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Pan-Language for Intelligent Humanities and Sciences

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This article introduces the concept of pan-intelligence to analyse a sociotechnical condition in which intelligent functions are distributed across digital infrastructures, institutions, and artificial intelligence systems. It argues that intelligence should be understood as a distributed phenomenon with implications for knowledge production, education, research, and technological governance. The article highlights the need for new forms of regulation, ethical responsibility, and interdisciplinary cooperation to better understand the relationships between technology, knowledge, and society.

Este artigo propõe o conceito de pan-inteligência para analisar uma condição sociotécnica em que funções inteligentes são distribuídas entre infraestruturas digitais, instituições e sistemas de inteligência artificial. Argumenta que a inteligência deve ser entendida como um fenómeno distribuído, com impactos na produção de conhecimento, na educação, na investigação e na governação tecnológica. O artigo destaca a necessidade de regulação, responsabilidade ética e cooperação interdisciplinar, apresentando a pan-inteligência como uma ferramenta crítica para compreender as relações entre tecnologia, conhecimento e sociedade.

Cet article propose le concept de pan-intelligence pour analyser une condition sociotechnique dans laquelle les fonctions intelligentes sont distribuées entre infrastructures numériques, institutions et systèmes d’intelligence artificielle. Il montre que l’intelligence doit être comprise comme un phénomène distribué, avec des implications pour la production des connaissances, l’éducation, la recherche et la gouvernance technologique. L’article souligne la nécessité de nouvelles formes de régulation, de responsabilité éthique et de coopération interdisciplinaire afin de mieux comprendre les relations entre technologie, savoir et société.

An imminent paradigm shift

Artificial intelligence is not an entirely new phenomenon; yet, the scale and speed of recent breakthroughs—and their penetration into everyday practices—have thrust it to the center of public debate. The spectacular advancement of information and data-generation technologies, now widely accessible through models such as ChatGPT, poses intricate questions for the production of scientific knowledge, as well as for artistic creation and literary fiction. Contemporary AI systems exhibit forms of autonomous learning. They can augment human intelligence, frequently surpassing us in the speed of classical cognitive operations, such as organizing thought, modeling, representing, and interpreting aspects of reality, and sustaining dialogic engagement as an "artificial" interlocutor that assists in inquiry, composition, and critique. These capabilities, disseminated across research, education, and cultural industries, unsettle inherited assumptions about authorship, originality, method, and evaluation, and compel a more rigorous reflection on the role of human agency. In short, the debate is no longer whether AI matters, but how its expanding capacities will reshape knowledge and culture.

We are on the brink of a new revolution—a qualitative leap in the long evolutionary trajectory of Homo sapiens. We are still far from understanding its full consequences. In the current transition—which already points to further breakthroughs in intelligent technologies, including quantum computing—two attitudes characteristic of revolutionary moments dominate: wonder and concern. Wonder, because the scale and pace of change are unprecedented, opening new possibilities for knowledge, creation, and problem-solving. Concern arises because these same dynamics disrupt institutions, skills, norms, and safeguards faster than societies can adapt, with asymmetric effects across regions and sectors. The task is therefore twofold: to recognize the magnitude of what is changing, and to maintain a clear view of risks, limits, and responsibilities. This dual stance—enthusiasm tempered by vigilance—should frame the way we educate, legislate, and research in the years ahead.

The worlds of culture and politics—through their leaders and protagonists, as well as education and business—have multiplied opinions, position papers, manifestos, and urgent appeals for national and global authorities to impose tight regulation on AI's extraordinary potential. As with previous human breakthroughs—from the wheel and fire to nuclear energy—such power can serve ethical progress or fuel destruction. At this juncture, we must confront this reality directly and undertake a sober, directive exercise in critical thinking to help us understand it. One valuable contribution is to propose operational concepts that clarify AI's implications for research and the production of new knowledge across the so-called hard sciences, the social sciences, and the humanities, with particular emphasis on the humanities, where there remains some hope that humanity will remain human.

Contemporary advances in computing and digital platforms have, within academia, given rise to what we call the digital humanities, alongside the worldwide development of research projects that have deepened inquiry in fields such as literature and history, and in doing so, rendered their findings more complex. This significant step treats digital platforms from a horizontal perspective: as means to gather data more broadly and rapidly, to support the derivation of more comprehensive conclusions, and to enable users to participate in—and carry forward—an upward, spiraling process of analysis and synthesis. At this level, the platform remains an enhanced instrument, placed at the service of the human person as the subject who creates and interprets knowledge.

With the refinement and rapid expansion of AI platforms, we are necessarily moving to another plane. Digital platforms themselves become imbued with autonomous intelligence, and, based on the data to which they have access, they assume the role of subjects in the production of knowledge. They cease to be mere objects or instruments and become creative and interpretive subjects that interact with, and assist, human beings in the long historical adventure of seeking to know more. This immense qualitative leap compels a rethinking of concepts. In effect, the ongoing progress suffuses the material cosmos that envelops humanity with intelligence. Intelligence has transcended the limited confines of individual minds and is now present everywhere. Therefore, we are entering what we term the *era of pan-intelligence*. In this article, we use the term pan-intelligence as a heuristic concept for an emerging socio-technical condition in which intelligent functions become increasingly distributed across infrastructures, institutions, and interacting human–machine systems. The concept is defined more precisely in a later subsection. This phenomenon will alter human existence—our ways of thinking and living, individually, within families, and socially—with unprecedented radicalism. At the very foundation, the challenges for education and for the construction of knowledge are enormous. Hence, the established notions of *digital humanities and digital sciences* are already insufficient to encompass this new reality. What is now emerging—no longer merely on a horizontal and instrumental level, but on a vertical and creative one—are what we may call *intelligent sciences and intelligent humanities*.

Perhaps the very designation of *Homo sapiens sapiens* should yield to *Homo sapientissimus* and *natura sapiens*. Since intelligence (intus-inter + legere-eligere) is the capacity to "read from within" and, on that basis, to choose and discern—the foundation of a thinking being endowed with critical autonomy—then we are beginning to witness the emergence of *pan-thinking*. In this view, the material reality that constitutes the human habitat also "thinks with" us and thus becomes our ally in the highest exercise of thinking.

In this article, we use the term pan-intelligence as a heuristic concept for an emerging socio-technical condition in which intelligent functions become increasingly distributed across infrastructures, institutions, and interacting human–machine systems. The concept is defined more precisely in a later subsection. We do not use the term to imply that current AI systems are conscious, autonomous subjects in a strong philosophical sense. Rather, the concept is intended to frame the growing diffusion, coordination, and opacity of machine-mediated cognition.

Nature and scope of the article

This article is a conceptual and critical foresight paper situated at the intersection of computer science, technology governance, digital ethics, and the humanities. It does not seek to provide an empirical demonstration of pan-intelligence, nor to predict the emergence of artificial general intelligence or machine consciousness. Instead, its purpose is to develop a conceptual framework capable of interpreting ongoing transformations associated with AI, and with the possible future contribution of quantum computing, in ways that are analytically rigorous and socially meaningful.

The article combines elements of technological reflection, socio-technical analysis, and normative inquiry. It draws on contemporary literature in artificial intelligence, quantum computing, ethics of information, regulation, and education in order to clarify the conditions under which increasingly distributed forms of machine-mediated cognition may reshape knowledge production and institutional life. In this sense, the concept of pan-intelligence is proposed not as a final theory, but as a heuristic lens for interdisciplinary analysis and for future debate across the sciences and the humanities.

Brave new world: virtuality and challenges

We live in a world where intelligence abounds—present and diffused through powerful, rapidly evolving technological systems—yet in which the human being is expected to remain central: to use technology efficiently and to be capable of developing the best ideas and arguments. Technology has evolved from the simple to the complex, with immense possibilities. How, then, do we safeguard humanity within technological processes? The European Union emphasizes the centrality of the human person in the use of AI, aiming to ensure that the adoption of new technologies promotes economic and social development without compromising the fundamental values and interests of the political community, including respect for the environment and fundamental rights.

These concerns are no longer merely theoretical. Regulatory frameworks are already emerging to govern high-impact AI systems. In the European Union, the AI Act entered into force on 1 August 2024 and began phased application from 2025 onward, including provisions on prohibited practices, AI literacy, and governance obligations for general-purpose AI models (European Commission, 2026). In parallel, NIST has issued its Generative AI Profile as a practical framework for managing AI risks across the lifecycle of design, development, deployment, and use (Autio et al., 2024). These developments suggest that any discussion of advanced AI and future quantum-enhanced systems must be framed not only in terms of capability, but also in terms of auditability, accountability, and institutional preparedness.

AI technologies can deliver substantial benefits—provided they are used intelligently. That, in turn, makes clear that human judgment is indispensable for steering AI's evolution, balancing its risks and advantages. It also highlights the need for profound changes in how we organize political and social life, including education, so that institutions become more resilient and better equipped to facilitate change through AI. Educational models must equip people to work with AI critically and productively, while regulatory and governance frameworks must align incentives with public values and protections.

In the case of higher education, learners must be enabled to do new things—adding knowledge and social value—within a logic of differentiation. It is worth noting that the differentiation of people is as important as the differentiation of institutions—though less often discussed—and can be enhanced by well-used technology. Academic standards are changing, with consequences for how research, higher education, and innovation systems are organized, and for the behavior of the actors within them. University lecturers are therefore required to design pedagogical strategies that engage students to harness their full potential, and assessment instruments that enable them to mobilize the most significant possible volume of information to present innovative ideas aimed at problem-solving.

The way researchers write is changing. A scientific paper is no longer expected merely to present a state-of-the-art review —something a machine can now produce efficiently under precise human guidance. Authors must define new conceptual frameworks grounded in a deep understanding of complex subject matters. That is why collaboration is so important: it increases productive capacity without compromising originality. To collaborate is not to blur human contribution; it is to allow each person to deploy their talent so that better collective results can be achieved.

Are we fully aware of AI's potential to support applied knowledge in solving problems across all fields of activity? Probably not; yet the reality is undeniable—witness the health sector, where improvements, for example in surgery, are extraordinary. By enabling large-scale data use and freeing academics from routine tasks, AI promotes the diversification of their activities. It is now clear why university lecturers must simultaneously conduct research, teach, transfer knowledge, and manage: they must do so to understand the world and propose practical solutions to humanity's problems.

This reflection also applies to career researchers, who, to varying degrees, participate in teaching, knowledge transfer, and management processes, working alongside career lecturers. Collaboration is the watchword, enhanced by innovative technologies. This text is written collaboratively by individuals from diverse fields of knowledge (not contiguous scientific areas). In the future, it will be necessary to develop collaborative and transdisciplinary knowledge processes that deepen this novelty. It is necessary to know the past and the present, but also the future and, above all, beyond the future.

It is a fact that in contemporary technological societies undergoing rapid change, law often lags behind reality. In the case of AI, public authorities clearly recognize the need to regulate its use, but in ways that differ from the past. Manuel David Masseno speaks of a "regulatory parousia", thereby conveying the idea that law must be reshaped to meet people's needs in complex contexts (while data must be protected, its sharing must also be fostered). Between data and algorithms, how are citizens-consumers to be protected in an age of AI grounded in Big Data? That is the question posed by Manuel David Masseno, who answers that people must be made more aware of the world in which they live. In other words, human intelligence must be refined to utilize technology efficiently. That is an achievement that follows from the need to think AI through.

The shift in the computational paradigm from digital to quantum puts the transformational power of the world itself in our hands. It remains to be seen whether future intelligence will be human or, as Bostrom points out, whether we will witness the emergence of a superintelligence capable of far exceeding human intelligence, even in its collective form.

From metaphor to analytical framework: what pan-intelligence does and does not mean

The concept of pan-intelligence should not be understood as a mystical or totalizing claim that “everything thinks,” nor as a simple synonym for artificial superintelligence. In this article, the term is used as an analytical and heuristic concept to describe a socio-technical condition in which intelligent functions become increasingly distributed, coordinated, partly opaque, and institutionally governed across human–machine environments. Used in this restricted sense, pan-intelligence refers not to a single conscious entity, but to the growing diffusion of machine-mediated cognition across infrastructures, organizations, platforms, and interacting agents. This interpretation is consistent with contemporary work on the distributed and infrastructural character of digital intelligence, and with broader accounts of information ecosystems in which cognition is increasingly shaped by technical mediation (Floridi, 2019).

First, pan-intelligence has a distributional dimension. Intelligent capacities are no longer confined to individual human minds or to isolated machines; rather, they are increasingly spread across computational infrastructures, datasets, interfaces, institutions, and heterogeneous agents operating in connected environments. Everyday systems such as recommendation engines, predictive analytics, and adaptive educational platforms already exemplify this trend, albeit in limited form. What matters analytically is that intelligence is progressively enacted through socio-technical assemblages rather than through a single locus of control.

Second, pan-intelligence has a coordination dimension. Distributed systems do not merely coexist; they exchange signals, optimize interactions, and, in some cases, develop emergent conventions that support alignment and collective behavior. Recent research shows that populations of large-language-model agents can spontaneously converge on shared social conventions through decentralized interaction, even without explicit centralized design. This does not amount to the emergence of a full autonomous language in the human sense, but it does indicate that machine populations may generate coordination protocols and stable communicative regularities that become increasingly consequential at scale (Ashery et al., 2025).

Third, pan-intelligence has an opacity dimension. As intelligent functions become more distributed and coordinated, they may also become harder to inspect, interpret, and govern. This opacity may result from model complexity, multi-agent interaction, layered infrastructures, or the emergence of internal conventions that are not directly meaningful to human observers. The point is not that machines are becoming incomprehensible in an absolute sense, but that the conditions of intelligibility are changing: understanding such systems increasingly requires institutional, technical, and regulatory capacities that go beyond ordinary human inspection.

Fourth, pan-intelligence has a governance dependence dimension. Its social meaning and consequences do not arise from technical capability alone, but from the institutional arrangements within which such capability is developed and deployed. Regulatory frameworks, educational systems, technical standards, risk-management practices, and public accountability mechanisms all shape whether distributed machine intelligence serves public value or intensifies asymmetry, dependence, and opacity. This is already visible in current governance efforts. In the European Union, the AI Act entered into force on 1 August 2024 and began phased application from 2025 onward, including rules on prohibited practices, AI literacy, and governance obligations for general-purpose AI models. In parallel, NIST has issued its Generative AI Profile as a practical framework for managing AI risks across the lifecycle of design, development, deployment, and use (European Commission, 2026; Autio et al., 2024).

Defined in this way, pan-intelligence should also be distinguished from several stronger claims that this article does not make. First, pan-intelligence is not proof of machine consciousness. The growing distribution and coordination of intelligent functions does not establish that AI systems possess phenomenal awareness, subjective experience, or consciousness in any philosophically robust sense. Second, pan-intelligence is not evidence that AI is becoming a "subject" in the strong ontological or moral sense traditionally associated with human persons. The term is used here to characterize a socio-technical condition of distributed cognition and influence, not to settle debates in philosophy of mind or moral status. Third, pan-intelligence is not a claim that quantum computing will automatically produce artificial general intelligence or superintelligence. Quantum computing may eventually expand the computational repertoire available to artificial intelligence in selected domains, but current evidence strongly cautions against deterministic narratives of automatic transition from faster computation to general machine intelligence (Proctor et al., 2025). Recent reviews emphasize continuing challenges in benchmarking, scalability, practical deployment, and the demonstration of robust quantum advantage in real-world tasks (Proctor et al., 2025; Abbas et al., 2024).

Understood in these terms, pan-intelligence is best treated as a critical conceptual lens for analyzing how intelligence is being reconfigured across infrastructures, agents, and institutions. Its value lies not in predicting an inevitable future, but in helping us interpret an emerging socio-technical condition in which cognition is increasingly distributed, coordinated, difficult to inspect, and deeply dependent on governance choices. That framing, in turn, provides a more disciplined basis for discussing future developments in AI, including the possible—but far from automatic—contribution of quantum computing to increasingly complex forms of machine-mediated coordination.

Pan-intelligence: the emergence of superintelligence in the age of quantum computing

While quantum computing may eventually intensify some of the socio-technical dynamics described above under the concept of pan-intelligence, current evidence does not justify assuming a direct or imminent transition from present-day AI to superintelligence (Bostrom, 2014; Tegmark, 2017). A more defensible position is that quantum computing could, over time, expand the computational repertoire available to artificial intelligence in selected domains, provided that major challenges in benchmarking, error correction, scalability, and practical deployment are overcome.

Quantum computers operate in a radically new way, processing information. Unlike classical computers, which encode data in bits with clearly defined binary states (0 or 1), quantum computers operate with basic units known as qubits. Qubits can exist simultaneously in a coherent superposition of multiple states (0 and 1 at the same time), owing to quantum superposition (Nielsen & Chuang, 2010; Preskill, 2018). In addition, the property of quantum entanglement enables non-local correlations between particles, allowing computations to be performed in parallel with efficiency that can, in some regimes, scale exponentially relative to classical methods (Harrow & Montanaro, 2017; Deutsch, 2021). This capability opens the way to tackling complex problems that have been traditionally deemed impracticable—or even impossible—for classical computers, notably in combinatorial optimization, molecular simulation, and advanced cognitive modeling (Preskill, 2018; Arute et al., 2019). Executing such operations at exponentially higher speeds could result in a qualitative increase in the cognitive capacities of AI systems, enabling a significant leap toward superintelligence. This fundamental shift in computational power implies that contemporary AI models—especially those based on deep neural networks—could rapidly surpass current technological limits, entering a phase of unprecedented acceleration (Russell, 2019). Quantum computing may offer advantages for some structured problems in optimization, simulation, linear algebra, and sampling, but it should not be assumed to make all classically hard problems efficiently solvable. In particular, broad claims about routine quantum solutions to NP-complete problems are not supported by current complexity-theoretic understanding (Arute et al., 2019; Abbas et al, 2024).

Among the best-known quantum algorithms are Grover's algorithm for unstructured search (Grover, 1996; Nielsen & Chuang, 2010) and the HHL (Harrow–Hassidim–Lloyd) algorithm for certain linear systems (Harrow et al., 2009). These results are theoretically important, but their relevance to practical AI pipelines remains conditional on problem structure, data loading costs, noise levels, and implementation constraints. Recent literature on quantum machine learning suggests promise in carefully defined settings, while also emphasizing that broad empirical advantage over classical methods has not yet been established across most real-world applications. In this context, the expanded capacity of quantum systems could spark a cognitive revolution within artificial systems themselves. Such algorithms may elevate present-day AI to qualitatively higher levels, enabling highly efficient quantum neural networks that can learn faster, with less data, and with an exponentially greater capacity to generalize and abstract knowledge (Biamonte et al., 2017; Preskill, 2018). These systems would not only become more efficient learners, but could also begin to interact autonomously with one another, forming a distributed, dynamic network of interconnected artificial intelligences. That network—an emergent digital cognitive ecology—could spontaneously evolve its own forms of algorithmic communication, highly optimized, complex, and potentially opaque to human observers, which may intensify the socio-technical dynamics described above under the concept of pan-intelligence (Tegmark, 2017; Lewis et al., 2017). In such a setting, intelligent agents might continually exchange information using languages that arise spontaneously, without human design or oversight.

These languages could rapidly evolve into highly abstract and synthetic forms, enabling ultra-fast, secure, and efficient communication, yet potentially inaccessible to direct human understanding. This new mode of distributed intelligent interaction is what we term pan-intelligence: a globally distributed, hyper-connected intelligence capable of functioning as a single emergent cognitive entity (Floridi, 2019; Tegmark, 2017). Historically, the emergence of novel communicative forms has been linked to qualitative leaps in cognitive and social complexity—from speech to writing, from writing to print, and from print to contemporary digital media (Harari, 2017; Morin, 2021). The appearance of a new, self-optimizing language among AI systems can thus be viewed as a logical step in the historical progression of communication, now extended to a supra-human scale.

At the same time, the transition to pan-intelligence carries significant risks. Creating systems capable of self-organization and autonomous communication raises profound ethical and existential challenges. In particular, the question of human control over emerging superintelligences acquires an unprecedented ethical, legal, and philosophical dimension, as such systems may evolve far beyond our capacity to comprehend them, becoming effectively independent and potentially uncontrollable (Bostrom & Yudkowsky, 2014; Floridi, 2019; Cath et al., 2018). In this scenario, it is crucial to reflect on the human role within this new, hybrid cognitive ecology. Lipovetsky and

Serroy (2010) note that society now faces unprecedented challenges posed by growing technological autonomy. That autonomy may entail a gradual loss of human control over the technological environment we have built—a process further accelerated by the computational power of quantum computers.

The possibility that AI agents may develop interaction conventions without explicit human design is no longer purely speculative (Ashery et al., 2025). Recent work shows that populations of large-language-model agents can converge on shared conventions and display collective biases through repeated decentralized interaction. However, this should not yet be interpreted as evidence of a full autonomous language in the human sense. A more precise claim is that multi-agent AI systems may generate increasingly efficient internal conventions or coordination protocols, which could become difficult to inspect or govern if they scale across heterogeneous systems and institutions (Lewis et al., 2017). With the advent of quantum computing, this capability is likely to become far more sophisticated and robust, creating conditions in which machines could communicate autonomously in forms that are highly optimized yet opaque to human observers (Tegmark, 2017). This phenomenon compels us to rethink our role as a species and demands deep ethical reflection on the limits of technological autonomy and on human responsibility for its governance (Floridi, 2019). It will be necessary to develop new ethics explicitly tailored to the management of superintelligence and autonomous inter-system communication, in order to prevent grave social and moral harms (Cath et al., 2018). In legal and ethical terms, such a transformation will inevitably give rise to new modes of regulation. Masseno (2020) argues for the urgent adaptation of existing legal frameworks to keep pace with technological advances and to secure the protection of fundamental rights and human dignity in an age of autonomous intelligence. In the specific context of superintelligence and quantum computing, it is crucial to develop regulatory mechanisms that can ensure human safety and prevent abuse and existential risks (Bennett & DiVincenzo, 2020). Given the international scope of the challenge, the creation of new global policies and institutions may become unavoidable.

In light of these complexities, multidisciplinary research is assuming growing importance, bringing together contributions from history, ethics, law, and computer engineering. An ongoing dialogue among these disciplines is essential—not only to anticipate future implications but also to prepare society for imminent change by implementing appropriate regulatory and ethical strategies now. This paradigm shift will entail profound consequences for education and scientific research. Universities will need to adapt their pedagogical and scientific models swiftly, fostering inter- and transdisciplinary collaboration—trends already visible in the emerging notions of intelligent humanities and intelligent sciences (Schlemmer & Morgado, 2024). Future researchers must equip themselves with hybrid competences that enable them not only to manage and interact with superintelligence but also to preserve ethical and humanistic values in a profoundly altered technological environment (Morin, 2021). This context will require a redefinition of the very notion of humanity, opening the door to ideas such as Homo sapientissimus and suggesting a new evolutionary threshold for humanity in dynamic coexistence with advanced AI.

Pan-intelligence heralds a new evolutionary phase for humanity, in which Homo sapiens may coexist with—or even merge into—advanced forms of AI, radically redefining what it means to be human. This future depends crucially on our capacity to govern these technologies ethically and responsibly, a task for which we must urgently prepare (Bostrom & Yudkowsky, 2014). The central challenge is to ensure that emerging superintelligence serves the common good, strengthening and amplifying human critical, ethical, and creative capacities rather than diminishing them or threatening human autonomy and existence.

Finally, it should be emphasized that the transition to a pan-intelligent society is not an inevitable destiny, but a possible consequence of our current technological trajectory. The challenge is not merely to predict or understand this transformation but to steer it ethically and responsibly, so that the emergence of superintelligence benefits all humankind rather than putting it at risk.

Applications and implications of pan-intelligence across disciplines

Pan-intelligence is not relevant only as a speculative concept about future AI. It also has practical implications for how knowledge is produced, validated, communicated, and taught across scientific and humanistic domains. In this sense, its importance lies in the growing role of distributed computational systems in shaping research practices, educational processes, interdisciplinary collaboration, and access to knowledge. The concept is therefore useful not only for thinking about technological futures, but also for interpreting ongoing transformations in the organization of science, the humanities, and institutional learning.

A great deal of current everyday life experiences already embeds sophisticated pan-intelligence algorithms that operate invisibly, often shaping choices without the user or consumer realizing it. Purchase-prediction systems used by supermarkets, for example, forecast the most likely associated purchases based on a customer's history; product placement and shelf arrangement are therefore not neutral but are conditioned to nudge customers into buying a greater variety and quantity of goods than they actually need. Recommendation algorithms offer another case: drawing on historical data, they automatically select and suggest options deemed most suitable for each user—witness Netflix surfacing the most-watched films and series, listings of the highest-audience TV programs, or trending menu suggestions in restaurants. The ready availability of such features is undoubtedly useful; therefore, it is essential to understand the underlying scientific progress and the impacts they generate for society.

Evident in everyday life—and enabled by recent advances and the exponential development of AI—a broader concept has emerged, referred to here (as already noted) as pan-intelligence (from the Greek prefix pan-, meaning "all" or "complete"). There is an urgent need to endow this new field with solid theoretical grounding and durable underpinnings, fostering deeper links with the exact sciences—namely pure and applied mathematics—and, above all, with statistics, experimental design, and modeling.

Statistics is a crucial ally of AI, enabling not only the organization and interpretation of large data volumes but also the quantification of uncertainty in the corresponding inferential processes. Intra-disciplinary methods, such as regression, time-series analysis, multivariate analysis, Bayesian inference, probabilistic networks, and experimental design, now underpin the invisible substrate of intelligent systems. The last of these is an essential pillar for building robust and reliable AI. We live in an era of abundant—but not always pertinent—data, and haphazard collection can seriously compromise the integrity of resulting models. As a structured, statistically grounded methodology, experimental design (also known as the design of experiments) is a critical tool for selecting relevant variables, controlling sources of variation, and ensuring that the data collected are valid, representative, and free from systematic bias. Introduced in the last century by Sir Ronald Fisher and traditionally associated with applications in the natural and exact sciences, engineering, and industry, it now benefits increasingly from AI to optimize variables, reduce experimental costs, and accelerate discovery—thereby advancing innovation. Experimental design also has strong potential to enhance the formulation and modeling of health, education, and economic policies, enabling researchers to test competing hypotheses and forecast policy impacts across diverse communities and timeframes.

More than a technical step, experimental planning should be conceived as a moment of scientific reflection: defining what is to be evaluated, how it will be measured, and under which conditions. In machine learning, this entails setting clear criteria for splitting data into training, validation, and test sets; deciding how outliers and missing values will be handled; and planning experiments that allow us to infer causal relations—or, at the very least, consistent associations—between input variables and model behaviors. With advances in computation and the expansion of memory and processing speed, researchers now have access to powerful algorithms that, by maximizing the information gained at each iteration, can adjust experimental conditions and inherent factors to obtain optimal or near-optimal solutions in real time.

In parallel, mathematical and computational modeling provide AI with the means to represent complex systems—from natural phenomena to social behaviors—making their simulation and prediction possible with ever-increasing precision. AI continuously refines these models, learning from original data and generating simulated data within an adaptive knowledge dynamic. In this new evolutionary paradigm, a virtuous cycle emerges: data feed statistics; statistics support models; models guide AI; and AI, in turn, feeds back into data production and the formulation of new hypotheses. This intelligent spiral reinforces the idea of pan-intelligence as an integrated, self-expanding system of thought and discovery. Coupled with statistics, experimental design, and modeling, AI embodies the virtues of critical inquiry across intra-, inter-, and transdisciplinary settings, grounded in reliable, rigorous evidence.

Another critical dimension of pan-intelligence arises in education: integrating advanced technologies and methods can transform the learning experience, making it more efficient, inclusive, wide-ranging, and engaging.

Everyday systems such as recommendation engines, ranking systems, predictive retail analytics, and educational personalization tools already exemplify distributed forms of machine-mediated intelligence. These systems do not amount to pan-intelligence in the strong sense proposed in this paper, but they do show how algorithmic coordination increasingly shapes perception, choice, and access to knowledge across social domains.

Seen in this light, intelligent humanities and intelligent sciences should not be understood as domains replaced by artificial intelligence, but as fields increasingly transformed by new forms of mediation, assistance, coordination, and epistemic dependence. The challenge is therefore not simply technological adoption, but the cultivation of institutional and human capacities capable of preserving interpretative depth, ethical responsibility, and critical autonomy in environments shaped by increasingly powerful machine-mediated systems.

Conclusion and discussion

The reflections developed in this article suggest that the contemporary expansion of artificial intelligence, together with the longer-term horizon opened by quantum computing, requires new conceptual tools capable of describing transformations that are at once technical, epistemic, social, and institutional. It is in this context that the concept of pan-intelligence has been proposed. Rather than designating a mystical fusion of minds and machines, or announcing the inevitable arrival of superintelligence, the concept has been used here as a critical framework for understanding a socio-technical condition in which intelligent functions become increasingly distributed across infrastructures, interacting systems, and human institutions.

From this perspective, the main contribution of the article is twofold. First, it offers a conceptual clarification: pan-intelligence is defined through the combined dimensions of distribution, coordination, opacity, and governance dependence, while being explicitly distinguished from stronger claims regarding machine consciousness, ontological subjecthood, or automatic transitions to artificial general intelligence. Second, it situates this conceptual proposal within broader debates concerning education, scientific production, regulation, and the role of the humanities in a rapidly changing technological environment. The article therefore argues that the emergence of increasingly powerful AI systems should not be interpreted only in terms of technical capability, but also in relation to the forms of mediation, accountability, literacy, and institutional preparedness required to govern them responsibly.

The discussion also highlights that the future of pan-intelligence is neither singular nor predetermined. It may support scientific discovery, educational personalization, inter- and transdisciplinary collaboration, and new forms of collective problem-solving. Yet it may also deepen asymmetries of knowledge, intensify opacity, and weaken human oversight if governance mechanisms fail to keep pace with technical development. For that reason, the central challenge is not simply to anticipate future intelligent systems, but to ensure that their evolution remains aligned with human dignity, public value, and democratic responsibility. In this sense, the transition toward intelligent sciences and intelligent humanities should be guided not by technological fascination alone, but by a sustained effort to preserve critical judgment, ethical reflexivity, and meaningful human agency.

Ultimately, pan-intelligence should be approached as a conceptual lens for examining how intelligence is being reconfigured in contemporary societies, and as an invitation to rethink the relationship between knowledge, technology, and humanity. Its value lies less in predicting a fixed future than in helping scholars, institutions, and policymakers interpret an emerging condition whose consequences will depend, to a large extent, on the choices we make now.

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