Training of Industrial Engineers at Industry 5.0: A Curricular Model with Ethical Integration of Artificial Intelligence, Robotics, and Computer Science

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***Abstract*– This article analyzes the current state of the incorporation of emerging technologies—computer science, robotics, and artificial intelligence—into the Industrial Engineering curricula at sixteen Peruvian universities. Using a qualitative documentary analysis methodology, a partial and disjointed integration was identified, with an emphasis on computer science and a clear gap in AI and robotics. Based on this diagnosis, a pedagogical and curricular intervention model is proposed based on five dimensions: curriculum redesign, pedagogical innovation, teacher training, educational infrastructure, and entrepreneurship. This model, aligned with international frameworks such as the educational approach of the university in Northern Lima where this study was developed, seeks to promote ethical, active, and humanistic education in line with the principles of Industry 5.0.**

***Keywords*-- Industrial Engineering, artificial intelligence, curriculum, teacher training, Industry 5.0, emerging technologies.**

I. Introduction

The Fourth Industrial Revolution has brought with it an environment characterized by automation, artificial intelligence (AI), the Internet of Things (IoT), robotics, and big data analytics, which profoundly impact industrial, social, and educational processes. In this context, industrial engineering training must be rethought to respond to new technological, social, and human demands [1].

Various investigations such as [2] and [3] agree that the role of the industrial engineer is no longer limited to process control or continuous improvement, but requires hybrid skills: from mastery of digital tools to soft skills such as adaptability, critical thinking and the ability to lead multidisciplinary teams in automated environments.

In [4] a critical gap is identified between the graduate profiles and the real demands of Industry 4.0, which is aggravated by an insufficient curricular offer in topics such as artificial intelligence, collaborative robotics, cyber-physical systems or predictive analytics. This situation is replicated in multiple Latin American countries, as evidenced in [5] where it was found that in eight Mexican universities only one mandatory course related to these skills is offered.

Added to this is the analysis in [6], which indicates that traditional pedagogical models have been surpassed by active approaches such as Project-Based Learning (PBL), which allow the articulation of technological content with real-life contexts. This methodological transformation must be aligned with the progressive implementation of models such as Education 4.0 and Engineering Education 5.0 indicated in [7][8], which emphasize the personalization of learning, digital interaction, and training in socio-emotional and cutting-edge technical skills.

For its part [9] shows how digitalization has reshaped the expectations of the labor market in industrial engineering, evidencing a disconnect between what universities teach and what industries demand in global environments. At this point, automation is not only seen as a driver of efficiency, but also as a potential threat to those professionals who do not achieve continuous reskilling, that is, a permanent updating of their skills [10][11].

In the face of these challenges, some countries have taken firm steps. [12] documents the case of India, where two-thirds of the manufacturing sector is adopting national Industry 4.0 strategies; while in the United Kingdom, the "Build Back Better" program promotes training in cybersecurity, data science, and digital design, integrating technical education with the real needs of post-COVID-19 industry.

At the local level, [1] highlights the urgent need for curricular updating in Peru and other Latin American countries, where the technological lag is more noticeable. According to the World Competitiveness Ranking [11], Peru ranks 60 out of 69 in global competitiveness, due to factors such as deficiencies in educational infrastructure, low investment in science and technology, and teacher training that is poorly articulated to the needs of the digital age [13].

Likewise, the proposal of [14] on an ecological framework for educational policies in AI reinforces the idea that any technological integration in university teaching must consider not only pedagogical aspects, but also governance and operational dimensions, including technological infrastructure and teacher training as essential pillars for ethical and effective adoption.

Furthermore, [15] demonstrates that the use of adaptive learning technologies, personalized feedback, and AI-based interactive tools has a direct and positive impact on student engagement, provided that users have sufficient digital literacy. This finding is relevant for the design of curricular proposals that seek to integrate AI in university contexts, ensuring not only technological access but also its meaningful use.

The proposed curriculum evolution model is closely aligned with the program's professional profile and graduate competencies, ensuring that the academic training responds to the needs of both the productive sector and society. According to the Graduted Profile established by the Universidad de Ciencias y Humanidades and the national guidelines of the Peruvian Ministry of Education (MINEDU), graduates are expected to demonstrate not only technical and disciplinary knowledge but also skills in critical thinking, teamwork, ethical responsibility, and innovation. By structuring the curriculum evolution around these competencies, the model guarantees that the program outcomes are consistent with the institutional mission and with national educational priorities.

Furthermore, the model incorporates internationally recognized standards such as those established by ICACIT in Peru and accreditation frameworks like ABET (Accreditation Board for Engineering and Technology), which emphasize student outcomes in problem-solving, professional ethics, communication, and lifelong learning. By integrating these criteria, the curriculum ensures global relevance and prepares graduates to perform in competitive and multidisciplinary environments. This alignment between the curricular evolution model, the professional profile, and international standards strengthens the program's capacity to produce competent professionals who contribute effectively to continuous improvement and innovation in their respective fields.

Consequently, this article proposes the following hypothesis: in the university education of industrial engineers, there has been some progress in including computer science-related content; however, the curricular approach to artificial intelligence and robotics remains incipient, fragmented, and dependent on individual initiatives, lacking a comprehensive and articulated vision.

The objective of this research is to critically analyze the curricula of the Industrial Engineering program at sixteen Peruvian universities, with the goal of identifying the degree of integration of emerging technologies—computer science, robotics, and artificial intelligence—and, based on this, formulate a proposal for pedagogical and curricular transformation. This proposal seeks to guide the evolution of teaching models toward internationally comparable frameworks, based on the humanistic, ethical, and active educational approach of the university where this study is conducted.

II. METHODOLOGY

This study adopts a qualitative descriptive-explanatory approach using documentary analysis techniques. This methodology was chosen in response to the need to understand the current state of integration of emerging technologies—particularly artificial intelligence, robotics, and computer science—in the training of industrial engineers at Peruvian universities, as well as to provide a basis for a proposal for curricular and teaching interventions.

The proposed model arises from the identification of significant gaps in the current curriculum structure, including fragmented learning outcomes, limited integration between theory and practice, and insufficient alignment with the graduate profile defined in accreditation frameworks. Prior evaluations and accreditation reports, both at the national level (MINEDU and ICACIT) and international level (ABET), have highlighted the need for greater coherence between competencies, course design, and assessment practices. Studies such as those by Biggs and Tang (2011) on constructive alignment and by Harden (2001) on curriculum mapping emphasize the risks of maintaining curricula that do not adequately integrate professional competencies or respond to evolving industry demands. These limitations justify the necessity of a comprehensive model that systematically addresses alignment, evaluation, and continuous improvement.

In addition, global trends in higher education emphasize competency-based curricula and outcome-oriented frameworks, as reflected in reports from UNESCO (2019) and OECD (2020), which call for curricula that foster transversal skills such as critical thinking, digital literacy, and adaptability. Comparative analyses with existing curriculum evolution models—such as the continuous improvement cycle in ABET accreditation or the outcome-based education approaches in Europe and Asia—demonstrate that successful programs incorporate structured mechanisms for periodic review, stakeholder participation, and evidence-based adjustments. By situating the proposed model within these international trends and best practices, the study not only addresses the current curricular deficiencies but also ensures long-term relevance and competitiveness in higher education.

The design of the proposed curriculum evolution model was guided by parameters such as the graduate competencies established in the institutional Graduate Profile, the program learning outcomes defined by national accreditation standards (ICACIT, MINEDU), and international benchmarks like ABET criteria. Previous curricular structures and course maps were systematically analyzed to identify redundancies, gaps, and opportunities for integration. The adjustment criteria included alignment of courses with program outcomes, distribution of academic hours to balance theory and practice, incorporation of information technologies and digital competencies, and integration of transversal skills such as teamwork and ethical responsibility. This approach ensured that the redesigned curriculum maintains coherence with the professional profile, optimizes workload across semesters, and strengthens the connection between academic training and industry requirements.

A. Universe and sample

The study population consisted of Peruvian universities offering undergraduate Industrial Engineering programs. To define the sample, intentional selection criteria were applied to ensure the relevance, accessibility, and institutional diversity of the analysis. Only institutions with publicly available and up-to-date curriculum information—curricula and/or syllabi—available on their official websites were included, a necessary condition to guarantee the methodological viability of the documentary study.

Likewise, a balanced representation was sought in terms of management system (public and private), geographic location (coast, mountains, and jungle), and institutional maturity in continuous improvement processes, whether through formal accreditation or self-assessment for quality purposes. Priority was also given to the inclusion of universities with active enrollment and presence in national rankings, reinforcing the validity and relevance of the analysis in light of the country's higher education landscape. As an exclusion criterion, institutions that did not have publicly accessible curricular information or whose programs were discontinuous or lacked institutional visibility at the time of the review were excluded.

The resulting sample size was sixteen universities, representing approximately 30% of the Peruvian institutions offering this program. This percentage allowed us to identify recurring patterns, trends, and gaps with an acceptable level of representativeness. The sample was composed of six public universities: National University of San Marcos (Lima, 2023), National University of Engineering (Lima, 2018), Federico Villarreal National University (Lima, 2019), National University of San Agustín (Arequipa, 2025), National University of Trujillo (La Libertad, 2025), and National University of Callao (Callao, 2023); and ten private universities: Pontifical Catholic University of Peru – PUCP (Lima, 2025), University of Lima (Lima, 2025), University of Sciences and Humanities – UCH (Lima, 2025), San Ignacio de Loyola University – USIL (Lima, 2025), Peruvian University of Applied Sciences – UPC (Lima, 2025), ESAN University (Lima, 2024), University of Engineering and Technology – UTEC (Lima, 2024), Technological University of Peru – UTP (Lima, 2025), Private University of the North – UPN (Lima, 2025) and University of Piura (Piura, 2024).

Additionally, it was found that several of these institutions had current accreditation processes granted by organizations such as ICACIT, SUNEDU, or recognized international agencies, which made it possible to verify whether this factor influenced the curricular integration of emerging technologies.

The unit of analysis consisted of each institution's official curriculum. These were examined using a structured matrix that allowed for the systematic identification, classification, and coding of the following variables: i) presence of subjects related to computer science, robotics, and artificial intelligence; ii) methodological integration or cross-curricular use of these technologies; iii) predominant pedagogical approach; and iv) stated or suggested use of technological tools, simulators, or virtual environments.

B. Collection techniques and instruments

For data collection and analysis, a curriculum analysis matrix was designed to systematize information from the curricula and curriculums of the selected universities. This matrix was conceived as a structured documentary observation instrument, aimed at capturing the presence, depth, and pedagogical approach to the integration of emerging technologies in the training of industrial engineers. The construction of the instrument was based on the adaptation of the framework proposed by [16], who developed a rubric for the evaluation of digital competencies in university education for sustainability purposes, which was previously validated in Latin American contexts. Based on this model, four analytical dimensions were designed, each operationalized through observable indicators and qualitative coding criteria:

- Explicit or implicit presence of subjects that address content related to computer science, robotics, and artificial intelligence, whether as independent courses, integrated modules, or declared training objectives.
- Declared or inferred pedagogical approach based on a review of the curriculum structure, competencies per subject, and methodologies outlined in the syllabi. This analysis allowed each case to be classified according to a traditional, active, digital, or hybrid model, in line with the categories proposed by [6].
- Use of technological tools in teaching-learning processes, including learning management systems (LMS), simulators, virtual laboratories, modeling environments, intelligent agents, or generative artificial intelligence systems, when these were mentioned as part of the methodological development.
- Reference to the development of transversal skills, such as computational thinking, digital literacy, 21st century skills (creativity, collaboration, problem solving), or training for the ethical and responsible use of emerging technologies, as proposed by [1].

This matrix allowed for a systematic comparison of the differences and similarities between the curricula analyzed, generating solid empirical evidence for the development of the model proposed in subsequent sections.

C. Procedure

The methodological procedure followed in this research was structured in three main phases: document collection, qualitative coding and normative comparative analysis.

In the first phase, a systematic compilation of the curricula and syllabi of the Industrial Engineering program from sixteen Peruvian universities was carried out, obtained exclusively from official institutional sources—primarily the academic websites of each university. This process was conducted between March and May 2025, ensuring the validity of the information and allowing for a consistent and traceable review. For each university, the syllabus' correspondence with the most recently published curriculum version was verified, and metadata such as the year the document was issued, the training modality (in-person, hybrid, or virtual), and the type of document consulted (general plan, syllabus by subject, academic regulations, etc.) were recorded.

The second phase consisted of qualitative coding of the curriculum content, using the previously validated analysis matrix described in the previous section as a basis. The coding process adopted an inductive approach, allowing the analysis categories to gradually emerge from the systematic examination of the documents. The coding units were the courses or subjects identified in the curriculum frameworks, as well as the descriptions of competencies, methodological strategies, and technological resources specified in the available syllabi.

The third phase focused on normative and propositional contrast with recognized international standards. Specifically, the European framework DigCompEdu [14] was used as a reference. This framework establishes competencies for professional teacher development in the digital field, organized into six areas: professional commitment, digital resources, teaching and learning, assessment, student empowerment, and development of students' digital competencies. This framework was adapted as a transversal evaluative criterion to interpret the level of alignment of the analyzed curricular proposals with the training challenges of contemporary digital society.

In addition, conceptual and operational references of educational transformation models associated with the transitions of Education 4.0 and Education 5.0 were integrated, which promote a pedagogical approach centered on the student, with the use of disruptive technologies, personalized training and active learning oriented to the solution of real problems [7][8]. This analysis allowed to identify to what extent Peruvian universities are articulating their training processes with the emerging demands of Industry 5.0, which requires not only technical skills, but also an ethical, human and sustainable approach in technological management.

D. Limitations

Among the study's main limitations was the partial access to detailed syllabi for some subjects, which restricted in-depth analysis of the methodologies and resources used. Furthermore, the lack of explicit explanations about pedagogical approaches in several curricula forced inferences to be drawn from general descriptions and declared competencies. It is also recognized that, given the dynamic nature of curricular processes, some curricula may have been updated after the collection period (March to May 2025), affecting the validity of certain data. Nevertheless, the documentary analysis allowed us to identify significant patterns and support a robust pedagogical intervention proposal, thanks to the representative diversity of the sample.

III. ANALYSIS AND RESULTS

The results are presented organized into three thematic axes that emerge from the analysis matrix: computer science, robotics, and artificial intelligence. Each axis considers both the formal presence in the curricular structure and the associated pedagogical approach and methodological use.

A. Presence of computer science in Industrial Engineering training

The analysis of available curricula and syllabi showed that, among the emerging technologies studied, computer science is the one with the highest degree of formal incorporation into Industrial Engineering curricula. Indeed, 11 of the 16 universities analyzed (68.75%) include at least one required course with content related to computer science, information technology, or basic computing. These courses are typically offered in the first three academic cycles, under titles such as Fundamentals of Computer Science, Applied Office Automation, Information Systems, Digital Tools for Engineering, or Basic Computing.

The predominant content in these courses covers the use of spreadsheets, word processing, presentations, internet concepts, institutional email, and, in some cases, basic principles of structured programming. A smaller number of universities incorporate modules on relational databases, introduction to SQL, or business process analysis using ERP (Enterprise Resource Planning) systems. Despite this initial thematic presence, there was little vertical coordination between computer science courses and the rest of the curriculum. In other words, the development of digital skills does not follow a continuous progression nor is it integrated as a methodological or technical support in intermediate or advanced subjects.

Regarding digital teaching infrastructure, it was found that all the universities analyzed use LMS (Learning Management Systems) platforms, such as Moodle, Canvas, or Blackboard, for basic academic management (posting materials, assignments, and announcements). However, the use of specialized software for modeling, simulation, or industrial data analysis—such as MATLAB, Arena, AutoCAD, Minitab, or SCADA software—was reported in only four institutions, and in all cases, it was limited to elective courses or in laboratories with little connection to the general curriculum.

Another important limitation identified was the absence of explicit institutional strategies for the progressive development of digital competencies throughout the program. No evidence was found of transversal training paths, progressive certifications in digital technologies, or formal assessment of computer skills beyond the initial course. This situation aligns with what was noted by [6], who points out that in many Latin American engineering programs, the teaching of digital tools remains disconnected from the expected professional profile and lacks a systemic approach that promotes their integration from the first cycles.

Finally, it is worth noting that only two universities explicitly mention the term "digital skills" in their curriculum documents, and none consider computer science as a cross-curricular methodological resource for teamwork, problem-solving, or independent learning. This finding is even more significant when considering that process digitalization is an important skill in the transition to Industry 4.0 and Industry 5.0, and that a superficial approach to it can compromise the employability and adaptability of future industrial professionals.

B. Inclusion of robotics in the curriculum

The presence of robotics in the Industrial Engineering curricula of the universities analyzed is significantly more limited than that of computer science. Of the sixteen universities reviewed, only six (37.5%) incorporate robotics-related content into their curriculum. In most of these cases, robotics is not listed as a required, standalone subject, but rather as part of broader courses related to industrial automation, process control, or electronic instrumentation. These subjects, although they mention concepts such as sensors, actuators, or programmable logic controllers (PLCs), do not always develop specific modules focused on the construction, programming, or simulation of robotic systems.

Furthermore, three additional universities identified implicit mention of robotics-related content through the inclusion of related skills or topics, such as mechatronic design, embedded systems, or flexible automation. However, in these cases, no practical activities, specialized robotics literature, or applied simulation environments were specified. Therefore, the presence of robotics in these programs cannot be considered substantive or educational in technical or pedagogical terms.

A particularly critical aspect is the complete absence of robotics as a cross-curricular methodological tool. None of the universities analyzed use robotics kits (such as Arduino, LEGO Mindstorms, Dobot, among others) or simulation platforms (such as VPL, Tinkercad Circuits, or ROS) in subjects outside the automation field. Nor was there evidence of robotics being integrated into multidisciplinary projects, extracurricular training activities, or interfaculty laboratories, which reflects a still-restricted view of this technology as exclusively technical content rather than as a resource for active, collaborative, or experimental learning.

Likewise, no institutional guidelines or curricular policies were identified to guide the progressive incorporation of robotics as part of the graduation profiles or as a strategic axis of pedagogical innovation. This situation represents a relevant gap with respect to international reference frameworks, such as those described by [12], which highlights robotics not only as a key technical competence within training programs for Industry 4.0, but also as a transversal pedagogical component for the development of logical thinking, creativity, problem solving and teamwork.

The lack of structured training in this field limits graduates' opportunities to enter advanced industries or participate in technological innovation projects with a humanistic approach. Consequently, the incorporation of robotics in the programs analyzed can be considered incipient, fragmented, and with a minimal instrumental focus, lacking a clear connection to the training challenges of Industry 4.0 or to the pedagogical potential this technology offers in terms of active and contextualized learning.

C.Inclusion of Artificial Intelligence in the curriculum

Among the three emerging technologies analyzed in this study, artificial intelligence (AI) is undoubtedly the one with the lowest degree of curricular incorporation in the Industrial Engineering programs reviewed. Of the sixteen universities considered, only four (25%) include content directly related to AI. In these cases, inclusion occurs through elective courses, generally located in the final academic years, under titles such as Introduction to Artificial Intelligence, Data Science and AI, or Intelligent Systems. No university offers it as a required subject, nor was a progressive training path identified that articulates this content with the rest of the curriculum.

Furthermore, these courses are not structured as part of a continuing education program in advanced analytics, machine learning, or intelligent systems applied to industrial environments. Rather, they respond to an isolated logic, unconnected to other subjects or the graduate profile defined for the program. This lack of integration limits the potential of AI as a cross-curricular training tool and reduces its impact to a superficial or introductory approach.

From a methodological perspective, no documented evidence was found of the use of artificial intelligence tools as part of the teaching-learning process. None of the universities analyzed explicitly mention the use of generative AI systems such as ChatGPT, coding assistants such as GitHub Copilot, automatic feedback platforms, adaptive environments, or conversational agents based on NLP (natural language processing). This omission is significant considering the exponential growth in the use of educational AI internationally and the opportunities it offers to personalize teaching, expand automated tutoring, and diversify assessment methods.

This finding directly contrasts with [15], which shows that the use of adaptive and generative AI technologies has a positive impact on student motivation, engagement, and performance in university contexts, provided they are implemented with appropriate ethical and pedagogical criteria. Recent literature also emphasizes the potential of these tools to strengthen transversal competencies such as computational thinking, academic self-efficacy, and creativity in solving complex problems.

In short, the integration of artificial intelligence into the curricula analyzed is still incipient, optional, and poorly articulated, both in terms of its disciplinary content and its methodological application.

TABLE I
COMPARATIVE SUMMARY OF THE INCLUSION OF EMERGING TECHNOLOGIES IN INDUSTRIAL ENGINEERING CURRICULA

No.	University	Type	Computing (Mandatory)	Robotics	AI	Pedagogical Use of AI
1	UNMSM	Public	Forks	Implicit	No	No
2	UNI	Public	Forks	Explicit	No	No
3	UNFV	Public	Forks	No	No	No
4	UNSA	Public	Forks	Explicit	Forks	No
5	UNT	Public	Forks	No	No	No
6	A Callao	Public	No	No	No	No
7	PUCP	Private	Forks	Explicit	Forks	No
8	University of Lima	Private	Forks	No	No	No
9	UCH	Private	Forks	No	No	No
10	USIL	Private	Forks	Implicit	No	No
11	UPC	Private	Forks	Explicit	Forks	No
12	ESAN	Private	No	No	No	No
13	UTEC	Private	Forks	Implicit	Forks	No
14	UTP	Private	Forks	No	No	No
15	UPN	Private	Forks	No	No	No
16	University of Piura	Private	Forks	Explicit	Forks	No

The sample was validated through a triangulated process that combined expert judgment, institutional documentation, and alignment with accreditation requirements. Initially, the selected participants and data sources were reviewed by academic coordinators and curriculum specialists to ensure their representativeness of the program's context. Additionally, the sample was contrasted with previous accreditation self-study reports and institutional assessment records to confirm its consistency with the competencies and learning outcomes under evaluation. This validation process guaranteed that the evidence collected was both relevant and reliable for supporting the proposed curriculum evolution model.

In summary, the findings confirm the study's initial hypothesis. The incorporation of emerging technologies into Industrial Engineering curricula at Peruvian universities has shown uneven and fragmented progress. Computer science is predominantly present, although limited to introductory courses without cross-curricular integration or educational progression throughout the program. Robotics, meanwhile, is poorly represented, mostly implicitly or relegated to elective courses with little practical development. Artificial intelligence is the most lagging area, with occasional inclusion in some elective courses and without methodological integration or didactic use in teaching practices.

Taken together, these results reveal a partial and disjointed integration of key technologies for the transition to Industry 4.0 and 5.0, highlighting the need for a structural, gradual, and strategically targeted curriculum reform.

IV. Proposed Model

In line with the study's findings and the specialized literature on educational transformation, a comprehensive curricular evolution model is proposed for the Industrial Engineering program, aligned with the principles of Industry 5.0 and the humanistic educational model of the university where this study is conducted. This model aims to close the gaps identified in the incorporation of emerging technologies—computer science, robotics, and artificial intelligence—from a perspective focused on the ethical, social, and professional development of students.

The proposed model is based on five strategic dimensions, conceived as articulated components of a curricular and pedagogical roadmap, which integrate content, method, and technique, in line with the university's formative principle: educating to transform social reality.

A. Curriculum redesign with a transversal and ethical approach

The proposed curriculum redesign stems from the need to incorporate mandatory subjects focused on mastering emerging technologies applied to industrial contexts, particularly AI, robotics, and advanced computing. The goal is not to add isolated content, but rather to build progressive training pathways that develop technological competencies from the first cycles to the final year of training, integrating theory and practice in real-life contexts.

Furthermore, the alignment between technological content and ethical, social and sustainability competencies is emphasized, in line with the reference frameworks proposed by [14] and [17]. This responds to the principle of the university's educational model of promoting the comprehensive training of professionals capable of applying technology to the service of the common good. Likewise, the development of digital skills is proposed as a cross-cutting axis, as highlighted by [18], ensuring that all courses incorporate digital literacy objectives and relevant use of technological tools.

B. AI-mediated pedagogical innovation

This dimension proposes to transform teaching practice through the incorporation of generative artificial intelligence systems (such as ChatGPT, Copilot, Grammarly or Wolfram Alpha), not only as complementary tools, but as active tutoring assistants, automated feedback, and support in complex cognitive processes [2][19].

Similarly, the integration of interactive virtual environments, industrial simulators, and conversational agents is proposed, especially in subjects such as logistics, quality control, industrial processes, or production systems. These environments promote active, contextualized, and problem-solving-oriented learning, in line with the recommendations of [20].

C. Continuing teacher training and innovation communities

The model recognizes that curricular transformation will only be effective if accompanied by teaching transformation. Therefore, the design of continuous training programs in emerging technologies and active methodologies is proposed, focusing on adaptive learning, the development of computational thinking, and the critical integration of AI in teaching [6] [21].

Likewise, it is recommended to implement academic communities of practice, where teachers share experiences, experiment with new tools, and co-construct pedagogical knowledge. These communities would function as spaces for permanent innovation, aligned with the principle of the university's educational model of interdisciplinary collaborative work [22].

D. Educational infrastructure and technological governance

A real transformation requires adequate institutional conditions. The proposal is to create educational innovation labs equipped with robotics kits, applied AI stations, data analytics platforms, 3D printing, and simulated industrial environments. These spaces must be available for regular courses, formative research projects, and extracurricular activities.

In parallel, the design of institutional guidelines for the ethical, transparent and safe use of artificial intelligence in educational environments is proposed, promoting a culture of digital responsibility and prevention of academic risks [14].

E. Interdisciplinary projects and technological entrepreneurship

Finally, the model proposes consolidating a learning ecosystem that links technological training with the resolution of specific social, environmental, or productive problems. Interdisciplinary projects will be promoted in which students use emerging technologies to co-create innovative solutions, articulated with the needs of the environment and under Project-Based Learning methodologies [2][4].

This model represents a viable and contextualized roadmap for transforming the teaching of Industrial Engineering in Peru, promoting the transition from traditional approaches to active, digital, ethical, and well-being-centered training.

TABLE II
SUMMARY OF THE PROPOSED HUMAN-CENTERED MODEL FOR THE INTEGRATION OF EMERGING TECHNOLOGIES IN INDUSTRIAL ENGINEERING EDUCATION

Dimension	Objective	Key Actions and Tools
A. Curricular Redesign	Integrate emerging technologies as core competencies with ethical alignment.	Mandatory courses in AI and robotics Cross-cutting digital skills-Alignment with sustainability and ethics
B. Pedagogical Innovation with AI	Transform teaching and learning through intelligent support tools.	Use of ChatGPT, Grammarly, Copilot as tutors Interactive virtual labs AI-assisted feedback and coding
C. Continuous Teacher Training	Strengthen teacher digital and didactic capacity for adaptive education.	Training in digital pedagogy and emerging tech- Academic communities of practice Computational thinking
D. Infrastructure and Governance	Build enabling conditions for innovation and ethical AI deployment.	Labs with robotics, AI, 3D printing Institutional AI ethics policies Open access to simulation tools
E. Applied Projects and Entrepreneurship	Link learning to real-world problem-solving and innovation ecosystems.	Interdisciplinary problem-based projects Partnerships with industry and public sector AI for social innovation

TABLE III
DETAILED ROADMAP FOR CURRICULAR TRANSFORMATION (2025–2027)

Strategic Dimension	Purpose	Concrete Actions (2025–2027)
A. Curricular Redesign	Align academic content with Industry 5.0 by embedding emerging technologies and ethics.	Design 2 mandatory courses: AI for Industry and Applied RoboticsMap syllabus to embed digital skillsUpdate graduate profile with digital-ethical competencies
B. Pedagogical Innovation with AI	Enhance engagement and personalization using generative AI and simulations.	Pilot ChatGPT and Copilot in 4 core subjectsImplement adaptive LMS feedback toolsUse 2 industrial simulators in logistics and production
C. Continuous Faculty Development	Strengthen digital teaching capacity and peer collaboration.	Offer 3 annual workshops on AI/ICT in educationCreate an interfaculty Innovation Teaching LabLaunch digital badge system for teacher certification
D. Infrastructure & Governance	Provide enabling conditions for innovation with ethical oversight.	Equip 2 AI-ready multifunctional classrooms Deploy open-source simulation platforms (eg, Tinkercad) Approve institutional code of ethics for AI use
E. Interdisciplinary Projects & Entrepreneurship	Promote real-world problem solving and innovation.	Launch capstone projects with social/industrial AI applicationsCreate innovation challenges with partner companiesTrack impact via student portfolios and alumni data

V. CONCLUSIONS AND FUTURE WORK

This study has allowed us to characterize the current state of the incorporation of emerging technologies—computer science, robotics, and artificial intelligence—into the Industrial Engineering curricula of sixteen Peruvian universities, representative of their institutional and geographic diversity, and their maturity in continuous improvement processes. The results obtained show that this curricular integration is still incipient and disjointed, with a clear predominance of basic computer science, a marginal presence of robotics, and minimal inclusion of artificial intelligence both as content and as a pedagogical tool.

This situation reflects a significant gap between the training challenges posed by the transition to Industry 5.0 and the current configuration of higher education in industrial engineering in the country. In particular, there is a lack of a cross-cutting strategy for the progressive development of digital skills, a limited incorporation of technologies in real-life learning contexts, and a poor alignment between technological content and the ethical, social, and sustainable values that should guide the training of engineers with a human focus.

Given this diagnosis, the model proposed in this article seeks to offer a concrete and contextualized roadmap for transforming the teaching of Industrial Engineering in Peru. This model is based on five strategic dimensions—curricular redesign, AI-mediated pedagogical innovation, ongoing teacher training, educational infrastructure with technological governance, and engagement with real-world projects and entrepreneurship—and is based on the principles of the university's educational model, which promotes active, ethical, and committed training for social transformation.

The viability of the model lies in its comprehensive approach, its support for international standards, and its ability to adapt to different institutional contexts. However, it is recognized that its implementation will require concrete institutional decisions, sustained investment in human and technological resources, and a progressive process of evaluation, piloting, and adjustment. In this sense, the model should not be understood as a one-size-fits-all, but rather as a guiding framework that can be adapted and scaled by universities interested in aligning their programs with the demands of higher education in the digital age.

During the analysis stage, several alternatives were considered for addressing the curricular gaps. The first option was to maintain the current curriculum with no significant modifications; however, this approach was deemed insufficient given the persistent misalignments between learning outcomes, competencies, and professional requirements. A second option explored was to implement minor adjustments, such as updating syllabi or adding elective courses, but this was also considered inadequate as it would not resolve structural issues such as the imbalance between theory and practice, the lack of integration of digital competencies, and the limited coherence across the program map. The third option—proposing a comprehensive curriculum redesign—emerged as the most suitable because it addressed both structural and pedagogical challenges while ensuring alignment with institutional goals, national standards (MINEDU, ICACIT), and international benchmarks such as ABET.

Nevertheless, the proposed model also presents limitations. Its successful implementation requires significant institutional commitment, faculty training, and continuous monitoring mechanisms that may extend beyond the scope of a single evaluation cycle. Furthermore, resource constraints, resistance to change, and the need for technological infrastructure could slow down the adoption process. Future work should include pilot testing of selected curriculum components, systematic feedback from stakeholders—including students, employers, and accreditation bodies—and iterative refinement of the model. These steps will help ensure that the redesigned curriculum not only remains academically rigorous but also responsive to the evolving demands of industry and society.

As future lines of work, we propose empirical studies to evaluate the effectiveness of the model in real-life implementation contexts, as well as comparative research across Latin American countries to identify best practices in the pedagogical integration of emerging technologies. We also propose the development of institutional self-assessment tools based on the model's dimensions to guide curriculum redesign processes with faculty and student participation. Finally, we suggest exploring the impact of artificial intelligence as a transformative agent of university teaching, not only as a disciplinary content but also as a mediator of learning, personalized tutoring, and ethical evaluation in professional training.

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