

# Artificial Intelligence in Engineering Education: Enhancing Human Capabilities, Not Replacing Them

L. K. Herrera-Quintero<sup>1</sup>, J. M. Sánchez-Torres<sup>2</sup>, L. Chaparro-Díaz<sup>3</sup>, S. P. Carreño-Moreno<sup>4</sup>  
and Y. E. Sánchez-Mendoza<sup>5</sup>

The irruption of artificial intelligence (AI) in higher education – especially its generative forms, *i.e.*, models capable of producing text, images, or code – has rapidly transformed pedagogical, administrative, and assessment practices in our institutions. We are facing a reconfiguration of the university space that cannot be reduced to the adoption of tools; instead, it demands a critical examination of its epistemic, ethical, and pedagogical implications. Generative AI has established a set of practices that, if not continuously monitored, could compromise the very essence of education in engineering and other disciplines [1].

Today, engineering, historically positioned as the engine of technical and scientific development, faces a paradox: leading innovation without succumbing to thoughtless automation. AI cannot be assumed to be a cognitive shortcut or a substitute for thinking, but rather an opportunity to deepen human capabilities, *i.e.*, discerning, questioning, and proposing. This tension has been extensively documented in recent scientific literature [2]–[4], which warns about the risk of erosion of critical skills due to the superficial, uncritical, and decontextualized use of AI.

At Universidad Nacional de Colombia, we have taken on this challenge as an opportunity to rethink our mission-related functions. The proposal we share today, developed collaboratively and involving different disciplines, is based on the conviction that it is possible and necessary to incorporate AI into public universities in a strategic, ethical, and situated manner [5]. This implies not only regulating its use but also educating, researching, and extending from a paradigm that reaffirms the value of critical thinking, transparency, and social responsibility.

Within this framework, we propose three lines of action that are closely aligned with our university's academic and social dynamics. The first of them, CUIDAMOS-IA, proposes a pedagogical approach that recognizes student agency, promotes formative assessments, and strengthens the

necessary competencies to understand and engage with AI without becoming subordinate to it. As reported in [6], the vieJIAS initiative, an interdisciplinary academic collective, has led critical AI appropriation processes at Universidad Nacional de Colombia. This experience has integrated interdisciplinary workshops, teacher training spaces, and the development of AI-based conversational agents, involving more than 180 members of the university community. Its ethical, pedagogical, and collaborative approach embodies the type of educational environment that we promote in this line of action. This initiative has enabled the practical application of principles such as care, critical reflection, and shared responsibility in the use of these technologies within the university setting.

The aim is to train men and women engineers who can effectively interact with advanced technologies while remaining mindful of the ethical dilemmas, epistemic gaps, and social consequences associated with the use of AI. To this effect, it is necessary to create a learning environment that anticipates AI practices, preserves academic integrity, and fosters critical thinking.

The proper use of AI in teaching becomes possible in an environment of reflective pedagogical practice, which materializes through actions such as the inclusion of a transparent statement in course *syllabi* that details the use of AI, emphasizing how, why, and for what purpose this technology is used and how it is useful, but also what its risks are. The reality of using AI in higher education, whether its use is authorized or not, forces teachers to rethink their content and pedagogical strategies so that personal authorship, critical reflection, and human supervision are demanded, as no task carried out with the support of AI should overlook at least two reviews, one by the author and one by the teacher. Understanding the potential risks of indiscriminate, unsupervised, or unreflective AI usage is fundamental to preventing its use as a shortcut to the cognitive and reflective processes necessary for genuine learning.

<sup>1</sup> Department of Mechanical and Mechatronics Engineering, Faculty of Engineering, Universidad Nacional de Colombia, Bogotá Campus. E-mail: [lkherreraq@unal.edu.co](mailto:lkherreraq@unal.edu.co)

<sup>2</sup> Department of Systems and Industrial Engineering, Faculty of Engineering, Universidad Nacional de Colombia, Bogotá Campus. E-mail: [jmsanchezt@unal.edu.co](mailto:jmsanchezt@unal.edu.co)

<sup>3</sup> Department of Nursing, Faculty of Nursing, Universidad Nacional de Colombia, Bogotá Campus. E-mail: [olchapparrod@unal.edu.co](mailto:olchapparrod@unal.edu.co)

<sup>4</sup> Department of Nursing, Faculty of Nursing, Universidad Nacional de Colombia, Bogotá Campus. E-mail: [spcarrenom@unal.edu.co](mailto:spcarrenom@unal.edu.co)

<sup>5</sup> Department of Physics, Faculty of Science, Universidad Nacional de Colombia, Bogotá Campus. E-mail: [yesanchezm@unal.edu.co](mailto:yesanchezm@unal.edu.co)

Implementing a training system with AI support and developing it within a context of care should go beyond mere control. On the contrary, the goal is to rebuild trust in pedagogy through innovation. Therefore, it is not advisable to act as judges or executors regarding the use of AI, nor to monitor its use through AI detection platforms, as these platforms have their own biases and are prone to false positives. Instead, from a caring perspective, it is advisable to promote critical competencies to compare, validate, and debate the production of AI, e.g., by proposing exercises in critique and contrast of AI and human products, transforming the classroom into an ethical, reflective, and metacognitive laboratory.

The second line, REFLEXIONAMOS-IA, corresponds to the field of research. Through a set of recommendations organized around reflection, we have built an institutional guide that emphasizes ethical responsibility, academic integrity, transparency in documenting the use of AI, the prevention of AI-mediated plagiarism, and the care of sensitive data. This proposal does not intend to replace the researcher's judgment, but to strengthen it through clear criteria that position AI as a support tool, never as a hidden author or an intellectual replacement [5], [7].

Reflecting on AI support in research involves placing integrity and transparency at the center of the scientist's work. Among the processes that could be expedited with the use of AI are literature reviews and the projection of hypotheses and analysis pathways, for which it is necessary to thoroughly document the prompts used as well as each human intervention aimed at achieving the results. By explicitly declaring AI-mediated procedures, the traceability and reproducibility of research processes are favored, in addition to ensuring intellectual sovereignty.

REFLEXIONAMOS-IA is not only based on norms but also on the imperative of continuous training for research teams within a process of critical AI literacy, where the technical functioning of AIs is understood, as well as their limitations and political, economic, social, technological, environmental, and legal risks. In this sense, it is essential to take direct actions to avoid dependence on AI and, conversely, to promote a critical autonomy that encourages using AI as an assistant rather than a leader in generating knowledge. Thus, critical and reflective AI-supported research must take place in an environment nourished by human judgment, creativity, awareness, and responsibility.

In this context, it is essential to provide examples of how AI is used in engineering. Some of these include its application in additive manufacturing, automated microstructural analysis using computer vision, and the optimization of thermal and mechanical processes in materials engineering. These cases exemplify how AI can function as a technical assistant in simulation, classification, quality control, or experimental design tasks without replacing the researcher's judgment. Its inclusion strengthens the bridge between ethical reflection and everyday scientific practice in the field of engineering.

The third line, TEJEMOS-AI, responds to the need to think about university extension, also called the *third mission*, from an intercultural and territorial perspective [5]. Active student participation in co-creation processes with communities can be a key component of this line of action. Faced with the temptation of homogeneous and decontextualized solutions, we propose the use of AI in service of the social and environmental challenges of our regions. Critical extension is not limited to technological transfer; it enables co-creation processes with communities, recognizing their knowledge, languages, and needs. This is, perhaps, the most urgent dimension, given the deep digital inequalities that persist in our Latin American reality.

In this vein, proposals for the third university mission should begin with a participatory diagnosis that identifies the gaps and needs of communities. During these processes, AI can serve as a data collection, analysis, and reporting assistant, in addition to participating in the proposed solutions, generating responses to address the problems identified – that said, everything must be tailored to the level of AI access and appropriation exhibited by the community with which the work will be carried out. Weaving contextually appropriate solutions for and with communities assumes that AI is a bridge and not a barrier, always prioritizing the shared responsibility between the university and the community.

Weaving, as an exercise in AI-assisted co-creation between the university and the community, is a process that must take place within the framework of technological justice, wherein open and free access platforms should be used, preferably AI-supported solutions under the domain and governance of the university that aim for the social appropriation of knowledge, which transcends its mere transfer and advances towards the articulation of diverse, contextual knowledge based on real and experienced problems of the community. Thus, it is important to evaluate the impact of these initiatives through co-created indicators, document successful experiences, and ensure economic and environmental sustainability from the outset, which allows scaling up good practices and closing digital gaps. TEJEMOS-IA views AI as a tool to enhance care, solidarity, and innovation. Its aim is to build a living fabric of collaboration between academia and the community, which shapes citizens capable of transforming their reality with judgment and empathy.

These proposals do not emerge from improvisation; they are based on a comparative review of more than 350 policies and institutional guidelines on AI, in dialogue with frameworks such as the UNESCO recommendation [8], Colombia's CONPES 4144 [9], and other directives that guide the responsible use of emerging technologies. What distinguishes our approach is its internal coherence: five strategic axes (governance, training, curriculum, innovation, and sustainability) allowing for a progressive and transversal institutional implementation that is also capable of self-regulation.

Public universities cannot limit themselves to a passive adaptation to technological advancement; they are called to exercise ethical, pedagogical, and epistemic leadership. Therefore, incorporating AI cannot be a technical decision, but rather a collective, deliberative process that strengthens the innovative and ethical horizon of the university. Engineering, as an innovative discipline, holds an irreplaceable responsibility: to develop solutions that work and make sense, that build the future without relinquishing critical awareness [5].

If this moment teaches us anything, it is that the most powerful intelligence is not the one that automates at the highest speed, for the power lies within human beings who can stop and think, prioritizing situated and rigorous intelligence. This will, without a doubt, be reflected in the commitment to the responsible practice of engineering in the 21st century.

**Final note.** Members of the vieJIAs collective collaboratively wrote this document. This is a group of women professors from the Bogotá campus of Universidad Nacional de Colombia who are committed to a critical, pedagogical, and ethical reflection on the use of AI in university contexts.

## REFERENCES

- [1] A. Abulibdeh, C. Chatti, A. AlKhereibi, and S. Menshaw, "A scoping review of the strategic integration of artificial intelligence in higher education: Transforming university excellence themes and strategic planning in the digital era," *Eur. J. Edu.*, vol. 60, no. 1, art. e12908, 2025. <https://doi.org/10.1111/ejed.12908>
- [2] S. Khairullah, S. Harris, H. Hadi, R. Sandhu, N. Ahmad, and M. Alshara, M. "Implementing artificial intelligence in academic and administrative processes through responsible strategic leadership in the higher education institutions," *Front. Edu.*, vol. 10, art. 1548104, 2025. <https://doi.org/10.3389/feduc.2025.1548104>
- [3] C. Zhai, S. Wibowo, and L. D. Li, "The effects of over-reliance on AI dialogue systems on students' cognitive abilities: A systematic review," *Smart Learn. Environ.*, vol. 11, no. 1, 28, 2024.
- [4] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, "Systematic review of research on artificial intelligence applications in higher education—Where are the educators?" *Int. J. Educ. Tech. Higher Edu.*, vol. 16, no. 1, pp. 1-27, 2019.
- [5] J. M. Sánchez-Torres, L. Chaparro-Díaz, L. K. Herrera-Quintero, S. P. Carreño-Moreno, and Y. E. Sánchez-Mendoza, *Recomendaciones para el uso de la inteligencia artificial en actividades de docencia, investigación y extensión universitaria*. Bogotá DC, Colombia: Universidad Nacional de Colombia, 2025.
- [6] Agencia de Noticias UNAL, "ViejIAs lideran la apropiación crítica de la inteligencia artificial en la UNAL", Universidad Nacional de Colombia, 2025. [Online]. Available: <https://agenciadenoticias.unal.edu.co/detalle/viejias-lideran-la-apropiacion-critica-de-la-inteligencia-artificial-en-la-unal>
- [7] N. McDonald, A. Johri, A. Ali, and A. H. Collier, "Generative artificial intelligence in higher education: Evidence from an analysis of institutional policies and guidelines," *Comp. Human Behavior. Art. Humans*, vol. 3, art. 100121. <https://doi.org/10.1016/j.chbah.2025.100121>
- [8] UNESCO "Recommendation on the ethics of artificial intelligence," 2021. [Online]. Available: <https://unesdoc.unesco.org/ark:/48223/pf0000381137>
- [9] Departamento Nacional de Planeación, "Política nacional de transformación digital e inteligencia artificial, documento CONPES 4144," 2023. [Online]. Available: <https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/4144.pdf>