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ERASMUS+ Cooperation partnerships in higher education (KA220-HED)

LEONARDO 

Learning & Experimentation Open-Access factory for industrial workforce 5.0



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# Webinar Agenda



## The European context

Why higher education must shift - and why now



## From Technology- to Pedagogy-First

Rethinking how digital tools enter the classroom



## Digital Tools in Practice-Oriented & Interdisciplinary Learning+

Concrete frameworks and evidence



## The LEONARDO Response

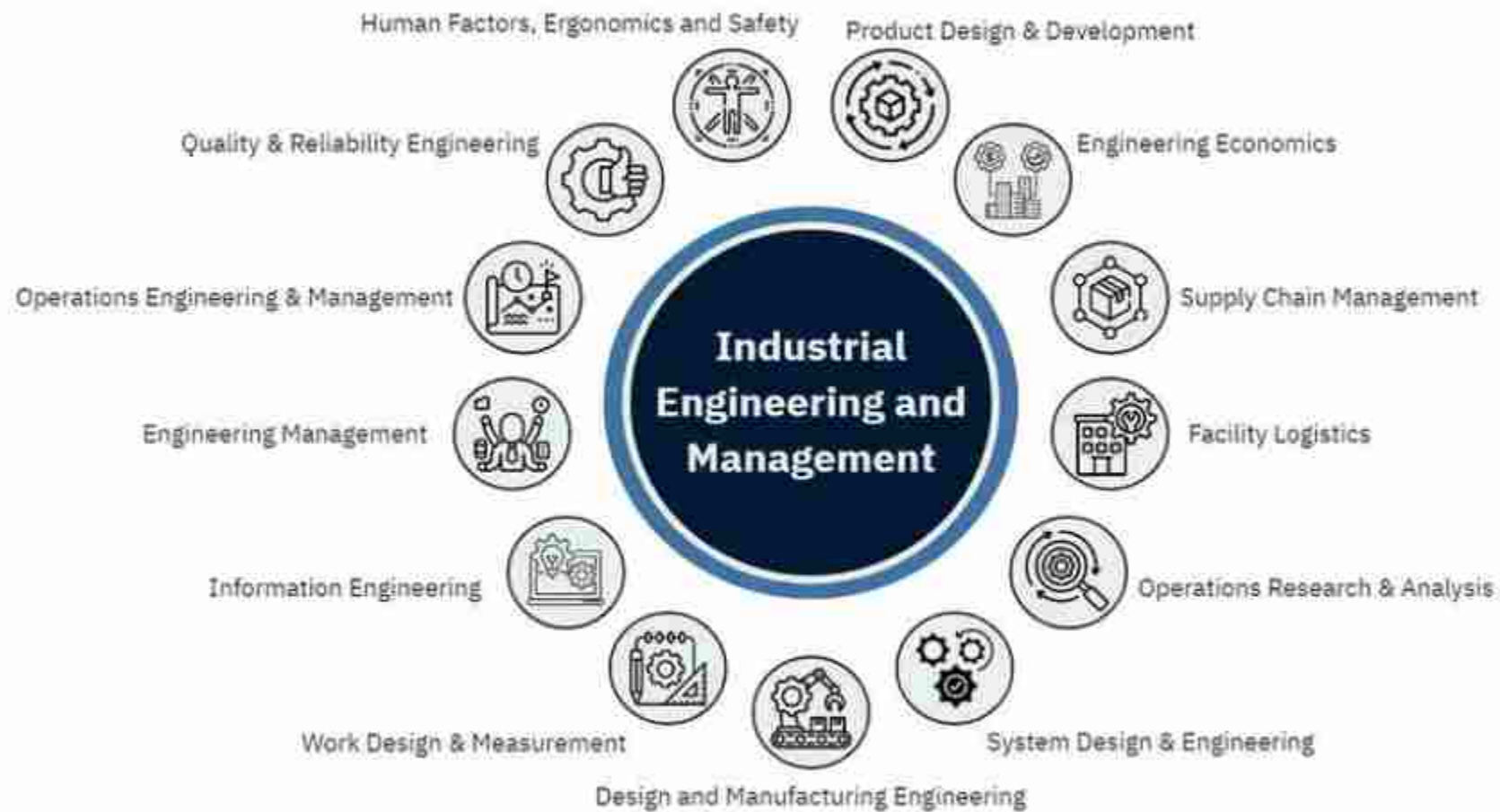
Project architecture, LEAFs, and key results

# ERASMUS+ LEONARDO project

Introducing the LEONARDO project



## What we have been learning/teaching about IEM so far

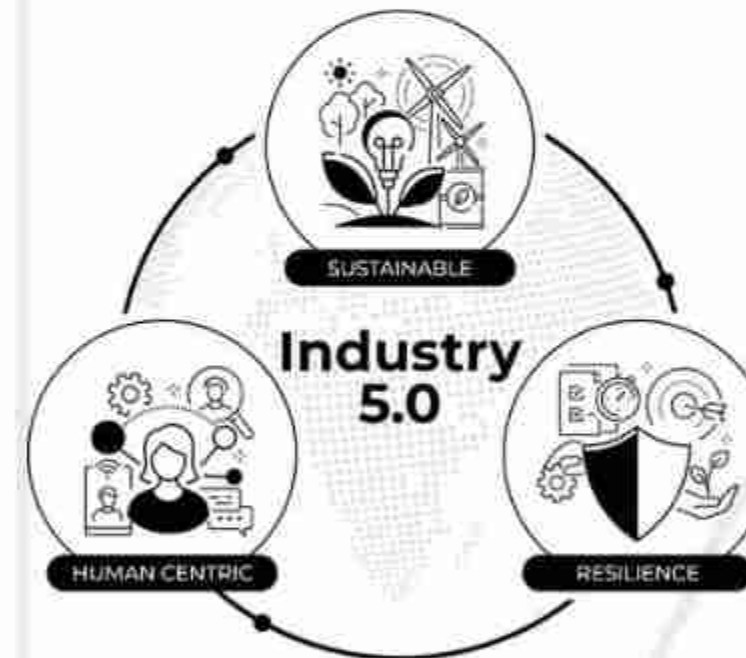


### References

Maynard's Industrial and Systems Engineering Handbook, 6th Edition  
Industrial and Systems Engineering Body of Knowledge (ISEBoK)  
Industrial Engineering and Management, by Pravin Kumar

## Driving force and policy-driven impetus for change

How education and training are changing in response to the Industry 5.0 pillars



Breque et al. (2021). Industry 5.0: Towards a sustainable, human-centric and resilient European industry. Policy brief, European Commission.



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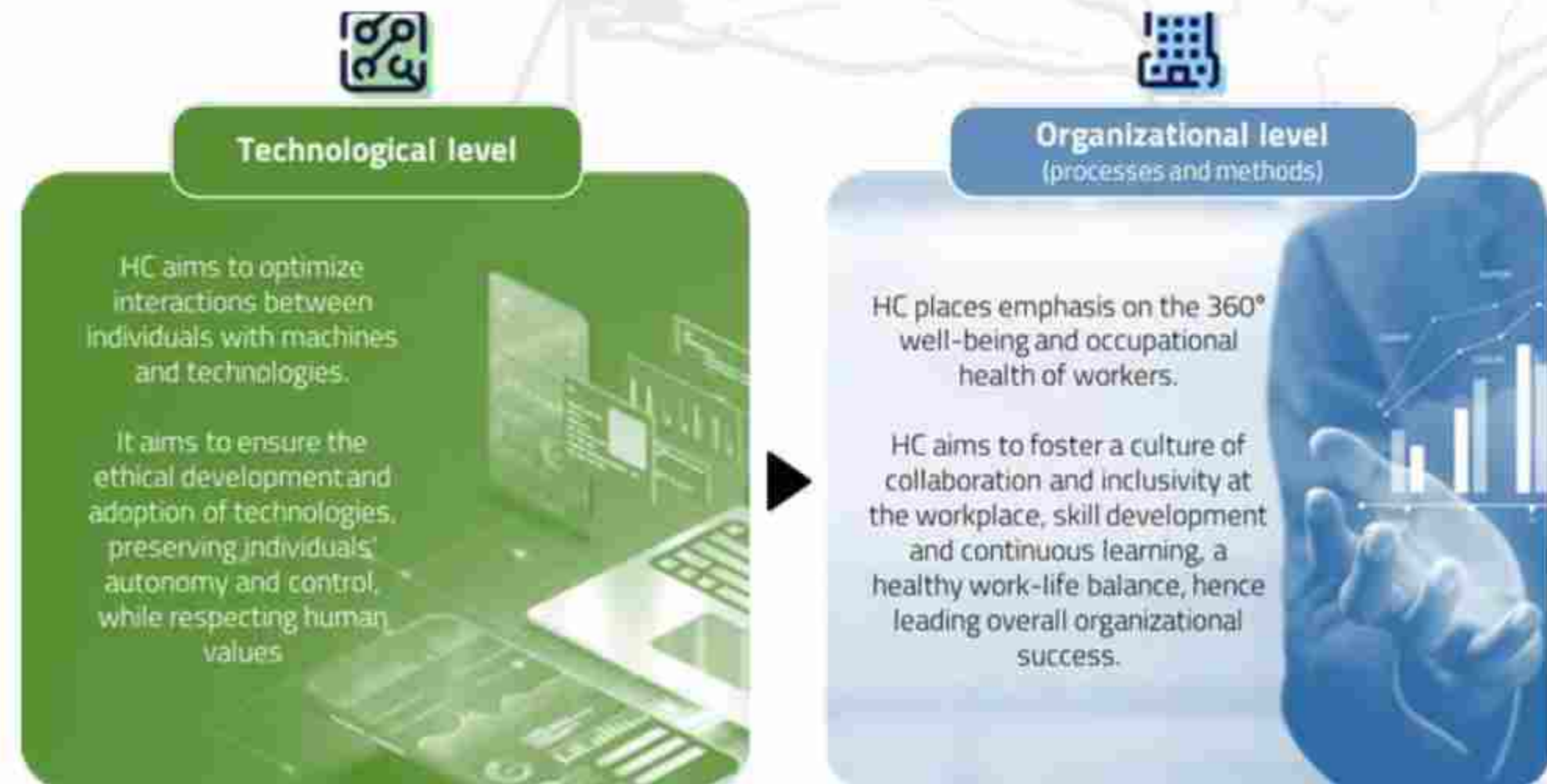
## Introducing the LEONARDO project



Human centricity is a multidimensional framework that places human needs, characteristics, motivation and experiences at the centre of **design, development, and implementation of technological solutions and organisational practices** that not only meet functional requirements but also enhance human well-being, capabilities, skills, and working conditions.



Breque et al. (2021). Industry 5.0: Towards a sustainable, human-centric and resilient European industry. Policy brief, European Commission.



# ERASMUS+ LEONARDO project

## Motivations

### From ergonomics to human-centricity

For a long time, human-centricity in industrial engineering was largely reduced to ergonomics and occupational health and safety. Industry 5.0 now demands a broader interdisciplinary perspective: humans are not only to be protected, but empowered, augmented, ethically supported, and actively involved in decision-making within socio-technical systems.

### Engaging new generations

At the same time, new generations of learners and workers bring different expectations, values, and motivations. Education and training institutions must rethink how they engage students—moving beyond traditional teaching models toward purpose-driven, experiential, and human-centered learning environments that resonate with today's and tomorrow's workforce.

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## Motivations

### EU Priorities

**1** Provide appropriate education and training to mitigate skills shortages and mismatches in human-centric industrial engineering and management



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**2** Develop and use "sandboxes" for human-centric and purpose-driven technology development experiments and dialogues at the organisational level

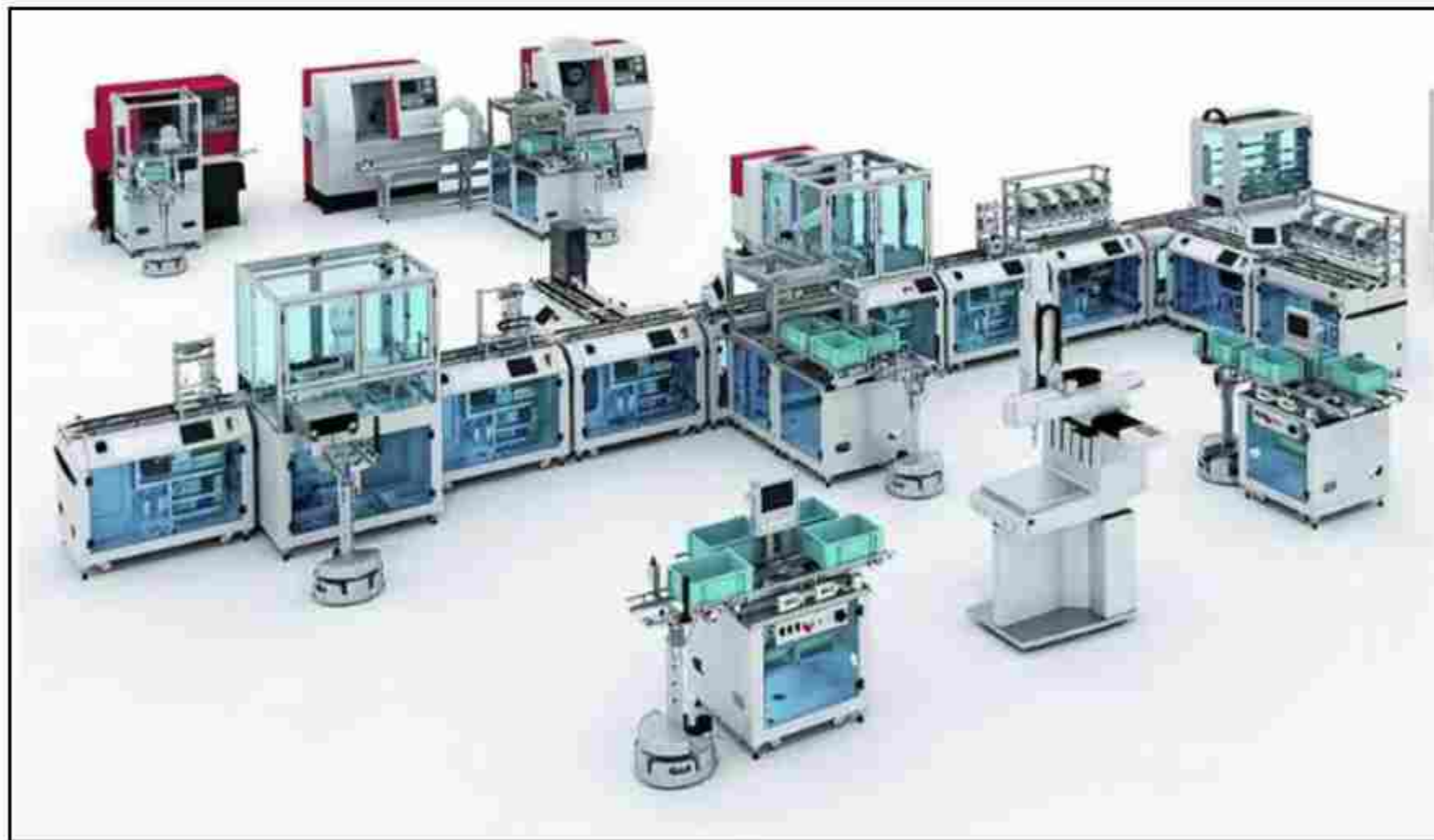




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The idea of learning factories

**Learning factories** are the gold standard for IEM education and training nowadays, but...



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Learning factories are often costly and difficult to deploy, particularly for small universities and laboratories.



They are typically built around automation and control, not around human-centric industrial and managerial competencies.



**How can we rethink learning factories to place humans - not machines - at the center?**








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From Technology-Oriented to Pedagogy-Oriented

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## Technology-Oriented Approach

-  Tool adoption is the goal
-  Platform capabilities shape the curriculum
-  One-size-fits-all digital infrastructure
-  Human factor is secondary (automation first)
-  IEM curricula still 4.0-techno-centric

The educator must ask:






- *What competence do I want this student to have?* (Intended Learning Outcomes - ILOs)
- *What activity will build it?* (Teaching & Learning Activities - TLAs)
- *How will I assess whether they have it?* (Assessment)

Only then - once those three are coherent - the question become: "*which tool best supports this?*"

The Learning Factory we built is **pedagogically intentional: purposely not fully automated**, preserving human role in line with Industry 5.0 principles.



## Pedagogy-Oriented Approach

-  Learning outcomes drive tool selection
-  Curriculum constructively aligned first; technology serves it
-  Differentiated tools for Operator / Analyst / Manager profiles
-  Human-centricity is the design principle (Industry 5.0)
-  H-IEM curriculum embeds ethics, ergonomics, HRC as core modules

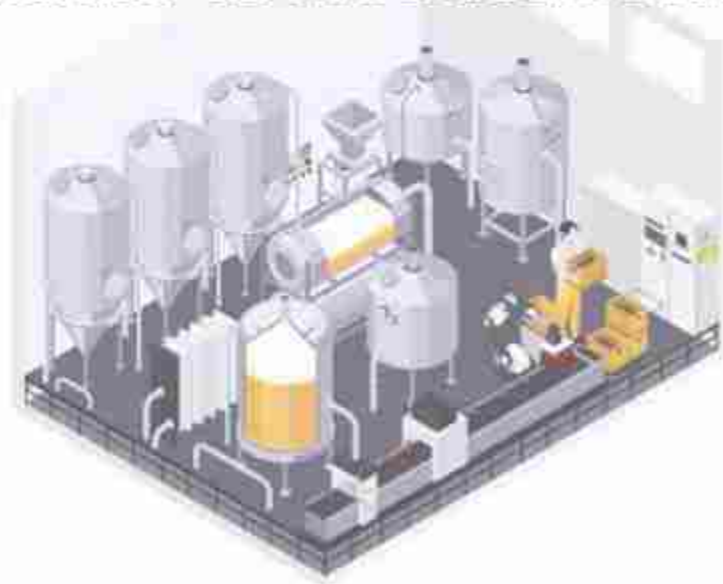
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## Project objectives

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**Main Objective** | LEONARDO aims to devise, develop and test innovative teaching methods, materials and tools for human-centric industrial engineering and management (H-IEM) in the light of the emerging Industry 5.0 paradigm.

- 1** To design, install, and “5.0-tize” a small-scale replica of a brewing system (called LEAF, Learning and Experimenting open-Access Factory) that will serve as a hands-on learning environment and as an incubator for human-centric student’s ideas



- 2** To shape the future of H-IEM Education & Training and equip individuals with the skills, knowledge and tools they need to thrive in an ever-evolving industrial environment



- 3** To nurture a European community of faculty and HEI staff committed to reinforce the education & training systems and trigger a modernisation of IEM education in the light of human-centricity in Industry 5.0



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Project team

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Manufacturing

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Manufacturing



# The LEONARDO smart brewing learning factory

## Beyond Industry 4.0 learning factories

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LEONARDO **reimagines the concept of learning factories** through human-centric, accessible, and digitally enhanced educational experiences.

LEONARDO emphasizes **open, interoperable, and ethically grounded systems** that allow students not only to operate machinery but also to understand the broader **socio-technical implications of digital transformation in manufacturing and supply chains**.



### Unconventional learning

LEONARDO smart brewing learning factory goes beyond industrial automation, smart manufacturing and technical skills. Learning with fun adds a layer of motivation and stimulation. Brewing is an engaging, enjoyable and rewarding process that encourages innovation, entrepreneurship and curiosity.



### A focus on human-centric IEM

Through the integration of AI, XR, and human-AI collaboration, LEONARDO empowers learners to engage with complex socio-technical systems, develop collective intelligence, and explore the long-term effects of technological decisions aligned with the demands of Industry 5.0.



### Multidisciplinary collaboration

LEONARDO fosters multidisciplinary collaboration by integrating engineering, social sciences, and ethics, enabling learners to co-create responsible, human-centric solutions for complex industrial challenges in line with EU priorities.



### A playground for experimentations and innovative teaching

Hands-on teaching to integrate theory with practice in tech-enhanced environments where learners and educators co-create, test and refine human-centric industrial solutions (e.g. ethical development of technologies, AI for workers with disabilities, digital twins for sustainable development)



# The LEONARDO smart brewing learning factory

## Beyond Industry 4.0 learning factories

LEAF in UNICAL is more than a pilot plant - it is a sandbox for learning, innovation, and co-creation, enabling students to experience the intersection of technology, process, and humans in modern manufacturing and nurturing a new generation of learners who are not just technically skilled but also socially and ethically aware.

The LEONARDO factory is a **compact, digitally enhanced brewing system** - spanning from malt milling to bottling - designed as a hands-on educational platform and incubator for human-centric student innovation.

Fully automated and digitalized, LEAF integrates technologies like **TULIP**, **Node-Red**, and **Grainfather**, with AI-driven analytics powered by **Python**, **OpenCV**, and **YOLOv8** for real-time monitoring, predictive modeling, and root cause **analysis**.

A simulation-based digital twin build in AnyLogic allows students to experiment with process scenarios and remote operations, while an augmented reality tool developed for **Microsoft Hololens** with **Unity** provides intuitive guidance, live visualizations, and interactive work instructions.

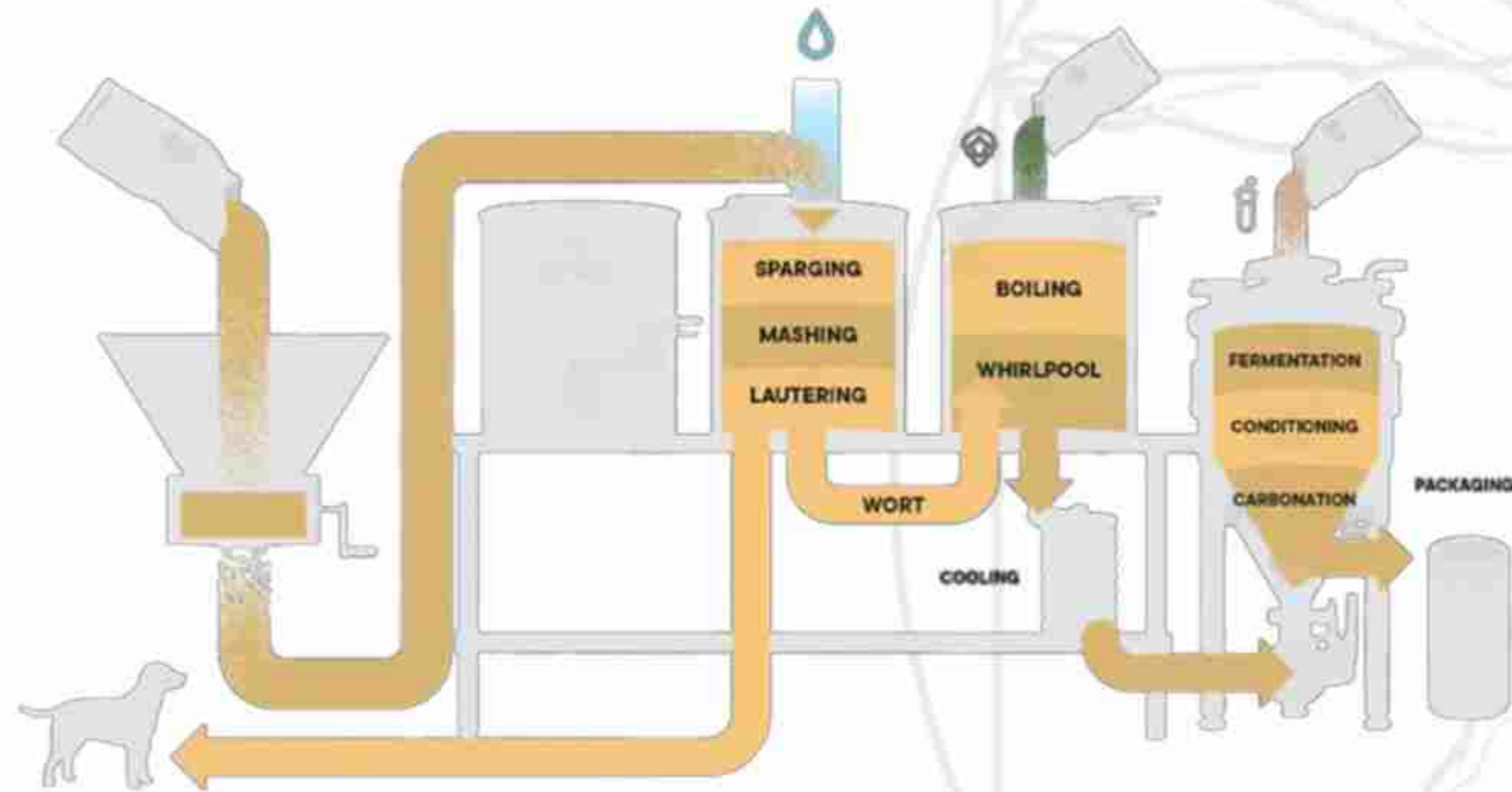


Part of the **Catalogue of Smart Factory Labs – Worldwide** promoted by the **United Nations Industrial Development Organization (UNIDO)**



# The LEONARDO smart brewing learning factory

Beyond Industry 4.0 learning factories





# The LEONARDO smart brewing learning factory

## Beyond Industry 4.0 learning factories

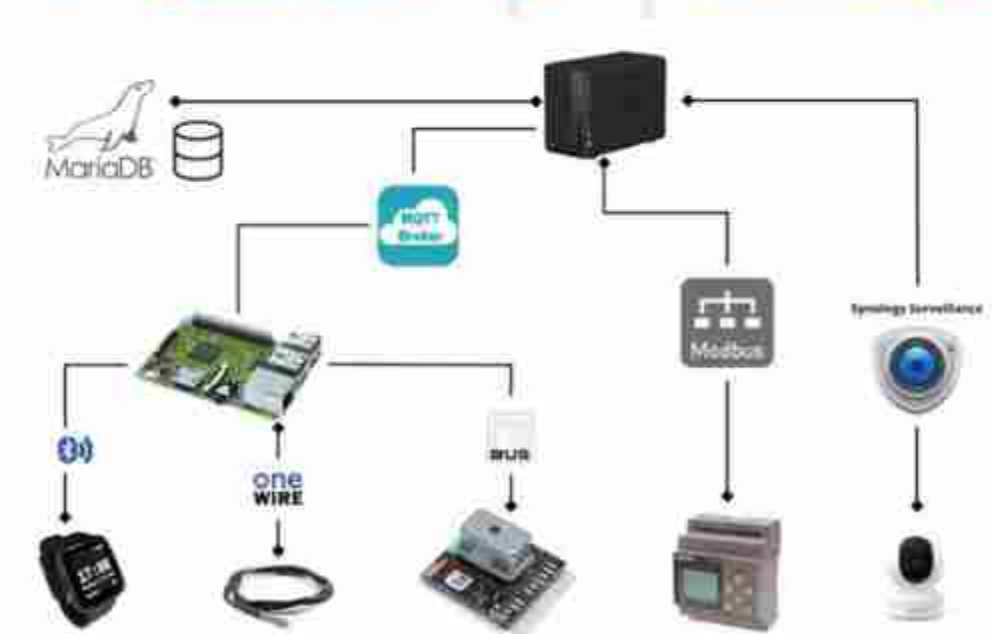
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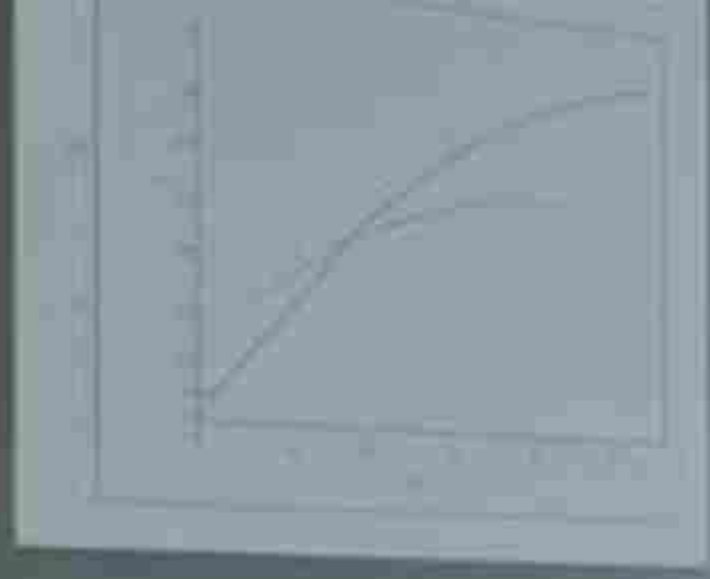
While the UNICAL factory provides a controlled, experimental setup optimized for didactic exploration and rapid reconfiguration, the FHOOE installation in Upper Austria exposes students to the complexity of operating within an existing industrial system.

**Real-world brownfield learning factory:** The FHOOE LEAF is implemented within an existing, fully operational small-scale brewery (Gerstl Bräu), enabling direct access to real industrial processes, constraints, and continuous production data.

**Continuous access to real production data:** Unlike purely experimental setups, the productive nature of the brewery provides regular, real-life process data, enabling realistic analysis, monitoring, and decision-making scenarios for education and training.

**Remote accessibility and global learning:** IoT connectivity enables remote access, allowing students and educators to engage with the system independently of location, in line with the project's open-access and international learning objectives.





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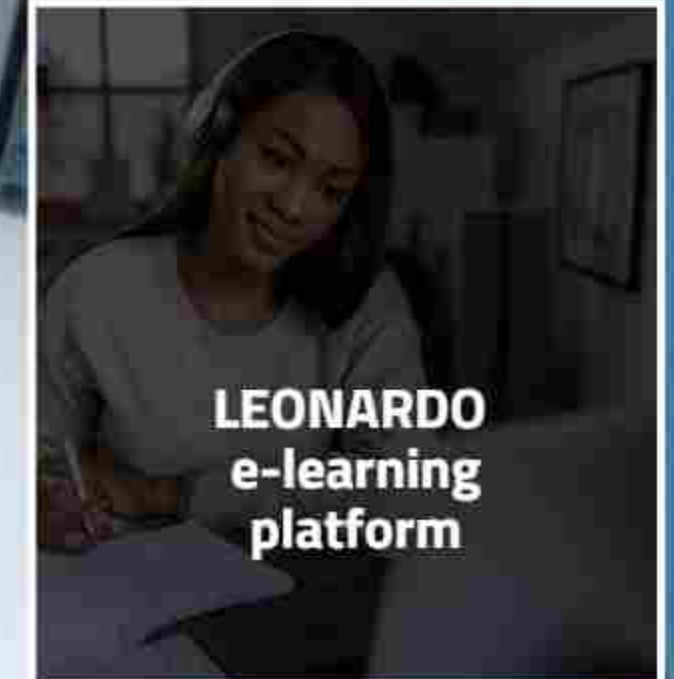
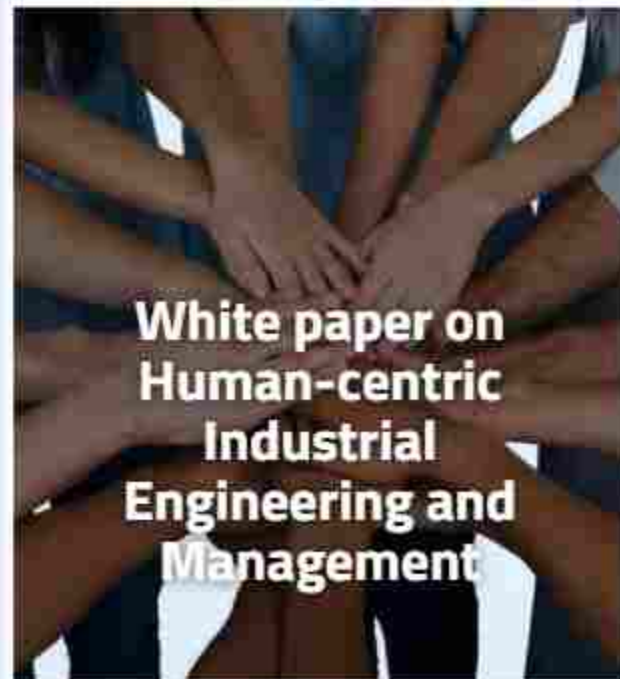
# Open Educational Resources for human-centric IEM



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# OER summary

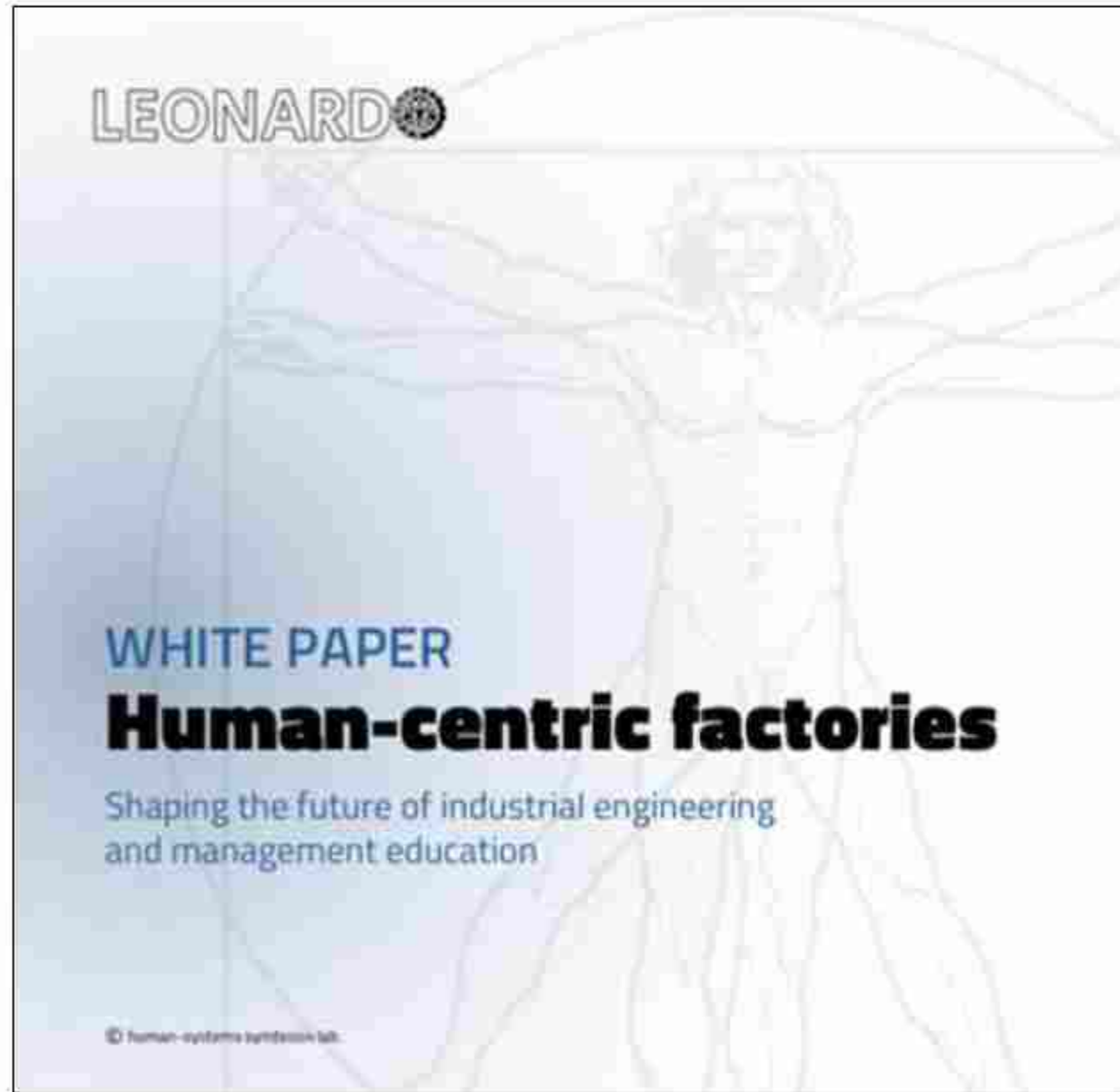
LEONARDO aims to devise, develop and test innovative teaching methods, materials and tools for human-centric industrial engineering and management (H-IEM) in the light of the emerging Industry 5.0 paradigm.



# Open Educational Resources for human-centric IEM

White Paper on Human-centric Industrial Engineering and Management

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**SCAN ME**

to download  
the white  
paper

# Open Educational Resources for human-centric IEM

White Paper on Human-centric Industrial Engineering and Management

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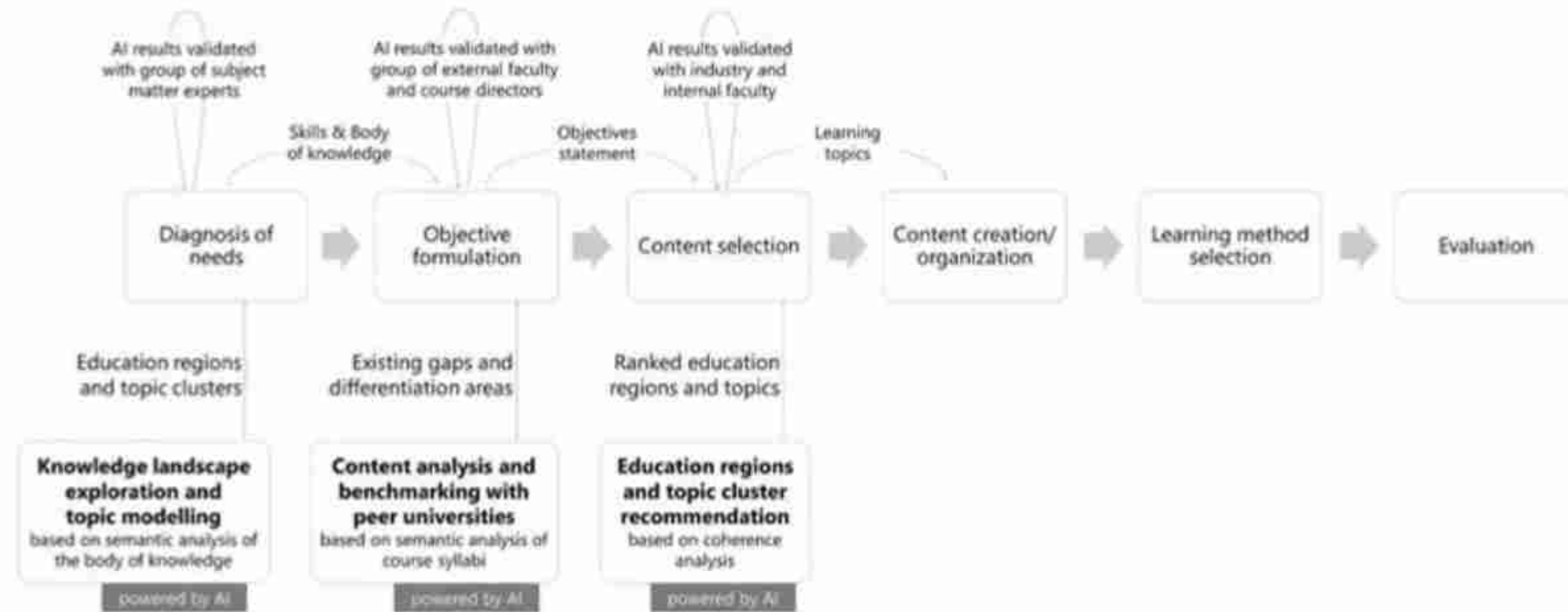
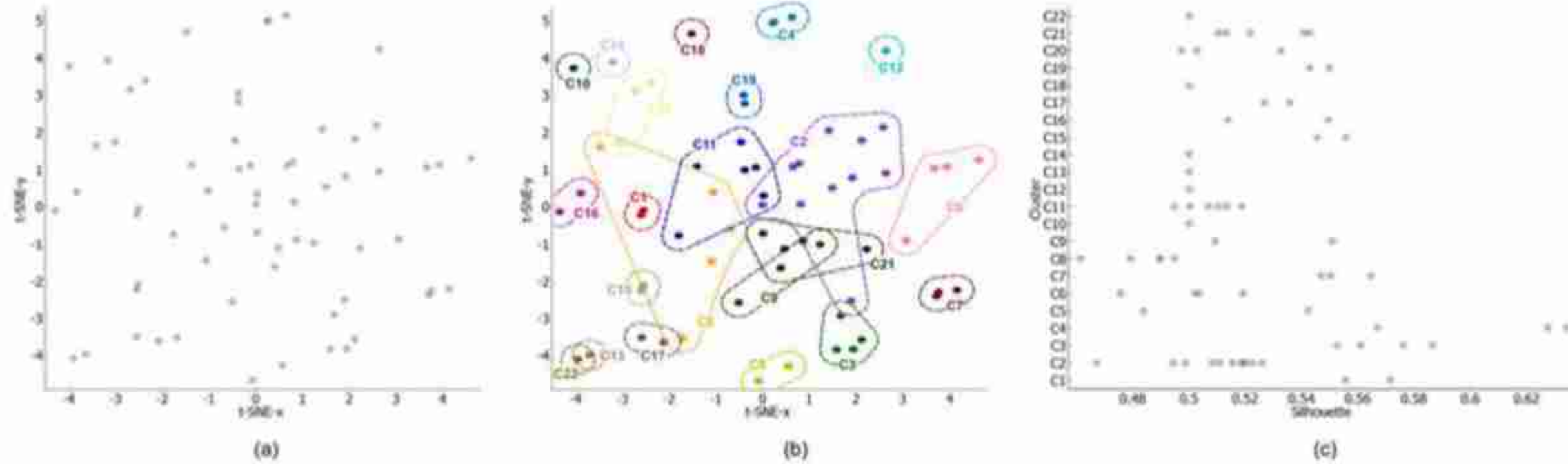


Fig. 2. AI-powered curriculum development framework.

# Open Educational Resources for human-centric IEM

White Paper on Human-centric Industrial Engineering and Management

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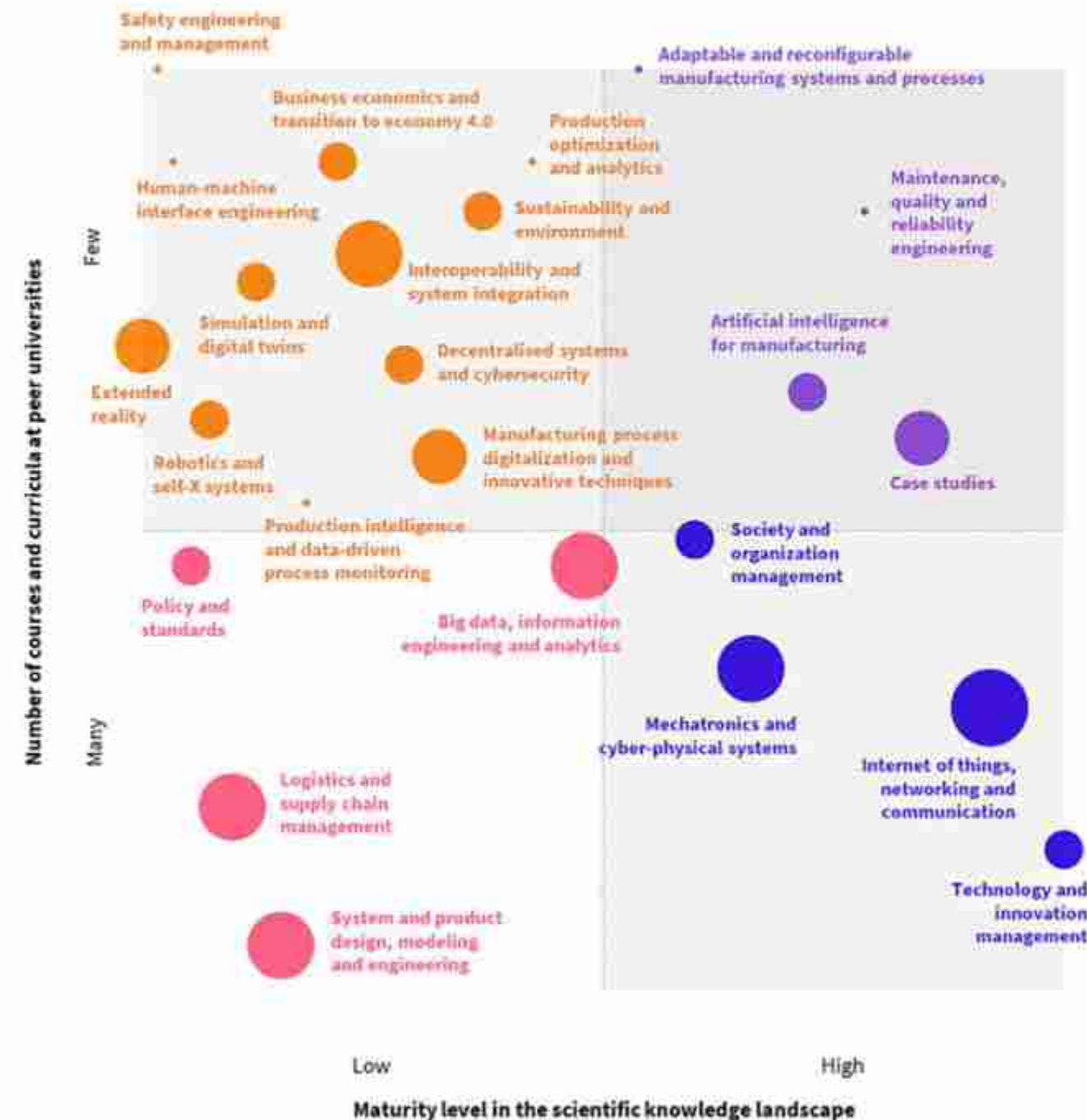
C1: matlab, theory, regression, formulate, clustering  
C2: 3d, motion, opportunity, change, disruption  
C3: lot, sensor, thing, enabling, node  
C4: critical, ethical, social, inherently, thinking  
C5: lot, environmental, monitoring, mission, reflectometry  
C6: structural, vibration, modal, identification, behaviour  
C7: security, cryptographic, attack, cipher, confidentiality  
C8: service, innovation, theory, cycle, product  
C9: simulation, modeling, oriented, operation, decision  
C10: community, legal, know, copyright, protection  
C11: manufacturing, factory, innovation, supply, chain

C12: ai, ethics, ethical, artificial, intelligence  
C13: dimensional, cad, drawing, graphic, rendering  
C14: anitrust, competition, eu, italian, law  
C15: manufacturing, defect, process, parameter, show  
C16: grid, smart, energy, network, distribution  
C17: production, line, automatic, machinery, robotic  
C18: reflection, ethical, ethic, fact, historical  
C19: institution, firm, investments, economic, policymakers  
C20: law, protection, legal, digital, building  
C21: module, output, workload, parallel, machine learning  
C22: cad, surface, curve, parametric, modeling

Fig. 4. Clustering university courses by topic.

# Open Educational Resources for human-centric IEM

## Gap analysis report and mismatches with Industry 5.0 requirements



The quadrant-based matrix appeared in a recent scientific study outlines four strategic approaches for curriculum development in emerging industrial education:

- **Quadrant I – Innovate and Pioneer (Low maturity, Few courses)** features emerging topics with low scientific maturity and limited existing courses. This quadrant invites bold, innovative curriculum design to address underdeveloped areas such as interoperability, simulation and digital twins, extended reality, and decentralized systems. It holds the highest number of topics, highlighting the need for foundational educational content.
- **Quadrant II – Specialize and Develop (High maturity, Few courses)** includes scientifically mature topics that remain underrepresented in curricula. These areas, such as AI in manufacturing, adaptable systems, and reliability engineering, offer strong potential for advanced and specialized courses.
- **Quadrant III – Monitor and Expand (High maturity, Many courses)** contains mature fields with well-established educational coverage, including IoT, cyber-physical systems, and innovation management. The focus here is on updating and enriching existing curricula with the latest developments.
- **Quadrant IV – Explore and Enhance (Low maturity, Many courses)** covers relatively new yet already popular topics like big data, system design, and supply chain management. The strategy involves monitoring trends and enhancing current offerings to meet demand.



# Open Educational Resources for human-centric IEM

The evolution of learning

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## Learning 1.0

This stage represents the most intuitive and experiential form of learning, where individuals acquired knowledge by observing natural phenomena, mimicking animal behaviors, and interacting directly with their environment. It was unstructured but deeply immersive and contextual. Learning was holistic and integrated into daily survival, creativity, and community life. While primitive by modern standards, this form of learning emphasized curiosity, observation, and adaptation – qualities still essential in today's educational systems.



## Learning 2.0

With the invention of writing and the printing press, knowledge became codified and transferable across time and space. Books, encyclopedias, and manuals provided a structured, formalized way to disseminate information. This stage marked the rise of institutionalized education, where learning became associated with schools and academic systems. The key feature here was access to curated and reliable information, which laid the foundation for widespread literacy and the development of disciplines.



## Learning 3.0

Learning 3.0 introduced digitized learning tools, enabling faster, multimedia-rich, and interactive access to knowledge. CD-ROMs and digital encyclopedias represented early efforts to enhance engagement and broaden educational reach beyond print. This era signaled the beginning of edtech, introducing learners to nonlinear navigation, multimedia integration, and personalized pacing. It also prepared the ground for more connected and flexible learning models.



## Learning 4.0

This phase marks the digital transformation of education through the rise of the internet, e-learning platforms, MOOCs, and virtual classrooms. Learning 4.0 enables access to global knowledge networks, expert-led video instruction, and collaborative learning experiences. It reflects a shift from teacher-centered to learner-centered paradigms, supporting self-paced, location-independent education. However, it also highlights challenges such as digital inequality, attention fragmentation, and a need for new pedagogical frameworks.



## Learning 5.0

It's the era of AI-assisted and personalized learning, where virtual tutors, chatbots, and generative AI tools (like GPT-based assistants) tailor content to individual needs, goals, and contexts. This stage blends human cognition with machine intelligence, enabling adaptive learning pathways, real-time feedback, and inclusive educational access. It supports lifelong learning, enhances learner autonomy, and opens new frontiers for hybrid human-machine collaboration in education. It also raises questions around ethics, data privacy, and the role of human educators in a tech-driven landscape.

# Open Educational Resources for human-centric IEM

## White Paper on Human-centric Industrial Engineering and Management



### PILLAR 1

## Empowerment and Inclusivity

Individuals are now enabled (with or without aid of technology) to make informed decisions, operate systems and develop the skills and confidence to pursue their goals. All individuals, regardless of their background, identity or abilities, have equal access to opportunities, resources and participation within the industrial setting.

### Anthropometry, biomechanics, ergonomics and usability engineering

Integrating anthropometric data, biomechanical modeling, and usability engineering into production system design enables task optimization, reduces musculoskeletal risk, and boosts worker efficiency. Ergonomically engineered workstations and interfaces not only minimize injury-related downtime but also enhance precision and throughput –delivering measurable ROI through improved performance, safety compliance, and workforce satisfaction.

### Augmenting technologies for assisted work

Augmenting technologies empower workers by enhancing their physical, cognitive, and sensory capabilities. In smart factories, tools like exoskeletons, AR interfaces, and AI-driven assistants support tasks that are repetitive, complex, or physically demanding – promoting efficiency, safety, and inclusivity while ensuring humans remain central to industrial processes.

### Lifelong learning and skills development

Continuous skills development is essential as industrial roles evolve with digitalization and automation. Implementing structured lifelong learning programs – through AR/VR training, upskilling platforms, and human-machine interaction modules – enables a future-ready workforce. This not only reduces skill gaps and turnover but also enhances adaptability, innovation capacity, and long-term operational resilience.

### Inclusivity and diversity in production systems

Today's workforce is significantly changing—it is more diverse, increasingly aged, and equipped with varied skillsets. Inclusivity in production systems means designing environments that adapt to these shifts. By embracing universal design and assistive technologies, smart factories can ensure all workers, regardless of age, background, or ability, can contribute effectively.

### Remote working (or work at a distance)

Remote working in industrial settings leverages IoT, digital twins, and XR technologies to enable supervision, diagnostics, and collaboration from afar. This flexibility reduces travel costs, ensures business continuity, and expands access to specialized talent – supporting agile operations and resilient production models in increasingly decentralized manufacturing ecosystems.

# Open Educational Resources for human-centric IEM

## White Paper on Human-centric Industrial Engineering and Management



### PILLAR 2

## Empathetic and social workplaces

Organizations are challenged to create a supportive work environment where employees feel valued, understood and connected to one another.

Moreover, as humans work alongside machines and AI systems in future factories, promoting social and empathetic interaction (H2H, H2M and M2M) becomes vital for effective collaboration, mutual learning and understanding, and building human-centric workplaces.

### Emotional intelligence and empathy-driven AI system

Empathy-driven AI systems equipped with emotional intelligence capabilities enhance human-machine interaction by recognizing and responding to users' emotional states. In industrial settings, this fosters better user experience, reduces cognitive strain, and supports mental well-being—driving engagement, safety, and acceptance of automation in increasingly human-centric production environments.

### Social engineering design at the workplace

Social engineering design in the workplace focuses on structuring environments that foster collaboration, trust, and inclusive behavior. By applying principles from organizational psychology and human factors engineering, companies can optimize team dynamics, reduce conflict, and enhance worker engagement—driving productivity, innovation, and retention in high-performance industrial settings.

### Adaptive and intuitive human-robot interaction

Adaptive and intuitive human-robot interaction enables seamless collaboration by aligning robotic behavior with human intent and context. Leveraging real-time perception, learning algorithms, and multimodal interfaces, these systems minimize training time, reduce errors, and improve safety—driving operational efficiency and user acceptance in dynamic, human-centric manufacturing environments.

### Generative AI and human-AI collaboration

Generative AI enables real-time design, decision support, and content creation, augmenting human capabilities in industrial contexts. Human-AI collaboration streamlines complex problem-solving, enhances creativity, and accelerates innovation cycles. By embedding explainable and user-aligned AI systems, organizations can boost productivity while maintaining human oversight, accountability, and strategic control.

### Social sustainability and social leadership

Social sustainability and leadership involve fostering inclusive, fair, and resilient workplace cultures. By prioritizing worker well-being, equity, and participatory governance, organizations build trust and long-term value. Strong social leadership drives engagement, reduces turnover, and aligns industrial performance with ESG goals, enhancing both reputation and operational sustainability.