ai>), can provide sources (but without guaranteeing their relevance or completeness).

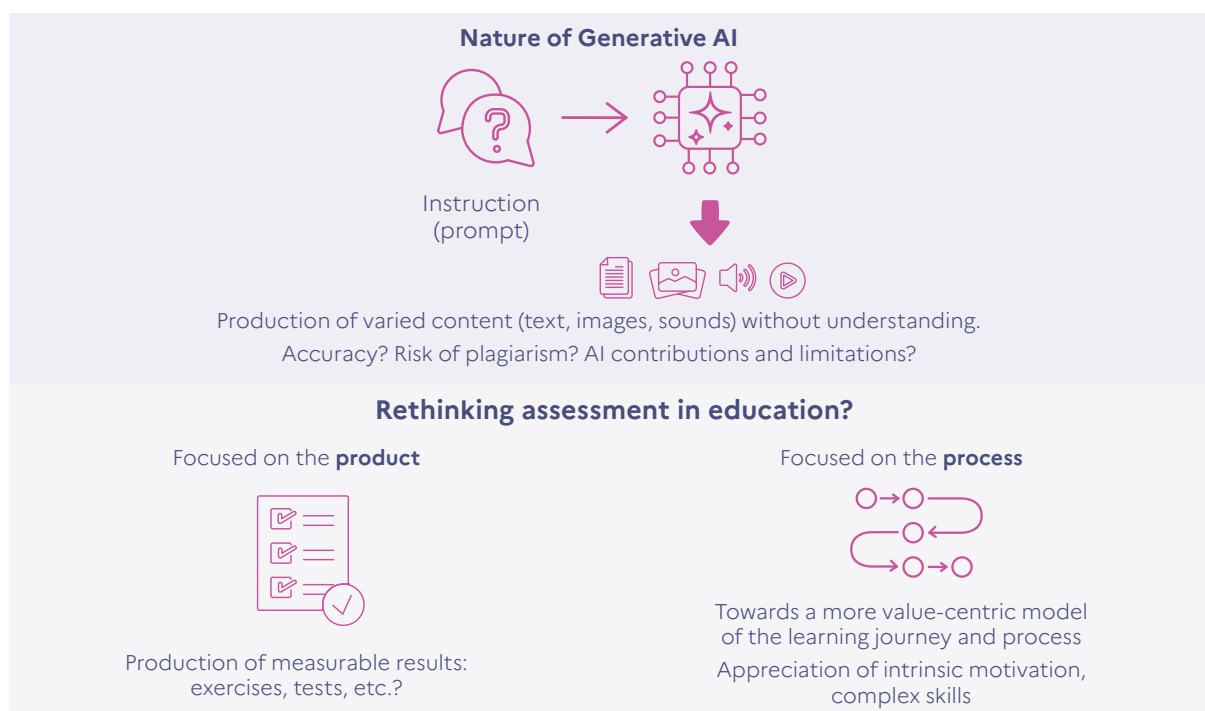
The **environmental impact** of this type of model, which is not specific to ChatGPT, should also be noted:

“Training OpenAI’s GPT-3 has been estimated to have required as much energy as driving a car to the moon and back, thus generating an equivalent of 85,000 kg of CO<sub>2</sub> emissions (Quach, 2020). Energy consumption is now widely understood to be a major challenge for data-driven AI (Strubell et al., 2019).”

(Holmes & Tuomi, 2022)

In summary, the main opportunities to explore are primarily assistance (see examples pp. 39 and 41), inspiration, and complementing or furthering knowledge. Indeed, such a technological leap is inviting researchers and teachers in particular to innovate, collaborate, inform and **educate themselves, remotely and with a critical mindset**, to support students in their learning and training.

## A major publication on the evolution of assessment methods with generative AI (Cao & Dede, 2023) Harvard



“An education that is heavily focused on products reduces learning to a transaction, exchanging a product for a grade, rather than providing a transformative human experience. (...) If the education system is mainly based on extrinsic motivation, plagiarism is going to be rampant.(...) **Educators can also encourage learners to leverage generative AI to enhance their process of learning, emphasizing the value of the journey rather than just the final product.**”

(DNE-TN2, 2024) from (Cao & Dede, 2023)

## Risks and potential benefits related to the five assessment challenges of generative AI in education

	<b>Generative AI characteristics</b>	<b>Risks incurred</b>	<b>Educational potential in assessment</b>
<b>The Understanding challenge</b>	AI systems with highly complex functioning	Neglecting the study of how generative AI systems work	Understand statistical predictions and the influence of the data harvested
<b>Simulation challenge</b>	Action on the form giving the illusion of reliability as to the content	Failure to detect anthropogenetic illusions	Develop the study of illusions producing a halo effect
<b>Truthfulness challenge</b>	Generative AI errors and hallucinations	Being fooled by false information	Counteract disinformation by varying sources to detect it
<b>Ethical challenge</b>	Shift to more automation at the expense of reflection	Take the easy way out to achieve effortless results	Oblige ourselves to comply with the formative process
<b>Application challenge</b>	Tendency to technify assessment in the sense of control	Fail to or poorly integrate these AI systems into teaching	Develop educational assessment with AI

“Generative AI productions **affect students as well as teachers and ordinary citizens**. The development of technologies will continue to strive for **increasingly spectacular results** to act on the emotional fibre and to mark minds (imitation of the human voice, problem-solving, exploitation of personal data that everyone provides freely and without necessarily being aware of it to the tech giants). In this sense, while generative AI offers the **prospect of a contemporary assessment challenge**, it seems that only **education and training of citizens of all ages** will help to take it up.”

(Audran, 2024)

## What are the prospects for aesthetics and creation?

“The *print and trace paradigm* has accompanied the entire history of photography from its invention to the advent of digital images. Digital photography challenges the notion of *print*. With its coming, photographic images are no longer a silver image of a photochemical impression on a photosensitive film. We then ask ourselves about the reference point of the digital image. This question of the photographic reference point must be put into perspective with the advent of AI. **With artificial intelligence, there is no longer one single reference point, but a set of referential layers**. The *primary reference point*, on which AI image generation is based, is composed of digital images captured from reality. The *secondary reference point* is located in the latent space that the algorithm has produced based on an ontology of the so-called primary images. **The image created by AI is therefore the result of this series of multiple references that is very difficult to trace**. This work of *referencing* and *decomposition* of the sources of the digital image was undertaken at the **Academy of Toulouse** in cycle 4. Thus, the teaching sequence ***Behind the scenes of your image*** (<https://edubase.eduscol.education.fr/fiche/19817>) developed as part of **shared academic work on plastic arts** (TraAM), offers students the opportunity to use digital as a medium for producing an image, but also as a tool that can capture traces and explain the steps in the **creative process of a hybrid digital image**. In this educational scheme, the digital medium is therefore an element that enables us to think about the question of the reference in the new digital image generation systems. The image generated by artificial intelligence is therefore no longer an image thought of as the photosensitive trace of reality, but as a possible image.”

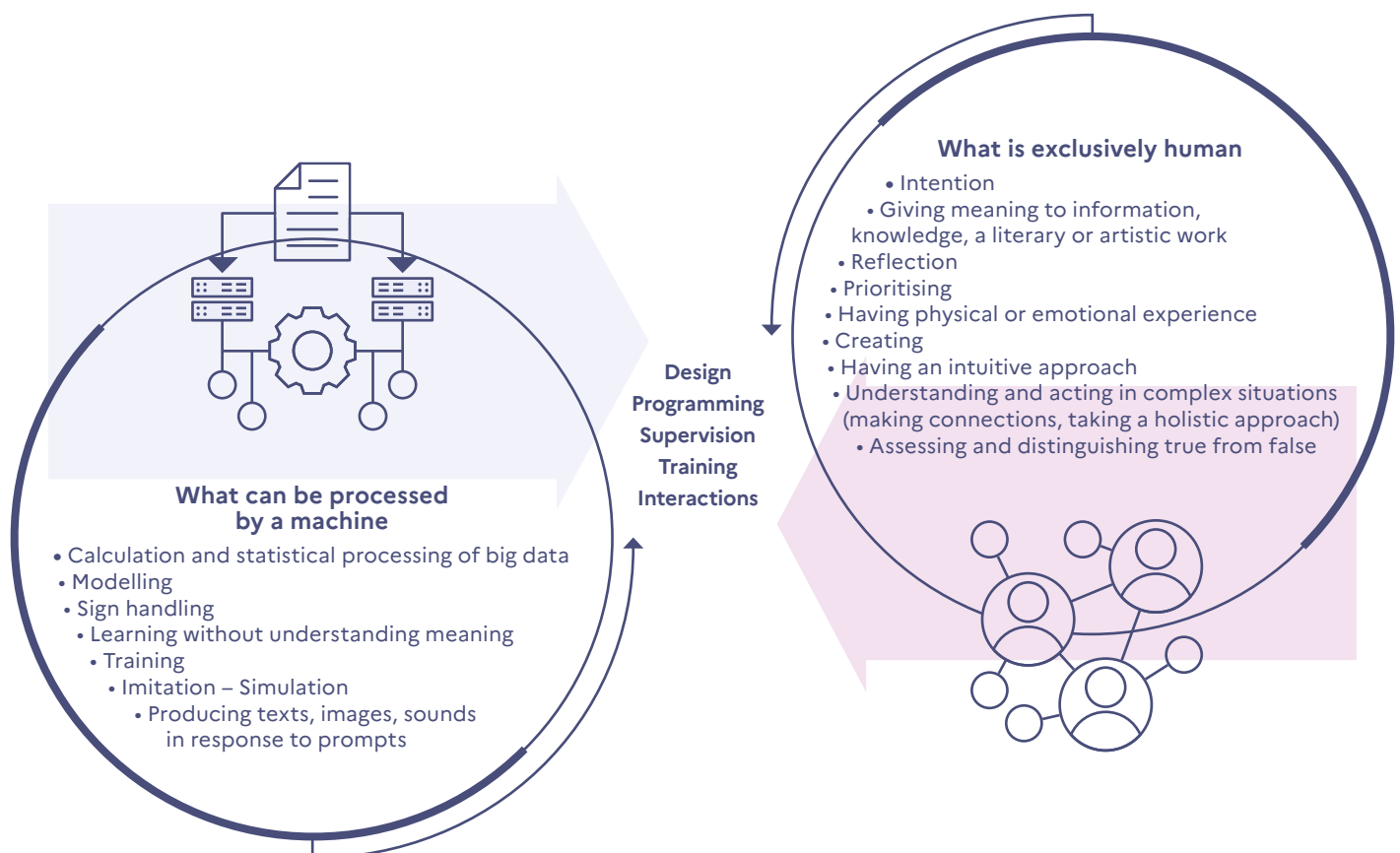
(Ministry of Education, 2024)



# Conclusion: markers and prospective elements

## What can and can't be AI

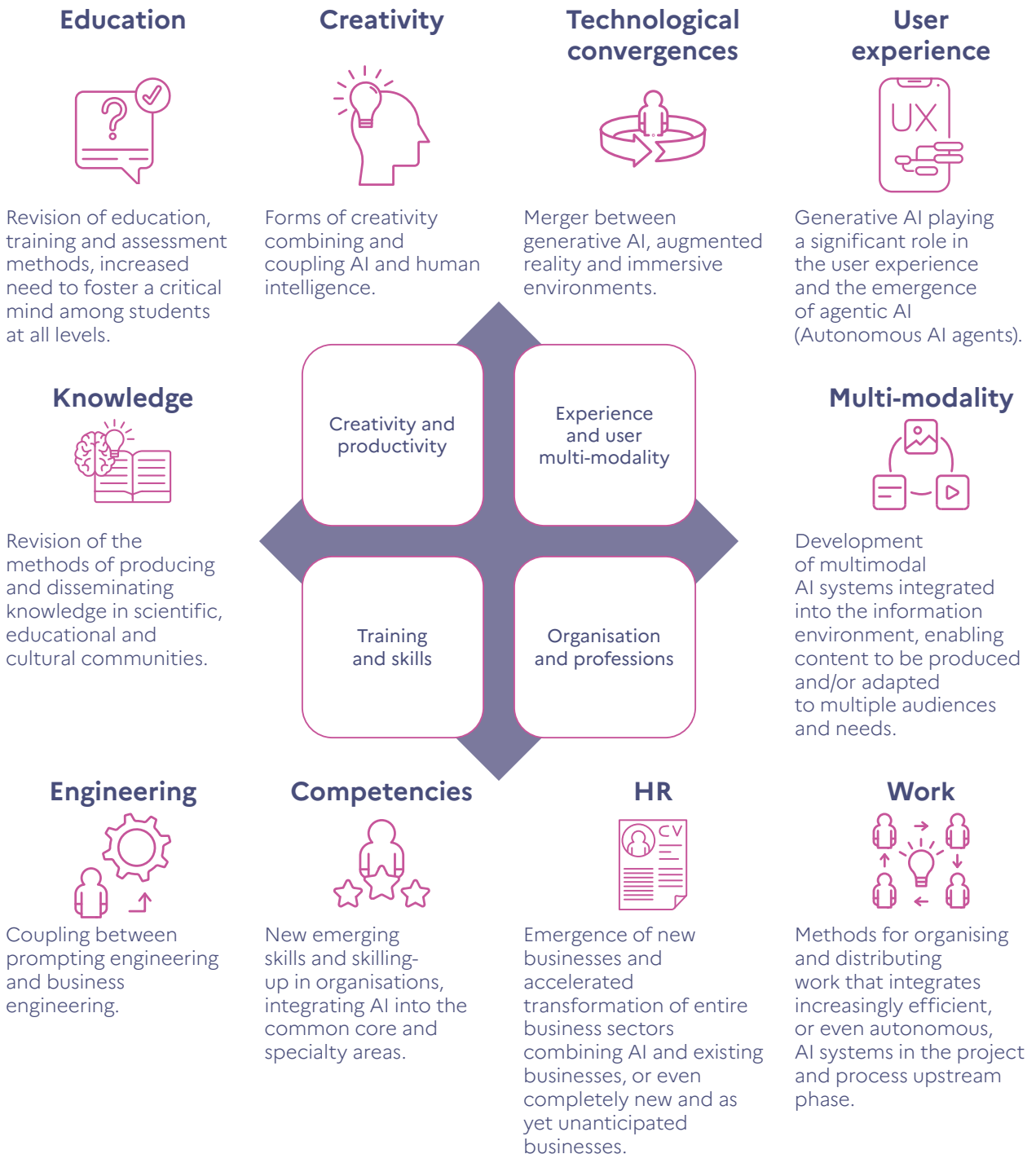
As the diagram below suggests, one of the challenges to overcome is the **distinction to be made with students between what is exclusively human** – giving meaning to information, knowledge, a literary or artistic work – **and what can reliably be entrusted to AI**: processing and computing big data, beyond human capability, for the purposes of prediction, probability or optimisation, but without intent or comprehension of what is produced.



(DNE-TN2, 2023)

# Prospective aspects

Generative AI, education and society: what are the emerging trends over the next 3-5 years?



Elie Allouche DNE-TN2 (2024)

## Systemic digital modelling in education and the outlook for generative AI

Systemic modelling: units of action	Emerging trends related to Generative AI
1. Change in the information environment	Development of multimodal AI systems integrated into the information environment enabling content to be produced and/or adapted to multiple audiences and needs. Revision of education, training and assessment methods, increased need to foster a critical mind among students at all levels. Challenge for media and information education.
2. Instrumenting practices	Generative AI playing an increasingly significant role in the user experience in leading office suites, applications, platforms and social media.
3. Evolution of skills and training methods	New emerging skills and skilling-up in organisations AI into the common core and specialty areas. Coupling between prompting engineering and business engineering.
4. Transforming spaces and organisations	Merger between generative AI, augmented reality and immersive environments.
5. Practitioner networking	Methods for organising and distributing work that integrates increasingly efficient, or even autonomous, AI systems right from the project and process upstream phase.
6. Digitalisation of knowledge	Interaction between literacies (digital/informational, data, AI).

(Allouche, 2024)

## Towards autonomous AI agents? Agentic AI

“Agency refers to the ability of artificial intelligence to perform more **or less autonomous actions** to achieve objectives. An AI system capable of performing such tasks autonomously is called an ‘agent’. This agency, rather than being a binary characteristic that models may or may not have, refers rather to the higher degree of autonomy given to applications and which would qualify them as agents.

Psychologist Daniel Kahneman distinguishes between two ways of thinking used by the brain, one to process information, the other to make decisions, system 1 and system 2: the challenge of agency is to move AI from the first phase to the second.

**The AIs of LLM should become LAMs or Large Action Models.**

Yann LeCun, Head of AI at Meta and who met with your reporters at the New York University where he is a professor, sees agency as **one of the main vectors of artificial intelligence development**. Indeed, he believes that the scalability of AI models based on Transformer technology will come up against a barrier that can only be overcome by developing new technologies that will make systems more agentic. In this regard, he talks about artificial intelligence models driven by their objectives, called ODAI for Objective-Driven AI. OpenAI’s statements in November 2024 also go in this direction: AI systems that enable autonomous tasks to be performed is likely to be the **next breakthrough in artificial intelligence.**”

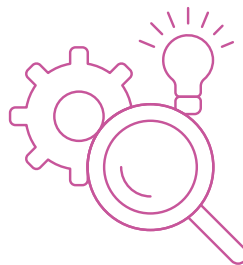
(Sabatou *et al.*, 2024).

## AI, Education and Applied Research

### Suggestions for work paths to be explored in 2025 and stabilised by 2030

1. Towards a renewal of the foundations and organisation of education (meaning and purposes, articulation between thought and language, distinctions and complementarities between humans and machines, etc.)?
2. Towards which specificities of the digital transformation of education in a period of acceleration and innovation (steering and governance, organisation of innovation ecosystems, links between global technological acceleration, systemic approach and local innovations, between applied research and practice communities, etc.)?
3. What are the methods for ethical and responsible, individual and collective appropriation of AI in education (schools, practice communities)?
4. What is the role of AI and what are the developments in the teaching and educational triangle (engineering/educational design, teacher-AI-learner interactions, revision of learning and assessment methods, etc.)?
5. What place does AI literacy have in school, university and education pathways?
6. What changes need to be made to the (initial and on-going) training of teachers and management staff?
7. What complementarity, crossover and hybridisation between disciplinary skills and AI literacy?
8. How can we support, train and prepare for the growing challenges of media and information education and the fostering of critical thinking?
9. What specific language models for teaching and learning (disciplinary, interdisciplinary and transdisciplinary)?
10. What collaboration types and methods for designing and co-designing AI models in education?
11. What methods to develop accessible and inclusive AI services in schooling, especially for pupils with special educational needs?
12. What role for autonomous AI agents and what new agency for education players in educational, teaching and training processes?

(DNE-TN2, 2025)



## References

- Abdelghani, R. (2024). Guider les esprits de demain : Agents Conversationnels pour Entraîner la Curiosité et la Métacognition chez les Jeunes Apprenants [Thèse, Université de Bordeaux]. <https://theses.hal.science/tel-04697786>
- Abdelghani, R., Wang, Y.-H., Yuan, X., Wang, T., Lucas, P., Sauzéon, H., & Oudeyer, P.-Y. (2023). GPT-3-driven pedagogical agents for training children's curious question-asking skills. *International Journal of Artificial Intelligence in Education*. <https://doi.org/10.1007/s40593-023-00340-7>
- Allouche, E. (2023a, janvier 5). Sens et finalités du numérique en éducation – Hors-série : Tests et simulations d'« entretien » avec ChatGPT (Open AI) [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/7635>
- Allouche, E. (2023b, octobre 2). IA génératives et ingénierie pédagogique : Le *prompting*, pistes de travail et applications [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/9934>
- Allouche, E. (2024). Transformation numérique de l'éducation, approche systémique et recherche appliquée. *Médiations et médiatisations*, 17, Article 17. <https://doi.org/10.52358/mm.vi17.392>
- Allouche, E. (2024, septembre 4). IA et éducation : 10 repères [Billet]. *Éducation, numérique et recherche*. <https://doi.org/10.58079/128ve>
- Association for the Advancement of Artificial Intelligence, & Computer Science Teachers Association. (2020). AI4K12. AI4K12. <https://ai4k12.org/>
- Association Française pour l'Intelligence Artificielle (AFIA). (2022, janvier 6). Journée Enseignement et Formation en IA : « IA pour l'enseignement ». *AfIA*. <https://afia.asso.fr/efia-2022/>
- Audran, J. (2024). Cinq enjeux d'évaluation face à l'émergence des IA génératives en éducation : Five Evaluation Challenges in the Face of the Emergence of Generative AI in Education. *Mesure et Évaluation en Éducation*, 47(1), 6-26. <https://edition.uqam.ca/mee/article/view/2609>
- Bengesi, S., El-Sayed, H., Sarker, M. K., Houkpati, Y., Irungu, J., & Oladunni, T. (2023). *Advancements in Generative AI: A Comprehensive Review of GANs, GPT, Autoencoders, Diffusion Model, and Transformers* (arXiv:2311.10242). arXiv. <https://doi.org/10.48550/arXiv.2311.10242>
- Boa Sorte, P., Farias, M. A. de F., dos Santos, A. E., Santos, J. do C. A., & Dias, J. S. dos S. R. (2021). Artificial intelligence in academic writing: What is in store with the GPT-3 algorithm? *Revista EntreLínguas*, 7(00). <https://periodicos.fclar.unesp.br/entrelinguas/article/download/15352/11410/51225>
- Bocquet, F. (2023, janvier 23). État de l'art et de la pratique de l'intelligence artificielle dans l'éducation (Holmes & Tuomi, 2022) [Traduction] [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/8350>
- Boisson, J., & DNE-TN2. (2023, janvier 12). Intelligence artificielle, traitement automatique des langues et agents conversationnels [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/8235>

- Cao, L., & Dede, C. (2023). Navigating A World of Generative AI : Suggestions for Educators. *Harvard Graduate School of Education*. <https://nextlevellab.gse.harvard.edu/2023/07/28/navigating-a-world-of-generative-ai-suggestions-for-educators/>
- Cardon, D., Cointet, J.-P., & Mazieres, A. (2018). La revanche des neurones : L'invention des machines inductives et la controverse de l'intelligence artificielle. *Réseaux*, 5(211). <https://doi.org/10.3917/res.211.0173>
- Cisel, M., & Baron, G.-L. (2019). Vers des intelligences artificielles pour l'enseignement de la démarche d'investigation. *Educational Journal of the University of Patras UNESCO Chair*, 0, Article 0. <https://doi.org/10.26220/june.2990>
- CNIL. (2024, avril 8). IA : La CNIL publie ses premières recommandations sur le développement des systèmes d'intelligence artificielle. CNIL. <https://www.cnil.fr/fr/ia-la-cnil-publie-ses-premieres-recommandations-sur-le-developpement-des-systemes-dintelligence>
- CNIL. (2024, juillet 12). Entrée en vigueur du règlement européen sur l'IA : Les premières questions-réponses de la CNIL. CNIL. <https://www.cnil.fr/fr/entree-en-vigueur-du-reglement-europeen-sur-lia-les-premieres-questions-reponses-de-la-cnil>
- CNPEN. (2023, juin 30). Avis 7 du CNPEN Systèmes d'intelligence artificielle générative : Enjeux d'éthique. Comité Consultatif National d'Éthique. <https://www.ccne-ethique.fr/fr/publications/avis-7-du-cnpem-systemes-dintelligence-artificielle-generative-enjeux-dethique>
- CNRS. (2022, juillet 12). Livraison du plus grand modèle de langue multilingue « open science » jamais entraîné. CNRS. <https://www.cnrs.fr/fr/livraison-du-plus-grand-modele-de-langue-multilingue-open-science-jamais-entraine>
- Collin, S., & Marceau, E. (2021). L'intelligence artificielle en éducation : Enjeux de justice. *Formation et profession*, 29(2), 1. <https://doi.org/10.18162/fp.2021.a230>
- Commission de l'intelligence artificielle. (2024, mars 13). *Un rapport pour saisir les opportunités de l'intelligence artificielle*. <https://www.gouvernement.fr/actualite/25-recommandations-pour-lia-en-france>
- Conseil de l'Europe. (2023, décembre 9). Législation sur l'intelligence artificielle : Le Conseil et le Parlement parviennent à un accord sur les premières règles au monde en matière d'IA. Conseil européen - Conseil de l'Union européenne. <https://www.consilium.europa.eu/fr/press/press-releases/2023/12/09/artificial-intelligence-act-council-and-parliament-strike-a-deal-on-the-first-worldwide-rules-for-ai/>
- Cour des comptes. (2023). *La stratégie nationale de recherche en intelligence artificielle*. Cour des comptes. <https://www.ccomptes.fr/fr/publications/la-strategie-nationale-de-recherche-en-intelligence-artificielle>
- CSEN, & DNE-TN2. (2022, novembre 7). Synthèse et recommandations du groupe de travail « Intelligence artificielle et numérique pour l'éducation » du CSEN [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/6707>
- De la Higuera, C., & Bocquet, F. (2020, juillet 9). L'éducation, la formation des enseignants et l'apprentissage de l'intelligence artificielle : Un aperçu des questions clés [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/1973>
- Devillers, L. (2023, février 20). ChatGPT et « intelligences » artificielles : Comment déceler le vrai du faux. *The Conversation*. <http://theconversation.com/chatgpt-et-intelligences-artificielles-comment-deceler-le-vrai-du-faux-200181>

Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2019). *BERT : Pre-training of Deep Bidirectional Transformers for Language Understanding* (arXiv:1810.04805). arXiv. <https://doi.org/10.48550/arXiv.1810.04805>

Direction du développement de la culture numérique - Sous-ministériat du numérique et de l'information. (2024). L'utilisation pédagogique, éthique et légale de l'intelligence artificielle générative — *Guide destiné au personnel enseignant*. Ministère de l'Éducation - Gouvernement du Québec. <https://cdn-contenu.quebec.ca/cdn-contenu/education/Numerique/Guide-utilisation-pedagogique-ethique-legale-IA-personnel-enseignant.pdf>

Directorate-General for Education, Youth, Sport and Culture, Y., & European Commission. (2022). *Lignes directrices pour les enseignants et les éducateurs en matière de lutte contre la désinformation et de promotion de l'habileté numérique par l'éducation et la formation*. Publications Office of the European Union. <https://op.europa.eu/en/publication-detail/-/publication/a224c235-4843-11ed-92ed-01aa75ed71a1/language-fr>

DNE-TN2. (2021, juin 30). Le deep learning, un tournant épistémologique pour les SHS ? (Huma-Num LAB, 2020) [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/3203>

DNE-TN2. (2022, janvier 20). Les enjeux éducatifs à l'ère de l'Intelligence Artificielle : GTnum #Scol\_IA – Maison de l'Intelligence artificielle [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/3898>

DNE-TN2. (2023a, mars 9). Intelligence artificielle et éducation ouverte : Retour sur la journée du GTnum #IA\_EO (26/01/23) [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/8605>

DNE-TN2. (2023b, juillet 10). Enseigner et apprendre à l'ère de l'intelligence artificielle : Portfolio du GTnum #Scol\_IA [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/9593>

DNE-TN2. (2023c, septembre 6). Intelligence artificielle et éducation ouverte : Portfolio du GTnum #IA\_EO [Billet]. *Éducation, numérique et recherche*. <https://edunumrech.hypotheses.org/9781>

DNE-TN2. (2024a, février 14). IA génératives et établissements scolaires du Grand-Est : Présentation du GTnum #IA2GE [Billet]. *Éducation, numérique et recherche*. <https://doi.org/10.58079/vu1d>

DNE-TN2. (2024b, mars 22). Intelligence artificielle générative et grands modèles de langage en éducation : Présentation du GTnum #GenIAL [Billet]. *Éducation, numérique et recherche*. <https://doi.org/10.58079/w2i5>

DNE-TN2. (2024, septembre 16). IA générative et apprentissages : Évaluer la production ou le processus ? (Cao & Dede, 2023) [Billet]. *Éducation, numérique et recherche*. <https://doi.org/10.58079/12b2i>

DNE-TN2. (2024, septembre 23). CREIA – Communauté de Réflexion en Éducation sur l'Intelligence Artificielle [Billet]. *Éducation, numérique et recherche*. <https://doi.org/10.58079/12cac>

Draghi, M. (2024, septembre 9). EU competitiveness : Looking ahead - European Commission. Commission Européenne - European Commission. [https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead\\_en](https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en)

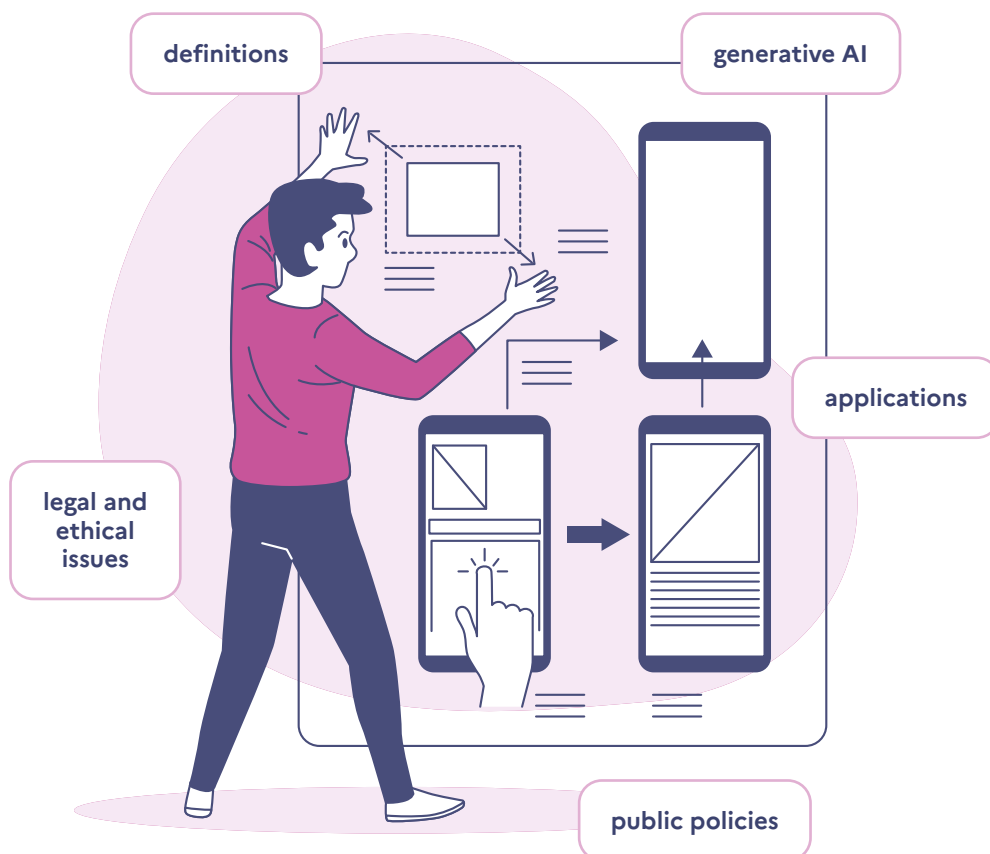
- European Commission. Directorate General for Education, Youth, Sport and Culture. (2022). *Lignes directrices éthiques sur l'utilisation de l'intelligence artificielle (IA) et des données dans l'enseignement et l'apprentissage à l'intention des éducateurs*. Publications Office. <https://data.europa.eu/doi/10.2766/153756>
- Formet, B. (2023). *Une IA par jour*. Une IA par jour. <http://uneiaparjour.fr/>
- Frau-Meigs, D. (2024). L'autonomisation des utilisateurs grâce aux réponses apportées par l'éducation aux médias et à l'information à l'évolution de l'intelligence artificielle générative (IAG). *UNESCO Digital Library*. [https://unesdoc.unesco.org/ark:/48223/pf0000388547\\_fre](https://unesdoc.unesco.org/ark:/48223/pf0000388547_fre)
- Ganascia, J.-G. (2022, juin 10). *Intelligence artificielle et épistémologie. Allers-retours indispensables*. JECIS. <https://hal.science/hal-03760357>
- Gao, Y., Xiong, Y., Gao, X., Jia, K., Pan, J., Bi, Y., Dai, Y., Sun, J., Guo, Q., Wang, M., & Wang, H. (2024). *Retrieval-Augmented Generation for Large Language Models : A Survey* (No. arXiv:2312.10997). <https://doi.org/10.48550/arXiv.2312.10997>
- Gelin, L. (2022). *Reconnaissance automatique de la parole d'enfants apprenants-tes lecteurs-trices en salle de classe : Modelisation acoustique de phones* [Thèse, Toulouse 3]. <https://hal.science/tel-03715653v1>
- Gouvernement - Direction générale des Entreprises. (2023). *Éduquer à l'Intelligence artificielle*. Stratégie nationale pour l'intelligence artificielle. <https://www.entreprises.gouv.fr/fr/numerique/enjeux/developper-ecosysteme-de-talents>
- Gouvernement français. (2024). *Avec France 2030, la France positionne l'IA comme un accélérateur et un différentiateur d'innovation* : Dossier de presse. Gouvernement de la République française. <https://www.info.gouv.fr/upload/media/content/0001/10/1e3304508d16af36727cd284ced41f53f9bfd346.pdf>
- Gozalo-Brizuela, R., & Garrido-Merchan, E. C. (2023). *ChatGPT is not all you need. A State of the Art Review of large Generative AI models*. <https://doi.org/10.48550/ARXIV.2301.04655>
- Grand lexique français de l'Intelligence artificielle. (2021). DataFranca Wiki. <https://datafranca.org/wiki/Accueil>
- Herft, A. (2023). *Guide de l'enseignant—L'usage de ChatGPT « ce qui marche le mieux »* (A. Gagné, Trad.). <https://labua.univ-angers.fr/wp-content/uploads/2023/01/ChatGPT-Guide-de-lenseignant-FR.pdf>
- Holmes, W., Persson, J., Chounta, I.-A., Wasson, B., & Dimitrova, V. (2022). *Artificial intelligence and education—A critical view through the lens of human rights, democracy and the rule of law*. Council of Europe. <https://rm.coe.int/artificial-intelligence-and-education-a-critical-view-through-the-lens/1680a886bd>
- Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, n/a(n/a). <https://doi.org/10.1111/ejed.12533>
- Hsiao, S. (2023, décembre 6). *Bard gets its biggest upgrade yet with Gemini*. Google. <https://blog.google/products/bard/google-bard-try-gemini-ai/>
- IID - Institut intelligence et données, ULaval (Réalisateur). (2024, octobre 29). L'IA générative au service de l'apprentissage : *Perspectives et enjeux pédagogiques* - Ange Tato [Enregistrement vidéo]. <https://www.youtube.com/watch?v=sc2TpJQQHQ0>

- Inria, & AI4T. (2023). *Intelligence artificielle pour et par les enseignants*. FUN MOOC. <http://www.fun-mooc.fr/fr/cours/intelligence-artificielle-pour-et-par-les-enseignants-ai4t/>
- Inria, & Class'Code. (2020). *L'Intelligence Artificielle... avec intelligence ! (MOOC)*. FUN-MOOC. <https://www.fun-mooc.fr/fr/cours/lintelligence-artificielle-avec-intelligence/>
- Inria Flowers (Réalisateur). (2023a, mars 8). *Comment fonctionne ChatGPT? Un tour d'horizon en moins de 5mn*. <https://www.youtube.com/watch?v=K8gOvC8gvB4>
- Inria Flowers (Réalisateur). (2023b, mars 13). *Le prompting, ou l'art de se faire comprendre par ChatGPT : Explication en 5mn*. [https://www.youtube.com/watch?v=8IQ9i\\_QoA3A](https://www.youtube.com/watch?v=8IQ9i_QoA3A)
- Kasneci, E., Sebler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneci, G. (2023). *ChatGPT for Good? On Opportunities and Challenges of Large Language Models for Education*. <https://doi.org/10.35542/osf.io/5er8f>
- Khosravi, H., Shum, S. B., Chen, G., Conati, C., Gasevic, D., Kay, J., Knight, S., Martinez-Maldonado, R., Sadiq, S., & Tsai, Y.-S. (2022). Explainable Artificial Intelligence in education. *Computers and Education: Artificial Intelligence*, 100074. <https://doi.org/10.1016/j.caeai.2022.100074>
- Langlais, P.-C. (2023, février 7). ChatGPT : Comment ça marche ? [Billet]. *Sciences communes*. <https://scoms.hypotheses.org/1059>
- Le Blanc, B. (2014). Alan Turing : Les machines à calculer et l'intelligence. *Hermès, La Revue*, 68(1), 123-126. <https://doi.org/10.3917/herm.068.0123>
- Le Cun, Y., Brizard, C., & Brizard, C. (2019). *Quand la machine apprend : La révolution des neurones artificiels et de l'apprentissage profond*. Odile Jacob.
- Le Cun, Y. et al. (2022, février 2023). *Yann LeCun on a vision to make AI systems learn and reason like animals and humans*. Meta AI. <https://ai.meta.com/blog/yann-lecun-advances-in-ai-research/>
- LeCun, Y. (2022). *A Path Towards Autonomous Machine Intelligence*. <https://openreview.net/pdf?id=BZ5a1r-kVsf>
- Lex Fridman (Réalisateur). (2024, mars 7). *Yann LeCun : Meta AI, Open Source, Limits of LLMs, AGI & the Future of AI | Lex Fridman Podcast #416* [Enregistrement vidéo]. <https://www.youtube.com/watch?v=5t1vTLU7s40>
- Lepage Alexandre (Réalisateur). (2022, mars 3). *L'intelligence artificielle en éducation*. <https://www.youtube.com/watch?v=ZAu0xllcls>
- Lo, C. K. (2023). What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature. *Education Sciences*, 13(4), Article 4. <https://doi.org/10.3390/educsci13040410>
- Lorenz, P., Perset, K., & Berryhill, J. (2023). *Initial policy considerations for generative artificial intelligence*. OCDE. <https://doi.org/10.1787/fae2d1e6-en>
- Luccioni, S., Trevelin, B., & Mitchell, M. (2024, septembre 3). *The Environmental Impacts of AI -- Primer*. Hugging Face. <https://huggingface.co/blog/sasha/ai-environment-primer>
- Miao, F., & Cukurova, M. (2024). *AI competency framework for teachers*. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000391104.locale=fr>

- Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research*. UNESCO Bibliothèque Numérique. <https://unesdoc.unesco.org/ark:/48223/pf0000386693>
- Miao, F., & Shiohira, K. (2024). *AI competency framework for students*. UNESCO. <https://doi.org/10.54675/JKJB9835>
- Ministère de l'éducation nationale. (2024). Esthétiques de l'artificiel (*Lettre d'information sur le numérique éducatif* No. 24; *ÉduNum Thématique*). <https://eduscol.education.fr/document/61099/download?attachment>
- OCDE. (2023, mars 28). *Is Education Losing the Race with Technology?: AI's Progress in Maths and Reading*. OCDE. <https://www.oecd.org/education/is-education-losing-the-race-with-technology-73105f99-en.htm>
- OCDE, Varsik, S., & Vosberg, L. (2024). The potential impact of Artificial Intelligence on equity and inclusion in education (*OECD Artificial Intelligence Papers 23; OECD Artificial Intelligence Papers, Vol. 23*). <https://doi.org/10.1787/15df715b-en>
- OpenAI. (2023). *GPT-4 Technical Report*. OpenAI. <https://cdn.openai.com/papers/gpt-4.pdf>
- Oregon State University, E. (2024). Bloom's Taxonomy Revisited – Artificial Intelligence Tools. *Faculty Support | Oregon State Ecampus*. <https://ecampus.oregonstate.edu/faculty/artificial-intelligence-tools/blooms-taxonomy-revisited/>
- Pierre-Yves Oudeyer (Réalisateur). (2024, février 9). Intelligence artificielle, curiosité et éducation [Enregistrement vidéo]. [https://www.youtube.com/watch?v=J-p\\_E\\_lwff0](https://www.youtube.com/watch?v=J-p_E_lwff0)
- Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education : The three paradigms. *Computers and Education: Artificial Intelligence, 2*, 100020. <https://doi.org/10.1016/j.caeai.2021.100020>
- Parlement européen. (2023, décembre 9). *Artificial Intelligence Act: Deal on comprehensive rules for trustworthy AI*. News European Parliament. <https://www.europarl.europa.eu/news/en/press-room/20231206IPR15699/artificial-intelligence-act-deal-on-comprehensive-rules-for-trustworthy-ai>
- Pôle d'expertise de la régulation numérique. (2023). ChatGPT ou la percée des modèles d'IA conversationnels. *Gouvernement français*, 6. [https://www.peren.gouv.fr/rapports/2023-04-06\\_Eclairage%20sur\\_CHATGPT\\_FR.pdf](https://www.peren.gouv.fr/rapports/2023-04-06_Eclairage%20sur_CHATGPT_FR.pdf)
- Pôle d'expertise et de régulation numérique. (2024). Open source et IA : des synergies à repenser ? *Éclairage sur...* [https://www.peren.gouv.fr/rapports/2024-04-03\\_Eclairage%20sur\\_OpenSource-IA\\_FR.pdf](https://www.peren.gouv.fr/rapports/2024-04-03_Eclairage%20sur_OpenSource-IA_FR.pdf)
- Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning, 12*(1), 22. <https://doi.org/10.1186/s41039-017-0062-8>
- Romero, M., Aloui, H., Heiser, L., Galindo, L., & Lepage, A. (2021). *Un bref parcours sur les ressources, pratiques et acteurs en IA et éducation*. <https://hal.archives-ouvertes.fr/hal-03190014>
- Romero, M., Heiser, L., Lepage, A., Gagnebien, A., Bonjour, A., Lagarrigue, A., Palaude, A., Boulord, C., Gagneur, C.-A., Mercier, C., Caucheteux, C., Guidoni-Stoltz, D., Tressols, F., Alexandre, F., Céci, J.-F., Metral, J.-F., Camponovo, J., Henry, J., Fouché, L., ... Borgne, Y.-A. L. (2023). *Enseigner et apprendre à l'ère de l'intelligence artificielle : Livre blanc du G7num #Scol\_IA: Vol. Livre blanc*. <https://hal.science/hal-04013223>

- Sabatou, A., Chaize, P., & Narassiguin, C. (2024). *ChatGPT, et après ? Bilan et perspectives de l'intelligence artificielle*. Sénat - OPECST. <https://www.senat.fr/salle-de-presse/dernieres-conferences-de-presse/page-de-detail-2/chatgpt-et-apres-bilan-et-perspectives-de-lintelligence-artificielle-4126.html>
- Singh, R., & Gill, S. S. (2023). Edge AI : A survey. *Internet of Things and Cyber-Physical Systems*, 3, 71-92. <https://doi.org/10.1016/j.iotcps.2023.02.004>
- Stokel-Walker, C. (2023). ChatGPT listed as author on research papers: Many scientists disapprove. *Nature*. <https://doi.org/10.1038/d41586-023-00107-z>
- Susnjak, T. (2022). *ChatGPT: The End of Online Exam Integrity?* (arXiv:2212.09292). arXiv. <https://doi.org/10.48550/arXiv.2212.09292>
- Tatot, F., & Vermot Desroches, G. (2024). Impacts de l'intelligence artificielle : Risques et opportunités pour l'environnement. Conseil économique social et environnemental. <https://www.lecese.fr/travaux-publies/impacts-de-lintelligence-artificielle-risques-et-opportunités-pour-lenvironnement>
- Thouverez, P. (2024, novembre 21). Agents autonomes : L'IA en roue libre ? *Techniques de l'Ingénieur*. <https://www.techniques-ingenieur.fr/actualite/articles/agents-autonomes-lia-en-roue-libre-139345/>
- Touvron, H., Lavril, T., Izacard, G., Martinet, X., Lachaux, M.-A., Lacroix, T., Rozière, B., Goyal, N., Hambro, E., Azhar, F., Rodriguez, A., Joulin, A., Grave, E., & Lample, G. (2023). *LLaMA : Open and Efficient Foundation Language Models* (arXiv:2302.13971). arXiv. <https://doi.org/10.48550/arXiv.2302.13971>
- UNESCO. (2019). *Consensus de Beijing sur l'intelligence artificielle et l'éducation*. UNESCO Bibliothèque Numérique. <https://unesdoc.unesco.org/ark:/48223/pf0000368303>
- UNESCO. (2021). *IA et éducation : Guide pour les décideurs politiques*. UNESCO Bibliothèque Numérique. <https://unesdoc.unesco.org/ark:/48223/pf0000380006>
- UNESCO. (2022). *K-12 AI curricula: A mapping of government-endorsed AI curricula*. UNESCO Bibliothèque Numérique. <https://unesdoc.unesco.org/ark:/48223/pf0000380602>
- UNICEF. (2021, novembre). *Orientations stratégiques sur l'IA destinée aux enfants 2.0*. UNICEF. <https://www.unicef.org/globalinsight/fr/rapports/orientations-strat%C3%A9giques-sur-lia-destin%C3%A9e-aux-enfants>
- UNESCO. (2023). *Enseigner l'intelligence artificielle au primaire et au secondaire : Une cartographie des programmes validés par les gouvernements*. UNESCO Digital Library. [https://unesdoc.unesco.org/ark:/48223/pf0000380602\\_fre](https://unesdoc.unesco.org/ark:/48223/pf0000380602_fre)
- Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, L., & Polosukhin, I. (2017). *Attention Is All You Need*. <https://doi.org/10.48550/ARXIV.1706.03762>
- Wang, Z., Bi, B., Pentyala, S. K., Ramnath, K., Chaudhuri, S., Mehrotra, S., Zixu, Zhu, Mao, X.-B., Asur, S., Na, & Cheng. (2024). *A Comprehensive Survey of LLM Alignment Techniques : RLHF, RLAI, PPO, DPO and More* (No. arXiv:2407.16216). arXiv. <https://doi.org/10.48550/arXiv.2407.16216>

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