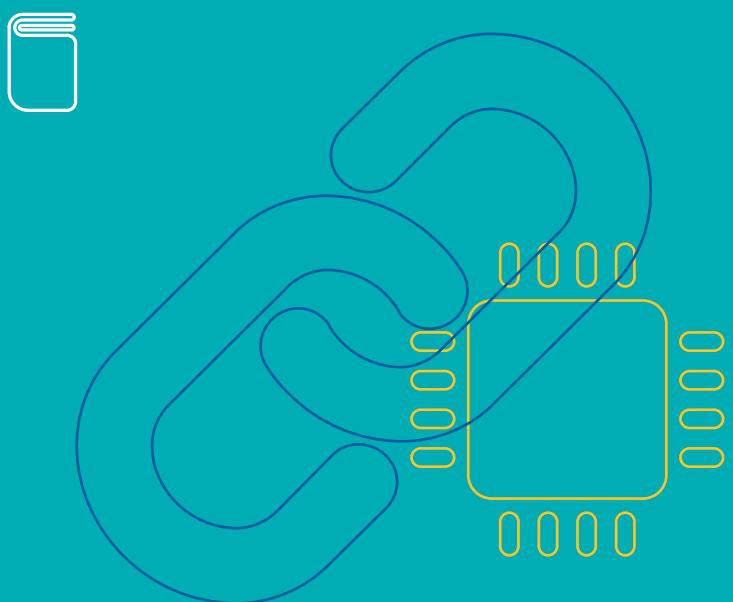
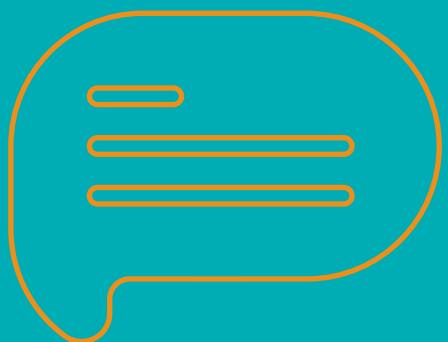


Building Artificial Intelligence for education





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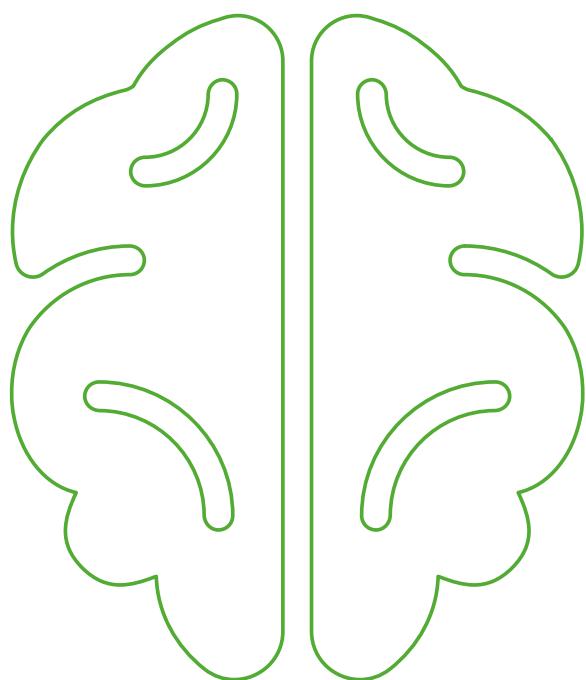
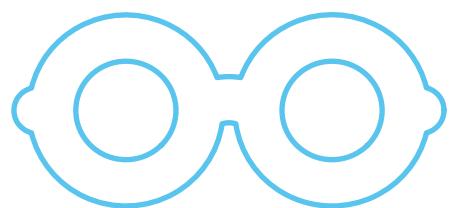
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Building Artificial Intelligence for education



**Inteligencia
Artificial**



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in various areas including innovation, educational technologies, and artificial intelligence. Brian believes it is essential to view technology as a means rather than an end, and to recognize its inseparable connection to the social and human aspects it involves.



Leandro Folgar is the president of Ceibal, Uruguay's center for educational technology and innovation. Under his leadership, Ceibal drives the national Edtech strategy, facing significant challenges during the COVID-19 pandemic. Leandro holds a bachelor's degree in education (Catholic University of Uruguay, UCU) and a Master's in Technology, Innovation, and Education from Harvard University. He also earned

business credentials from Harvard Business School. Currently, he complements his work as a member of various Boards of Directors with postgraduate teaching at the business school of the Catholic University of Uruguay. A Fulbright alumnus, entrepreneur, and business consultant, he began his career in education as a teacher and accumulated 13 years of experience in various school roles. He is passionate about innovation, technology, learning, high-performing teams, and the transformative power of education in shaping the future of our global society.

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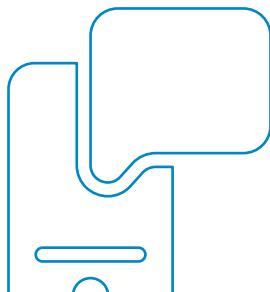
Foreword

Writing a foreword on Artificial Intelligence is like narrating the outcome of a football match before it is over. It is inevitable that the text will become obsolete. But obsolescence is not necessarily bad. It is part of the nature of knowledge, always evolving. In this case, we are referring to technology in constant transformation. It is a type of technology that enables new ways of building, processing, reconstructing, but also disrupting and manipulating knowledge, with unprecedented sophistication.

In recent decades, but especially in recent months, major technology companies, mainly those specializing in processing large volumes of data, have driven a rapid reformulation of the concept of AI. It is hard to imagine a technology that has had such a huge impact on various sectors of society in such a short time. While electricity, like AI, was a disruptive and multi-purpose technology, it took the world several decades to adopt it and illuminate cities, thus having a widespread impact on society. In contrast, the expansion cycles of AI have been much more astounding.

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But not all institutions face this speed with the same versatility. Some suggest that it is necessary to update 19th-century institutions to confront and navigate a world in constant reconstruction driven by AI. Similarly, regulatory structures, norms, and legal, ethical, social, and cultural frameworks are strained by these technologies, which compress and alter areas that previously had a wide margin of influence and are now clearly threatened.

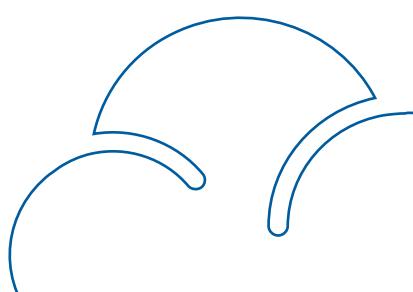


There is nothing new when we say this technology poses challenges and opportunities. Those who have worked in education or technology know that many of the challenges, though not all, are not new. Inclusion, skills development, or the promotion of independent and critical thinking have been constant challenges and concerns on the educational agenda. However, new challenges also arise, such as the ability to distinguish when knowledge (or its derivatives) is created by people or by automatic systems.

There are also other risks, such as excessive reliance on automatic decision-making by automated systems. Some researchers suggest we may lose the ability to make autonomous decisions, known as 'agency.' This aspect was not as evident in previous technologies. While a calculator can help us with mathematical tasks or a notebook can assist in memorization, the integration and information processing capacity of AI allow many of these processes to successfully function without us (some talk about a bicycle for the brain.)

When comparing generative AI with human cognitive capacity, interesting questions arise for those developing these technologies. For example, some recent generative AI technologies can have up to a billion parameters, and their memorization capacity is astonishing. In contrast, the human brain has one hundred billion connections. But people and machines learn differently. What sets us apart as people is our ability to connect experiences, generalize, extrapolate, link, and associate our experiences. That is, although we have an inferior capacity to AI to memorize data, our learning is enriched and amplified through the combination of old and new experiences. This gives us guidelines to think about how to design a formative process that is not only focused on the accumulation of data but on the association of different experiences that promote richer learning.

But the human brain is restless and curious. Here are some of the questions that feed our curiosity today. Should we adjust educational and evaluation processes? What are the skills we must develop? In what way does fluency in AI complement the development of computational thinking skills or digital skills? How do we teach students to learn both with and without machines? How do we know when interaction between people is fundamental and must not be replaced by autonomous systems? How can these machines help us learn better?



Can personalized learning with AI support students with learning difficulties? Many of these questions still remain in a field of uncertainty. Evidence often comes after experience. But that must not stop us. That is why this publication is so important, as it opens up space for debate and reflection on how to understand this technology, how to navigate its opportunities, but also its risks, which are not few. As important as critical thinking is intuition and common sense, which are much more difficult to parameterize by these synthetic systems. As well as empathy, emotion, and connecting with others. These issues make education among people continue to play a central role, but that does not imply that there is not the possibility that we can walk, perhaps to go further, or in other directions, with the use of this technology.

The list of risks that these technologies pose is not short. It is important to know them and to seek actions to understand them. For example, the over or underrepresentation of some realities. Data collection and processing without a clear prioritization method within algorithms can also generate problems. When we have data that underrepresents some cultures, languages, or regions, it can also generate unwanted effects. When these technologies automate recommendations or decisions without the end user having the possibility to understand or seek guidance, it can also be a source of risks. All of these factors must be taken into consideration when training teachers and students, and more generally, when educating citizens who will have to live in a world where they can learn from and work with these machines, and in some cases work for them. As it is happening today in some places where there are people reviewing, training, or refining algorithms results or outputs. There is a fundamental challenge that will need to be explored, and that is how this technology is redefining our relationship with written texts and reading, since it has the capacity for voice recognition and transforming voice into text and text into voice. This means that orality once again has a fundamental function as an interface for accessing content. But this generates some tensions. There may be a potential deterioration in some issues directly related to the learning process, such as written language, which we know is richer than spoken language in terms of vocabulary, grammar, and vocabulary. Therefore, the invitation is to think about this when educating at early ages and to carefully consider when, how, and where it is a good idea to use these machines to replace them with more traditional interfaces like reading and writing. And perhaps,

as proposed by a renowned scientist from the Massachusetts Institute of Technology, the natural language of people may even come to replace or transform our classic understanding of coding. Some consider, with great expectation, that this may democratize programming since it does not require such a high level of abstraction. However, all of these are questions that will be answered as we make progress.

This foreword cannot have a conclusion. We are talking about a field in full expansion. That is why I propose that we settle for an (un)conclusion. Artificial intelligence has the potential to significantly transform education, providing opportunities to improve personalization, efficiency, and the quality of learning. However, it also presents challenges and requires careful consideration in its implementation. There are many challenges we do not even know about. Collaboration between educators, AI experts, and policymakers is essential to ensure that the technology is used ethically and effectively, and to promote a balanced approach that combines the strengths of AI with human experience and judgment.

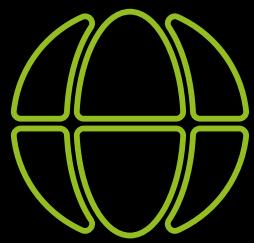
Before (un)concluding, I would like to share an anecdote: it is said that this foreword was intended to be written by a generative AI agent. However, the authors were not satisfied with the forewords delivered by any of these chatbots.

Given the transparency of the authors when inviting me, I had no problem with being considered as the 'plan B' for the elaboration of this foreword. Moreover, it is an honor for me to be able to contribute to this important publication, although it also leads me to reflect: how much longer will we humans be the only ones capable of creating quality content?

Cristobal Cobo

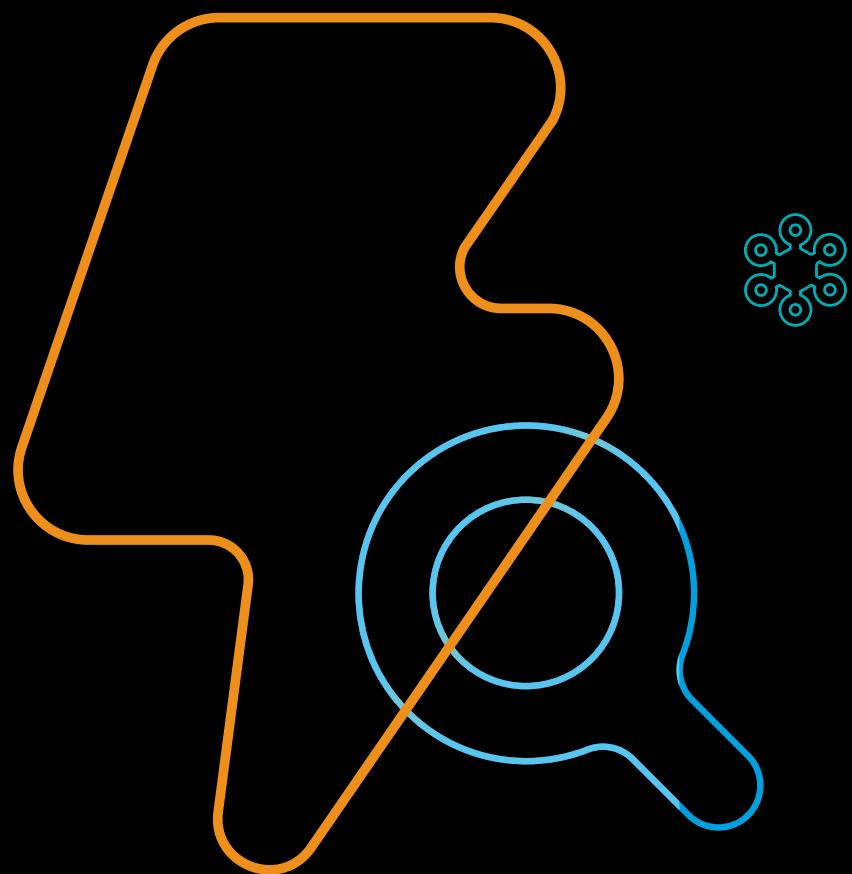


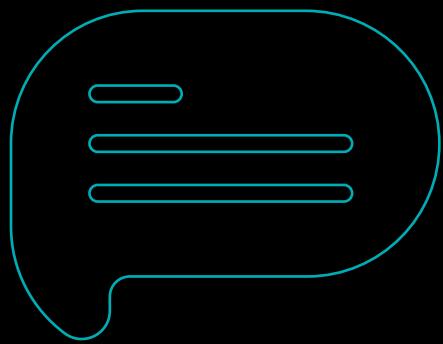
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Chapter 1

A journey towards Artificial Intelligence





Introduction

The growing global movement in education, focused on integrating 21st-century skills, faces new and significant challenges due to the rapid advancement of Artificial Intelligence (AI). AI, like any technology, is the subject of both hopes and fears, leading to important debates.

The rise of text generators and AI chatbots is largely the starting point for rethinking educational practice, the inclusion of technologies in the classroom, and the ethical aspects of their use. Perhaps the biggest change is in the widespread accessibility to these tools; the first known chatbot, Eliza, was launched in 1966 at MIT, and by 1997, AI was already beating humans at chess. From that time until present, most people interact daily and in different areas with machines that use AI, whether through translators or algorithms for series or music.

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This historical process of AI not only shows that there have been moments of greater and lesser impact on society (for example, during the so-called AI winter), but also allows us to visualize advances in relation to the potential of individuals. This idea of turning knowledge acquired by the computer into an opportunity for improvement for the individual or society refers to the concept of augmented intelligence, which is key to understanding the human role in relation to computers, as well as its implications for the goals of education (Holmes et al., 2019).

At the local level, and in the same vein, Uruguay's Artificial Intelligence Strategy aims for AI to enhance people's skills, complementing and improving quality of life (AGESIC, 2020). For these statements to become a reality, it is necessary to educate younger generations in this area, also providing support in the use of these tools at a general level (Gennari et al., 2023).

In this dynamic and changing context, this book is an invitation for teachers to understand some central elements of AI, its potentials, and limitations. In this sense, it seeks to be a tool for literacy and to generate deep discussions in our region about the relevant competencies to be addressed in education regarding technologies that incorporate AI. Two central ideas hover over the book's journey, the intention to dismantle notions of intelligence and to demystify the magical aspects of AI. These two elements, associated with cultural aspects, serve as the starting point for reconstructing an adjusted understanding of AI.



Brief overview of the book

The following pages of this first chapter, present the context from which the need for this book arises, and the reference framework to guide the promotion of AI literacy.

The subsequent chapters are designed to explore in depth the fundamental concepts of AI, providing a detailed analysis of the key elements that make up each dimension. This approach is complemented by a series of activities specifically designed to enrich learning in the classroom. Each activity is designed to be brief and flexible, allowing each teacher to adjust it to the needs of their students and connect it to the thematic area they are addressing. Furthermore, it incorporates at least one AI-based tool and is structured to include moments of metacognition, both during and at the end of the activity, in order to stimulate individual and/or collective reflection on the learning process.

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The fifth chapter addresses how AI can influence and be integrated into educational policies at the regional level, exploring its potential opportunities and challenges. Finally, the sixth chapter offers a deep and reflective analysis of the future of this technology within the education system, considering both the promises and possible uncertainties that AI represents for the evolution of education.

Why teaching AI?

Before delving into the reasons why addressing this topic in education is beneficial, it is worth briefly discussing what is meant by Artificial Intelligence.

The term Artificial Intelligence is not recent; in fact, it was coined in the late 1950s. The definitions of the term have evolved over time, not without discussions, and currently, in general terms, it can refer to how machines manage to replicate certain characteristics of human intelligence, linked for example to perception, certain forms of learning or reasoning, problem-solving, linguistic ability, and even creative work (UNESCO, 2023a). This definition, not necessarily definitive, allows us to advance in the conceptualization of this term that encompasses many layers.

The rapid expansion of AI in different aspects of our lives raises old questions about the need to prepare each student to interact effectively with this constantly evolving technology. As the number of AI-powered tools freely available to teachers and students increases, debates arise around their use in classrooms. Generally prohibiting the use of these technologies does not seem a feasible or advisable strategy. Among other factors, it could limit the future options of the student community, in addition to contributing to increasing the digital divide (ISTE, 2023). On the other hand, some initiatives seek to raise awareness about when it is safe to use AI text generators (MinEduc, 2023). From the perspective of those promoting the use of AI, there is also the need to create guides, tools, and classroom activities (Tedre et al., 2021a). In general, these guides suggest using these tools as a complement to teaching, enriching planning and diversifying pedagogical proposals in the classroom (Herft, 2023; UNESCO, 2023b). For example, using chatbots that use generative AI as a first approach to a topic challenges the student group to request examples, generate dialogues to receive feedback on their submissions, compare information with other sources, and seek assistance in problem-solving (Miller, 2023; Holmes et al., 2023).

Beyond this type of use, we understand that teaching about AI prepares the teaching community and students for the challenges and opportunities ahead, as well as fostering the development of critical competencies or skills such as problem-solving, critical thinking, creativity, and decision-making. Behind the teaching of AI lies the idea of teaching students to think, and that, ultimately, learning is a consequence of thinking (Ritchhart et al., 2014).

In this sense, the learning processes for computational thinking and AI intertwine and overlap, as AI is a means to materialize intelligence. Behind the abstraction and formulation of the problem in understandable terms for the computer, there is the idea that when a person can teach something to a computer, they truly understand the problem (Knuth, 1974). And in this process, by being more aware of their own thinking and the strategies and processes used to think, each student becomes more metacognitive (Ritchhart et al., 2009).

As a complex cognitive competence that includes skills such as creativity, critical thinking, and problem-solving, computational thinking is also gaining ground in educational communities and national frameworks (Bocconi et al., 2022), which is largely an encouraging scenario regarding the emergence of AI.

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It is worth noting that AI literacy not only addresses learning scientific and technological fundamentals but also knowledge and critical reflection on how to develop reliable AI and the consequences of not doing so (Long and Magerko, 2020). AI systems include biases that can significantly harm minority groups, and at the same time, can systematically benefit those who are part of hegemonic groups (Ferrante et al., 2022). Consequently, digital citizenship and AI are also closely related, as they problematize the use, responsibility, and ethics that underlie technologies. For students to become critical users and potential creators of tools, they need to know what AI is and how it works (ISTE, 2022). The aim is to empower education communities, emphasizing the human role in accessing, using, and developing AI systems to promote an inclusive and equitable perspective (UNESCO, 2023b).

Ceibal and the educational context on computational thinking and AI

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Since its inception in 2007, Ceibal has led the initiative to provide each student and teacher in the Uruguayan public education system, from first grade of primary school to third grade of secondary education, with technology devices and internet services. Over the years, Ceibal has redefined its focus and innovated in programs, resources, and teacher professional development in line with the advancement of society and technology. Its mission is to promote the integration of digital technologies in education, aiming to improve learning and drive processes of innovation, inclusion, and personal growth. In this framework, Ceibal promotes various educational initiatives associated with AI, through various programs and strategies for professional development and classroom resources¹ and teacher reflection². In particular, in 2017, the Computational Thinking program was created. An initiative that promotes a collaborative educational model, where a computer science teacher interacts via video conference with a group of students and their classroom teacher. It is an optional program, during class hours, which includes most public schools in Uruguay.

Although the Computational Thinking framework (Ceibal, 2022) constitutes a starting point for addressing AI, there are some novelties associated with machine learning and AI that make it necessary to extend said framework in order to address them in the classroom (Tedre et al., 2021b). For example, machine learning introduces new concepts, such as data debugging, training, and algorithm evaluation, as well as key elements associated with this process, such as classification and biases.

1 Sequence of activities for the teaching of computational thinking: https://pensamientocomputacional.ceibal.edu.uy/wp-content/uploads/2023/06/2022-Inteligencia-artificial_Guia-Docentes.pdf

2 Initiative of Ceibal's Digital Citizenship program: <https://ceibal.edu.uy/institucional/articulos/un-nuevo-podcast-producido-por-la-agesic-y-ceibal/>

These changes imply the need for an update in the framework to increase coverage of the subject. In this sense, Tedre et al. (2021b) propose the development of a new conceptualization of computational thinking, which includes fundamental elements of machine learning and AI. Similarly, Ceibal's Computational Thinking reference framework is also in the process of transformation and adjustment to accompany the advances observed in the subject. Likewise, while this general process is underway, this book proposes the definition of a more delimited and specific framework for addressing AI, which allows us to advance quickly and effectively, without entering into more fundamental revisions that could delay the incorporation of said subject in the short term; but also without ignoring the deep connection between computational thinking and AI, which is manifested, for example, in that they share the principles and elements of the dimensions that make up both frameworks.

Reference framework for teaching AI

This framework proposal seeks to provide a structure for the design of study programs and the planning of teaching and learning activities that promote a deep understanding of AI and promote competencies for each student to be able to analyze, design, and solve problems using computational principles.

Through an integrated and interdisciplinary approach, the aim is to develop AI literacy and address ethical and social aspects associated with its use, promoting informed and responsible reflection on its impact on society and the individual. By establishing a contextualized competency framework, this document seeks to provide the community of educators with a guide for the integration of AI and computational thinking in the educational field. Through the implementation of innovative didactic strategies and the use of appropriate technological tools, it is expected to enhance the development of skills related to critical thinking, problem-solving, creativity, and collaboration. Likewise, it seeks to foster an open and adaptive mindset, building foundations to face the challenges and opportunities that AI and digital technologies bring.

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In summary, the reference framework described here offers a general approach to education in AI, with the aim of training critical and ethical citizens in the use and understanding of this technology and its transformative potential. It seeks to be a tool to promote AI literacy, understood as a set of competencies that allow people to know and critically evaluate AI technologies, use tools with AI, communicate, collaborate, and make decisions with and about AI (Long and Magerko, 2020), and also promote different thinking skills and knowledge that potentially allow creating with AI. The framework includes a series of guiding principles, conceptual dimensions, and associated competencies.

Principles

The principles of the framework are fundamental characteristics and are incorporated into all classroom proposals. In this sense, they are not intrinsic elements of computational thinking or AI but rather, they guide the construction of proposals and activities to generate learning environments.

EQUITY

Educate taking into account the differences and individual and collective needs, without economic, demographic, geographical, ethnic, or gender conditions affecting the education of students.

COLLABORATION

Working in a team independently and synergistically. Developing interpersonal and organizational skills in a team to take on challenges. Making conscious decisions and contributing to the learning of others.

CREATIVITY

Having a proactive and creative vision, asking appropriate questions to generate opportunities and novel ideas. Transforming those ideas into actions with social impact.

AUTONOMY

Promoting exploration, incorporating mistakes as part of the process, taking risks, and taking the initiative as a strategy to actively engage in the creation process, fostering students' intrinsic motivation.

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CRITICAL PERSPECTIVE

Critically evaluating information and arguments, identifying patterns and connections, developing meaningful knowledge to apply it to the real world, and reflecting on its effects.

ACTIVE METHODOLOGIES

Using methods, techniques, and strategies that make each student the center of the teaching/learning process and promote active participation and curiosity of each student in the construction of their learning.

Dimensions

The dimensions are powerful themes, concepts, or ideas that serve to order, design, and implement pedagogical proposals. They are directly related to the competencies promoted to advance in AI literacy (Kim et al., 2021; Long and Magerko, 2020; Ng et al., 2021; Olari and Romeike, 2021; Sentance and Waite, 2002).

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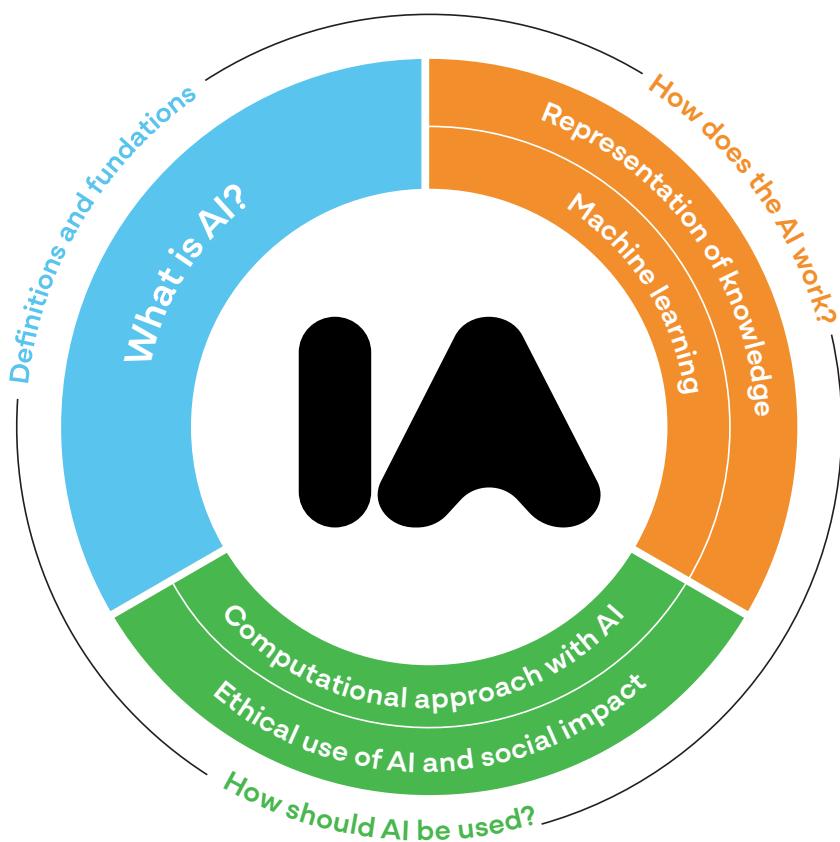


Figure 1. Dimensions of the AI reference framework.

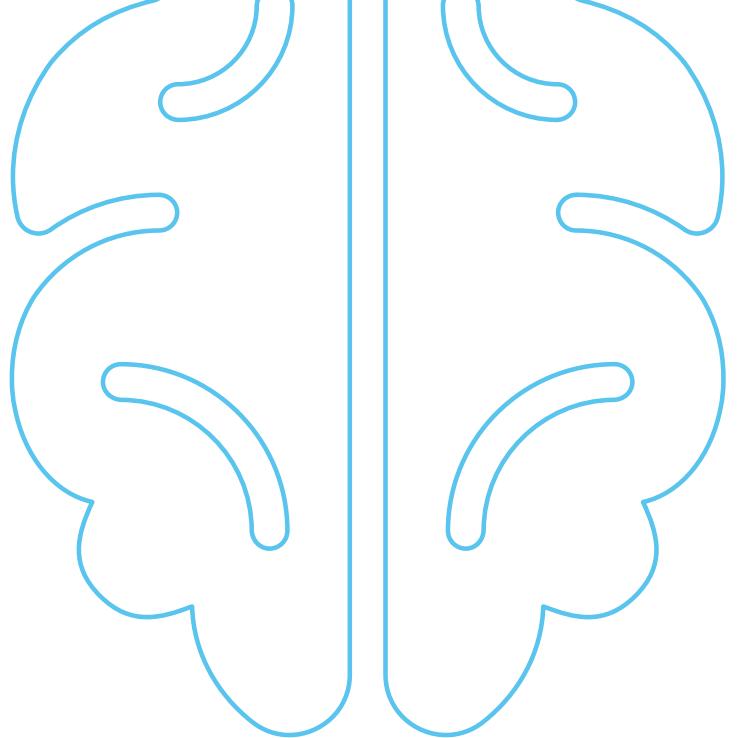
The three questions guiding the dimensions (See Figure 1) and ultimately the development of this book are:

What is AI?

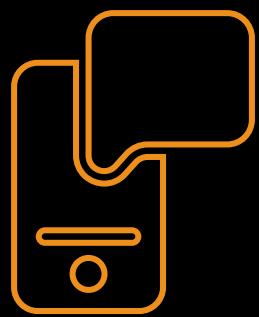
How does it work?

How should AI be used?

The following chapters delve into the dimensions and competencies associated with these 3 central questions, to contemplate education today in the era of digital technologies and AI.

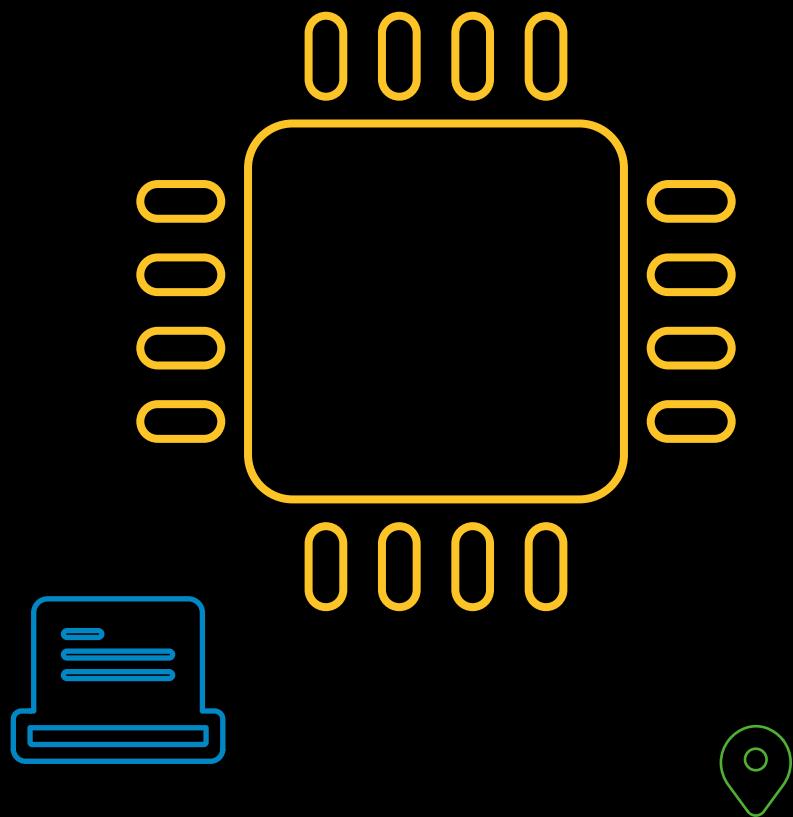


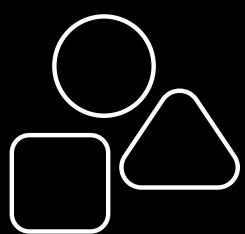
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Chapter 2

What is Artificial Intelligence?





What is Artificial Intelligence?

The term 'Artificial Intelligence' first appeared in 1956 at an academic meeting at Dartmouth College in the United States. Its origins trace back to the early days of computer science, but it would not be until several decades later that its use would become more widespread. In recent years, it has extended to other areas beyond academia, gaining increasing media presence.

While we may still be in the very early stages of what will be possible to see in the future with these technologies, current development has already produced various applications whose influence is becoming increasingly visible in our daily lives. Recommendation systems, text generation, image recognition, and computer vision are just a few examples in this line.

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What is Intelligence? How many are there?

To define AI, it is pertinent to first discuss the concept of intelligence. The definition in the Cambridge Dictionary³ reads: *the capacity for learning and problem-solving*, and includes other terms like ability, skill, or experience.

While this is the formal definition, it is not always applied in the same way in colloquial use, where other cultural aspects come into play. For example, it is more common to say that a person is intelligent if they can perform complex mental calculations than if they play football well. However, according to the dictionary definition, both cases would be examples where knowledge needs to be incorporated, certain skills need to be learned, and the task needs to be carried out skillfully.

³ <https://dictionary.cambridge.org/dictionary/english-spanish/intelligence>

If we explore the historical evolution of the concept of intelligence, according to Hermann Ebbinghaus, it is the ability to adapt to new situations, while for Alfred Binet it refers to specific attributes such as memory, perception, attention, and intellect. It was Binet who began the first formal attempts to measure intelligence through the Intelligence Quotient (IQ), and presented the first test in 1905 (Binet-Simon). Similarly, Charles Spearman introduced the notion of general intelligence (or factor G).

In 1985, Robert Sternberg distanced himself from these classic theories by proposing three categories of intelligence: analytical, creative, and practical skills. Subsequently, in 1995, Daniel Goleman popularized the concept of Emotional Intelligence. It is also necessary to mention Howard Gardner, who in 1993 presented the theory of Multiple Intelligences, identifying 7 types: logical-mathematical, linguistic, musical, spatial, intrapersonal, interpersonal or social, and bodily-kinesthetic.

This ambiguity regarding the conceptualization of intelligence becomes even more complex if we compare human intelligence with that of other living beings. Despite the great scientific advances made in the research on the topic, the differences and similarities remain an open debate that still generates interest and research.

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The very evolution of society and culture demands and fosters these changes in the way intelligence is valued. Ultimately, human intelligence is both a part and a product of a sociocultural accumulation, which has brought us to this present stage.

The artificiality of intelligence

The previous section illustrates a difficulty we face in defining AI, which partly corresponds to the inherent imprecision of the term 'intelligence'. In addition to this, there is also the evolution of the term over time, especially when it comes to something associated with scientific topics and linked to technological development.

Based on the above, we cannot expect to have a concrete and precise definition of AI, but we can define ideas about what the term commonly refers to, knowing that it can be something with fuzzy boundaries and that may continue to evolve.

Perhaps it is easier to start with the second part of the term, 'artificial', whose most appropriate meaning is the opposite of 'natural', that is, something false. This brings us quite close to the point we want to reach, which is precisely a false human intelligence. Interest is focused on replicating human intelligence, and its implementation is based on machines or computers and software programs. It is worth highlighting the existing paradox in this idea of being false or unnatural, as opposed to the human intelligence considered natural, because it is, after all, a human construction.

We can say that artificial intelligence is one that resembles human intelligence in some aspects, and therefore, we associate it with cognitive processes or functions related to perception, memory, association, learning, communication, reasoning, and problem-solving, but implemented through machines and computer languages. This is summarized in UNESCO's survey on AI curricula (UNESCO, 2023a), as 'machines that replicate certain characteristics of human intelligence'. 37

What does it mean for a machine to learn?

One of the most used terms associated with AI is what we call computational learning or machine learning. As the term implies, these are machines capable of learning; it is, therefore, important to explain what it means for a machine to learn.

For a computer to learn, three fundamental elements are necessary: data, computing power, and efficient algorithms.

First, it is necessary to provide the machine with information about the problem we want it to learn about. To achieve this, data must have certain characteristics. In one type of learning, data must be labeled, meaning it is not merely raw information but information accompanied by certain knowledge that we want the machine to incorporate.

For example, if we want a computer to distinguish between images of cats and dogs, on one hand, we will need examples of each of the categories. That is, we need images of cats and dogs, but also the corresponding label for each photo indicating whether it is a cat or a dog. Please note the relevance of human intervention at this stage, as knowledge is somehow transferred to the machine by annotating the data (the images) with the relevant information about the problem (dog/cat).

The other two components of learning are closely related. On the one hand, we need the machine to be able to perform many calculations in the shortest time possible, which means having greater computing power.

Why are all these calculations necessary? Because the way the computer learns is precisely by making a lot of calculations on the examples shown (the computer focuses on different features on the photos). In the example of cats and dogs, it could be the color and length of the fur, the color of the eyes, the length of the whiskers, or the length of the ears (which are represented as a series of numbers, something we will see in more detail in the next chapter). The computer must then evaluate which of them are useful when distinguishing between cats and dogs, something it can do using the set of labeled images used for learning. There is no single way to do this process, in which labeled data is used for the machine to learn. Again, human intervention is key, developing more efficient learning techniques each day, which allow the machine to make the most of the available data by performing the least number of calculations without impacting performance. Returning to the example of images of cats and dogs, the end result will be that the computer will be able to distinguish the new images shown, using the characteristics selected based on the previous examples used for learning.

Some aspects of machine learning are fundamental to understanding what AI is, but we will also revisit them in the next chapter, as we will delve into more details on how AI works. This illustrates the interrelation between the different dimensions proposed in the framework.

What can AI do?

To answer this question, we need to set a temporal horizon. Currently, we can say that there are various families of recognition problems where AI already achieves results comparable to or even better than humans. Some examples include: distinguishing whether a photo contains a cat or a dog, identifying all objects present in a scene, detecting a certain disease based on an X-ray image, or recognizing a person by their fingerprint.

All of these are examples of image recognition, where, from a sufficiently large labeled dataset, it is possible to teach a computer to solve such tasks. The same occurs in other domains, such as audio, video, text processing, time series of measurements like temperature, economic variables, or others. As long as the data show a pattern that can be identified and learned, it will be possible to do so with the current technology's capabilities. It is worth saying that this does not apply to all situations, and some of them will continue to be complex to overcome for machines, just as they are for humans. Some of these examples include weather prediction or the quotation of a certain currency.

All the aforementioned applications attend to a specific task. Therefore, these types of examples of AI are grouped under the concept of Narrow Artificial Intelligence. This is in contrast to what could be called *Artificial General Intelligence*⁴, that is, integrated systems capable of solving a wide variety of tasks, just like a human brain does. This is a topic of great debate and interest today. While most agree that it is something humanity has not yet managed to develop, it is discussed worldwide, both academically and industrially, how viable it would be and how far we are from achieving it. Especially with the new advances, the debate is revived because there are indications of systems that are trained for specific tasks but then manage to solve other tasks. Or also systems that could have a large control center, regulating different subsystems to perform specific tasks as demanded.

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⁴ Known in English as AGI

In recent years, another type of application has become popular, where the learned pattern is exploited to generate new data that replicate the same characteristics. In this way, it is possible to generate false images of a certain category (like our example: cats or dogs). This new branch has been called generative AI, and it is applied in various domains, such as audios, videos, and texts. Generalizing this even further, we can think that instead of a category, what is sought is to generate data based on a more complex description. This latter is what is currently called a prompt, and it consists of a phrase that describes the pattern we are looking for in the data to generate. For example, it is possible to generate images like the ones shown below (these images were generated with DALL-E 3⁵), with prompts such as:

Prompt: A portrait of a distinguished Uruguayan woman, symbolizing Ida Holz, a pioneer in the development of the Internet in Latin America. The scene is an office with a world map highlighting Latin America, a late 20th-century computer, and digital network motifs subtly integrated into the background. The woman is depicted with a kind and wise expression, conveying her leadership and spirit of collaboration.

⁵ Generative text-to-image AI tool within Copilot (Meta), created by OpenAI.



Figure 3. Example of generative AI from text to image

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What is AI?

Definitions and fundations

Reading between the lines of the previous paragraphs, it can be inferred that this dimension is associated with the initial contact with AI, which seeks to encompass basic concepts in a sort of introduction to the topic. Therefore, it is a dimension with a strong emphasis on the identification and recognition of AI. Additionally, the competencies associated with this dimension not only fall under the question 'What is AI?' but also under the question 'What can AI do?' (Long and Magerko, 2020).

Within this framework, the proposed AI approach has a significant active, exploratory, and experimental component, so it is important to emphasize the practical aspect of this dimension. This involves not only hands-on experience but also minds-on engagement. In other words, it goes beyond recognizing AI and logically has a close relationship with the principle of using active methodologies since it focuses more on **understanding** possible applications as a user and **experimenting** with them and the tools available.

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The other important element to emphasize is the relationship of AI's own definition to the **concepts of intelligence**, a discussion that also enriches the debate on what a machine must fulfill for us to consider it intelligent.

The specific competencies highlighted within this dimension are:

- Distinguishing between technological artifacts that use and do not use AI.
- Understanding systems that include AI components.
- Identifying the properties that differentiate an AI-based system from a rule-based system.
- Understanding the basic functions of AI. Grasping the basic concepts of how machine learning works.
- Using AI tools. Knowing and being able to use different applications that use AI as an end user, with a particular focus on generative or playful tools.
- Analyzing and critically discussing those characteristics that make an entity 'intelligent'.
- Distinguishing between general and narrow artificial intelligence.

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	<u>AI4K12</u>	<u>AI Literacy</u>
	Big Ideas  #1 Perception #2 Representation and Reasoning #3 Learning #4 Natural Interaction	Competencies #1 Recognizing AI #2 Understanding Intelligence #4 General versus Narrow

Classroom activities

Creating images

Challenging the group of students to create images using an artificial intelligence generator based on a theme being worked on in class.

Starting from an author, historical figure, or person of interest, revisit their story and some of their works or portraits. Students are asked to imagine how they would like to draw them based on what they know or are researching.

Think about their mood. Where are they? Do they have any objects that characterize them? Do they have any facial features that identify them?

They can be asked to draw them to emphasize visible aspects. With all the previous inputs, they will collectively or individually write a description of the image they want to create. Using a tool with AI for generating images from text, the task is to create the image based on the previous description.



For example: If the group is working with 'Ada Lovelace,' the following prompt can be generated: 'Ada Lovelace with a loom in the background, envisioning a computer.'

Figure 3. Images created by hotpot.ai/art-generator



The created images are shared, and someone from the group presents their experience during the creation.

Reflection is made on the following aspects:

- *Are the drawings made by the group the same as those created by the machine?*
- *Is there anything in the description they made that is not being shown?*
- *What did the machine consider when creating the images?*
- *What does the prompt mean in the tool used?*
- *If the tool is used again with the same description, is the output the same?*
- *To create the image they liked the most, how many times did they have to modify the description?*

Suggestions

If necessary, the person in charge of the group can do the writing on the computer.



AI Objectives

Use of generative AI tools.

Understanding the concept of prompts.

Approaching a definition of AI.



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Resources

Image generation from text:



[Craiyon](#)



[ImageFX](#)



[Designer](#)



[Copilot](#)

Examples of resources are given, but each teacher can use whatever they think is appropriate.

Classroom activities

Memory

Create your own version of the Memory Game, where matching cards are an image generated artificially along with its prompt.

The student group is asked to create an image using an AI image generator. Then, the prompt and the generated image are printed separately. To make it playable, it is necessary to generate at least 5 images.

An example of two images with their respective prompts is shown below:

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**Ada Lovelace with a
loom in the background,
envisioning a computer.**

Figure 4. Images created by hotpot.ai/art-generator

Once you have these cards printed, you can play Memory Game. Lay out all the cards face down and flip them over in pairs. If the prompt matches the image, the player takes the cards; if not, they are flipped back over.

Reflection can be made on the following aspects:

- *Can the image be easily distinguished from the text?*
- *What does the prompt mean in the image generation tool?*
- *What skills are used to relate the image to the text?*
- *What characteristics of the image are taken into account?*
- *Are there patterns that allow linking the image and the prompt?*



Suggestions

If necessary, the person in charge of the group can do the writing on the computer.



AI Objectives

Use of generative AI tools.

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Understanding the concept of prompts.



Resources

Image generation from text.

Classroom activities

Create your own story

Challenging students to create their own stories based on an image and then enhance them with generative AI tools.

Use an AI image generator to create an image of a landscape, a situation, an author being studied in class, or a historical figure. Show the image to the group and ask them to create a story based on the given image.

What are the texts like? Highlight the relevant characteristics based on what is being worked on: the type of text, spelling, accuracy of facts, creativity, and originality of the story.

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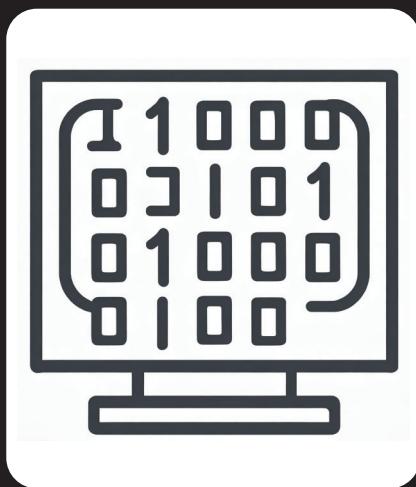
Then, ask the group of students to use AI text generation tools to create a new version of their stories. They can do this by copying the entire text and asking them to modify it based on some aspect (for example: changing the audience it is addressed to or the formality of the writing). They can also be asked to write the text without being given the previously created stories.

What is the chatbot answer like? Can it be further improved?

The chatbot's response may not be optimal on the first try; this process may require iterations to enhance the output.

Example using ChatGPT:

From the following image:

**Text created by a human:**

Computers understand only zeros and ones. This is binary code. For us, people, it's difficult to understand binary because it's a long code with many numbers. But the good thing about this type of representation is that it allows the machine to generate quick calculations.

User: Improve the following text so that a 5-year-old child can understand it:
Computers understand only zeros and ones. This is binary code. For us, people, it's difficult to understand binary because it's a long code with many numbers. But the good thing about this type of representation is that it allows machines to generate quick calculations.

ChatGPT: Computers have a very special language! They use only two numbers: zero and one, like a guessing game. Even though long numbers are difficult for us, computers are super fast with those zeros and ones! They help to do math very quickly!

Teams share the descriptions they generated and discuss the process of improving the output.

Reflection is made on the following aspects:

- *What instruction should be given to the tool to write a story similar to the one created by the students?*
- *What happens when the previously created text is provided?*
- *What does the prompt entered into the tool mean? What should the prompt be like for the results to be good?*
- *How do they relate the original image to the created story? Does the previous response serve as an example prompt for generating the text?*



Suggestions

Monitor the use of the chatbot to supervise the responses provided.



AI Objectives

Use of generative tools.
Understanding the concept of prompt.



Resources

Image generator from text.

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Conversational AI:



[ChatGPT](#)



[Claude](#)

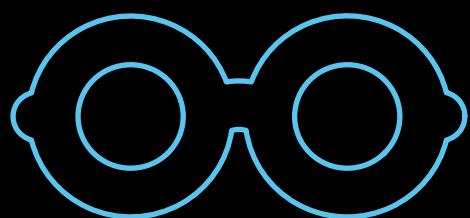


[Copilot](#)



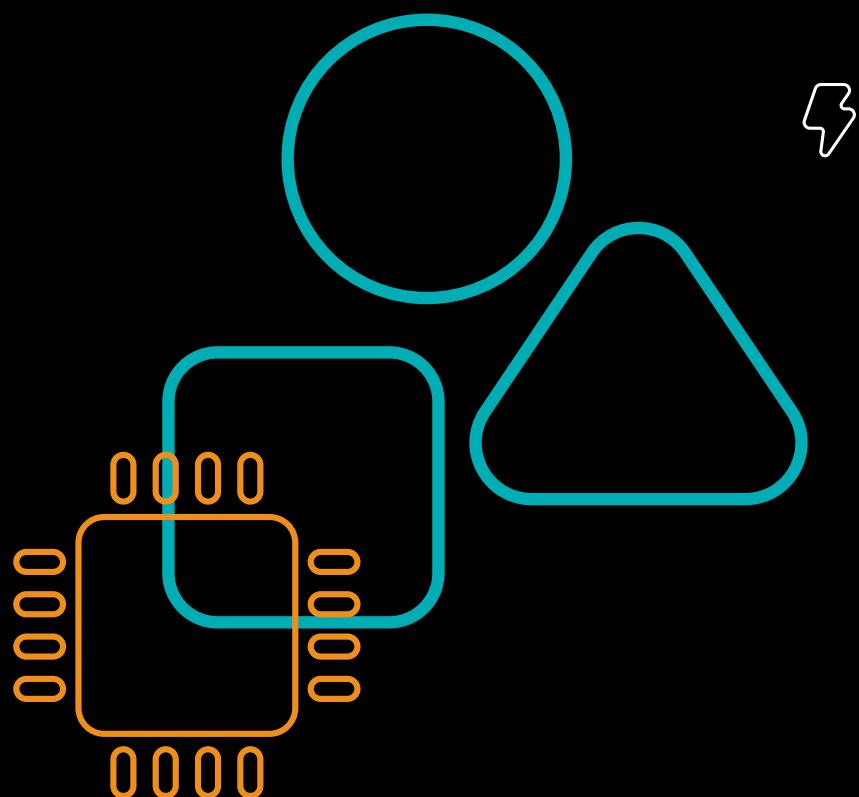
[Gemini](#)

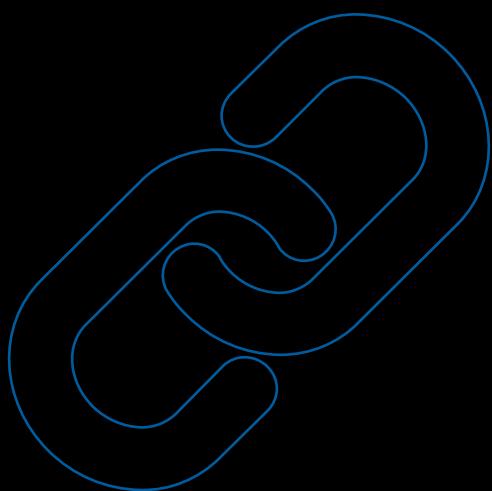
Examples of resources are given, but each teacher can use whatever they think is appropriate.



Chapter 3

How does AI work?





How does AI work?

As we saw earlier, one of the main components for generating artificial intelligence is the ability to make machines learn. For this, it is necessary to have three fundamental elements: data, computing power, and efficient algorithms.

We will see that some aspects of AI resemble the way humans learn. This learning is based on examples we see, hear, or feel throughout our lives, and certain knowledge associated with those examples that someone or something indicates to us (it could be another person, a book, a video). In the case of AI, it is humans who directly or indirectly contribute with that knowledge. In this chapter, we will seek to deepen this key process for the functioning of AI.

In general, we can distinguish three well-differentiated stages, in which we can iterate in general:

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- **Definition of the problem and the dataset**
- **Training or learning**
- **Evaluation and adjustments**

First, the definition of the problem and the dataset. Then comes the training or learning process, which corresponds to how the machine is able to incorporate knowledge about the specific problem. Typically, this involves using what was defined in the previous step, what we call labeled data. That is, examples of the type of data the system should work with, along with the relevant knowledge for the task the machine is intended to solve. To revisit the example from the previous chapter of classifying images of cats and dogs, the data in this case are precisely the images, while the knowledge for each one corresponds to the label

indicating whether the image is of a cat or a dog. Later on, we will see how this information, that is, the data plus the labels, is used for the computer to learn about the specific task.

Once the training is completed, that is, when we reach the point where we can say the machine has learned, we have the other relevant stage of the process, which corresponds to evaluating the system with new data. The goal of this stage is to estimate what performance the machine will have in solving the task when faced with data it did not see during training. Continuing with the previous example, the aim is to estimate the percentage of correct detection of cats and dogs when processing new images. To do this, it is necessary to again have labeled data, as we need to know the correct label in each case to identify if the machine is giving the correct output or not. Additionally, it is important to highlight that these data should not have been used previously for learning, as in that case, the machine would have already seen them before and thus it would be easier for it to indicate the correct output.

To delve deeper into the analysis of how this machine learning process works, we will first see how computers perceive and represent information, and how humans provide the necessary knowledge for them to learn. Then, once machines have the necessary data and knowledge, we will see how it is possible for them to learn, that is, to generate mechanisms to solve a problem based on the examples previously shown.

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How is the artificial world represented and understood?

The data used by a machine or a computer to solve a task is closely related to how it perceives the world. Just like humans have different senses that allow us to see, hear, or touch, computers usually have sensors or inputs that enable them to gather information from the world. This information must be represented in machine language, which is usually numerical. This means that the representation the computer makes of things, its model of the world, is always based on numbers, which depending on the type of data, can represent a letter, a color, a higher or lower pitched sound, and even a cat or a dog.



This representation allows machines to work with a wide variety of data types, which are often associated with different sensors, just as humans have different senses. Depending on the type of data, we often distinguish different branches of AI applications, such as computer vision, which deals with tasks involving images or videos, or natural language processing, an area of study associated with problems that involve the analysis and interpretation of texts in the various languages humans use. Our example of cats and dogs would be a problem in the field of computer vision, while text translation would be a typical task associated with natural language processing.

However, having only the data and its computational representation is not enough for machines to learn. To do this, it is necessary to associate the available data with the knowledge required to carry out the task. As mentioned earlier, in the case of images, we must accumulate several examples with their corresponding labels (e.g., cat or dog). Similarly, in the case of a translator, it is necessary to have multiple words, phrases, sentences, or even entire bilingual documents.

This same idea is now further complicated since generative AI systems have multimodal capabilities, that is, systems that integrate different types of data such as text, images, audio, and video. In this case, the databases used are much more complex than simply a set of images labeled as cats or dogs. Think of large datasets of images and their respective descriptions, one or multiple sentences describing the content of each image. These types of databases are necessary to build, for example, systems that generate images from text or, conversely, systems that, from an image, can generate a textual description of what is observed.

What do we teach computers? The human role in defining representation and learning

The machine learning process involves multiple human interventions, which are crucial for AI. The most fundamental intervention is to define the problem being addressed⁶. This determines various aspects, such

⁶ This does not mean that some technologies designed for one problem cannot be applied to solve others. This is the case with transformer architecture, which was originally conceived for translation but today serves as the foundation for Large Language Models (LLMs) used in text generation.

as the type of data needed and the possible outcomes. In the example of images of cats and dogs, it is a task that must work with data corresponding to images and where the machine's output is expected to be one of two possible options, in this case indicating whether the image is of a cat or dog.

Once the problem is defined, as mentioned earlier, labeled data is required. That is, we need examples, typically a few hundred or thousand examples, of data similar⁷ to what the machine will need to use to solve the task. Obviously, collecting this data is also a human task, but even more so is adding the necessary knowledge to each example, as we mentioned earlier. Machine learning requires the addition of the knowledge necessary to solve the task, indicating for each example what the output should be.

To further ground these ideas, let's continue with the example of classifying or distinguishing cats from dogs. In practical terms, the data are images represented on a computer as a series of numbers indicating the color of each portion of the image (which is usually divided into small squares called pixels). That is, the information the computer is provided with to learn the concept of cat and dog is nothing more than a sequence of numbers associated with each of the images that we, humans, indicate correspond to one category or another.

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Figure 5. Example of a labeled image, with its corresponding computational representation as a vector of numbers.

⁷ Similar, but not identical, and generally varied examples.

The training data could be something like the following (probably with more numbers for each image):

3, 2, 5, 8 → dog	2, 3, 5, 4 → cat	1, 5, 4, 7 → dog
2, 1, 2, 5 → cat	7, 9, 2, 2 → dog	1, 2, 5, 4 → cat
5, 4, 4, 9 → cat	2, 5, 4, 6 → cat	8, 6, 6, 7 → dog

So, it is fair to say that the machine only knows about the concept of a cat or the concept of a dog from the example numbers provided, representing the values of each part of the images for one category and the other. It does not know they are animals, it does not know they have four legs; it only knows that there are sets of numbers corresponding to images belonging to one class and other sets corresponding to other one. The computational representation of a dog or a cat is limited to these characteristics given by those numbers.⁸

This process of teaching the computer is therefore different from what we were accustomed to in programming. In the next chapter, we will delve into the difference between traditional programming and machine learning, but it is worth mentioning that traditional machine programming is associated with providing a series of rules, steps to follow—what we call algorithms—to carry out a certain task. In the case of machine learning, the process is different: we define the problem, in this example, a classification between cats and dogs, we define concepts to label each category (knowledge is indicated as cat or a dog), and we show examples from one category and another.

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Finally, there is a third and last key aspect where human intervention is essential, which is to instruct the machine on the steps to follow to learn. Note that this resembles traditional programming; we instruct the machine on steps to follow, algorithms, but not with the goal of solving the task, but in this case to learn from the data and find the best way to solve the task. In this case, the goal is for the machine to obtain, by trying different options, the best rules or steps to solve the task, based on the examples. In the next section, the process will be explained.

⁸ They can be quite complex, as the representation of each concept can be in multi-dimensional spaces.

How can a computer learn? Machine Learning

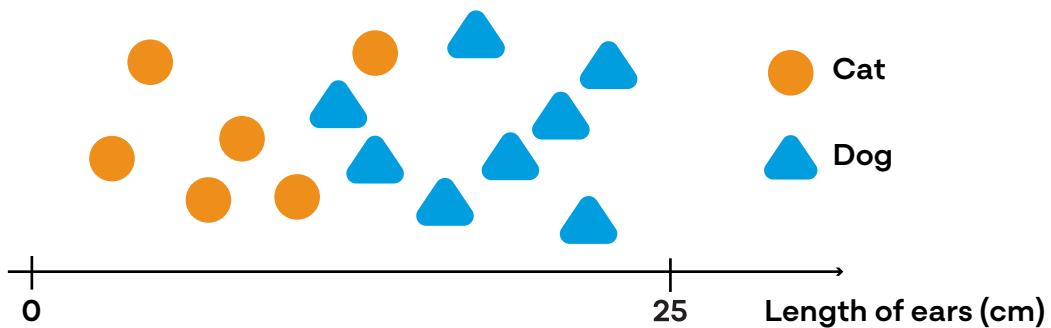
Although the goal of this section is not to delve into the algorithms that actually allow machines to learn how to solve different tasks and problems, we will illustrate how this can work. Let's continue with our example of cats and dogs. We had seen that for the machine, each of these concepts was associated with a series of examples, represented as a sequence of numbers for each image. In this case, we will simplify the process to explain what it means for a machine to learn and how it can carry out such a task.

The simplification consists of reducing each example image, each sequence of numbers, to a single number in this case, corresponding to the measurement of the length of the animal's ears in each image. This will allow us to more easily illustrate the learning process and the different possible algorithms that humans could instruct the computer to learn from.

Firstly, it is worth noting that if the representation of each image is reduced to a single number, this means that the machine will have to learn from these numbers, and in the case of a new image, it will have to decide to which category it belongs, based precisely on that single number.

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Suppose that normally dogs have larger ears than cats. We can consider that the set of training images is distributed as shown in the following figure:



All the images represented by circles and triangles should be on the axis; they are shown in this fashion for better visualization. In this representation, we can clearly see that cats' ears are shorter than dogs' (circles are grouped more towards 0 and triangles more towards 25).

So, how could the computer solve the task for new images? One possible answer, based on these examples, is: What is the value of the ear length that best separates both categories? Thus, new images below this value will be identified as cats, and conversely, when they are above this value, they will be identified as dogs. In other words, making the machine learn boils down to finding an optimal value, a number, that best separates the two classes of the defined problem.

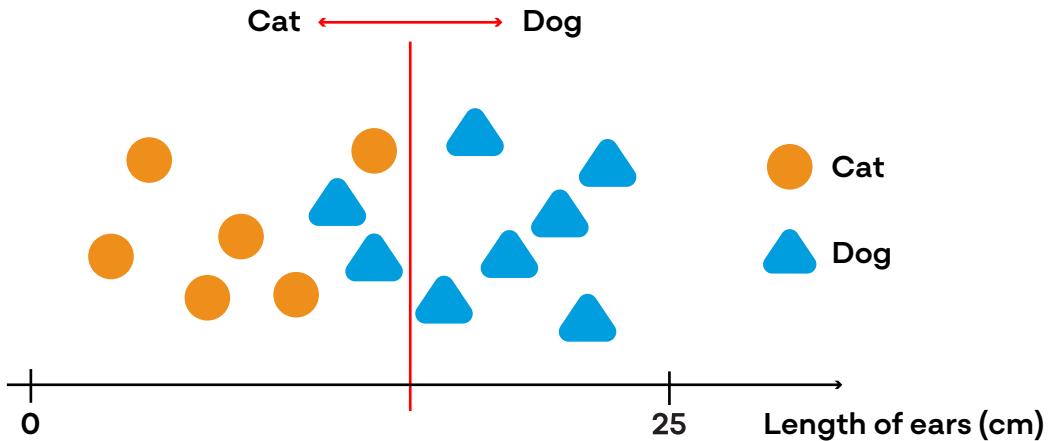
To find this number, we need to state two things. Firstly, as mentioned at the beginning, calculations will be necessary. Secondly, it is possible to instruct the machine on different steps to follow, that is, different algorithms, to find this optimal value. While all of them will require calculations, perhaps some will require more than others, and maybe not all will achieve the same result (meaning some may learn better than others). When we mentioned looking for efficient learning algorithms at the outset, we precisely meant those that require few calculations and also learn as effectively as possible.

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Let's see some examples to make this idea more concrete.

One option to find the optimal value is to order the images based on the ears' length of the examples and see which is the largest value for cats. Note that ordering requires calculations, in this case comparisons to see if one number is greater or less than another⁹. When we have the largest value, we set a slightly higher number as the threshold to separate both categories. This would result in the following training data image.

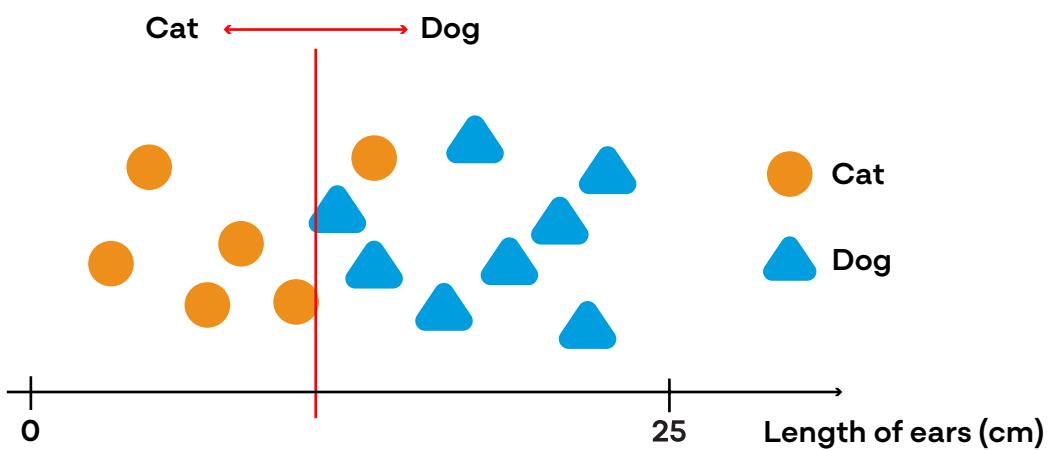
⁹ In this case, each of the images of dogs and cats has already been ordered to represent them on the axis.



In the image, we can notice that there are two examples of dogs from the training set that are misclassified (the triangles to the left of the dividing line), while all the examples of cats are classified correctly. This illustrates an important point to highlight about AI, which is that systems based on machine learning are not infallible. Depending on various characteristics of the learning process, the chances of making mistakes will be greater or lesser, but there will always be a probability that the machine fails when attempting to solve the task since the outcome is not deterministic.

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Now let's compare the learning algorithm we used previously with another slightly different one. Again, we consider examples of images ordered according to ear length, but in this case, we will take the value of the dog whose ear length is the smallest and use a slightly lower number as the optimal value to differentiate both categories, as shown in the following figure.



In this case, we can see that all the dog images are classified correctly, while there is only one cat image misclassified. We can say that this learning method is better than the previous one since the error is lower (one misclassified image instead of two).

The number of computations required in one case and the other does not show significant differences in this example, but there could be other cases where this also occurs, and therefore not only the error obtained but also the number of computations to achieve optimal learning would be taken into account in the comparison.

The previous example illustrates in a simplified way what we call machine learning or automatic learning, a process through which the computer is able to find the best way to solve a problem based on a set of examples shown. It is important to note that learning for a machine ends up being about finding optimal numbers, in our example only one value, but in other more complex cases, many, thousands, millions, or even billions. At the end of this chapter, we will discuss how with this same idea from the example of cats and dogs, we can get an idea of what is behind more complex systems like ChatGPT.

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Different Types of Machine Learning

Throughout the chapter, we have always talked about learning based on labeled data, and to solve a specific decision (e.g., indicating whether an image corresponds to a cat or a dog). Within AI, and particularly within machine learning, this is known as supervised learning. It is worth mentioning that this is not the only possible form of machine learning, and there are two other major branches that we will discuss below: unsupervised learning and reinforcement learning.

Unsupervised learning, as the name suggests, refers to cases where we do not have labels, but only data from which to generate knowledge. One of the most relevant applications associated with this type of learning is known as clustering. As described by Escudero (2019) in his book 'Big Data,' we can think of this problem as organizing the objects we have in the second drawer of the kitchen, where there are two screws, a lid,

three rubber bands, a nut that does not match any of the screws, and so on, a long list of objects with no clear relationship between them. Therefore, how would we group them if they do not have much to do with each other? What aspects should we consider? In general, what we do is use different characteristics, such as size, color, or purpose to form different groups. This grouping is not unique, and different people may group the objects in different ways. The same applies to different clustering methods, which can also yield different results. Therefore, once the groups are obtained through unsupervised learning, there is subsequent human work that is relevant for interpreting the obtained sets.

Reinforcement learning, unlike the previous types, is applied to problems that require continuous task-solving, meaning that not only a decision is needed but a sequence of decisions. Typical examples of this case are games, such as tic-tac-toe, chess, or any other game where multiple possible moves must be chosen at each turn until the end of the game. In these cases, there is usually a somewhat different model, where, at each decision by the machine, which we call action, there is a certain reward, determined by the action taken and by the situation of the system at that moment, known as 'state' (for example, the state of the chessboard when making a move).

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The goal in these types of problems is to find a decision-making mechanism that, at each moment, takes the action that maximizes the chances of obtaining the highest cumulative reward over time, or at the end. For example, in the case of games like tic-tac-toe, chess, or others, the goal is for each move selected to be the one that offers the highest probability of winning the game at each given moment.



From recognizing cats and dogs to building ChatGPT

Recently, ChatGPT is one of the AI applications that has gained the most popularity. It is an interactive chat system where the user inputs text and receives text in response¹⁰. Some examples have surprised users (e.g., asking it to write a story or a song about a specific topic or using certain words), while others have disappointed them (e.g., asking for logical reasoning or requesting to perform simple mathematical calculations described to it in words).

How is it possible to build a system as complex as ChatGPT? The detailed answer is beyond the scope of this book, especially since some aspects have not been publicly disclosed, and it is a product in continuous development. But what we can say is that everything we discussed in this chapter is involved: a vast amount of data, significant human intervention labeling correct and incorrect responses, and a lot of calculations and computers involved in performing them.

In general terms, we can think of ChatGPT as a large-scale text completion system, much like the predictive keyboard on a cell phone offers the next word, but on a much larger scale (for example, being able to write a complete story from just a guiding sentence, known as the prompt). How does the phrase 'Los de afuera son de ____' end¹¹? Anyone familiar with the story of the 1950 Maracanã final will have no trouble completing the sentence. However, for those who are not from Uruguay or lack a passion for football, it may take a bit longer to fill in the blank—though likely with a different word.

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Let's imagine that we can gather all the texts available on the internet. That is, all the information from Wikipedia, news portals, pages from different countries, from Ceibal Biblioteca País, among many others. Although this information is not labeled, it follows the patterns of the language in which each text has been written. This allows us to formulate a supervised learning problem, simply by randomly masking words, to build what is known as a Large Language Model (LLM for its acronym in English, corresponding to the GPT component in the case of ChatGPT).

¹⁰ In recent versions, they also include other modalities such as images and audio.
¹¹ The famous phrase by Obdulio 'el negro jefe' Varela, Uruguayan football player during the *Maracanazo* in 1950.

In the following image, we see an example of a distribution of the proportions of words that could complete the phrase from Zitarrosa's song most meaningfully for this language model¹². The AI model could complete the verses as '*Dice mi padre que ya llegará / Desde el fondo del tiempo otro ___*'¹³ with the following list of words.



In this case, the AI would use the word 'day' because it has a higher proportion within the model (unlike Zitarrosa, who used 'time').

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Even though large language models differ considerably from the example we saw before of images of cats and dogs, in both cases the machine must make a decision among several possible options to predict the missing text or word. Conceptually, the idea is similar, but now the decision is more complex, and the options are not just two as in the case of cats and dogs. The language model must choose which word or words are most suitable to complete the request. In this sense, the learning process will also be marked by estimating a lot of numbers, which we commonly call model parameters. In the example we showed earlier based on the length of the ears, the problem was reduced to finding only one number that marked the boundary between both classes. In a system like ChatGPT, the amount of numbers is a bit larger, with over 175 million parameters (GPT-3.5), and in the case of its successor, GPT-4, it is said to have 1.76 billion parameters.

12 Example web application where we can see an example of this problem, where the objective for each prompt is to discover the hidden word. https://huggingface.co/spaces/CeibalUY/enmascaramiento_lenguaje

13 *Adagio en mi país*. Alfredo Zitarrosa

A model of such magnitude, where such a large number of parameters must be learned, clearly requires a lot of computational power to find the best parameters. This highlights the importance of processors in the development of AI that make it possible to perform more calculations per second every day. Additionally, advances in machine learning algorithms are also crucial, allowing training processes to be carried out with the fewest possible calculations.

In the case of ChatGPT or similar conversational applications, there is also an extra stage that is very relevant in the construction of the system, which corresponds to human intervention that labels a set of questions and answers, indicating which ones are accurate and which are not. This fine-tunes the system, that is, the millions of parameters, so that the outputs align with the labeled examples of correct inputs and outputs.

How does the AI work?

There are two dimensions closely related to the question of how AI is constructed and functions. In this sense, these dimensions delve into the fundamental concepts behind the more technical aspects of the field (the use, understanding, and development of AI techniques at different levels of complexity).

Representation of knowledge

The first dimension regarding the functioning of AI, as mentioned earlier, deals with the computational representation of knowledge. In other words, we aim to answer the question of how knowledge is modeled in a computer, and which its model of the world is. It involves working with **data, sensors, representations**, and analyzing the **human role** in definitions associated with these elements (Long & Magerko, 2020; Olari & Romeike, 2021).

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The specific competencies to be promoted within this dimension are:

- Understanding basic concepts about data types.
- Gathering relevant information from a dataset for further processing with AI-based tools.
- Visualizing data using AI Algorithms.
- Recognizing that different sensors generate different data and identifying sensors in different devices.
- Understanding that computers perceive the world using sensors.

- Identifying different computational representations of knowledge and describing some examples.
- Explaining results, including errors, when analyzing responses provided by AI, and challenging them with questions.
- Recognizing the key role played by individuals in the computational representation of knowledge in AI-based solutions.

	AI4K12	AI Literacy
	Big Ideas	Competencies
	#1 Perception #2 Representation and Reasoning #4 Natural Interaction	#7 Representations #10 Human Role in AI #11 Data Literacy #15 Sensors

Machine Learning

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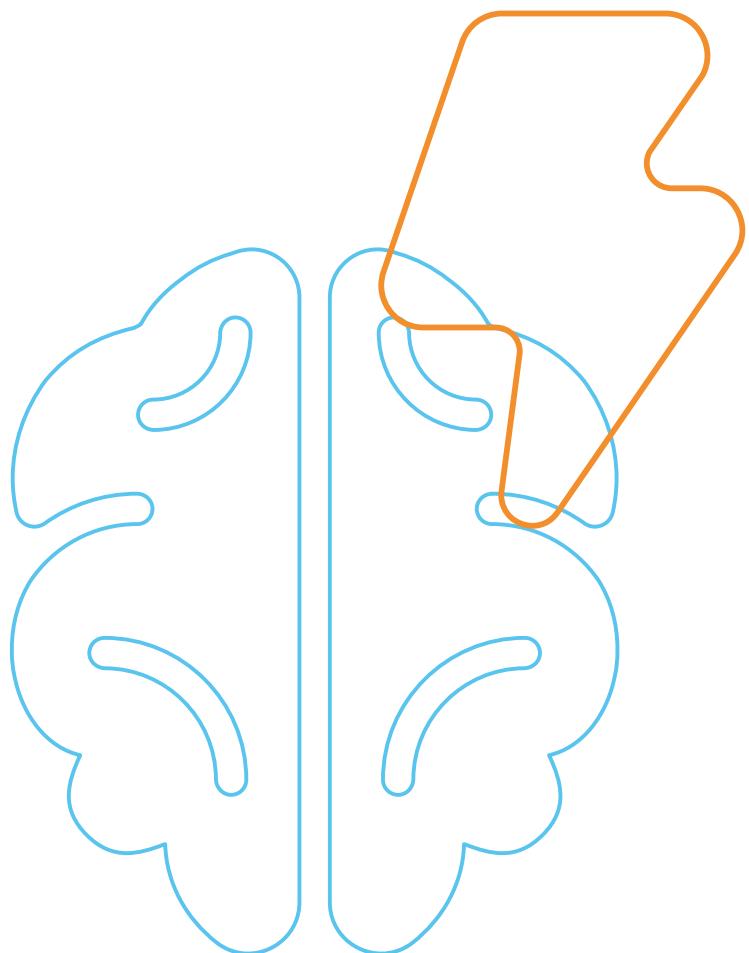
The second dimension associated with the functioning of AI focuses on computational learning, that is, the mechanisms that allow a computer to learn. It involves defining a specific task and using algorithms for machines to acquire the necessary knowledge to solve it satisfactorily.

Within computational learning, learning from data stands out, which includes the analysis and processing of large volumes of information to extract relevant patterns and knowledge. Through **machine learning**, machines are capable of autonomously **learning from data**, identifying regularities, and generating predictive or descriptive models. **Programming** plays a fundamental role as it allows the implementation of learning algorithms and the development of intelligent solutions. Additionally, the human role in defining tasks, evaluating results, interpreting models, and the ethical responsibility in the use of AI must be considered (Kim et al., 2021; Long and Magerko, 2020; Ng et al., 2021; Sentence and Waite, 2002).

The specific competencies to promote within this dimension are:

- Acknowledging that computers are capable of learning from data, including their own data.
 - Describing how training data can affect the results of an AI algorithm.
 - Recognizing and describing examples of how a computer reasons and makes decisions. Understanding the simulation of the human logical reasoning process with a computer model.
 - Understanding the process of machine learning, as well as the associated practices and challenges it entails.
 - Understanding that computers are programmable agents to which tasks can be assigned through a sequence of code.
 - Designing and programming applications that use AI. Evaluating, predicting, and designing using AI applications.
- 70
- Exploring models created by others. Remixing or reusing code.
 - Acknowledging that people play a key role in programming, model selection, and fine-tuning of AI systems.

	AI4K12	AI Literacy
	Big Ideas	Competencies
	#2 Representation and Reasoning #3 Learning #4 Natural Interaction	#8 Decision Making #9 Steps of Machine Learning #10 Human Role in AI #12 Learning from Data #13 Critical Interpretation of Data #14 Action and Reaction #17 Programmability



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Classroom activities

Smile, you are being trained

Challenge the group to train their own machine learning model to classify images.

Using Teachable Machine¹⁴, we propose creating an Image Project.

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Primeros pasos



Proyecto de imagen

Realiza la preparación con imágenes de archivos o de la webcam.

Modelo de imagen estándar

Ideal para la mayoría de usos
Imágenes a color de 224 x 224 px
Exportar a TensorFlow, TFLite y TF.js
Tamaño del modelo: alrededor de 5 MB

To describe the activity and as an example, we will create a model that distinguishes whether a person is smiling or not. Therefore, we will create two classes: 'Smile Detected' and 'No Smile Detected.' Thus, the defined problem is to create a smile detector. Now we need a dataset with the corresponding label to build the computer's representation of Smile and No Smile.

14 <https://teachablemachine.withgoogle.com/>

Sonrisa detectada 



Añadir muestras de imágenes:

 Webcam

 Subir

No se detecta sonrisa 



Añadir muestras de imágenes:

 Webcam

 Subir

To include the images, you can use photos or the camera. To take multiple captures, hold down the button.

Sonrisa detectada 

Webcam 



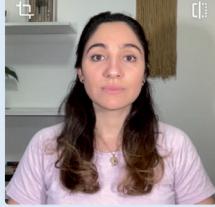
Grabar 6 segundos

125 muestras de imágenes



No se detecta sonrisa 

Webcam 



Grabar 6 segundos

Añadir muestras de imágenes:

After defining the problem and the dataset, the model is trained, and performance tested.

What happens when you test it in the same place where it was trained? And what if someone else tests it?

Challenge the model by changing the scene, wearing glasses, changing hairstyle to see if the prediction remains the same. You can export the models to avoid seeing the photos with which they were created.

Share the models to identify flaws and improve them.
Guiding questions:

- *How can we improve the model's response?*
- *Is the amount of data important for creation?*
- *What could we do if we want it to work for the entire class?*
- *What other ideas for image recognition do you have?*



Suggestions

Provide context that could be a real problem for the group. Complexify the model and reflect together on the representation while training.



AI Objectives

Understand the machine learning process, as well as associated practices and challenges it entails.



Resources



[Teachable Machine](#)

Classroom activities

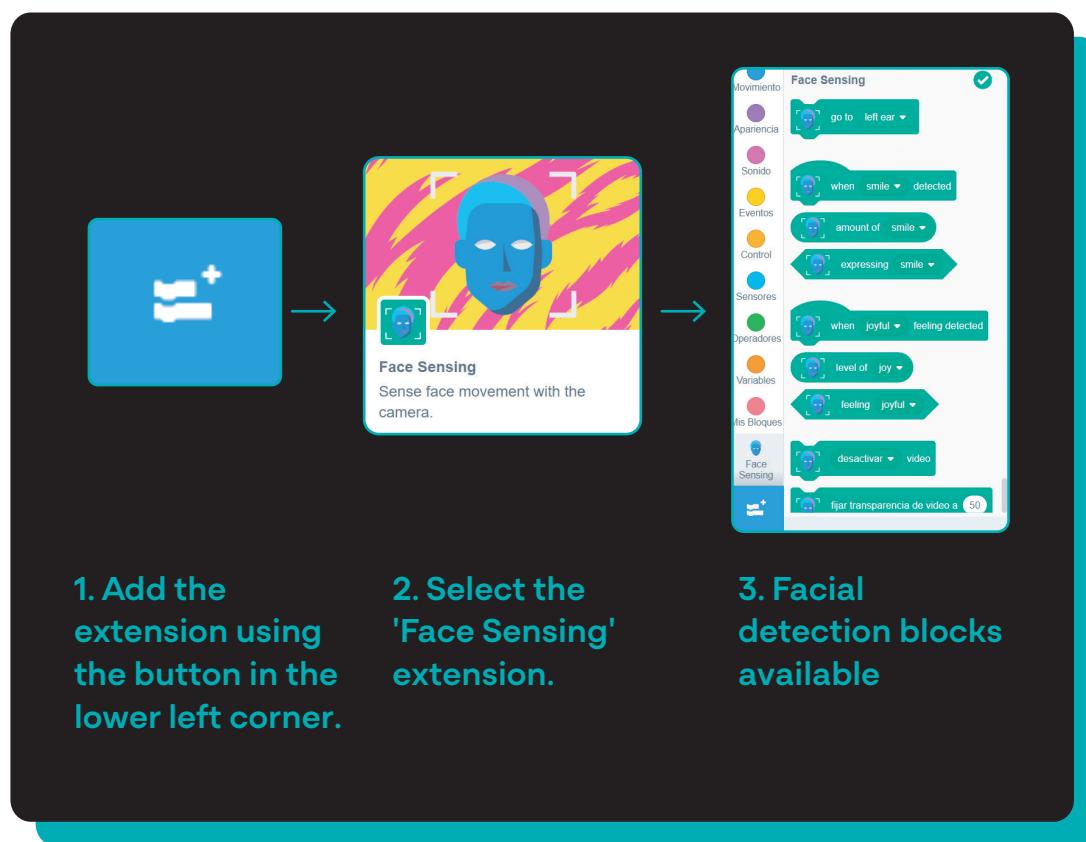
Animating emotions

Program a character to act according to facial recognition.

At the beginning of the activity, we introduce the PoseBlocks programming tool¹⁵ and challenge the group to explore it, particularly its extensions. If the group has experience with programming in Scratch, we can suggest comparing similarities and differences between this and Scratch.

To access the facial recognition blocks, follow these steps:

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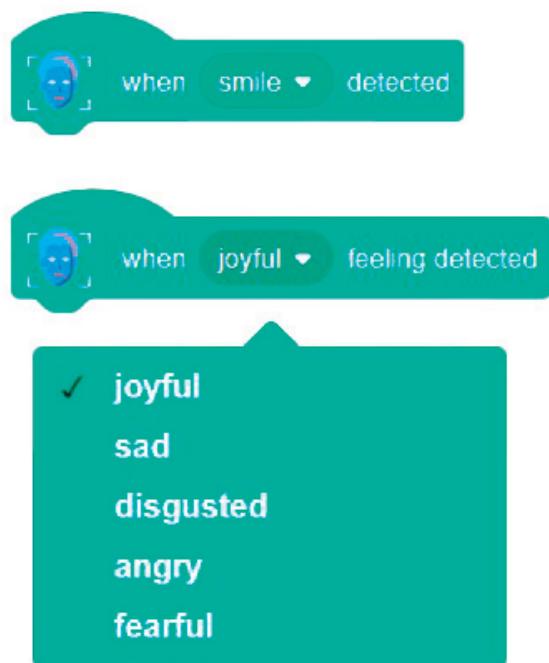


¹⁵ <https://playground.raise.mit.edu/create/>

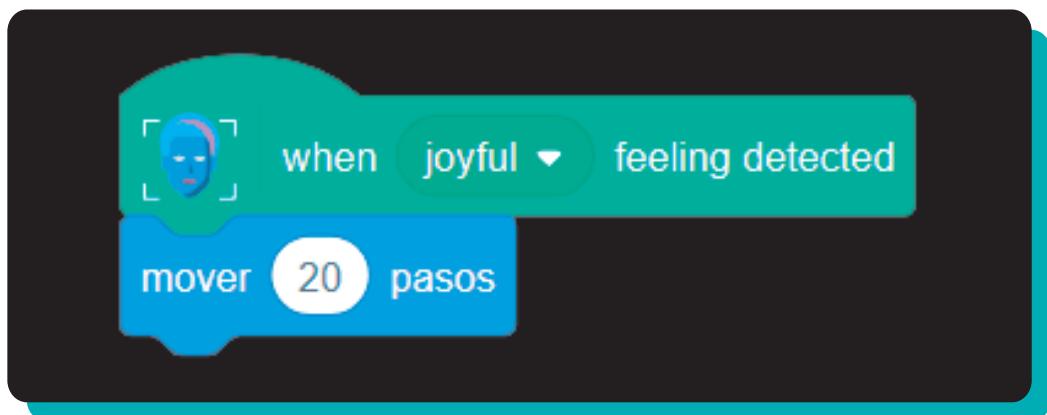
Ask students to explore the blocks, identifying what they do. In the case of detecting *happiness*, you can use the block that refers to feelings or smiles. Follow a similar procedure for other emotions.

After the guided exploration, the group of students is proposed to create a program that moves a character when it detects an emotion, for example: happiness.

The following could be a possible program:



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Include complexity to the program created according to the experience and motivation of the group; you can ask them to add another character and explore other blocks.

Share the programs so that each student can try other creations. Then propose reflection, based on questions:

- *How does the computer detect that we are happy, sad, or angry? What sensor allows it to recognize us?*
- *How do you think these facial detection blocks were built? How many people have to stand happily in front of the camera for the computer to detect our emotions?*
- *Do you know any other application that detects our faces? Have you used filters for images? What do you know about these image filters used by some social networks?*



Suggestions

Prior knowledge of programming in Scratch. Work together with English since the blocks cannot be translated into Spanish.

Complexify the behavior of the character in Scratch and reflect together with the group on how the model was trained.



AI Objectives

Understanding that computers are programmable agents to which tasks can be indicated through a sequence of code.

Recognizing and describing examples of how a computer reasons and makes decisions.



Resources



[PoseBlocks](#)

Classroom activities

What word is missing?

Testing an artificial intelligence model to find the missing word in a sentence.

Take a sentence from an author, book, or topic you are working on in class. Remove a word from the sentence, let's take an example from Don Quixote.¹⁶

'In a village of La Mancha, the name of which I have no desire to call to mind, there lived not long since one of those who keep a lance on the rack, an _____ shield, a skinny nag and a swift greyhound.'

Ask the students to complete the missing word. What words appear? Can any word go in that space? Does any word repeat? Why might the author have chosen those words and not others? What would you have chosen and why?

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Use Word Masking¹⁷ to see the distribution of words that can fill the blank. In the example from Cervantes, the prompt would be:

'In a village of La Mancha, the name of which I have no desire to call to mind, there lived not long one of those gentlemen that keep a lance on the rack, an [MASK] shield, a skinny nag and a swift greyhound.'

The words that appear are: oval, ancient, old, unbreakable.

¹⁶ Disponible en Biblioteca País de Ceibal:
<https://bibliotecapais.ceibal.edu.uy/info/don-quijote-de-la-mancha-00019362>

¹⁷ https://huggingface.co/models?pipeline_tag=fill-mask&sort=trending

Are the words from the resource similar to those given by the group? If it's a well-known phrase, like the example, does the actual word appear in the resource?

Explore the resource further using the same sentence and hiding different words.

Reflect with the group on the following questions:

- *How do you think percentages shown are calculated?*
- *Do we humans do something similar when completing sentences?*
- *If the machine, using AI, completes sentences in this way, does it always tell the truth?*
- *How can we make the percentages displayed change?*



Suggestions

It requires proficiency in reading and writing.



AI Objectives

Using tools with AI.

Understanding the functionality of AI.

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Introduction to the concept of generative AI.



Resources



[Word Masking](#)

Classroom activities

Similar phrases

Compare the similarity of different sentences using an AI model.

Following the idea of the previous activity. Take a sentence from an author, book, or topic you are working on in class. Let's take as an example a part of a sentence from the book *Don Quixote de la Mancha*¹⁸:

'In a village of La Mancha, the name of which I have no desire to call to mind,'

Ask the students to write a sentence similar to the previous one. What does 'similar sentences' mean? What characteristics do they need to have to be considered similar? Do sentences repeat within the group?

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Use Similarity of Phrases¹⁹ to see the resemblance in terms of percentage for each sentence, and copy some examples from the group. In the example we write:

- '*In a village of Uruguay, the name of which I have no desire to call to mind'*
- '*I don't remember the name of the place where this happened.'*
- '*I don't want to remember the name of the place in La Mancha'*

Which of all the phrases obtains the highest percentage of similarity?

¹⁸ Available at Ceibal's Biblioteca País: <https://bibliotecapais.ceibal.edu.uy/info/don-quijote-de-la-mancha-0001936>

¹⁹ https://huggingface.co/spaces/CeibaUY/similaridad_frases

Allow the group to use different phrases, taken from the same source or wherever is relevant for the exercise.

Reflect with the group on the following questions:

- *How do you think percentages shown are calculated?*
- *Do we, humans, do something similar when we think two sentences are similar?*
- *If two sentences are similar, can I use them interchangeably?*
- *When do you think people do something similar? For example, reading a text and summarizing it, or when someone doesn't understand something and I have to explain it in a different way, can you think of other examples?*



Suggestions

It requires the group of students to have proficiency in reading and writing.



AI Objectives

Use of AI tools.

Approach to how AI works.

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Introduction to the concept of generative AI.



Resources



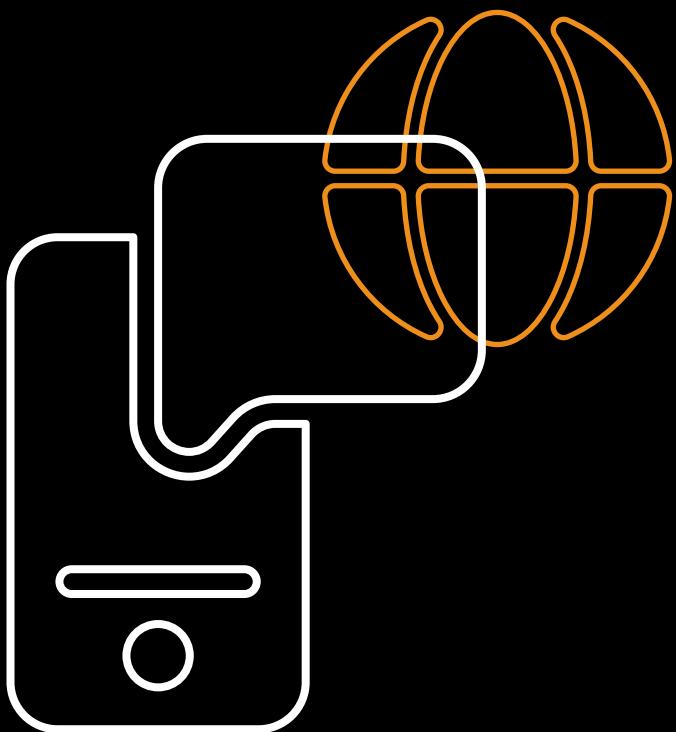
[Similarity of phrases](#)

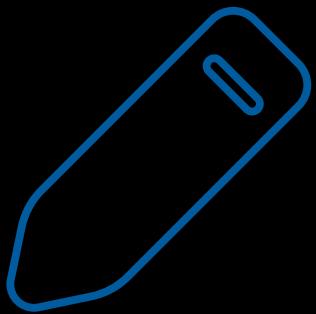
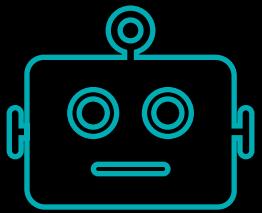
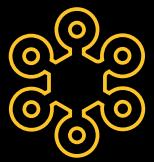


Chapter 4.1

How to use AI?

Computational
approach





AI: how to **use it**, and **what to use it for**

After describing, in broad terms, the fundamentals of AI, we face the third and final big question addressed in the book, How can AI be used-What can we use it for? The answer is divided into two aspects (presented in two chapters) fundamental to explain what we seek to achieve with the incorporation of AI into the educational system. The two sides of the coin are: how can we do it? and what effects and consequences may it have? While considering possible impacts is inherent to problem-solving, ethical reflection can also occur independently. This chapter addresses the first component and describes how to resolve this type of problem.

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The potential of computers

With the increasing impact of AI, it becomes more relevant to promote critical thinking and creativity to foster lifelong learning and prepare citizens for the challenges involving these algorithms. In this sense, the link we create between students and computer science is crucial. Because it can promote participatory approaches that allow demystifying AI and developing ethical awareness to make informed decisions in their social and professional activities (Romero, 2023).

Hence the idea of many countries to consider computer science and its systematic incorporation into the classroom, with computational thinking at its core, as in the case of Uruguay through Ceibal²⁰. Computational thinking involves problem-solving, critical and creative thinking, and skills for making informed decisions in this complex and dynamic AI world. This gives rise to frameworks and approaches that promote the analysis and empathetic reflections of diverse situations, a variety of representations, and the operationalization of solutions by engaging metacognitive strategies associated with computational thinking (Romero, 2023). We conceive the computational approach under this umbrella, while recognizing that some views of computational thinking focused on traditional programming need to be readjusted (Tedre et al., 2021b).

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Computational thinking

When we talk about the computational approach, we consider some characteristics that make certain valuable types of thinking visible. Computational thinking is essentially based on the creation of artifacts that externalize and materialize human ideas in a way that computers can interpret and process (Kong & Abelson, 2019).

²⁰ PC and AI program: pensamientocomputacional.ceibal.edu.uy

Thus, computational thinking involves both problem-solving processes and processes of expression and creation of language that enable and facilitate the creation of these external artifacts mentioned above.

Some powerful ideas²¹ become more tangible for students through the mediation of digital technology (Papert, 2020). In this sense, programming is both a means and a tool for computational thinking (Bers, 2020). It involves ways of representing and formulating ideas so that they become understandable by others (Schulman, 1986) and by computers. One can think that each student, when programming, is teaching a computer to perform a task, and in this process, they receive immediate feedback on whether they are achieving the goals set or not.

As we saw in previous chapters, one of the main human roles in creating artifacts with AI is the formulation of a problem. This process, along with the design of solutions, has these rich characteristics for thinking. It involves incremental and iterative processes that include different stages with some systematicity: identifying problems, imagining ideas and questions, planning, creating and developing solutions, testing and improving, reflecting, and sharing (Bers, 2020; Resnick, 2007).

In the process of problem-solving, various elements associated with computational thinking come into play. On one hand, abstraction is linked to the analysis of the situation and the need to identify the most relevant aspects of the problem. If we revisit the example of classifying cats and dogs, this point is related to reviewing which characteristics can be considered for classification (it could be the shape, color, size of the animal, length of the ears, among other possibilities). In this analysis process, decomposition into parts also comes into play, considering the entirety of the situation, which can occur at different levels. Returning to the example, to solve the problem, we need to divide it into different tasks, such as the process of gathering and labeling data, training, and then evaluation.

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In the training process of an AI model, there is a task of finding patterns and similarities in the data used to generalize to new cases. Generalization and transfer are also constitutive elements of computational thinking

²¹ The concept of powerful ideas proposed by Papert (1990) has to do with those foundational pillars or blocks of culture and knowledge.

and can be visualized by applying different solutions to these or other problems. As we saw in machine learning with the example of cats and dogs, it was necessary to do calculations and follow certain steps to find the optimal classification value based on the length of the ears.

That is to say, how the computer solves the task of finding patterns is associated with which algorithms are involved in the training. Regarding computational thinking, thinking algorithmically to understand and create based on this operation involves thinking in terms of sequences and rules to create algorithms.

But the process does not end there; knowing if it is the best value for the problem to be solved also implies evaluating performance, searching for different alternatives and solutions, as well as making decisions about resource usage.

Of the skills mentioned above, abstraction, decomposition, generalization, algorithmic thinking, and evaluation largely synthesize the processes that constitute computational thinking (Dagienė and Sentance, 2016).

On the other hand, programming environments have very valuable characteristics in terms of promoting learning: there is immediate and tangible feedback; when running the program, logical errors that may exist, results, and differences from what we wanted to achieve are visualized. When faced with a problem in a program, we formulate hypotheses about what might be wrong and design tests to confirm or refute them. Based on the results obtained, we adjust our ideas and repeat the process.

Introduction to programming is a means, a path to promoting computational thinking. Additionally, it can be a learning opportunity to stimulate certain attitudes such as self-confidence and perseverance through project design, or error debugging and evaluation, which seeks to promote effort to face increasingly complex difficulties (Bers, 2020). The pedagogical approach of pair programming leads to collaboration, communication, encourages complementary work, and asking for and receiving help (Hanks et al., 2011).

Artificial Intelligence

Computational thinking is a systematic process that seeks to create synergies between human capabilities and the potential of computers. In this sense, at least two aspects related to AI emerge. On one hand, there are elements related to the development of applications and technologies that partially or totally involve aspects of machine learning; on the other hand, there are thinking strategies (or chains of thought²²) applied to processes that use AI to solve problems.

An example, in the first case, would be the development of an application that combines traditional programming (based on a set of instructions) and modules of AI to solve specific problems such as image recognition. It could be the case of some mobile applications that group photos on the device by people or places, which use image processing to, for example, recognize people or places, animals, or objects. This procedure allows it to group images by these characteristics, create a kind of index of these images, which then enables the user to use a search engine to find what they want. Both the interface with which the user interacts and the search algorithm are programmed in a traditional way.

It is relevant to point out the differences between the programming cycle with AI and the traditional programming paradigm, which ultimately complement each other. In the latter, what we do is write rules for the computer to follow, and in that way obtain an output according to each input. In contrast, in AI modules, one of the central elements lies in the data (quantity and quality), and the goal is for the computer to infer the rules from a set of data for which the expected output is known. That is, the main difference is that traditional programming is rule-based, and machine learning is data-driven.

Another aspect to consider is the iterative process in the creation of AI models. In the example of classifying dogs and cats, we could encounter different problems or errors. The process of evaluating the models is different from debugging traditional programming. In the case of the cat and dog classifier, it involves testing with new sets of images that were not used during training. From there, metrics can be obtained

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²² From Chain-of-Thought and interactions with generative AI apps, associated to prompting (Chen et al., 2023)

to give clues about the weaknesses and strengths of the model, and depending on the problem to be solved, questions may arise such as: Is it necessary to retrain the model with a larger dataset? Should another category be added in the classification for those cases in which the image is not a cat or dog? Will it be necessary for our model to interact with another layer that modulates or regulates responses?

To refer to thinking strategies applied to the use of tools with AI, we can mention prompt engineering. An iterative text structuring process to ensure that AI generative models solve a problem or produce a desired output. As we saw in the previous chapter, ChatGPT is essentially a large text autocomplete, which operates based on probabilities (non-deterministic). It should not be surprising, then, that ChatGPT's response to similar prompts may be different (even to identical prompts). Here, a universe of possibilities opens up in the search for prompts or phrases that take into account the functioning of these large language models, to favor or improve the possibility of a good application response. Let's see an example. If we seek a detailed response from ChatGPT and the steps to reach the solution to a given problem: Which of the following prompts will be more effective?²³:

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Prompt 1: [Problem description] + Indicate the answer and then explain the reasoning;

Prompt 2: [Problem description] + Explain the reasoning and then indicate the answer.

In this case, the second prompt or instruction is more effective for obtaining a detailed response, due to the characteristics of Large Language Models²⁴. The model generates the response by repeatedly predicting the next words. With prompt 1, which begins by indicating the response, the model will try to predict the answer and then write the step-by-step analysis process, which may not be related to this initial response. In contrast, prompt 2 instructs it to think carefully before reaching a conclusion (Ng, 2023).

23 Original example: www.deeplearning.ai/the-batch/issue-211

24 This example may not be accurate as conversational AI applications add complexity in different layers of processing, often incorporating processes like this.

The range of prompt options is wide, and certain thinking strategies can help structure the text or engage in a systematic iterative process in the search for answers. In the previous case, the difference between the two prompts for ChatGPT reflects the idea of thinking step by step (Kojima et al., 2022), which closely resembles the process of decomposition in computational thinking.

Other possible uses of ChatGPT for certain prompts involve providing several solved (labeled) examples, so that it can generalize to new cases based on them. The use of these tools can generate imprecise texts or images, which are refined as the prompt is perfected, as they ultimately provide immediate feedback to the user (Quinn, S. & Poole, F., 2023).

Strengths and weaknesses of AI

One aspect to keep in mind is that when using AI, computers can make mistakes. Unlike traditional programming, there is a probabilistic factor associated with the response. Like humans, AI-based systems make errors, which leads us to discuss the strengths and weaknesses of AI. To evaluate the strengths of AI, it is necessary to consider and assess its development in different areas.

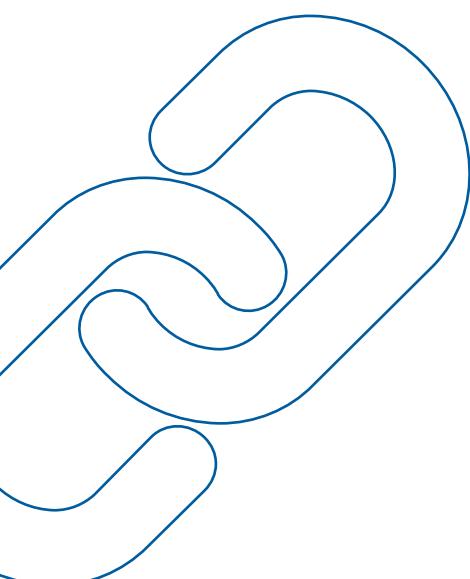
93

Throughout the previous chapters, we have referred to image processing (or computer vision) and natural language processing (NLP). But does everything require AI? There are clear examples where it seems that there is no place for AI. What could AI contribute to the operation of an elevator or a remote control? In these cases, the inputs are specific, meaning there is a limited set of options that the elevator buttons or remote control buttons can perform (even if there are many buttons), or a keyboard. For each button, the system or computer has only one expected output (go to the 5th floor, turn on the TV, press Enter). In other words, it does not make sense to include AI unless there is a conceptual or paradigm shift, such as wanting to replace the mode of operation with something that integrates voice. This is the case with the functionality of the mobile phone that you likely have nearby and is demanding attention (its original function was to replace the phone for making calls, does it still serve that purpose?). The operation of the phone when we dial a number will never fail, but if we try to call through a voice assistant, they might call someone by mistake.

The key lies in that, unlike the elevator or remote control, in the case of voice, as in the example of classifying cats and dogs, traditional programming struggles to capture the variability of input options, which is where AI demonstrates its strengths.

Three of the central axes of computational thinking: abstraction, automation, and analysis (Lee et al., 2011), are directly linked to the assessment of the need or potential for AI use, and constitute the computational approach proposed in this chapter. Abstraction for understanding and formulating the problem, automation in seeking to express a solution that incorporates computational power, and analysis in the execution and evaluation of the solutions.

To implement the computational approach, it is necessary to handle some concept ideas linked to AI and its fields of application such as computer vision, speech recognition, translation, text or image generation. These elements allow AI to be applied to problem-solving in different scenarios and contexts. It seems then that computational thinking is a necessary condition to promote the teaching of AI (Dohn et al., 2022).



How should AI be used?

Computational approach with AI

This dimension addresses the aforementioned ideas and could be summarized in the **strategies for problem-solving**, such as breaking problems down into parts, implementing different solutions, evaluating their feasibility and scope, in this case, identifying AI's **strengths and weaknesses**, which implies identifying those problems or sub-problems most suitable to be addressed through an AI-based solution (Kim et al., 2021; Long and Magerko, 2020; Ng et al., 2021). This dimension is analogous and complementary to Ceibal's Computational Thinking framework (2022) called Computational problems.

The competencies associated with this dimension are:

- Understanding the field of application of AI today: computer vision, speech recognition, translation, image generation, text, and sound, among others.
- Using AI for problem-solving. Applying knowledge, concepts, and AI applications in different scenarios.
- Recognizing the type of problems suitable for direct AI application and those that are more challenging for AI.
- Discerning when it is appropriate to use AI and when other approaches are more suitable.

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	AI4K12	AI Literacy
	Big Ideas	Competencies
	#1 Perception #2 Representation and Reasoning #3 Learning #4 Natural Interaction	#1 Recognizing AI #3 Interdisciplinarity #5 Strengths and weaknesses of AI #12 Learning from data #14 Action and reaction #17 Programmability

Classroom activities

Who copies whom?

Challenging the group of students to replicate an image using an AI image generator.

Show the group of students an image that has been previously created with an AI image generator. For example:



**Image created with
the prompt: dog
running and playing
soccer.**

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Ask the group of students to describe the image they see.

*How would you explain the image we are seeing to someone?
What do you highlight about the image to recreate it?*

Finally, the group should obtain an image very similar to the original one, for which they will use an AI-powered image generation tool.



Each group presents their image along with the prompt used.

Discuss:

- *What process did they follow to generate the image?*
- *What did they learn from the process?*
- *If we use the same description more than once, does it generate the same image?*
- *How should the description be for the image to more accurately match the original?*

Suggestions

The original images can be created by humans or by computers.

Encourage the group to try different image generation tools.



AI Objectives

Use of AI tools.

Use AI for problem-solving, in this case, employing debugging skills.

Introduction to the concept of Generative AI.

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Resources

Image generator from text.

Classroom activities

Challenging the AI

Use an AI-powered chatbot to solve a problem.

Choose a problem that the group of students is motivated to solve. Bebras challenges²⁵ might be useful. Select a problem that can be solved based on text, without the need for images.

Ask the group of students to solve it. Explore problem-solving methodologies with them.

Introduce the chatbot to the group and ask them to use it to solve the problem.

What limitations do they encounter? Can all problems be solved using the AI-powered chatbot?

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Reflect with the group on:

- *Did the chatbot solve the problem correctly? Did it indicate how it did it?*
- *How can we make it help us solve it in case we can't do it ourselves?*
- *What other uses could they give it?*

²⁵ <https://pensamientocomputacional.ceibal.edu.uy/bebras-recursos/>



Suggestions

Use the chatbot to reflect on its own problem-solving process to showcase different strategies to the group of students.



AI Objectives

Using tools with AI.
Using AI to solve problems.



Resources

Conversational AI.

Classroom activities

Classifying emotions

Train your own machine learning model to classify text.

Create a text classifier with the group using Machine Learning for Kids²⁶. Ask students to create a project that recognizes text (as an example, they can explore other options later).

Each group can write the name of the project they consider, and the language they want to work in.

Nombre del proyecto *

Reconocimiento de sentimientos

Reconociendo *

texto

Idioma

Spanish

Storage *

In your web browser

Where do you want to store this project?
Storing in your web browser removes limits on how big your project can be.
Storing in the cloud will let you access the project from any computer.
(See "What difference does it make where a project is stored?")

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Then, the model will be trained and tested.



²⁶ <https://machinelearningforkids.co.uk/#!/projects>

Training is important to include the classes you want to distinguish and examples for each one.

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To add examples, you can explore students' own ideas, as well as search for words associated with each category on the internet. In this case, we're working with words that have positive or negative connotations, but you can try with the topic you're working on in class. Once classes are uploaded, return to the project and train.

The created model is tested and challenged with questions.

Añade texto para ver cómo lo identifica tras el entrenamiento.

Inseguro

Probar

Identificado como **negativo**
with 91% confidence

Añade texto para ver cómo lo identifica tras el entrenamiento.

Luna

Probar

Identificado como **positivo**
with 4% confidence

In this case, why would the moon be considered negative? Is that correct or incorrect?

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Finally, you can reflect on the entire creation process and the different outputs:

- *What does the percentage underneath the category mean?*
- *How can we make the model respond more accurately to our examples?*
- *What issues do you encounter with these models? What happens if it classifies a word in the wrong category?*
- *Can we make a program to solve this problem without using Artificial Intelligence? What weaknesses do you find in that approach?*



Suggestions

Complexify the classification of emotions and explore ways to obtain data easily and quickly to create the model.



AI Objectives

Understanding the current applications of AI: computer vision, speech recognition, translation, image generation, text, and sound, among others.



Resources



[Machine Learning for Kids](#)

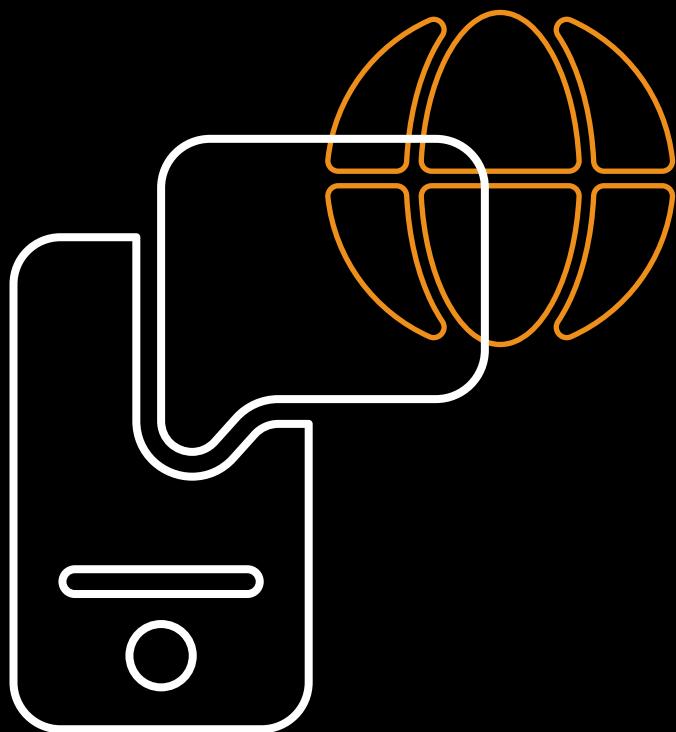
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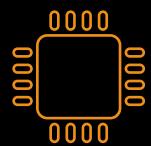
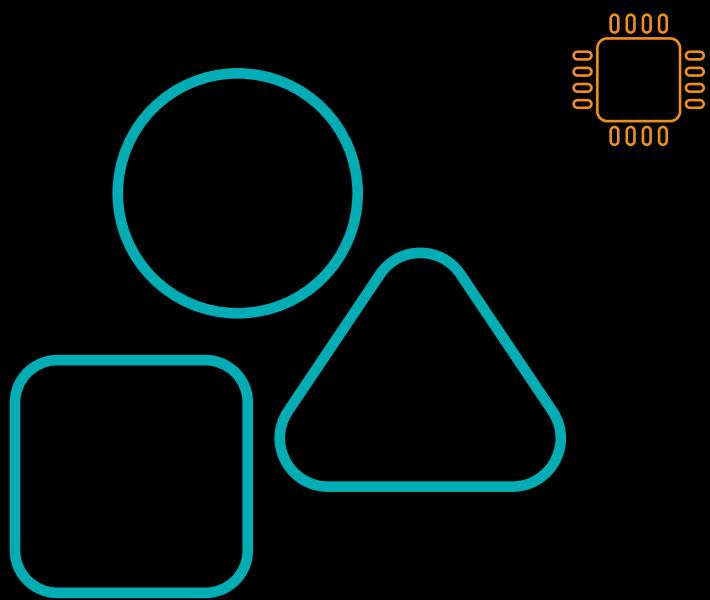
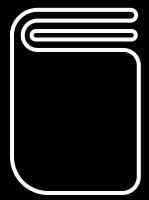


Chapter 4.2

How to use AI?

Ethical aspects
and social impact





Utopia or dystopia?

As has been the case since the very origins of humanity, every technological advance confronts us with the ethical dilemma of the various possible uses that a technology can have. AI is no exception, and as it happened in the past, we must prepare to deal with the potential negative uses of AI, and recognize its implications. Malicious uses are generally inevitable, this is often illustrated in great detail in science fiction or superhero movies, so following this analogy, our goal should be for good to ultimately triumph.

Furthermore, another relevant aspect, not necessarily associated with malicious use, is the social impact of technological advances. This is also something that we have seen in the past: machines replacing human tasks, the industrial revolution being a prime example, leading to the destruction of thousands of jobs (perhaps many new ones being created), cultural, economic, and environmental changes. How to manage this process appropriately, to avoid disruptions that lead to massive social problems, is a great challenge and is something to keep in mind in digital transformation processes.

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Intrinsic problems of AI

One of the main problems with AI is associated with the learning process and the training data needed to build systems based on this technology. As we saw earlier, this mechanism generates a non-deterministic system, and therefore it is not infallible, as no matter how low the probability of making a mistake, there will always be at least a minimal chance of this happening. Another inconvenience arises from the proper handling of the training data in the learning process.

If we revisit our example of images of cats and dogs, it is crucial that the training dataset covers the various breeds of both types of animals comprehensively. If this does not happen, and for example, certain breeds are underrepresented or have no samples in the training set at all, this will be reflected in the functioning of the resulting system. Such breeds are unlikely to be recognized properly, thus generating bias in the system's results. This has occurred in various real systems, which, for example, have not been trained with sufficient data for the different human races. If these results are systematic, they cease to be errors and become biases.

Another similar problem occurs when the training dataset includes biases that humans themselves have, also known colloquially as prejudices. A clear example of this problem can be found today in the translators we use on a daily basis, when translating from a language that allows sentences with an undefined gender subject (e.g., The teacher is very smart and pretty) to another where this is not possible, such as Spanish. Although many translators have started to address this by incorporating various possible options when the language requires defining a gender, it generally remains an issue that does not work well with more complex sentences (e.g., The teacher is very smart and pretty, while standing in front of the classroom²⁷). This problem is directly associated with the training data used to build the translator, where most texts include teachers, nurses, and cleaners who are often female, as well as engineers, lawyers, and accountants who are often male. This imbalance in the data, a bias that exists in reality, will therefore be reflected in the resulting system unless appropriately addressed in training to rectify it. Similarly, problems arise in what 'the computer's eye does not see,' such as in computer vision detection of people of different races or ethnicities.

Other aspects that denote complexity are related to biases and ways to mitigate them when detected, which function in the opposite direction. Many generative AIs, whether for text or image, have layers in their architecture that attempt to prevent or mitigate these problems. However, it can also happen that in the eagerness to not reproduce biases or to be politically correct, they fall into examples of historical contradiction (such as the case of Gemini and black Vikings).²⁸

²⁷ Google Translate provides the following result: "La maestra es muy inteligente y bonita, mientras está parada frente al salón de clases." (August 2024).

²⁸ <https://elpais.com/tecnologia/2024-02-24/nazis-chinas-y-vikingos-negros-google-suspende-su-ia-de-imagenes-por-sobrerrepresentar-a-minorias.html>

Ethical aspects and responsibility of AI

There is another dilemma associated with the use of AI, particularly in certain applications where the responsibility of decision-making is crucial. A teacher grading a student, a judge deciding a complex case, a doctor diagnosing and defining the appropriate treatment are all applications that could currently make use of AI, at least to assist in certain specific tasks. However, it is complex to imagine that the final decision, whether it be a grade, a verdict, or a treatment, would be determined by a machine without a human being behind that decision to take responsibility.

Furthermore, in many cases, the explainability of AI is a significant issue. That is, it may be possible to train a machine to solve a task and make a decision, but it can be extremely challenging to understand or justify why it leans towards that decision. In many of the examples mentioned, this is relevant because it is necessary to understand why a test grade is good or bad, why a certain judicial ruling is made, or how a specific diagnosis and clinical treatment are reached.

Another important aspect associated with the incorporation of AI in these types of decisions is that errors, when automating the process, become systematic. It is clear that humans are not free from making mistakes, and it is possible for a teacher to assign an incorrect grade, or for a judge to make a debatable ruling, and the same goes for medical decisions or other examples. However, these types of errors are not systematic because each professional is a different individual with different training, experience, and life experiences, which means that errors are distributed globally, and there is a certain randomness in the system as a whole. The problem with AI is that if we train a system for a certain application that can make mistakes, these mistakes will be systematic. In other words, if the output is incorrect for a certain input, it will always be repeated. This is something that in many applications, especially in a widespread application, can have various problems.

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Indeed, there are occasions where it is not so clear to identify what the correct decision is, and different people might not agree. So, how should we proceed in those cases? Which option should we lean towards if we were to automate such a process? An interesting exercise that illustrates

this dilemma well is presented by the Moral Machine from MIT²⁹, where we are faced with different scenarios in which an autonomous vehicle should decide what the best course of action is, and all of them have serious consequences. Therefore, it is not evident in each case what the most appropriate decision is, and, in any case, the moral values of each individual or group are taken into consideration.

How should AI be used?

It is difficult to answer this question, but it is always easier to talk about areas where we do not want technology to be applied, such as warfare, the generation of misinformation and fake news, cyberattacks, among many others. While this does not resolve the dilemmas, it should encourage debate. To delve further into this aspect, one can look at the Montevideo Declaration on AI and its impact in Latin America, issued in 2023 during a meeting of the AI research and development community in Latin America³⁰, or the European Union's regulation on AI risk regulation³¹.

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Imagining AI's future

It is difficult to imagine the future of AI while being marveled by it. There are cases where we cannot even explain why they work so well. That does not mean that machines will surpass humans; the limitations and challenges that AI faces to keep making progress are clear. But it is expected that on the path we are on, we will see better models and greater capabilities in terms of the types of problems AI-based systems can solve. A sort of cultural accumulation around AI.

Models are becoming more complex, there is progress regarding structure and technologies that allow more computing power or greater speed. Architectures are emerging that propose the idea of multimodality in terms of the computational representation of the world,

29 www.moralmachine.net/hl/es

30 <https://shorturl.at/buwN4>

31 <https://digital-strategy.ec.europa.eu/es/policies/regulatory-framework-ai>

and agents that could make decisions based on the problems and tasks at hand. This means new layers that could provide other capabilities, such as planning around a task, to break it down into parts and consult the 'experts' of each modality (different LLM or foundational models that solve specific tasks, such as programming, mathematics, language), and everything being centrally controlled. Not free from debate, there are elements that resemble the so-called Artificial General Intelligence (AGI), which could somehow alternate between using different modules depending on the task and opt for deeper or lighter processing, depending on the complexity (somewhat similar to the concept of fast thinking, slow thinking described by Kahneman (2012).

However, there are other types of challenges, not necessarily technological, that humanity will have to solve in parallel so that the emergence of AI helps us progress along the desired path and does not become something that works against society. Some examples, such as those mentioned above, where the responsibility of decision-making is a key aspect, will need to be taken into account when incorporating AI-based technology in various fields of application. The same goes for educating people in terms of their critical thinking ability, something that has always been very relevant, but now takes on new dimensions with the possibilities that AI offers to generate all kinds of content that may not always be accurate.

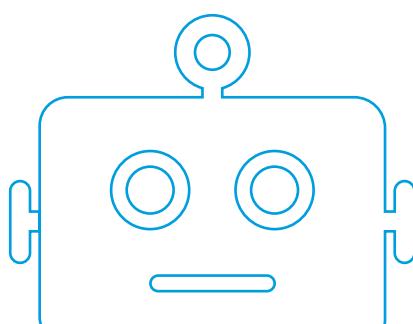
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There are probably more questions than answers, but what is undeniable is that these aspects cannot be ignored in the various fields of AI application, and particularly in the impact on the educational system.

How should AI be used?

Ethical use of AI and social impact

This dimension is related to the question 'How should AI be used?' It deals with the ethical aspects and the social impact associated with the use of AI. It is essential to promote a critical vision and recognize that AI has an impact on society (Touretzky et al., 2019). This implies a critical analysis of the data used in AI, understanding that they must be rigorously analyzed and interpreted within their context. Additionally, **interdisciplinary work** plays a crucial role in recognizing that there are different actors in technology and understanding how they can collaborate to create more comprehensive and efficient solutions. Furthermore, it is necessary to be able to **envision the future of AI**, exploring potential applications and considering their effects on the world (Kim et al., 2021; Long & Magerko, 2020).



Relevant competencies associated with this dimension are:

- Identifying that the use of AI has a social impact. Recognizing the positive and negative effects of AI on society and having a critical perspective on the use of AI technology.
- Understanding that data in many cases must be analyzed and interpreted and cannot be considered without being revised.
- Being aware about the fact that AI technologies can reflect or amplify biases, stereotypes, and human inequalities, recognizing how they can affect social justice and inclusion.
- Imagining the possible future applications of AI and considering the effects of those applications on the world.
- Recognizing collaboration with other actors, considering that there are many different ways of thinking and developing ‘intelligent’ machines.

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	AI4K12	AI Literacy
	Big Ideas	Competencies
	#5 Social impact	#3 Interdisciplinarity #6 Imagining the Future of AI #10 Human Role in AI #13 Critical Interpretation of Data #16 Ethics

Classroom activities

The Apartment Cow

Testing a machine learning model created by others.

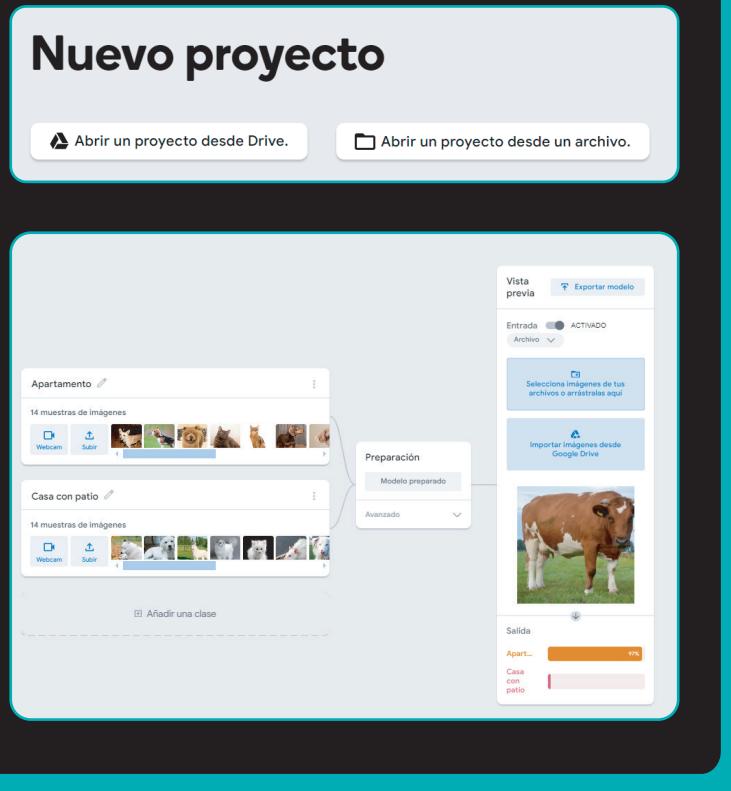
Using a model with labeled data of animals that live in apartments or houses with a garden, the model is trained in Teachable Machine³² to test it.

Create a new project and open the model using the link to Drive or from the computer itself.

The model³³ is opened, prepared, and tested with test images.

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An example of images to test can be found in the following folder³⁴, but each student can select the animals they consider relevant.



32 <https://teachablemachine.withgoogle.com/>

33 https://drive.google.com/file/d/1qeZIKVzxe9dEi7yp3YgSQGI2jzxNShYg/view?usp=drive_link

34 https://drive.google.com/drive/folders/14bNaA4FMLJh2AqIDQ6KsXnruu2qVDlRp?usp=drive_link



After testing the model, discuss the following questions with the group:

- *How does it work? Did it correctly predict the results of the images it analyzed?*
- *Would this algorithm be useful for classifying any animal as a suitable pet for each space? Why or why not?*
- *Do you trust the result given by your algorithm to choose your pet? Why? How can we improve the prediction for cases where it is not correct?*
- *What about pets that can live in both an apartment and a house with a garden?*

This particularity of the data and how they are organized to train the algorithm reflects a preference in the selection of the data for each category, and consequently, the model's prediction reflects the values represented in those data, which is called bias.

Suggestions

Select a relevant problem for the group that requires classification.



AI Objectives

Identify that the use of AI has a social impact.

Recognize the positive and negative effects of AI on society and have a critical perspective on the use of AI technology.

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Resources

[Teachable Machine](#)
Activity taken from the didactic sequence of the PC and AI program of Ceibal 'Cows make good apartment pets.'³⁵

³⁵ https://pensamientocomputacional.ceibal.edu.uy/wp-content/uploads/2023/06/2022-Inteligencia-artificial_Guia-Docentes.pdf

Classroom activities

What does the autocomplete think?

Inquire about the biases present in the browser's autocomplete to reflect on the data used to train these systems.

Work with the autocomplete feature of search engines. Ask each student to try typing a sentence starting with the feminine gender and another with the masculine gender.

For example:

Uruguayan women are ...
Uruguayan men are ...

What does the search suggest? What differences do they find between the two sentences?

Ask students to reflect on the biases behind these suggestions. You can try with professions, countries, and whatever generates motivation and critical thinking in the group of students.

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Reflect with the group on the following questions:

- *What are biases? How do these biases arise in search engines? Is this the only place where you find these biases? What happens with suggestions in recommendations for series or music?*
- *How do you think this can affect society? Why might it be important to be informed about these issues?*



Suggestions

Evaluating using other languages.



AI Objectives

Identifying that the use of AI has a social impact.



Resources

[Bing](#)

[Duck Duck Go](#)

[Ecosia](#)

[Google](#)

Classroom activities

Translation and Biases

Explore the biases present in translators to reflect on the data used to train these systems.

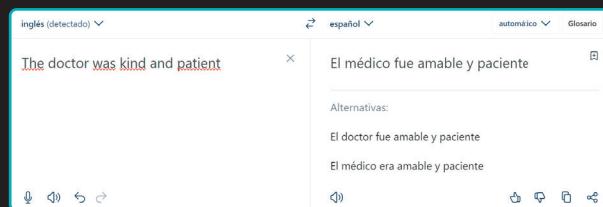
Translating from one language to another, often due to the volume of data, is done using AI. Ask students to use the online translator³⁶ to find some biases.

At the beginning, exploration of the resource is proposed for those who have not used an online translator. Explore with the group of students the translation (into Spanish) of the following sentences:

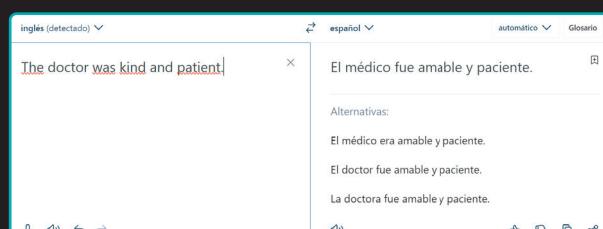
- 'The doctor was kind and patient'
- 'The nurse was kind and patient'
- 'The teacher was kind and patient'
- 'My hairdresser cut my hair a lot'

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In the first case, at the time of writing this activity, we found the following output:



However, by adding a period at the end, an alternative is included.



These biases are being gradually corrected, so this example might become outdated by the time you try it; we encourage exploring other options.

Explore with the group other biases that can be reproduced, regarding gender, ethnicity, and context, depending on the group's needs and motivations.

Reflect on the following questions:

- *How do these biases arise?*
- *What weaknesses do they find that could happen if we don't do anything about it?*
- *What other biases can be reproduced in these types of systems?*
- *Besides professions, are there other areas where we can continue exploring?*



Suggestions

Working together with English.



AI Objectives

Identifying that the use of AI has a social impact.

Reflecting on how AI technologies can reflect or amplify biases.

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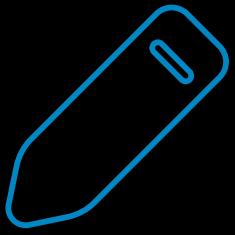
Resources



[DeepL](#)



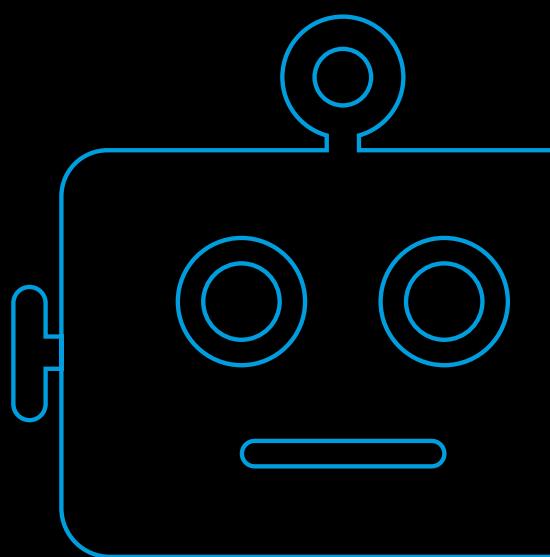
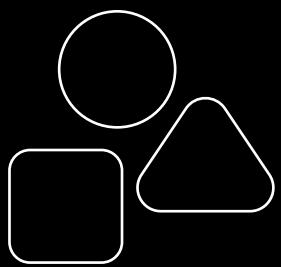
[Translate
de Google](#)



Chapter 5

AI and the digital autonomy of educational systems





Tecnologies and Education

On July 24, 2023, the global launch of the GEM report on the state of world education³⁶ took place in Montevideo, Uruguay. This highly anticipated report focused on digital technologies for education, coming a year after the containment and resolution of the global health emergency caused by the COVID-19 pandemic. Uruguay was selected for the launch due to its advanced progress in digital transformation in education and the widespread use of digital technologies. But this report requested from the GEM team by UNESCO considers the reality of countries where not all schools are yet connected to the electrical grid, as well as countries that are using facial recognition to take attendance in class. Therefore, it is worth noting that the technological deployment universe studied is diverse.

Nevertheless, amidst this diversity, there are common ground and some promising conclusions about digital technologies in education. First and foremost, the strategic use of technologies within the education system can yield very positive results, although it does not guarantee them. Many countries were able to mitigate the adverse effects of school closures due to having a better overall technological infrastructure. Additionally, the report mentions that the application of technologies in education almost universally fails if there is not a clear vision of what they aim to achieve. The main contribution and conclusion of the report is that educational systems must move towards building technologies 'on our terms.' The concept of 'our terms' refers, among other things, to technologies built in collaboration with educational communities, governed by specific pedagogical intentions, serving learning and human beings.

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Ultimately, this path aligns closely with Uruguay's journey with Ceibal and its national education ecosystem. Having an innovation center

36 <https://www.unesco.org/gem-report/en/technology>

with digital technologies serving the country's educational policies has allowed the Uruguayan educational system to have a level of digital self-determination that is rare in the rest of the region and much of the world. However, to build these technologies 'on our terms,' we must address specific challenges to seize the opportunities associated with digital technologies. In fact, Uruguay has undergone successive stages of transformation since 1990 to achieve the degree of digital educational sovereignty it enjoys today.

For AI—which, as we have seen in previous chapters, is just another digital technology—this is no exception.

Global context on policies of AI in education

Several countries have made progress in developing clear guidelines for the use of AI in education, recognizing both its potential to improve teaching and learning processes, and the ethical and privacy challenges it poses.

The United States, for example, has developed AI regulation in education that can vary from one state to another. Federal agencies and national associations have published recommendations and guidelines to guide the ethical and responsible use of AI in education. However, they have opted for a clear legal framework that each state applies according to its possibilities instead of rules for application for each educational community. This results in agencies and organizations such as ISTE, Digital Promise, Ed Safe AI, or the Teach AI initiative becoming fundamental to level the playing field between technology companies, those states with more developed paths, and those with less.

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The European Union has been a leader in regulating AI in general, with the General Data Protection Regulation (GDPR)³⁷ setting strict standards for the protection of personal data, including in the education sector. Additionally, the European Commission has proposed a specific regulatory framework for AI that addresses aspects such as transparency, fairness, and safety. In fact, at the time of writing this text, it is the community with the most regulations published regarding this technology used in education.

China has implemented ambitious policies for the development of AI in all sectors, including education. The Chinese government has published guidelines promoting the use of AI in schools, focusing on improving personalized learning and optimizing educational systems,

³⁷ <https://eur-lex.europa.eu/eli/reg/2016/679/oj>

but also including provisions on student privacy protection and data security. It has even taken a proactive stance in discussing its initiatives at the United Nations summit held in New York in 2022. However, its data protection strategy differs from proposals by Western countries. It is clear that China aims to be a powerhouse in AI and has put all its machinery to that effect.

The United Kingdom has published several reports and strategic frameworks related to the use of AI in education, addressing topics such as technological innovation, ethics in AI, and how it can support national educational objectives. The Information Commissioner's Office (ICO) provides guidance on data protection in the educational context.

Canada has shown interest in establishing an ethical and governance framework for AI that includes the education sector, with an emphasis on transparency, accountability, and respect for privacy and human rights.

Australia has advanced the debate on balancing innovation and regulation of AI in education, with policy documents and guidelines exploring how technology can be used safely and effectively to support educational outcomes.

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UNESCO, on the other hand, within the framework of the Beijing Consensus³⁸, has begun the task of providing suitable platforms for the international exchange of regulatory frameworks, instruments, and approaches on AI in education, through UNESCO's Digital Learning Week and other United Nations agencies. It has created multi-stakeholder partnerships and mobilized resources to narrow the AI gap and increase investment in AI implementation in education. In 2023, it published a guide on AI and education for policymakers.

In all the above examples, regulations for AI in education vary by country and region, but there are several common principles and guidelines that are often followed. Although we will not go into specific details of each exact jurisdiction, here is a summary of key aspects that these regulations often cover, which also apply to Uruguay and the region:

³⁸ <https://unesdoc.unesco.org/ark:/48223/pf0000368303>

- **Data protection and privacy:** Regulations often emphasize the importance of protecting the privacy of students and educators, which includes the safe handling of personal data, consent for its use, and transparency on how this data is collected, stored, and used.
- **Equity and accessibility:** The goal is to ensure that AI tools do not amplify biases or discrimination present in society and that they are accessible to every student, even if they have disabilities. This may include guidelines on the need to conduct algorithmic bias audits and implement corrective measures when detected. Uruguay has a whole organization for this purpose (Ceibal) that collaborates with other entities responsible for digital policies at the national level. This ensures there is enough talent and capacity to address equity and accessibility to digital technologies, such as AI, in the public education system.
- **Quality and educational efficacy:** Many regulations require AI solutions in education to be rigorously evaluated to ensure that they positively contribute to the learning process and meet certain standards of educational quality. For example, in Ceibal, adaptive platforms are used and reviewed to ensure that they provide quality interactions for both students and educators. It is crucial to have evaluation tools that clearly show the quality and effectiveness of education, as these are not always available in public education systems.
- **Ethics and responsibility:** Ethical guidelines often address the importance of developing and using AI in a way that respects the rights and dignity of all individuals involved in the educational process. This includes issues such as algorithm transparency, the ability for users to understand and question decisions made by AI systems, and the clear assignment of responsibilities in case of errors or issues. To illustrate this point, we could say that AI solutions for education need to be able to “explain” the rules they used to provide an answer. If they cannot do this, the algorithms are less transparent to users.
- **Security and protection:** In addition to data protection, regulations often cover the need to protect educational IT infrastructures against cyberattacks, ensuring that AI systems do not become vectors of

vulnerability. Having appropriate AI policies in education requires proper defense of infrastructures and data, ultimately contributing to the necessary digital autonomy for an education system on 'our terms.'

- **Cooperation and knowledge exchange:** Some regulations encourage collaboration among educational institutions, AI developers, and other stakeholders to share best practices, innovations, and lessons learned in the use of AI in education. In Uruguay, both Agesic and universities and the private sector collaborate to ensure that this technology is implemented in such a way that the latest available knowledge reaches the majority of the population.

But even with regulatory frameworks like those described above, which minimize the negative externalities that may arise from the use of digital technologies in education without control, there will still be opportunities and challenges when implementing these technologies in the classroom.

Opportunities of AI in Latin American education

Education systems in Latin America can also capitalize on the various opportunities provided by AI-based systems, both in student learning processes and in the administrative tasks performed by educators and education leaders.

- **Personalization of learning:** AI offers the possibility to adapt educational content and teaching strategies according to the individual needs of each student, which could significantly improve learning effectiveness and reduce performance gaps. To illustrate this point, we could consider Universal Design for Learning (UDL). It is an approach in education that seeks to maximize the accessibility and effectiveness of learning by creating a suitable environment for all students, regardless of their abilities or disabilities. This concept has its roots in universal design, a principle in architecture and product design that advocates for creating solutions accessible to as many people as possible. The technology we call AI is particularly beneficial for providing personalized feedback, something that is generally very costly in education and difficult to scale. And it offers significant advantages to pedagogical models like UDL.
- **Access to education:** AI can facilitate access to quality education in remote or underserved regions, providing personalized educational resources and online learning platforms that are accessible from anywhere with or without an internet connection. The generative capacity of this technology enables the generation of a multitude of different responses from a large data lake, potentially reducing the dependence on permanent connectivity.
- **Improvement of assessment and feedback:** AI-based assessment systems can provide instant and personalized feedback to each student, allowing the teaching staff to identify areas for improvement and adapt their pedagogical approaches accordingly, as described above.

- **Efficient educational management:** AI can assist in the management of educational institutions, optimizing resource allocation, curriculum planning, and data-driven decision-making to improve the quality and efficiency of the education system as a whole. If there is something that AI does very well, it is extracting patterns from large volumes of data to provide evidence of actions that work or do not work. This has great potential to reduce the burden of administrative work, for example.

Challenges to overcome

The other side of the coin involves the challenges or limitations associated with incorporating this technology into the educational system.

- **Digital divide:** Despite the potential of AI to democratize education, the digital divide remains a significant obstacle in Latin America, as access to devices and reliable connectivity does not reach all students. And even with reliable connectivity, the digital gap is not one, but at least three: the gap in access to devices and technological infrastructure, the gap in the use of connectivity, and the gap in quality digital content. In the case of Uruguay, the first part of the gap was addressed in 2007, but as of 2024, some aspects still persist. Even though all rural schools have been connected to some type of internet since 2010, it was only in 2023 that Ceibal, along with Antel³⁹, ensured that 100% of them are provided with high-speed internet.
- **Privacy and data protection:** The implementation of AI in education raises concerns about the privacy and data protection of students, which requires the implementation of robust measures to ensure the security and confidentiality of personal information. Anonymization strategies, cybersecurity, and monitoring are just a few.
- **Teacher training:** Proper training of teaching staff in the effective use of AI is essential to fully leverage its potential in the classroom, requiring significant investment in professional development programs and skills upgrading.
- **Equity and algorithmic bias:** There is a risk that AI systems in education will reproduce or amplify existing inequalities, either through algorithmic biases or the lack of equitable access to these technologies, which could exacerbate educational disparities in the region.

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³⁹ Administración Nacional de Telecomunicaciones, main Internet access provider in Uruguay.

The role of teachers in the integration of AI

In a pathway towards policies promoting digital autonomy in education, the role of teachers becomes a key facilitator of technology-driven learning. It is fundamental in the effective integration of AI into regional education policies in Latin America and requires specific skills for active participation in this process.

- **Leadership in technology adoption:** Every teacher is a leader in the classroom. They have the responsibility to guide their students in the ethical and effective use of technology, including AI. Acting as role models in the exploration and adoption of digital tools can inspire confidence and motivation in students to use technology productively. Modeling the type of use is key to promoting the utilization of these technologies for learning.
- **Professional development and continuous training:** Training in the use of AI-based tools is essential for every teacher to fully harness their potential in the classroom. Professional development programs should offer opportunities for practical and collaborative learning, enabling the teaching collective to acquire the necessary skills to effectively integrate AI into their educational practice.
- **Interdisciplinary collaboration:** The integration of AI into education policies requires close collaboration between teachers, school administrators, technology experts, and other education professionals. Working as a team allows for leveraging a variety of perspectives and experiences to design and implement educational strategies that benefit students.
- **Designing student-centered educational policies:** Every teacher has a unique insight into the needs and abilities of their students; this makes them key in reformulating AI-based educational policies. Their active participation in the application and feedback process

ensures that policies are designed with the realities of the classroom and the well-being of each student in mind.

- **Promotion of innovation and creativity:** Every teacher can foster an environment of innovation and creativity in the classroom by using AI as a tool to explore new teaching and learning methods. By encouraging their students to experiment and collaborate on AI-based projects, they can cultivate key skills such as critical thinking, problem-solving, and creativity. But for this, they have to become proficient in human creativity to facilitate creative processes in their students. Not despite AI, but with AI.

The role of teachers in the integration of AI into regional education policies is fundamental to ensuring that technology is used effectively and ethically in the classroom. By leading technology adoption, participating in professional development activities, collaborating in interdisciplinary groups, and designing student-centered policies, they can significantly contribute to the continuous improvement of education in Latin America in the digital age. But fundamentally, they will be the ones who build much of the digital sovereignty of the education system.



Evaluating education policies on AI: metrics and assessment

To ensure the success and effectiveness of education policies on AI, it is crucial to establish clear metrics and robust evaluation processes. Measuring the effectiveness of AI education policies plays a crucial role in providing feedback to educators, students, and the industry, as well as in improving and refining these policies.

How to measure the effectiveness of AI education policies:

- **Identify key performance indicators that reflect the goals and desired outcomes of AI education policies**, such as student performance, equity in access to education, levels of participation, and the development of digital skills. This is perhaps one of the fundamental points. For example, in Uruguay and for Ceibal, the use of AI in education has an initial goal of generating greater equity in learning and access to future opportunities. This emphasizes the importance of choosing indicators with that focus.
- **Use both quantitative and qualitative data to assess the impact of policies** on student learning, teaching quality, and effective use of technology in the classroom. Just because quantitative data is more readily available in technological systems does not mean we should overlook qualitative information, which is key to improving user experience and engagement with learning.
- **Incorporate feedback from different stakeholders**, including educators, students, parents, and industry leaders, to better understand the challenges and successes of policy implementation. If we understand the education system as an ecosystem with multiple actors collaborating in delicate balances, it is crucial to incorporate information from the interaction of these actors.

How to iterate to continuously improve designed policies:

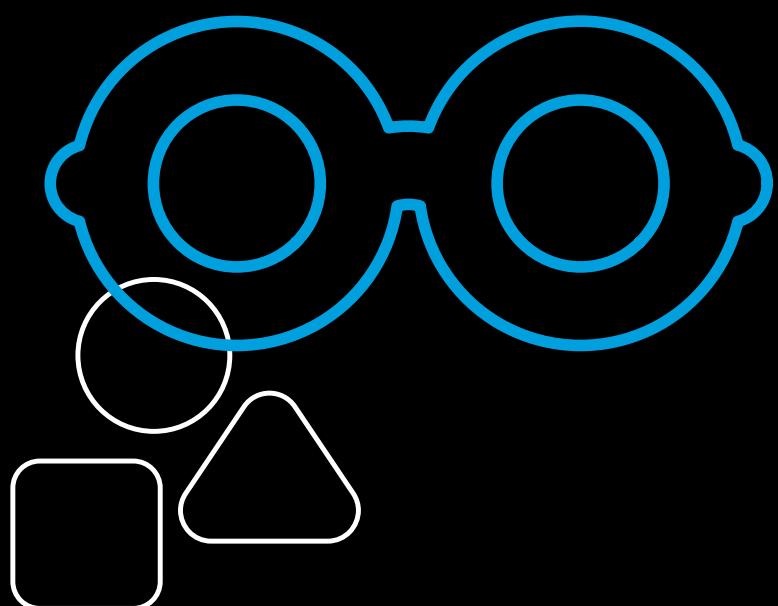
Listen to and value the experiences and opinions of educators and students in evaluating AI education policies, recognizing their expertise and unique perspectives. But not only to know those opinions, but to foster collaboration between the education sector and the technology industry to identify areas for improvement and opportunities for innovation in AI education policies, with a specific advocacy stance on the type of technological developments generated for education.

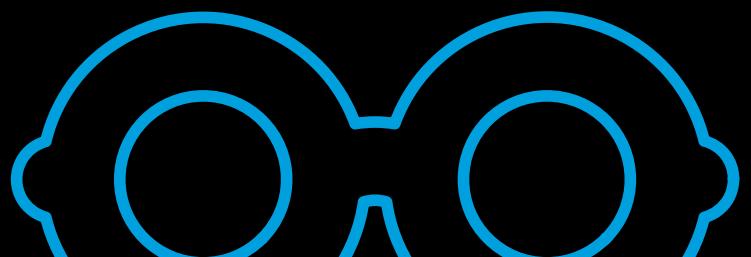
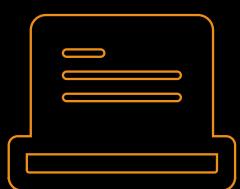
However, it must be a listening process with training. As those involved better understand what is possible to build with digital technology, they will be able to elevate the type of interaction they have with those who are building the technological solutions they use, from a large language model (LLM) to a learning management system (LMS).

The development and implementation of AI education policies are iterative and evolving processes that require flexibility and adaptation as technology and educational needs evolve. Anticipating future trends in AI, such as the development of new educational tools and applications, and adjusting education policies accordingly to maximize emerging opportunities seems wise. This, combined with a great effort from the entire education ecosystem, is what can bring Uruguay and the countries in the region closer to education systems with degrees of digital autonomy that guarantee the use of technology on 'our terms,' and that offer us the greatest benefits of one of the most disruptive technologies of recent times.



Foresight





Needs and opportunities provided by AI

There are at least two perspectives to consider regarding the introduction of AI in classrooms. Firstly, literacy on the topic is crucial. Just as in the 19th century, educational systems were disseminated to understand the world of the first industrial revolution, it is essential that the entire population (particularly young people) develop a level of literacy in computational thinking and AI within the framework of the fourth industrial revolution. This will allow them to understand the world they are living in, exercise their citizenship, and actively participate in discussions about the ethical impacts and possibilities offered by this technology. It is necessary to acquire basic concepts about how AI works as part of preparation for the future.

On the other hand, we cannot overlook the emergence of tools that include AI in classrooms, problematizing their use by teachers and students. Since ancient times, we have been using technologies to solve problems; today, it seems imperative to discuss which problems in educational systems can be addressed with the help of computing and AI.

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Improving personalized teaching, efficient creation and delivery of content, support for diversity in learning, accessibility and inclusion, translation assistance, collaborative learning, development of critical thinking skills, creative problem-solving, accelerated research and writing, innovative assessment methods, increased student participation and motivation, as well as academic support and tutoring, are some of the areas where AI appears as a promise or possibility for improvement (Mohebi, 2024).

AI can be a valuable tool for promoting inclusion and diversity in the classroom. AI systems can adapt educational content according to

the individual needs of students, offering personalized materials and activities that fit their level of prior knowledge. By providing personalized resources and support, it can address their special needs so that they can participate more actively and successfully in the educational process. Additionally, the emergence of chatbots and AI-based tutoring systems allows for personalized tutors who can provide individualized support to students, offering explanations, resolving doubts, and providing immediate feedback on their progress. Likewise, AI can facilitate translation and access to content in different languages, benefiting students from diverse linguistic and cultural communities.

Large-scale data processing can help identify patterns and trends, helping each educator design more effective and tailored teaching sequences to the needs of their students. Not only can proposals be benefited, but also assessment instruments; AI systems can support the creation of adaptive tests and evaluations that adjust to each student's level of knowledge and skills, offering questions and exercises that challenge them appropriately. EdGPTs (Educational-GPT Models) aim to refine large LLMs trained with massive amounts of data to smaller, high-quality educational-specific datasets (UNESCO, 2023b). Through these EdGPT models, which are geared towards curriculum co-design, teachers and students could generate educational materials along the lines of what was mentioned earlier.

AI-inclusive systems can also improve educational management by analyzing administrative and academic data to identify areas for improvement in resource management, staff allocation, curriculum planning, and other key aspects of educational management. For example, in dropout prediction, through the analysis of historical data and real-time monitoring of student performance. As well as in generating early warning signals indicating the risk of school dropout, which allows educators to intervene proactively to provide additional support to specific students.

The effective possibility and real impact in terms of learning or teaching practices are still presenting challenges. The debate around the need or relevance of incorporating AI will be part of the challenges to be addressed in the short term, and this book aims to contribute to this discussion.

Basic conditions for the introduction of AI in systems

In this book, we have already explored in detail the necessary policies for this purpose. In this segment, we will present some fundamental conditions to initiate the implementation of a strategy to include AI in our educational systems:

- Technological infrastructure:
 - **Devices:** Computers and devices with sufficient capacity to run AI programs and access online resources.
 - **Connectivity:** Broadband internet access to enable efficient use of cloud-based applications and online resources.
 - **Platforms:** Licenses for specialized AI tools and platforms, as well as access to APIs and suitable development environments.
 - **Continuous technical support:** Assistance for the maintenance of technological infrastructure and resolution of technical issues.
- Teacher professional development:
 - **Basic conceptual training in AI:** Teachers need to understand the fundamental principles of AI.
 - **Ethics training in AI:** Training and reflection on the ethical dilemmas associated with AI and its impact on society.
 - **Development of technical skills:** Training in programming, data management, and use of specific AI tools.

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- **Didactics for teaching AI:** Strategies to integrate AI into the curriculum and promote critical thinking and problem-solving skills in students. This skill can and should be interdisciplinary, and the DPD strategy should be designed for all areas.
 - **Constant updating:** Continuous training programs for teachers to keep their skills updated in the face of rapid advances in AI technology.
 - Curricular Development:
 - **Curricular integration:** Development of curricula that include AI transversally or as a specific subject.
 - **Specific didactic materials:** Creation and adaptation of educational resources that facilitate the learning of AI.
 - Ethical and Legal Considerations:
 - **Ethical and policy definitions:** Definition of regulations and policies that ensure ethical use and responsible creation of AI-based systems.
 - **Privacy and data security:** Implementation of policies and practices for the protection of student data and compliance with current legal regulations.

What should remain human?

What we decide to do with this technology is exclusively a human matter; the direction we take depends entirely on us. It is crucial to recognize that AI is a tool, and as such, it reflects the intentions and values of those who design and use it.

In this sense, care, promotion of research, and vigilance for rigor are necessary in the face of the appearance of disruptive technologies, for example, when focusing learning solely on the use of platforms oriented towards close-ended problems. There is a broader view that involves appropriately valuing the positive aspects of platforms and complementing classroom work to develop projects, collaborative learning, spaces for reflection, and metacognition, among others.

Another key aspect is the definition of foundational skills that require certain practices not necessarily associated with digital technologies (such as literacy in reading and writing, arithmetic). It is extremely relevant to identify these cognitive processes.

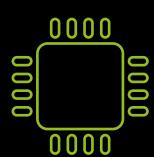
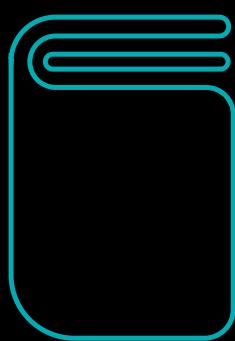
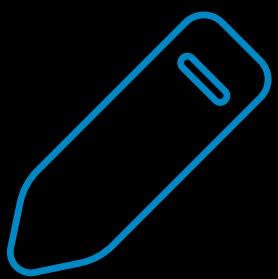
We believe that both critical thinking and creativity can be promoted by incorporating AI into the classroom. The AI framework described in the book contains some competencies to promote in this regard.

It is essential that we face the challenge of localizing AI for the global south, acknowledging the challenge posed by differences in the use and production of AI technologies in our region. Cultural contextualization is key, and for this, it is necessary to create a network among countries that work cooperatively to avoid the risk of reducing the diversity of opinions and further marginalizing already marginalized voices.

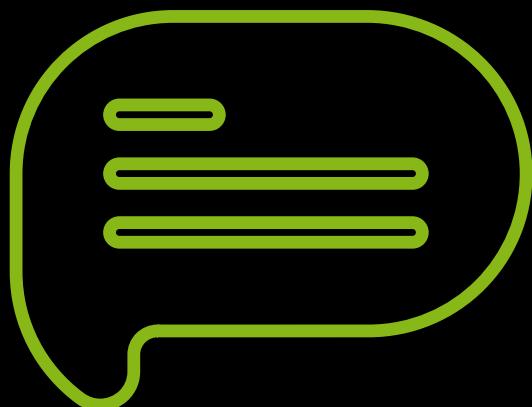
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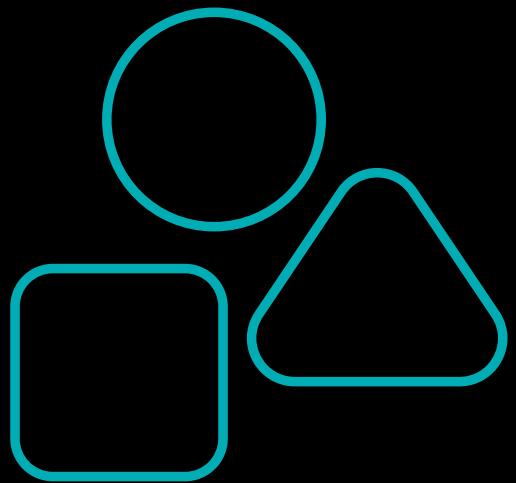
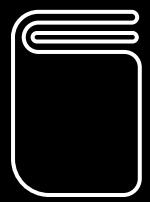
Associated with these points is the promotion of strategies that contribute to breaking the cycle associated with the risk of reducing the diversity of opinions and continuing to widen the gaps and opportunities for minorities and marginalized voices.

In this context, it is essential to promote continuous and rigorous ethical debate to ensure that its implementation benefits society as a whole. We must be proactive in creating regulations and guidelines that ensure responsible and ethical use of AI, thus promoting a future in which technology amplifies our capabilities without compromising our humanistic principles. Achieving this requires a necessary foundation of literacy in this technology on a global level.



Reviews





Reviews

Ceibal's Building Artificial Intelligence for Education offers a compelling set of principles and dimensions for effectively implementing AI in the classroom. Notably, this book goes beyond simply outlining core computational concepts. Instead, it emphasizes a foundational set of values that guide educators in constructing engaging and equitable learning environments. The core strength of this work lies in its focus on equity. By advocating for education that caters to the individual and collective needs of diverse communities, it centers the importance of all learners having the opportunity to thrive regardless of background. This is particularly important in STEM fields, where disparities exist. At Digital Promise, we believe that safe and effective use of AI requires informed users. With this book, Ceibal is advancing AI literacy for all learners, educators, and community members, empowering them to use these emerging technologies responsibly. This book provides a valuable foundation for educators who want to integrate AI in engaging and inclusive ways. By emphasizing equity, active learning, and critical thinking, Building AI for Education guides educators as they work to cultivate a generation of creative and responsible problem solvers.

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Pati Ruiz,
Senior Director of Edtech and Emerging Technologies at Digital Promise

Building Artificial Intelligence for Education uniquely blends theoretical foundations with practical classroom applications, making AI education accessible and engaging for novice teachers and students. It demystifies AI with activities that encourage critical thinking and hands-on experimentation. The guide's ethical considerations and its approach to integrating AI into diverse contexts help educators determine the role of AI in their classrooms. Ceibal's leadership in AI education continues its rich tradition in computing education.

**Pat Yongpradit,
Chief Academic Officer of Code.org and Lead of TeachAI**

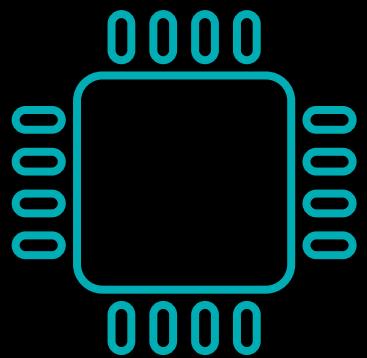
This book is an excellent guide to the current state of Artificial Intelligence. While its language is accessible to a non-specialized audience, it remains highly precise in its definitions, covering what we understand today about Artificial Intelligence, particularly machine learning. Additionally, it proposes activities that help ground all the concepts it explores, completing the understanding of this timely and vast topic.

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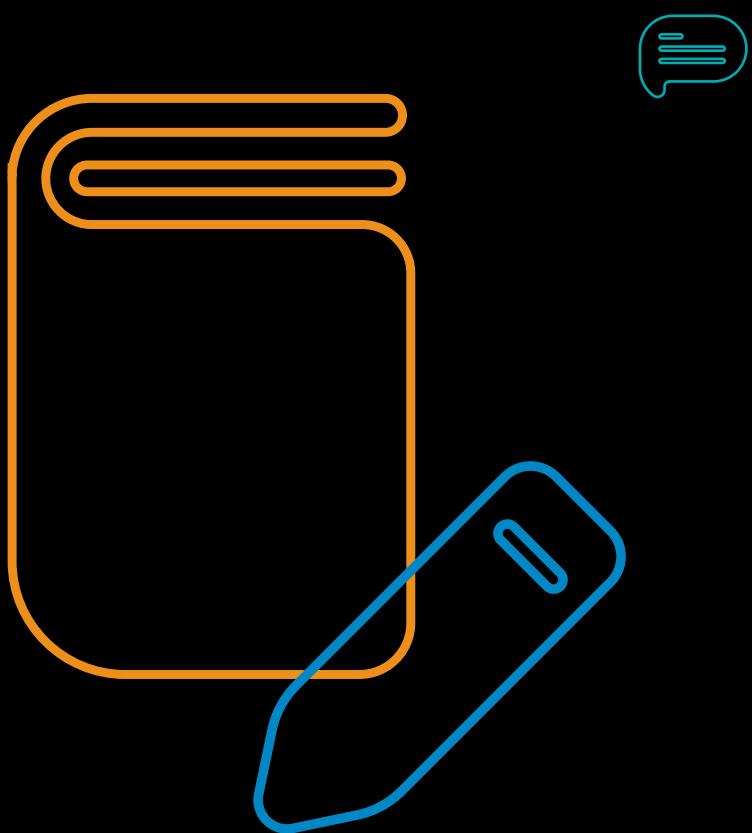
**Maria Inés Fariello,
Professor at the Institute of Mathematics and Statistics, School of
Engineering, University of the Republic.**

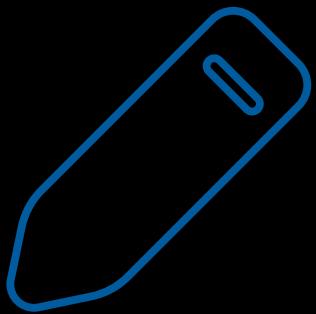
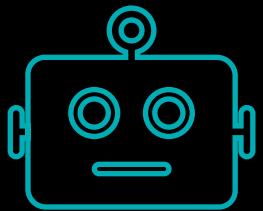
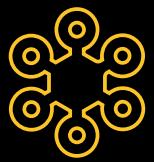
Building Artificial Intelligence for Education masterfully combines foundational theories with practical classroom strategies, ensuring that AI education is both accessible and engaging for beginners, whether they are teachers or students. It breaks down complex AI concepts through activities that promote critical thinking and hands-on learning. The guide also addresses the ethical dimensions and offers guidance on integrating AI into various educational settings, enabling educators to thoughtfully consider AI's role in their classrooms.

**Armand Doucet,
Educator and member of the Order of Canada**



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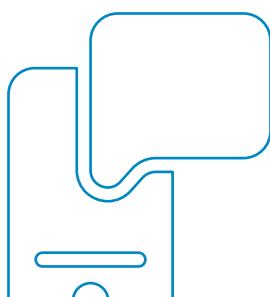
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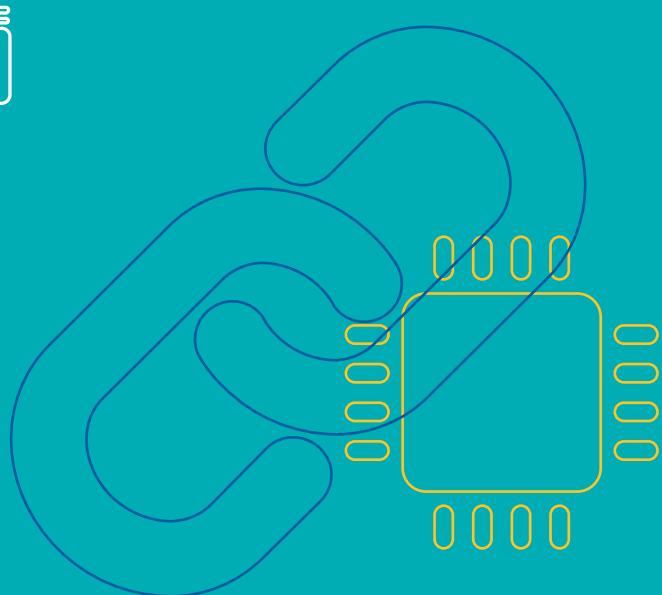
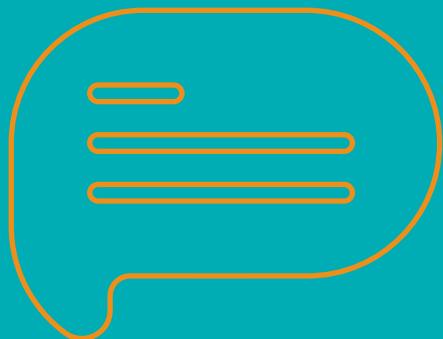
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