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# Metacognition and Pedagogy in the Era of Artificial Intelligence

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**This article explores the impact of artificial intelligence (AI)-based technologies on educational processes, emphasizing advances in machine learning, artificial neural networks, and pattern recognition. Traditional teaching approaches, focused on predictability, knowledge transfer, and memorization, are increasingly inadequate in a society marked by rapid change and instant, free access to information. In this context, pedagogy rooted in metacognitive predicates, particularly promoting self-knowledge, independent learning, and the ability to learn how to learn, emerges as the most effective response to social shifts driven by AI. The paper offers guidelines for integrating metacognitive practices into classroom settings, encouraging reflective consideration of their influence on learning. Additionally, it discusses the potential for AI itself to act as a partner in cultivating metacognitive skills, fostering more reflective and autonomous educational practices. Metacognition, often seen as uniquely human, is highlighted as a crucial differentiator in the competition with AI-driven machines, especially amid ongoing labor market transformations. The importance of establishing general guidelines for implementing metacognitive strategies in education and promoting reflection on their potential effects on learning is also emphasized.**

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## I. Impacts of Artificial Intelligence on Society

AI has fostered profound and multifaceted transformations within contemporary social dynamics, reflecting and influencing various cultural expressions. Its presence is increasingly evident across multiple domains of human activity, particularly in education, knowledge production, the arts, the labor market, and social values.

In the educational sphere, the integration of AI systems facilitates the personalization of the learning process, thereby contributing to the democratization of access to knowledge. Conversely, this technological advancement necessitates a reassessment of traditional pedagogical practices, prompting questions about the role of educators and the function of educational institutions. More than a mere innovation, the changes driven by AI require the development of novel pedagogical approaches, exemplified by contemporary debates surrounding metacognition and the cultivation of reflective skills.

Within the realm of knowledge production, AI has revolutionized data analysis methods, enabling rapid and efficient discoveries in fields such as medicine,

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technology, and both the natural and social sciences. Machine learning algorithms play a crucial role in identifying complex patterns, thereby accelerating scientific progress and fostering innovation. Furthermore, the capacity to generate automated and personalized content facilitates improved access to information, contributing to the democratization of knowledge. However, these transformations also raise ethical concerns regarding intellectual autonomy, the reliability of sources generated by algorithms, and the imperative of responsible technology use to ensure that scientific and social progress aligns with robust ethical values.

In terms of communication and social interactions, the presence of AI imposes significant changes through advancements in digital media, virtual assistants, chatbots, and automatic translation tools, which facilitate global communication. This evolution promotes the exchange of ideas and social inclusion; however, it also raises concerns related to authenticity, privacy, and the transformation of linguistic and relational habits, directly influencing our modes of coexistence and perception of the world.

In the arts, AI challenges traditional concepts of authorship and creativity. On one hand, algorithm-based tools and neural networks appear to enable artists to create potentially original works, manipulate images, compose music, and produce automated texts. In this regard, the convergence of art and technology is enriching the contemporary cultural landscape by expanding the horizons of cultural expression and encouraging new forms of artistic production. Conversely, AI-assisted art prompts ongoing debates regarding the role of human artists in the face of creative machines. A pressing question is whether we will lose control over a realm previously exclusive to humans to these new AIs or whether we will ever be surpassed in creativity by silicon components. In this context, the relationship between creativity, authenticity, and artistic value is continuously re-evaluated, revealing the complex intersections between technology and culture.

As with any technological advancement, the benefits of AI coexist with challenges and risks that remain to be addressed, including ethical issues related to privacy, algorithmic bias, and autonomy. The increasing presence of AI in the labor market, through the automation of repetitive tasks and the creation of new professions, also fuels debates about the value of human work, social inequality, and inclusion, factors that directly influence cultural values related to identity and life purpose.

Finally, technological development engenders unprecedented ethical dilemmas, given the rapid learning and evolving capabilities of machines that continuously adapt, including autonomously. These advances challenge moral and cultural foundations, necessitating ongoing reflection on principles of justice, social responsibility, and trust in technology to ensure that progress aligns with the social and ethical well-being of all [1].

AI is shaping contemporary culture in a complex and profound manner, requiring continuous reflection on the values to be preserved and promoted—ensuring that technological progress is responsibly oriented toward social, ethical, and cultural development.

## II. On the Need for a New Pedagogy

In the last century, we successfully trained higher education professionals based on content, procedures, and techniques, equipping them to meet the challenges


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of a relatively predictable labor market. For each profession, it was possible to define a minimum curriculum and subsequent curricular guidelines, enabling graduates to face their respective challenges competently and under conditions that generally ensured professional satisfaction. Compared to those with secondary education, higher education graduates were better remunerated, recognized, and socially respected. In sum, possessing a higher education degree in the twentieth century was a sine qua non condition, and often sufficient, to guarantee a minimally satisfactory life, both financially and in terms of social recognition.

In the twenty-first century, the digital revolution has significantly complicated this task, and many of the guarantees of previous times are gradually eroding. Expectations regarding future professional demands are in constant and radical transformation, influenced by an accelerated and unpredictable dynamic. The very volatility of the present makes daily life characterized by rapid changes, complicating the construction of a clear vision of the demands that lie ahead for professional practice and citizenship itself. Moreover, the advancements of the twenty-first century have made it evident that routine tasks based on recipes and standardized procedures are quickly being replaced by robots and AIs capable of autonomous learning and adaptation [2]. This reality necessitates the development of pedagogical strategies that are radically different from traditional approaches. To make the context even more complex, the rapid pace of global transformation hampers educational managers and teachers from immediately perceiving this new reality and from constructing pedagogical frameworks adapted to these novel demands and unprecedented challenges.

Given this scenario, it is essential to train learners to cope with abrupt changes through conscious adaptation processes, cultivating emotional balance and rationality in the face of unprecedented situations. However, socio-emotional and rational skills alone are not sufficient. It is fundamental for individuals to be capable of reflecting on their own emotions and thoughts. In summary, while until the end of the twentieth century cognition was considered a sufficient skill for a world of relatively simple professional relations, from the turn of the twenty-first century onward, it has become necessary to differentiate ourselves by developing metacognitive skills. Merely knowing is no longer enough; we need to know how to seek knowledge across diverse contexts and for various purposes. This entails replacing rigid learning with flexibility, shifting from disciplinary encyclopedic knowledge to a perspective that values multidisciplinarity, and developing resilience, teamwork, adaptability, and empathy as fundamental methods. Thus, a competence that was previously secondary, learning to learn continuously throughout life, rapidly emerges as a primary skill in this new landscape [3], associated with metacognition and a set of skills that we will explore next.

Complementing the importance of valuing metacognition is the fact that, fortunately, technologies can assist in the complex process of developing metacognitive skills. By utilizing learning analytics, it is possible to identify effective strategies for developing the specific skills and competencies of each student [4]. These tools enable both students and educators to engage in continuous reflection on their modes of learning and teaching, fostering lifelong learning skills and practices. This encapsulates the essence of metacognitive approaches, which focus on increasing awareness of the learning process itself and optimizing it across different contexts and for various purposes.

For example, the analysis of data generated by virtual learning environments provides systematic information about the student's educational journey. This allows for an in-depth understanding of their characteristics and learning preferences. Through monitoring these digital footprints, educators and students can identify which media enhance learning, determine the times or contexts in which performance is optimal, and assess which methodologies are most effective for each individual profile. Using this data, customized educational pathways can be created to meet the specific needs of each learner, considering their contexts and educational objectives.

In this scenario, especially when considering the world of work, it becomes evident that whether a future professional is a collaborator or a leader, their metacognitive skills are of utmost importance. Consequently, the training of contemporary professionals requires fostering independent and autonomous learning [5], along with logical reasoning (deductive, inductive, formal, informal), textual interpretation, and analytical thinking, as well as an understanding of the distinctions between causality and correlation, and concepts of probability and statistics, among other fundamental skills essential to rationality and scientific thinking [6]. These skills are fundamental for enabling professionals to observe "from an outside perspective," that is, metacognitively, how to develop both their rational and emotional capacities.

Therefore, contemporary educational projects, both formal and informal, should not only promote citizenship in the era of AI but also prepare professionals for a rapidly transforming labor market [7]. The accelerated changes in the job market compel professionals to engage in continuous qualification and often to undergo complete career shifts. This entire context underscores the urgent need for a new pedagogy capable of adapting to these challenges, ensuring an appropriate and sufficiently agile education system that can keep pace with such profound transformations.

## III. Metacognition: The Art of Learning to Learn Continuously Throughout Life

In the previous section, we outlined the overarching idea of the article, associating the past with the sufficiency of cognition and the future with the necessity of developing metacognition. To some extent, we have already defined metacognition; however, to connect its valuation to technological development, particularly with the advent of new AIs, it is important to examine this concept more closely.

Thus, if cognition can be broadly defined as the set of mental processes that enable us to process information (whether internal or external), then metacognition refers to the set of knowledge and beliefs we hold about our own cognitive processes—past, present, or future—as well as the processes that allow us to manipulate and regulate these [8].

An alternative way to understand metacognition is to consider it as a collection of approaches that transcend basic and direct cognition. It represents the mastery of internal skills that enable learners to reflect upon, monitor, and consciously regulate their own learning processes. Consequently, metacognitive skills can be divided into two main dimensions: (i) *metacognitive knowledge,* which encompasses understanding factors that influence learning performance, mastery of various cognitive strategies, and the ability to adapt them to specific situations, also involving the recognition of one's strengths and difficulties, as


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well as understanding when and how to employ certain techniques to optimize learning; and (ii) *metacognitive regulation,* which involves actions such as planning, goal setting, continuous monitoring, strategic control, and evaluation of outcomes, thus promoting more autonomous and effective learning, as it allows students to adjust their actions and strategies in response to progress and encountered obstacles.

Additionally, encouraging students to reflect on their own learning processes involves fostering self-reflection and developing self-awareness skills. Particularly, skills related to metacognitive regulation contribute to the development of the ability to work collaboratively, fostering understanding of others, empathy, and cooperation—competencies essential for collaborative learning. These skills, in turn, constitute fundamental elements in the formation of individuals capable of autonomous lifelong learning in an increasingly dynamic environment characterized by rapid and constant change.

Thus, in the student's developmental process, beyond acquiring traditional technical knowledge, room is also created for the conscious development of socio-emotional competencies. Many educators view this integration as a recovery of humanistic elements, which are essential for a more holistic education that balances an exclusive emphasis on technological and cognitive aspects. Consequently, the formulation of metacognitive strategies functions not only as a tool for "knowing how to learn" but also as a reaffirmation of humanistic values that prioritize understanding, empathy, creativity, and resilience.

Finally, this dynamic underscores the importance of a pedagogical approach that values not only technical content but also the development of these metacognitive and socio-emotional skills. Such an approach enables the formation of more independent, creative, critical, and adaptable individuals, qualities crucial for navigating a world marked by constant transformation. In the next section, focused on the preparation of professionals, we will explore, as an example, the impacts of this metacognitive approach on professional life.

## IV. Metacognition and the World of Work

As previously mentioned, new AIs have established themselves as one of the most significant technological transformations of the twenty-first century, bringing about profound and multifaceted changes to the world of work. This technology, which enables machines to learn, make decisions, and perform complex tasks autonomously, is reshaping traditional concepts of employment, productivity, and innovation. Initially, AI was primarily viewed as a tool for automating repetitive and routine tasks, impacting sectors such as manufacturing, logistics, customer service, and data analysis. However, its evolution has extended its capabilities to perform activities that were previously exclusive to humans, such as analyzing complex data, pattern recognition, trend forecasting, and even creative endeavors, prompting debates about the future of all jobs and the need for widespread professional requalification.

The impact of AI on the labor market is ambivalent. On one hand, it promises to increase efficiency, reduce operational costs, and generate new business opportunities and specialized employment. Companies adopting AI technologies can offer innovative products and services, improve the customer experience, and optimize internal processes. On the other hand, there are significant concerns regarding the displacement of traditional jobs, especially those involving routine and low-skilled tasks. Workers in industrial, administrative, and support sectors may face the threat of professional obsolescence, necessitating rapid adaptation, retraining, and the development of more complex skills such as critical thinking, creativity, and digital competencies [9][10].

To address these challenges, as previously discussed, investing in education, continuous training, and public policies that promote the acquisition of new skills is fundamental. Furthermore, the advancement of AI raises important ethical questions, including responsibility for decisions made by algorithms, data privacy, and the social implications of automation. The reality is that AI will not entirely replace human labor but will demand that professionals adapt to a more dynamic and complex environment. In this context, skills such as creativity, empathy, the ability to solve new problems, and self-management become essential to ensure employability and relevance in future professional life. Thus, AI presents an opportunity for innovation and growth but also calls for deep reflection on pathways for human, social, and economic development in the digital era.

In the context of rapid technological advancement, metacognition emerges as a crucial skill for future success in the workforce. It encompasses the ability to reflect on one's own thinking processes, consciously plan actions, engage in autonomous learning, and adapt strategies in response to new challenges in the labor market. This skill enables individuals to continuously evaluate their own learning strategies, facilitating the identification of areas for improvement and fostering ongoing personal development. Furthermore, metacognition promotes greater autonomy in decision-making and enhances efficiency in adapting to swift technological changes, thereby contributing to a proactive stance amidst market transformations. As professionals further develop their metacognitive skills, they become better equipped to navigate increasingly dynamic, disruptive, and challenging environments, where the capacities for reflection, learning, and adaptation constitute critical competitive advantages.

The strengthening of metacognition also underscores the importance of continuously developing higher-order cognitive skills, such as critical thinking, creativity, innovation, and adaptability. These competencies are essential for professionals to collaborate effectively with artificial intelligence technologies and to occupy roles that require heightened human judgment, ethical discernment, and the ability to resolve novel and complex problems. This new paradigm of professional development emphasizes self-awareness, self-evaluation, and lifelong learning, positioning them as fundamental pillars for ensuring employability, sustainable growth, and relevance in global professional life in the age of AI. Investing in metacognition and the enhancement of learning-to-learn skills constitutes a strategic approach to preparing professionals for future challenges, fostering a trajectory of success and continuous innovation.

Moreover, there is a growing demand for professionals capable of continuous and adaptable learning, occupying roles that necessitate ongoing updating and requalification. In this regard, lifelong education and training become imperative, promoting attitudes of curiosity, autonomy, and intellectual engagement. Organizations increasingly recognize that investing in the development of these skills not only enhances competitiveness but also cultivates more innovative, collaborative, and resilient work environments. Therefore, the development of metacognition should be viewed as a bridge linking complex cognitive abilities to the demands of a rapidly transforming labor market, ensuring that both individuals and organizations can thrive amidst ongoing change. Thus, a culture of autonomous and reflective learning emerges as a decisive strategy for maintaining relevance, employability, and competitiveness in the digital era, where the capacity for self-reflective thinking is increasingly regarded as a core 21st-century competency.

## V. Current Landscape of Artificial Intelligence

Given the evident transformations in the realms of education and employment prompted by the advent of new artificial intelligences, it is worthwhile to take a step back to better understand the significant advances of the past decade. In 1997, IBM's digital chess machine Deep Blue achieved a historic victory by defeating the then-reigning world champion, Garry Kasparov. This milestone marked a paradigm shift in our understanding of human cognitive capacities versus those of machines [11][12]. A few decades later, virtually any smartphone processor has become sufficiently powerful to beat a world-class chess player, exemplifying the exponential growth in computational power.

However, the challenge appeared even greater in the game of Go, due to its vastly larger number of potential variations and possibilities, which made programming machines capable of defeating top players especially difficult. Many experts believed that reaching this goal was still far off. This remained the case until 2016, when AlphaGo, an AI program based on artificial neural networks developed by DeepMind (acquired by Google), employed an innovative reinforcement learning model and defeated Lee Sedol, widely regarded at the time as the best Go player in the world [13]. The following year, AlphaZero, an even more advanced version, defeated Stockfish 8, then considered the strongest chess engine. Stockfish 8 was a direct successor to Deep Blue and relied on traditional evaluation methods and decision trees. This victory elevated the discourse to a new frontier in AI development.

The key innovation of AlphaZero lies in its starting point: it operates from scratch, without pre-established heuristics, databases, or fixed rules guiding its moves. Unlike Stockfish 8, which depends on predefined rules and extensive opening databases, AlphaZero learns by playing against itself, applying principles of machine self-learning. Remarkably, within just four hours, AlphaZero transformed from a novice into one of the best players in the world, all without any direct human intervention or external data, solely through trial-and-error-based learning.

## VI. Humans Versus Artificial Intelligence and Metacognition as the Final Frontier

In the preceding sections, we examined the recent digital revolution driven by the exponential growth of artificial intelligence across education, labor markets, and society at large. We provided an overview of how metacognitive skills contribute to achieving various educational objectives and their significance in professional activities. Additionally, we discussed ways to enhance these benefits while mitigating associated risks. These aspects are, in some way, connected to the so-called "Humans versus AIs" debate [12]. In this section, we will explore recent research and development areas concerning the capabilities and limitations of AI, focusing on the discourse surrounding alleged human metacognitive advantages over machines. This discussion is especially pertinent in the phase preceding a potential technological singularity.

To begin, let us compare humans and machines based on some core attributes of Homo sapiens: physical strength, cognition, and, most critically, metacognition. Historically, humans ceased to compete with machines in physical strength, being vastly outperformed. Currently, the greater challenge lies in recognizing that, in certain aspects of simple cognition, humans are gradually being surpassed by machines that learn and adapt. Consequently, humans are now tasked with preserving their advantages in the realm of metacognition, encompassing self-awareness and the self-regulation of mental processes, which are fundamental elements for improving deep learning, problem-solving, and decision-making in complex environments. In other words, metacognition, an activity that involves reflecting on one's own reflection, enables individuals to monitor and regulate thoughts, emotions, and behaviors, as well as assess their own performance. The key questions are: "Will developing these metacognitive skills be sufficient for humans to remain superior to machines in some respects?" or "Are machines also evolving their own metacognitive capabilities?"

These questions can be exemplified by considering the so-called large language models (LLMs), which represent a significant advancement in AI due to their capacity to comprehend and generate text in an advanced manner. These systems are trained on vast amounts of textual data through deep neural networks that learn linguistic patterns, relationships, and contexts. As a result, LLMs can perform a range of tasks: translating texts, creating creative content, supporting customer service, and producing educational or other material. Their architecture, based on machine learning algorithms, makes them powerful tools for automating language-related activities. Some of the most prominent LLMs include systems developed by renowned companies and institutions. The GPT (Generative Pre-trained Transformer), launched by OpenAI in November 2022, is widely used due to its excellent ability to understand and generate natural language. More recently, in January 2025, the DeepSeek model was introduced, which has caused a significant impact [14].

Regarding the advancements in various large language models (LLMs) and the emerging trends in developing metacognitive capabilities within machines, the DeepSeek-R1 and DeepSeek-R1-Zero models stand out. These versions appear to inaugurate a new phase in the evolution of AI reasoning, demonstrating the ability to monitor, understand, and adjust their own cognitive processes, an indication of progress toward metacognition. This innovation is primarily driven by the intensive use of Reinforcement Learning (RL), which replaces the previous emphasis on Supervised Fine-Tuning (SFT). This shift enables DeepSeek, employing different algorithms from those typically used, to develop sophisticated and innovative strategies for problem-solving [15].

This approach includes, notably, a "Eureka!" moment that exemplifies a distinctive feature of its complex reasoning capacity, akin to a reflection on the reflection process itself. For instance, when solving a quadratic equation with two roots, the conventional strategy might involve searching for the numerical solution by exploring all possibilities. In contrast, the innovative strategy employs two simultaneous procedures: one targeting the classical numerical solution and another seeking an analytical solution. If the analytical approach finds a generalizing solution, it is prioritized, immediately halting the case-by-case numerical search. This advanced reasoning ability, involving a reflection on the ongoing reflection that surpasses traditional procedures, can be considered an embryonic form of metacognitive behavior. Although it is premature to claim that full metacognition has been achieved, the evidence suggests that this type of control is not merely an auxiliary resource but a fundamental component of


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the process. This approach positions DeepSeek as a milestone in the trajectory of machines that, in the future, may be capable of more comprehensive simulation of metacognition.

## VII. Metacognitive Practices in the Classroom and AI Promoting Metacognition

Building upon the brief reflections on the impacts of new AI technologies in our lives and the ongoing contest between humans and machines, it is pertinent to revisit an educational model that fosters a metacognitive approach. Numerous teaching practices are already solidifying in this regard, although their application depends on the specific circumstances of each educational setting and the objectives of projects. Here, we will explore some examples to illustrate this approach, demystifying the notion that metacognitive pedagogy is still distant, costly, or complex.

One example concerns a simple procedure related to assessment [16]. Traditionally, a teacher divides content into topics, and formative assessments aim to measure students' mastery of these topics, techniques, and procedures. After each assessment, the most common approach, especially in traditional teaching, is for the teacher to introduce a new topic in the next class. Subsequently, graded exams are often returned without extensive commentary, merely providing a score or grade. A metacognitive approach, in contrast to this traditional pedagogical method, would involve promoting a reflective activity with students immediately after the assessment, preferably in the following class. This activity constitutes a central, inseparable part of the evaluation process, in which students analyze their own performance, identifying difficulties, successes, and strategies used. Thus, assessment shifts from mere grade assignment to fostering students' capacity to reflect on their own reflection, strengthening their autonomous capacity to "learn how to learn."

Various other practices support a metacognitive approach in the classroom, including: (i) self-questioning: students ask themselves questions about what they are learning, such as "Did I really understand this?" or "What strategies can I use to solve this problem?"; (ii) self-assessment: students reflect on their progress using checklists or rubrics to evaluate their own skills and knowledge; (iii) think-aloud: learners verbalize their reasoning while solving problems or reading, making their cognitive processes explicit; (iv) planning and goal-setting: before starting a task, students establish clear objectives and plan the strategies needed to achieve them; (v) comprehension monitoring: during the learning process, students pause periodically to verify their understanding, identifying confusing parts and seeking clarification; (vi) collaborative reflection: students share their thought processes and strategies with peers, promoting an exchange of perspectives and deepening understanding; (vii) reflection journals: students regularly record their learning experiences, reflecting on what they learned, which strategies were effective, and what needs further improvement; and (viii) use of graphic organizers: visual tools such as mind maps and concept maps help students structure and reflect on their knowledge, facilitating comprehension and retention [13][17].

The application of these practices, as well as other similar resources, enhances students' awareness of their own learning processes. This awareness contributes to a deeper understanding of content, improves academic performance, and fosters greater autonomy in knowledge construction.

Turning now to AI, it is important to consider strategies for teaching the fundamentals of how these systems operate, with the aim of developing metacognitive skills in learners based on this understanding. Our hypothesis is that AI itself, by demanding an innovative pedagogical approach, can also serve as a stimulus for metacognition [18]. Just as AI has been used as a tool to expand human intelligence, it can be integrated into education as a reflective object, aimed at fostering individuals' autonomy to think and learn [19]. In this context, Minsky [20] highlights the importance of providing learners with ideas and resources that enable them to develop their own theories about themselves (metacognition), thereby promoting cognitive autonomy.

Yadad et al. [21] emphasize the interrelationships between metacognition and computational thinking, as both pertain to skills oriented toward problem-solving. According to these authors, concepts of computational thinking, such as abstraction, decomposition, algorithmic reasoning, and debugging, can be linked to metacognitive skills, including "defining a problem," "selecting relevant elements," "decomposing a task," and "planning the steps to solve it." These competencies are employed by learners to monitor and self-regulate their cognitive processes. Thus, understanding how computers operate can foster reflections on human metacognitive processes, leading to a more profound understanding of oneself as a cognitive agent.

In this context, AI can be utilized as a tool that enables learners to reflect on their own cognition, whether by modeling their mental processes or by contrasting human cognition with artificial intelligence. Monitoring memory and regulating forgetfulness represent metacognitive skills, while understanding how memory functions, including its various categories and the factors influencing its performance, constitutes metacognitive knowledge.

A practical example of reflection on AI itself involves the use of LLMs or the simpler process of facial recognition. Both systems are based on massive amounts of data, involving billions of parameters. For instance, ChatGPT-3, in its most modest version, was trained on hundreds of billions of words, an amount far exceeding what a human could read in a lifetime. Consequently, most people use AI systems in functional, utilitarian, and immediate ways, often without interest in understanding the sophistication of the machine learning algorithms that underpin these models.

Our proposed approach encourages reflection on these experiences to identify differences between one's own way of thinking and how AI "thinks," as well as to deepen users' awareness of potential limitations. In this regard, educators should provide accessible technical explanations about how AI systems operate, fostering a more comprehensive understanding among students. This enables students to draw comparisons between the technical structures of machines and their own text production abilities, promoting greater awareness of their metacognitive and learning skills.

## VIII. Conclusions

Contemporary educational projects, beyond fostering citizenship in the era of AI, must focus on the development of professionals and citizens equipped with competencies aligned with the demands of this new period. This context highlights the urgent need for a novel pedagogical approach capable of adapting to constant challenges, ensuring agile, relevant, and socially and technologically responsive training. Consequently, it is crucial to cultivate metacognitive skills that enable individuals to become more autonomous, creative, critical, and adaptable, traits essential for success today.

AI systems based on neural networks and deep learning, unlike traditional approaches, dispense with predefined concepts or explicit logical inferences, instead relying on pattern detection and autonomous adaptation during training. In this landscape, where human physical and cognitive capabilities are progressively surpassed by machines, the ultimate battleground appears to focus on metacognitive competencies. Therefore, promoting the development of these skills becomes a strategic priority for humans to maintain a distinctive advantage, particularly in the capacity to reflect on their own reflection, learn how to learn, and continuously evolve throughout life.

In summary, a metacognitive approach in the classroom is fundamental for fostering students' self-awareness, combined with conscious reflection on their own learning processes, thereby supporting the development of autonomy and critical thinking. Such an approach can be effectively implemented through simple and accessible practices, including post-assessment reflections, self-questioning, verbalization of reasoning, self-evaluations, task planning, and the use of visual supports. These strategies encourage students to better understand their difficulties, identify effective strategies, and utilize available resources, strengthening their comprehension of content and their academic performance. Ultimately, metacognitive practice contributes to a more collaborative and critical pedagogy, promoting student autonomy in constructing their own knowledge and preparing them to face the key challenges of the contemporary world.

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### *Potential Competing Interests*

No potential competing interests to declare.

### *Data Availability*

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

### *Author Contributions*

R.M. and G.G. contributed equally to the conceptualization, writing, and critical revision of the manuscript. Both authors have read and agreed to the final version of the manuscript.

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