***International Multidisciplinary Journal of Emerging Technologies and Applications (IMJETA)***
*Vol. 1, No. 5, pp. 120-134, August 2026*
*Received August 02, 2026; Revised August 12, 2026; Accepted August 24, 2026*
*Published August 31, 2026*

# 1st International Conference on Competency-Based Engineering Education in the Face of Technological Transformation

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**Abstract.** The document systematizes the ideas shared at the "1st International Conference on Competency-Based Engineering Education in the Face of Technological Transformation", evaluating the urgency of reconfiguring higher education in the face of the Fourth Industrial Revolution and Generative Artificial Intelligence (GAI). It is determined that the traditional curricular model, fragmented into isolated subjects and focused on rote assessment, proves ineffective against the rapid obsolescence of technical knowledge. In response, Competency-Based Education (CBE) is postulated as a paradigm that understands competency as a demonstrated productive capacity for problem-solving in the workplace environment. This approach integrates five inseparable dimensions: knowing, knowing how to do, knowing how to be, wanting to do, and being able to do. Consequently, teaching practice evolves; the professor acts as a designer of experiences and applies longitudinal evaluations using rubrics. Furthermore, technological integration demands that the student's primary competency be "learning to learn". GAI should be used as a conversational and analytical scaffolding to understand complex cyber-physical systems, without this implying the abandonment of fundamental basic sciences. Finally, the analysis warns about the risks of extractivism and the climate crisis, requiring a transversal ethical commitment to avoid "technological somnambulism". As the speakers did not converse with each other, in this text their ideas are intersected to form a dialectical synthesis. To implement these changes, universities need to make their administrative structures more flexible, allowing certifications and intermediate exit qualifications that nimbly adapt their programs to labor market demands.

**Keywords:** Competency-Based Education (CBE); Technological Transformation; Generative Artificial Intelligence (GAI); Curricular Design; Engineering 4.0.

## 1. Introduction

The advent of the Fourth Industrial Revolution and the systemic emergence of disruptive technologies, particularly Generative Artificial Intelligence (GAI) and Large Language Models (LLMs), have triggered an epistemological and operational crisis in traditional educational paradigms. In general, and also in engineering. Facing this scenario, higher education institutions face the imperative to reconfigure their curricular designs to train suitable professionals capable of interacting in digital ecosystems and solving problems of high structural complexity. In response to this historical demand, the Central University of Venezuela (UCV), through its Faculty of Engineering (FiUCV), in alliance with the National Academy of Engineering and Habitat (ANIH), the Academy of Mérida, and the Hispano-Venezuelan Association of Engineering and Architecture (AHVIA), convened the "1st Conference," held virtually on June 11 and 12, 2026.

The context justifying this analysis transcends the mere updating of IT tools; it is inscribed in the need to endow the learner with metacognitive awareness capable of reasoning about their own thinking and sharing that attitude with peers. Drawing on contemporary theoretical constructs such as connectivism postulated by George Siemens, focused on learning for the digital age, and recent advances in neuroscience, engineering education can transition toward methodologies that train students to reason about their own thinking, subsequently building critical thinking and judgment.

At the regional and national levels, the shared ideas—especially the keynote presentation by FiUCV—acquire an unavoidable strategic dimension. Venezuela projects a macroeconomic transition oriented toward overcoming the rentier model to consolidate sustainable, diversified, and sovereign development. While the oil and mining sectors maintain their relevance as articulating axes for industrial linkages, the country demands the technological updating of its infrastructure through the implementation and support of Engineering 4.0, the Internet of Things (IoT), and GAI. This transformation requires an engineering professional equipped with a geopolitical vision, high technological adaptability for managing big data and advanced simulation, as well as collaborative leadership grounded in alterity and socio-environmental commitment.

The main objective of this article is to systematize and critically analyze the experiences and proposals emanating from the aforementioned International Conference. There was no panel discussion among speakers; therefore, in this article, confronting their ideas creates an imaginary dialogue, like a dialectical synthesis or an integrative hermeneutic dialogue. Through a reflective approach, the document evaluates the methodological transition from instruction based on learning objectives toward Competency-Based Education (CBE), establishing theoretical and practical guidelines for curricular innovation. The underlying academic intent is to provide engineering faculties with an argumentative foundation that facilitates overcoming fragmented pedagogical models, guiding teaching practice toward training individuals endowed with intellectual autonomy and prospective vision in response to the demands of the global productive environment.

## 2. Theoretical Framework: Foundations and Vision of Competency-Based Education (CBE)

The theoretical substrate of this analysis is built upon the propositions developed in the keynote presentation of the Conference, delivered by three professors from FiUCV, which presented the deconstruction—the analysis, dismantling, and revision of traditional curricular design, as well as experiences in operationalizing Competency-Based Education (CBE) in engineering sciences. The arguments of academics Paolo Maragno, María Esculpi, and Alejandro Guillén configure a conceptual framework that redefines the teleology or purposes, ends, and goals of professional training, the role of educational actors, and new assessment criteria and rubrics.

### 2.1. Deconstruction of the Traditional Curriculum and Redefinition of Competency

The educational model structured around instructional objectives has tended to organize knowledge into what Maragno conceptually defines as an "archipelago of subjects" (Maragno Giopardio, 2026, 00:09:41). This fragmented structure promotes the assimilation of disciplinary knowledge as an end in itself, limiting cognitive integration and prioritizing rote assessment over observable performance. According to Esculpi, this traditional paradigm generates a critical institutional risk: students can achieve formal approval of thematic contents without demonstrating the ability to articulate such knowledge to resolve problems in integrated professional contexts (Esculpi, 2026, 00:29:38).

In contrast to this fragmentation, CBE proposes an ontological redesign of training, where ontologically both teacher and learner change their way of being, interpreting, and acting within their context. Maragno establishes a fundamental distinction between "academic qualification" and "competency". While qualification represents merely a statistical probability of success based on course approval, competency is defined as a real, effectively demonstrated productive capacity oriented toward successful performance in a specific work environment (Maragno Giopardio, 2026, 00:10:25). This delimitation acquires an urgent legal character within the Venezuelan legal framework, where obtaining a university degree grants direct licensing for professional practice (Maragno Giopardio, 2026, 00:09:42). In the absence of intermediate external licensing mechanisms by professional associations, the university assumes full responsibility for the graduate's suitability, justifying the adoption of rigorous performance-based curricular standardization schemes.

### 2.2. Dimensional Structure of CBE and Transformation of Roles

The competency approach shifts the epicentre of the curriculum from content transmission to shaping the graduate profile (Esculpi, 2026, 00:30:45). To operationalize this profile, Esculpi breaks down suitable performance into five integrated dimensions: knowing (mastery of concepts and theories), knowing how to do (technical and methodological skills), knowing how to be (communication, social interaction, and collaborative work), wanting to do (motivation and ethical readiness), and being able to do (efficiency and mastery in execution) (Esculpi, 2026, 00:29:43).

This multidimensional taxonomy demands a reconfiguration of pedagogical practice. Teachers must abandon their traditional role as unidirectional transmitters of information to evolve into designers of training trajectories and evaluators of evidence (Esculpi, 2026, 00:30:42). Correspondingly, the student assumes the role of a central actor who decides, integrates knowledge, and solves open problems, simulating the pressures and demands of the industrial and work environment. Likewise, abstract training components such as ethics and research methodology cease to be conceived as isolated subjects and consolidate as immanent, integral transversal axes across the entire educational experience (Maragno Giopardio, 2026, 00:10:25).

### 2.3. Evaluative Praxis, Implementation Metrics, and Curricular Flexibility

The viability of CBE strictly depends on its evaluative instrumentation. Knowledge is not conceived as an isolated theoretical construct; rather, its assimilation is verified through quantifiable achievement indicators. According to Guillén and Esculpi, assessment in this model must be longitudinal and based on the use of methodological rubrics, allowing progression grounded in observable evidence (projects, simulations, prototypes) and continuous feedback (Esculpi, 2026, 00:32:21; Guillén Mujica, 2026, 01:55:23).

The empirical implementation of this theoretical framework in the Industrial Process Engineering degree program at the UCV Cagua campus yielded results that validate the model's effectiveness. Guillén reports that the student pass rate increased to 66% under the CBE design, contrasting with 45% under the traditional objective-based system, while course repetition rates decreased significantly (Guillén Mujica, 2026, 01:60:32). These findings align with previous longitudinal studies conducted at the UCV Faculty of Engineering, which quantitatively demonstrated that degree programs planned under a competency profile achieve higher academic performance and lower dropout rates compared to objective-based study plans (Guillén Mujica & Nieves De Freites, 2015).

In terms of social and productive relevance, the program achieved an 88% alignment level with industry needs, narrowing the gap between academic training and the labor market (Guillén Mujica, 2026, 01:65:00). This impact was boosted by the incorporation and integration of UCV's virtual platforms and media, which optimized pedagogical support and interactive simulation of operational competencies (Guillén Mujica & Soret Perdomo, 2016).

Guillén argues that the acceleration of knowledge—whose doubling time dropped from 150 years in 1960 to twelve hours today—invalidates the static retention of data, requiring the curriculum to develop in graduates the ability to nimbly unlearn and relearn (Guillén Mujica, 2026, 1:61). To sustain this dynamism, the theoretical framework of CBE incorporates structural flexibility, providing modular schemes that enable intermediate exit qualifications (such as Higher University Technician degrees) and the certification of prior knowledge and experience (Guillén Mujica, 2026, 01:65:12). This strategic vision is formally deepened by Alejandro Guillén Mujica in other works outlining the methodological and institutional pathways required for the structural updating of engineering study plans in the Venezuelan context (Guillén Mujica, 2026a).

In that work, it is argued that curricular modernization in emerging economies should not be limited to the uncritical importation of technological trends, but requires charting pedagogical innovation paths adapted to local dynamics, combining flexible training trajectories with international competency certification standards (Guillén Mujica, 2026a).

## 2.4. Critical Analysis of the Proposed Model

Despite the argumentative solidity of the model presented in the keynote address, critical analysis of its implementation reveals inherent methodological differences in the educational transition. A pertinent observation lies in the weighting assigned to evaluation instruments in some documented experiences. According to data provided by Guillén, the implemented evaluation scheme assigned 40% of the weight to “knowing” (theoretical knowledge), reserving smaller percentages for “knowing how to do” (20%) and “being able to do” (10%) (Guillén Mujica, 2026, 01:62:45). This weighting structure highlights an epistemological contradiction with the core tenets of CBE, which require subordinating conceptual memorization to practical demonstration and executive problem solving. To ensure paradigm consistency, rubric designs must invert these loads, prioritizing the statistical weight of integrated performance over isolated knowledge.

Additionally, the incorporation of GAI presents a paradigmatic inflection point. As Maragno warns, CBE must evolve from an approach focused on simple competent execution toward a model oriented to critical interaction with autonomous systems and the self-regulation of learning (Maragno Giopardio, 2026, 00:11:40).

## 3. Development and Analysis of Presentations

Analyzing the presentations delivered during the “1st Conference” requires moving beyond mere thematic description to establish a critical and dialectical synthesis among the speakers. The analytical lens of this review is grounded in the keynote address given by Maragno, Esculpi, and Guillén, which establishes that CBE is not a passing trend, but an ontological reconfiguration requiring the integration of knowing, doing, and being in high-tech volatility contexts.

To systematically structure this imaginary dialogue or dialectical synthesis, and evaluate the contributions of the eight guest speakers, a set of rigorous inclusion criteria was established across four fundamental analytical dimensions:

**Epistemological and Teleological Dimension**

- Redefinition of Educational Purpose: Inclusion of contributions that reorient teaching toward the "what for" (human and intellectual development) rather than purely technical instruction.
- Design as an Articulating Axis: Consideration of design and the "Action Design" model as the universal transversal epistemological activity of engineering.
- Reconceptualization of Basic Sciences: Inclusion of approaches that reinterpret mathematics and physics (e.g., fractional calculus and infinitesimals) to model complex real systems with historical memory and preserve abstract reasoning capacity.
- Theory of Objectification: Incorporation of learning as a socio-historical and cultural process of becoming aware of forms of thought.

**Socio-environmental and Ethical Dimension**

- Global and Regional Critical Diagnosis: Inclusion of analyses regarding the socio-environmental, water, and climate crisis, as well as the impacts of strategic mineral extractivism.
- Overcoming "Technological Somnambulism": Criteria to prevent the uncritical adoption of technologies and demand evaluation of the energy footprint and unsustainability of autonomous systems and AI.
- Transversality of Ethics: Integration of ethical commitment, alterity, and socio-environmental responsibility as evaluable transversal rubrics across all engineering projects.

**Curricular Dimension and Institutional Flexibility**

- Overcoming the "Archipelago of Subjects": Transitioning from fragmented instructional objectives toward Competency-Based Education (CBE), focused on demonstrated productive capacity in professional environments.
- Multidimensional Taxonomy of Performance*:* Balanced integration of five inseparable dimensions:
    - *knowing* (conceptual)
    - *knowing how to do* (technical/methodological)
    - *knowing how to be* (collaborative/social)
    - *wanting to do* (motivation/ethics)
    - *being able to do* (executive efficiency)

**Longitudinal Assessment and Metrics:** Inclusion of rubric-based matrix evaluation tools grounded in observable evidence (projects, simulations, prototypes) that prioritize practical execution over isolated theoretical memorization.

**Flexibility and Modular Structures:** Incorporation of administrative and academic mechanisms for structural flexibility, such as intermediate exit qualifications (e.g., Higher University Technician degrees), micro-credentials, and prior learning certifications.

**Technological Dimension and Cyber-Physical Systems:**

- The "Learning to Learn" Meta-competency: Focus on metacognitive autonomy, rapid unlearning, and relearning in response to technical knowledge acceleration and obsolescence.
- Instrumental Use of Generative AI (GAI): Integration of GAI and LLMs not as cognitive substitutes, but as analytical and conversational scaffolds (e.g., the MOSAT method).
- Cyber-Physical Modeling and Simulation: Inclusion of Industry 4.0 paradigms such as Cyber-Physical Systems (CPS), Cognitive/Agentic Digital Twins, and Model-Based Systems Engineering (MBSE) to optimize processes, improve efficiency, and mitigate operational risks.
- Leadership in VUCA Environments: Development of digital, analytical, and technological management competencies to navigate volatile, uncertain, complex, and ambiguous environments.
- Using these inclusion criteria as a methodological filter, the interventions of the guest speakers expand, confront, and operationalize the CBE model across the four subsections below.

## 3.1. Epistemological and Teleological Foundations of Engineering

The transition toward a competency-based curriculum demands, in the first instance, a revision of the foundational purpose of engineering. In this sense, Nagib Callaos postulates a teleological approach orienting academic education toward "what for" (human development) and not exclusively toward technical instruction (Callaos, 2026, 00:02:41). Callaos identifies "design" as the transversal epistemological element articulating all branches of engineering, defining it as a universal activity inherent to human designium (Callaos, 2026, 00:02:50).

This approach dialogues directly with Esculpi's vision, who maintains that CBE requires students to assume an active role as designers and integrators of solutions when facing open problems. Callaos's proposal to institute the "Action Design" model operationalizes the need for continuous formative assessment demanded by CBE (Callaos, 2026, 00:02:51).

In parallel, the epistemological foundation of basic sciences was presented by Julio Mosquera, who questioned the efficacy of traditional mathematics teaching (Mosquera, 2026, 2:25). Mosquera argues that contemporary practices must incorporate formalized infinitesimal calculus (Robinson) and fractional calculus (Caputo derivative) to model complex real systems possessing historical "memory" (Mosquera, 2026, 02:30:32). This restructuring of conceptual teaching finds a complementary framework in the Theory of Objectification applied to higher education, where mathematical and engineering learning is conceived as a socio-historical and cultural process of becoming aware of forms of thought (Avella Guevara, 2026b).

## 3.2. Socio-environmental Context and Ethical Commitment

The attitudinal dimension of CBE, defined by Esculpi and Guillén as "wanting to do" and "knowing how to be" (Esculpi, 2026, 00:32:18), acquires a sense of civilizational urgency in Alexis Mercado's presentation. Mercado presents a critical diagnosis based on the Doomsday Clock and global water crisis (Mercado, 2026, 01:14:32), demonstrating that current techno-economic trajectories deepen the planet's vulnerability. The author demystifies the energy transition narrative, showing that fossil fuel consumption persists and that strategic mineral extraction generates severe external costs in Latin America (Mercado, 2026, 01:15:20). Furthermore, Mercado warns about the ethical risks arising from the uncritical use of convergent technologies and GAI, whose self-referential development demands unsustainable energy consumption (Mercado, 2026, 01:17:31).

The connection between this presentation and CBE is core: ethics and socio-environmental commitment must be integrated as transversal rubrics in problem-solving. Competency-based training would fail if it produces skilled technicians operating under "technological somnambulism" (Mercado, 2026, 01:16:28); therefore, the curriculum must guarantee critical and responsible interaction with autonomous systems (Maragno Giopardio, 2026, 00:11:32).

## 3.3. Emerging Profiles and Curricular Flexibility in the Digital Age

The operationalization of new professional profiles was addressed by Vivian Floríndez Portela and Alonso Romero Martínez. Floríndez Portela, drawing on UNESCO guidelines, classifies emerging competencies into four domains: cognitive, digital, human, and strategic (Floríndez Portela, 2026, 00:04:32), emphasizing the need to move toward hybrid and flexible training trajectories (Floríndez Portela, 2026, 00:04:40).

For his part, Alonso Romero Martínez warns that the creation of new degree programs (such as bioengineering or sustainable architecture) responds to structural reconfigurations rather than passing fads (Romero Martínez, 2026, 00:25:52). A crucial contribution from Romero is his defense of basic sciences against the risk of over-specialization (Romero Martínez, 2026, 00:28:19). Romero argues that physics and mathematics must be reinterpreted to underpin technologies such as digital twins or advanced materials science, preserving the engineer's capacity for abstraction (Romero Martínez, 2026, 00:28:42).

This need for flexibility and diversification of professional profiles finds solid analytical support in curricular update proposals developed by Guillén Mujica (2026a), who proposes that career roadmaps integrate continuous learning structures and micro-credentials capable of dynamically adapting to the pace of industrial transformation.

## 3.4. Technological Integration and Cyber-Physical Systems

The impact of the Fourth Industrial Revolution on professional practice was outlined by Alfredo Avella and Antonio Silva Sprock. Avella describes a scenario of cognitive asymmetry, where data transmission speed (projected for 6G networks) and information volume exceed human processing capacity (Avella, 2026, 01:16:32). In this context, engineering education must be comprehensively reoriented to respond to Industry 4.0 requirements, combining advanced digital competencies with leadership of technological startups adaptable to volatile, uncertain, complex, and ambiguous (VUCA) environments (Avella Guevara, 2026a).

Antonio Silva Sprock operationalizes this technological integration through Cyber-Physical Systems (CPS) and Digital Twins (DT), which allow continuous bidirectional synchronization through real-time telemetry (Silva Sprock, 2026, 01:44:09). Silva illustrates how making errors in computational models guarantees operational accuracy in physical assets, reducing costs and operational risks (Silva Sprock, 2026, 01:52:21). Significantly, Silva emphasizes that the human factor remains the "soul of the system," requiring transdisciplinary competencies and complex thinking (Silva Sprock, 2026, 01:44:39).

This stance finds theoretical supporting foundation in recent advances regarding Cognitive and Agentic Digital Twin conceptualization formulated by Silva Sprock & Silva Sprock (2026). That research demonstrates that integrating agentic AI and Large Language Models (LLMs) into virtual representations overcomes passive simulation limits, endowing Digital Twins with reasoned autonomy for decision making, semantic interoperability, and self-evolving predictive capabilities in high-density data industrial environments (Silva Sprock & Silva Sprock, 2026).

However, to prevent uncritical automation or the blind delegation of decision-making to autonomous agents, the interaction between the engineering professional and Cognitive/Agentic Digital Twins must be guided by the principle of Generative AI as cognitive scaffolding. This directly aligns with the MOSAT method (Ontological-Systemic Method for Technological Learning) proposed by Montilva Calderón (2026). Under the MOSAT framework, GAI and agentic interfaces do not serve as substitutes for human judgment or critical thinking; rather, they act as conversational and analytical scaffolding that forces the learner to externalize, question, and validate their mental models against the digital twin's dynamic behavior. Consequently, the self-evolving predictive capacity of the Agentic Digital Twin (Silva Sprock & Silva Sprock, 2026) amplifies human comprehension of complex cyber-physical systems while ensuring that the core interpretative, creative, and ethical reasoning remains strictly centered on human cognition.

Furthermore, integration among Model-Based Systems Engineering (MBSE), Digital Twins, and Cyber-Physical Manufacturing Systems (CPMS) constitutes the indispensable structural framework to achieve operational and industrial excellence (Silva Sprock, 2026). As demonstrated by Oscar Silva Sprock (2026), formal adoption of MBSE allows explicit mapping of requirements, architecture, and dynamic system behaviors throughout its life cycle, ensuring the Digital Twin is not an isolated 3D replica, but an integrated, verifiable, and interoperable cyber-physical representation capable of optimizing efficiency and reducing uncertainty in smart manufacturing environments (Silva Sprock, 2026).

Finally, Jonás Montilva synthesizes the pedagogical challenge by instituting "Technological Learning" as an autonomous transversal discipline (Montilva Calderón, 2026, 00:49:52). Faced with rapid technical obsolescence, Montilva proposes the MOSAT method (Ontological-Systemic Method for Technological Learning), which articulates neuroscience of learning, technological thinking, and structured AI prompt engineering (Montilva Calderón, 2026, 00:51:12). Montilva's proposal embodies the pinnacle of CBE: the definitive competency of the 21st-century engineer is "learning to learn," using artificial intelligence not as a cognitive substitute, but as a conversational medium to accelerate the adoption, design, and development of new technologies.

## 4. Discussion and Systematization

### 4.1. Structural Consensuses: The End of the Fragmented Model

There is unanimous consensus among speakers regarding the inefficacy of traditional curricula based on memorizing isolated objectives. The expiration rate of technical knowledge, estimated by Guillén at 2.5 to 3 years (Guillén Mujica, 2026, 01:58:22), invalidates the claim of training engineers through mere accumulation of disciplinary knowledge. In this sense, the proposal by Maragno, Esculpi, and Guillén to move toward a model prioritizing observable performance and knowledge integration consolidates as the most solid institutional response paradigm (Guillén Mujica, 2026, 01:55:34; Guillén Mujica, 2026a). From this consensus stems unification around the supreme competency for 21st-century engineers: the ability to "learn to learn" (Montilva Calderón, 2026, 00:49:50; Floríndez Portela, 00:04:49).

### 4.2. Methodological Contradictions: Assessment and Teaching Praxis

Despite paradigmatic agreement, CBE implementation reveals significant contradictions between theoretical design and evaluative praxis. One of the most evident contradictions arises in weight allocations within evaluation rubrics. The experience presented by Guillén assigned 40% of evaluative weight to "knowing" (theoretical knowledge), far exceeding "knowing how to do" (20%) and "being able to do" (10%) (Guillén Mujica, 2026, 01:70:39).

This distribution conflicts directly with the ontological principles of CBE defended by Esculpi (2026, 00:34:20), which require practical performance evidence and problem solving to form the core evaluation axis. To overcome these gaps, Guillén Mujica (2026a) emphasizes the urgent need to implement systematic continuous curriculum review frameworks guaranteeing alignment between evaluation metrics used and performance profiles required in professional practice.

### 4.3. Epistemic Dialectical Synthesis Basic Sciences, Specialization, and Socio-environmental Ethics

A core dialogue identified during the conference revolves around the function of basic sciences facing pressure for rapid technological specialization. Romero Martínez warns that over-specialization weakens engineers' long-term adaptive capacity (Romero Martínez, 2026, 00:29:01). Instead of marginalizing these foundations, he proposes reinterpreting them to underpin complex phenomena—a position entering constructive dialogue with Mosquera's proposal on fractional calculus and infinitesimals (Mosquera, 2026, 02:30:42), providing students with theoretical frameworks capable of modeling physical systems' historical "memory".

On the other hand, a deep dialectical contradiction emerges between technological optimism and socio-environmental realism. While speakers such as Avella and Silva Sprock emphasize the advantages of automation, GAI, and cyber-physical simulation for productivity optimization (Avella, 2026, 01:20:45; Silva Sprock, 2026, 01:44:54), Mercado demonstrates that exponential energy and mineral consumption required by these technologies accelerates water crisis and climate breakdown (Mercado, 2026, 01:16:20).

In this epistemic crossroad, conceptual contributions from Silva Sprock & Silva Sprock (2026) and Silva Sprock (2026) acquire decisive value: implementing Digital Twins and Model-Based Systems Engineering (MBSE) must not focus solely on industrial maximization, but as computational infrastructure oriented toward operational sustainability, real-time energy optimization, and waste reduction in cyber-physical manufacturing processes. Technology cannot be assumed as inherently neutral; hence, moral, ethical, and research training must operate as an evaluable transversal axis in every engineering project (Maragno Giopardio, 2026, 00:12:18; Callaos, 2026, 02:52:32).

Furthermore, the convergence between Agentic Digital Twins (Silva Sprock & Silva Sprock, 2026) and structured learning frameworks like MOSAT (Montilva Calderón, 2026) resolves a fundamental epistemic tension in Engineering 4.0 education. While cyber-physical environments increasingly rely on agentic AI for autonomous simulation and real-time operational optimization, pedagogical integrity requires safeguarding the supremacy of human abstract reasoning. Within this synthesis, GAI embedded in Cognitive Digital Twins functions as dynamic instructional scaffolding: it handles massive telemetry data and generates predictive scenarios, but the MOSAT method requires the human mind to maintain ontological control over the underlying assumptions, operational boundaries, and ethical consequences of the engineered solution.

### 4.4. Administrative Challenges and Flexibility

Finally, the imaginary discussion showed that CBE cannot thrive within rigid regulatory frameworks. Adopting intermediate exit qualifications (such as Higher University Technician degrees) and formal certification of empirical knowledge, supported by Guillén and Romero (Guillén Mujica, 2026, 01:72:33; Romero Martínez, 2026, 00:26:47), requires deregulating university bureaucracy. Transitioning toward hybrid, interdisciplinary paths requires higher education governing bodies to adapt regulations to the speed of digital transformation, as formally demonstrated in university policy analysis by Guillén Mujica (2026a).

## 5. Conclusions and Findings

### 5.1. Final Reflections on Curricular Transition

Adopting Competency-Based Education (CBE) constitutes an unavoidable imperative for the survival and relevance of higher education institutions. The Fourth Industrial Revolution and accelerated obsolescence of technical knowledge have invalidated traditional models characterized by disconnected subject archipelagos. Findings confirm that educational quality in contemporary engineering is measured not by encyclopedic theory accumulation, but by demonstration of real, integrated, and observable productive capacities (Esculpi, 2026, 00:29:35; Maragno Giopardio, 2026, 00:09:42; Guillén Mujica, 2026a).

### 5.2. Practical Implications for Teaching and Administrative Praxis

Operationalizing CBE demands university faculty evolve into learning experience designers and practical evidence evaluators. This requires longitudinal and matrix tools, such as performance rubrics, certifying all five competency dimensions in a balanced manner (Esculpi, 2026, 00:29:35; Guillén Mujica, 2026, 01:55:35). At the administrative level, implementing flexibility mechanisms such as intermediate professionalization exits, micro-credentials, and empirical knowledge certification is indispensable (Guillén Mujica, 2026, 01:55:23; Guillén Mujica, 2026a).

### 5.3. Structural Contributions of Integrated Presentations

- Technological and Cognitive Autonomy: The primary competency to develop is “learning to learn”, where Generative AI is integrated via methods like MOSAT as a conversational tool to accelerate understanding of complex systems (Montilva Calderón, 2026, 00:52:18).
- Cyber-Physical Synergy, Agentic Scaffolding, and Basic Sciences: Disciplines like physics and advanced calculus must be reinterpreted as non-negotiable pillars to preserve abstraction and predictive modeling capacities for Cyber-Physical Systems (Romero Martínez, 2026, 00:25:42; Mosquera, 2026, 02:23:36). When integrated with Agentic Digital Twins (Silva Sprock & Silva Sprock, 2026) and Model-Based Systems Engineering (Silva Sprock, 2026), Generative AI operates strictly as a conversational and analytical scaffolding—guided by methods such as MOSAT (Montilva Calderón,

2026)—enhancing analytical depth without substituting human critical reasoning).

- Update Pathways and Socio-Environmental Responsibility: Curriculum development maps in emerging contexts require agile design methodologies (Guillén Mujica, 2026a), ensuring digital governance, life-cycle assessment, and algorithmic ethics form observable competencies to avoid training technicians prone to "technological somnambulism" (Mercado, 2026, 01:14:25).

### 5.4. Future Lines of Research

Empirical design and validation of metrics are required to triangulate graduate adequacy perceptions with real market demands. Likewise, it is imperative to research mechanisms to quantify attitudinal competencies in cyber-physical simulation environments and study the long-term cognitive impact of intensive GAI use on students' abstract reasoning capacity.

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