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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

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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

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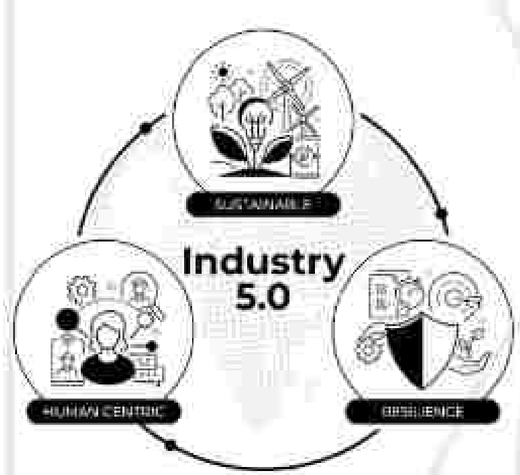
Driving force and policy-driven impetus for change

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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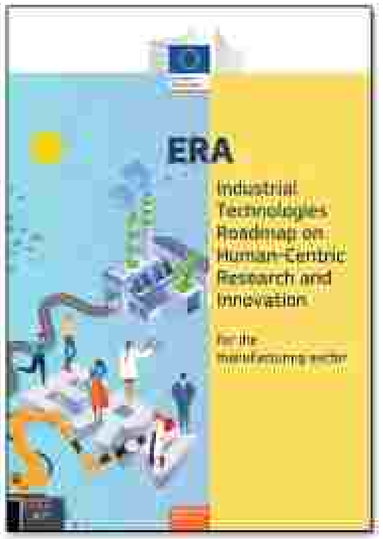
Introducing the LEONARDO project

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.

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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

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

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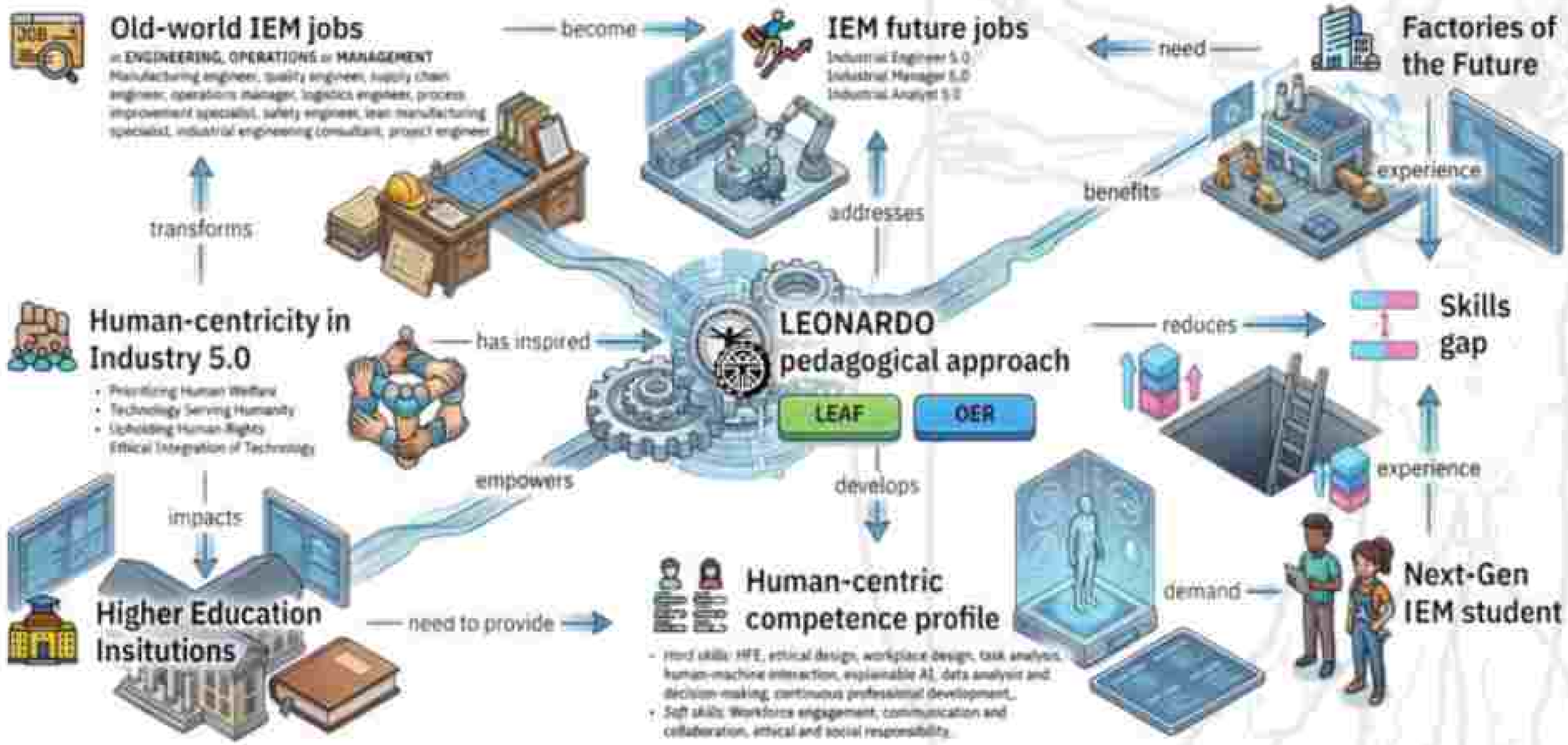
Our vision



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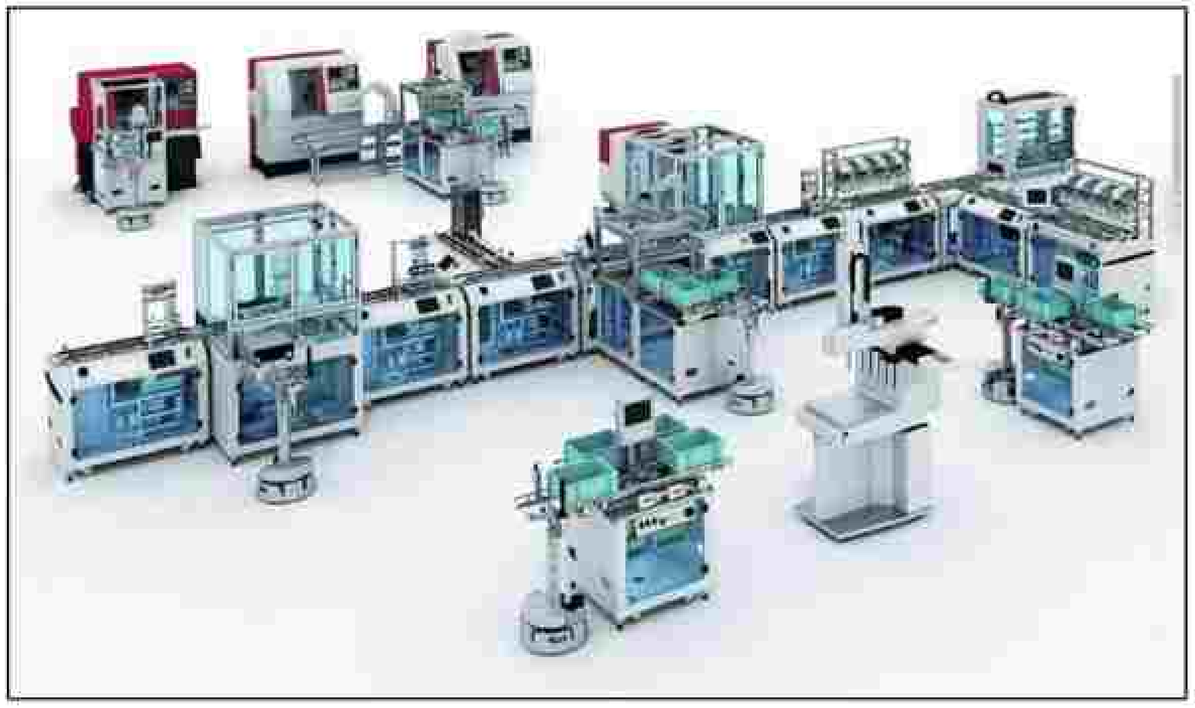
The idea of learning factories

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



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

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

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

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.

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Project objectives

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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human-systems symbiosis lab
uss-lab.it

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Pavel Kopylov
EIT Manufacturing North
SWEDEN

The LEONARDO smart brewing learning factory

Beyond Industry 4.0 learning factories

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.

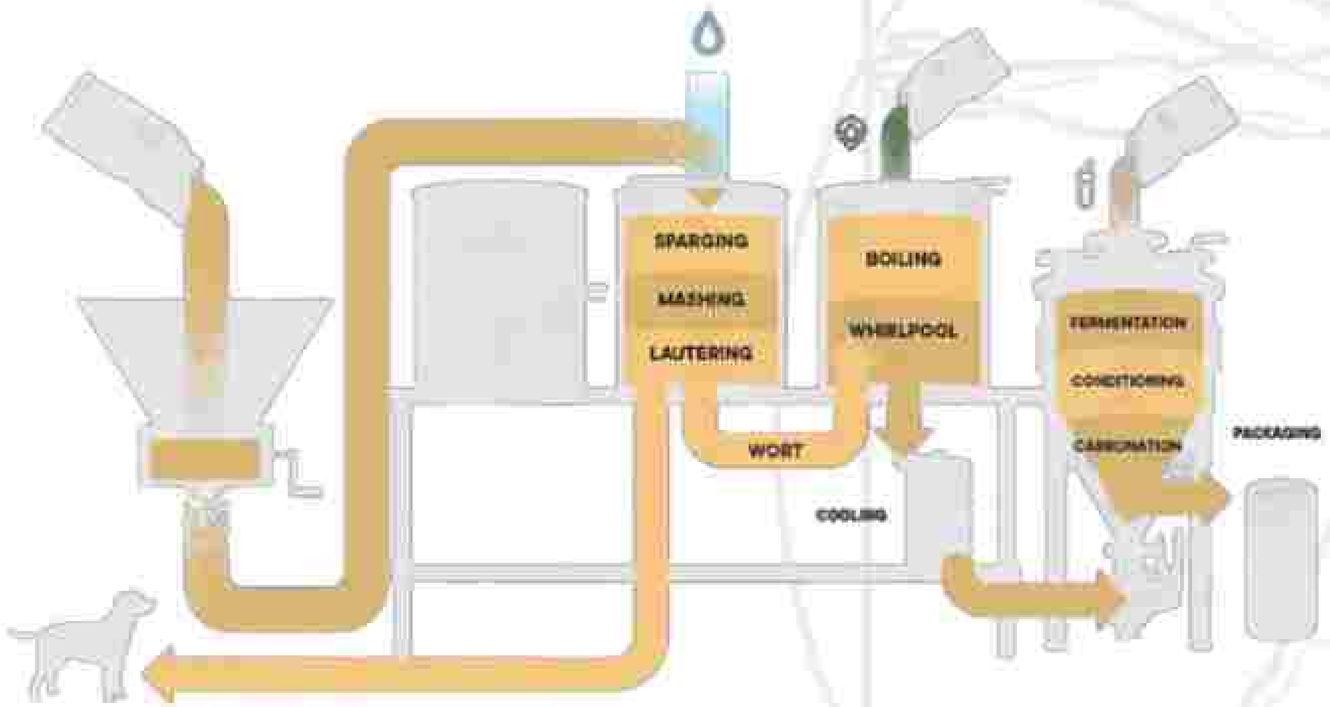
Fully automated and digitalized, LEAF integrates technologies like **TULIP**, **Node-Red**, and **Grainfather**, with AI-driven analytics powered by **Python**, **OpenCV**, and **YOLOv8** for real-time monitoring, predictive modeling, and root cause **analysis**.

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

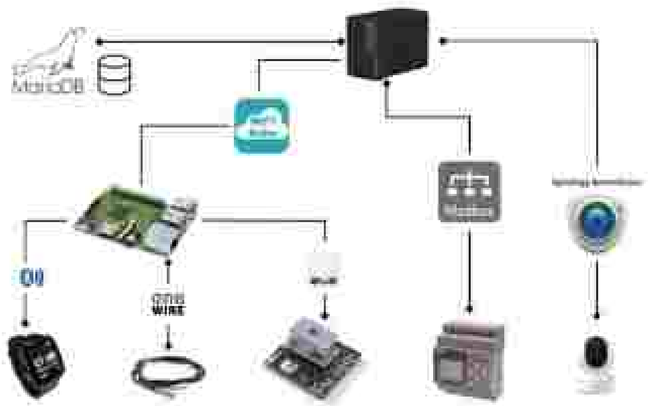
Beyond Industry 4.0 learning factories

> **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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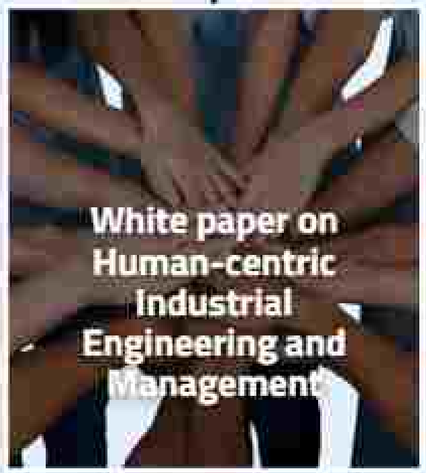
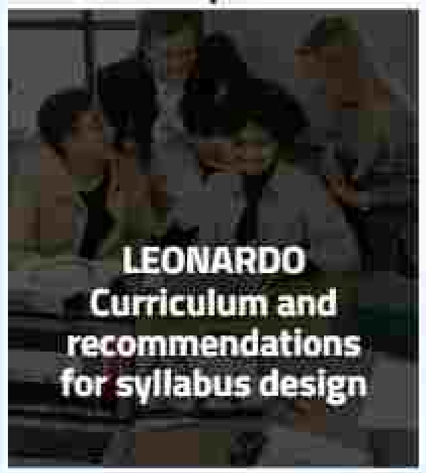
OER summary

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

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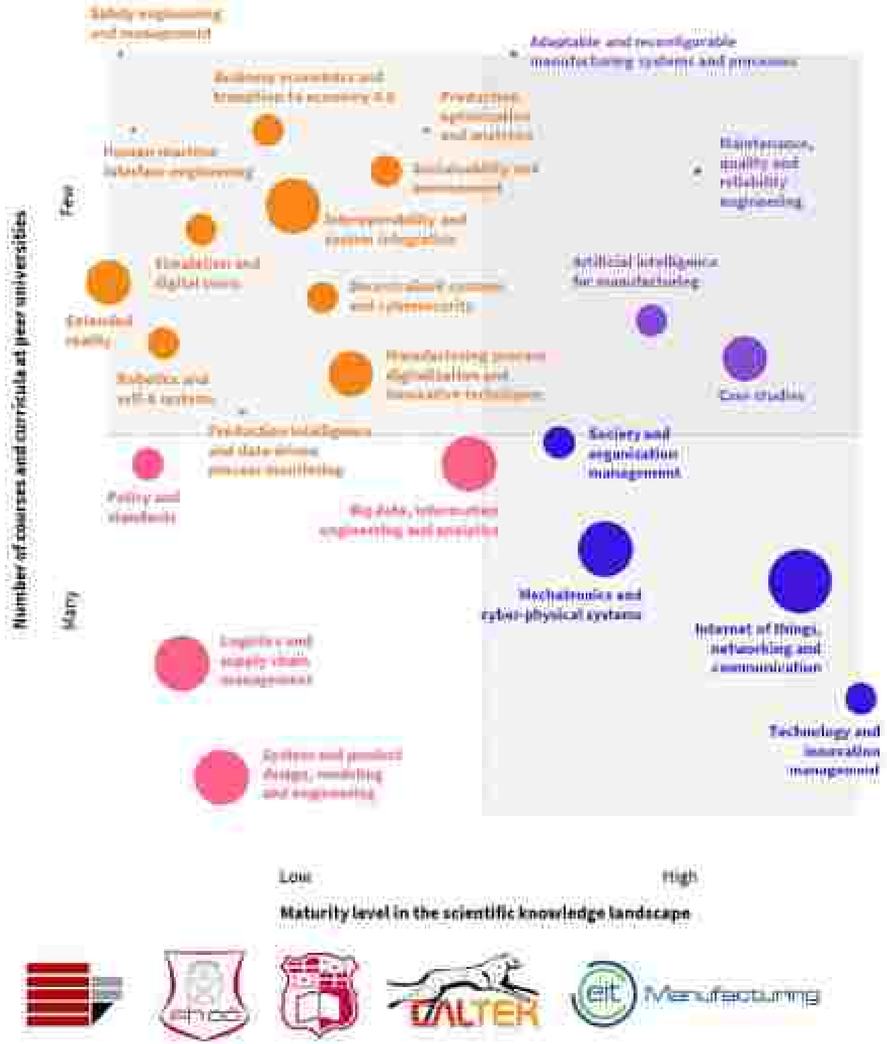
Gap analysis report and mismatches with Industry 5.0 requirements



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.

Padovano, A., & Cardamone, M. (2024). Towards human–AI collaboration in the competency-based curriculum development process: The case of industrial engineering and management education. Computers and Education: Artificial Intelligence, 7, 100256.

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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.

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White Paper on Human-centric Industrial Engineering and Management

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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.

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.

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.

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.

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.

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.

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White Paper on Human-centric Industrial Engineering and Management

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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.

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.

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.

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.

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.

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.

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White Paper on Human-centric Industrial Engineering and Management

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PILLAR 3

Ethical and responsible engineering

Engineers must commit to uphold fundamental human rights, values and dignity of users and stakeholders, prioritize transparency and accountability, while also considering the broader societal implications of technology innovation, including sustainability and environmental impacts.

Ethical and human-centered AI

Ethical and human-centered AI prioritizes transparency, accountability, and fairness in algorithmic decision-making. In industrial contexts, it ensures AI systems respect human rights, avoid bias, and maintain user trust. Embedding ethical principles from design to deployment enhances compliance, social acceptance, and the long-term sustainability of AI-driven operations.

Ethical audits, risk assessments

Human augmentation technologies—such as wearables, neurointerfaces, and exoskeletons—raise complex ethical questions around autonomy, consent, and equity. Responsible adoption requires clear governance frameworks to balance performance gains with workers' rights, ensuring enhancements are supportive, voluntary, and aligned with individual dignity and long-term social well-being.

Well-being and work-life balance

Promoting well-being and work-life balance in industrial environments enhances employee retention, productivity, and resilience. By integrating flexible scheduling, supportive digital tools, and health-oriented workplace design, organizations foster sustainable performance. Prioritizing mental health and work-life integration is not just ethical – it's a strategic imperative for long-term operational success.

Ethical governance and technology regulation, fairness and accountability

Ethical governance ensures that emerging technologies in industry operate transparently, fairly, and within regulatory bounds. Establishing clear accountability structures, inclusive decision-making, and compliance with frameworks like the EU AI Act helps organizations mitigate risk, build trust, and align innovation with societal values and legal responsibilities.

Ethical technology design for values

Ethical technology design embeds human values – such as autonomy, dignity, and justice – into the development process from the outset. In industrial settings, this approach ensures that digital systems align with societal expectations, user needs, and ethical norms, fostering trust, long-term adoption, and responsible innovation across production ecosystems.

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LEONARDO Curriculum

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Recommendations for a syllabus design

Course content

Topics		Sub-topics		ECTS	Lecture hours	
0	Human-centered Production	0.1	Human-centricity: motivation and vision	2	16	2
		0.2	Introduction to Industry 5.0 human-centered production principles			2
		0.3	Human-centered design: theory and applications			6
		0.4	Human factors and ergonomics in production systems			6
1	Empowerment and Inclusivity	1.1	Introduction to inclusive workspaces and empowered operators	3	25	1
		1.2	Inclusivity by design: diversity in production systems			4
		1.3	Technologies augmenting physical and cognitive capabilities			5
		1.4	Anthropometry, biomechanics and usability engineering			5
		1.5	Lifelong learning and skills development in high-tech production environments			5
		1.6	Human-centered design for working at a distance			5
2	Empathetic and Social Interaction	2.1	Introduction to empathetic and social workplaces	3	25	1
		2.2	Social engineering design: theory and principles			2
		2.3	Social engineering design: applications in the workplace and smart factories			2
		2.4	Generative AI and human-AI collaboration in the workplace			4
		2.5	Emotional intelligence and empathy-driven AI systems in industry 5.0			4
		2.6	Explainable AI and trust in collaborative workplaces			4
		2.7	Empathy and social bonding in human-robot interaction			4
		2.8	Social sustainability and social leadership			4
3	Ethical and Responsible Technology Engineering	3.1	Introduction to ethical and responsible design and use of technology	3	25	1
		3.2	Ethical implications of human augmentation			2
		3.3	Ethical audits and risk assessments			2
		3.4	Ethical and human-centered AI			4
		3.5	Data collection, workplace surveillance and privacy in industrial systems			4
		3.6	Well-being and work-life balance			4
		3.7	Ethical governance and technology regulation, fairness and accountability			4
		3.8	Ethical design: value-sensitive design and tarot cards			4
4	Case studies	4.1	Case Study 1 (Empowerment and inclusivity)	1	9	3
		4.2	Case Study 2 (Empathetic and Social Interaction)			3
		4.3	Case Study 3 (Ethical and Responsible Technology Engineering)			3
				12	100	

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Learning objectives

1. To understand the vision and principles of human-centered factories, human augmentation and empowerment, socially sustainable workplaces and ethical/responsible technology engineering
2. To apply emerging technologies in industrial settings by evaluating AI, automation, and human augmentation to enhance capabilities, productivity, and collaboration (human-human, human-robot, human-AI) while integrating emotional intelligence and responsible technology practices to ensure compliance and long-term sustainability.
3. To assess and refine enterprise transformation roadmaps by evaluating strategic frameworks, technological integration, and ethical implications to enhance organizational adaptability
4. To design and create factories of the future where the human element coexists symbiotically with the physical environment and technologies

Professional figures of the future

Manager 5.0 *Analyst 5.0* *Operator 5.0*

To develop analytical thinking, leadership and social influence, creative thinking, self-awareness, technological literacy, empathy and active listening (as defined by the Future of Jobs Report 2025)

Teaching methods

A combination of interactive theoretical lectures, formative assessments, and experiential learning approaches (project works) is recommended to foster critical thinking and problem-solving skill. Students should collaborate in interdisciplinary teams to tackle complex, real-world industrial challenges.

Open Educational Resources for human-centric IEM

Recommendations for a syllabus design

KEY EXPERT RECOMMENDATIONS FOR HUMAN-CENTRIC IEM EDUCATION

based on the feedback from 13 experts

1. Formulate Intended Learning Outcomes with **observable, action-oriented verbs** (e.g. analyze, design, evaluate, apply).
2. Indicate **how learning is evaluated**, including formative and summative approaches, reflective tasks, peer assessment
3. Make use of **synchronous and asynchronous activities** to enhance participation, reflection, and collaborative learning
4. **Avoid rigid generational labels** (e.g. "5.0") by framing professional roles as X.0 profiles
5. Explicitly include **safety, human factors, and emerging technologies** as core elements of human-centric industrial systems
6. Complement ethical and social dimensions with sufficient **technological foundations and economic reasoning**
7. Design learning activities that **connect these themes to concrete industrial challenges**

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Lecture slides & business cases

Module 0 | Human Centred Production

0.1 | The LEONARDO Vision for Human Centricity >
0.2 | Introduction to Human Centred Production and Industry 5.0 >
0.3 | Human Centred Design >
0.4 | Human Factors and Ergonomics in Production Systems >

Module 1 | Empowerment and Inclusivity

1.1 | The LEONARDO Vision for Inclusive Workspaces and Empowered Operators >
1.2 | Inclusivity by Design: Diversity in Production Systems >
1.3 | Technologies augmenting physical and cognitive capabilities >
1.4 | Anthropometry, biomechanics and usability engineering >
1.5 | Lifelong Learning and Skills Development in High-Tech Production >
1.6 | Human-Centered Design for Work at a Distance >

Module 2 | Empathetic and Social Interaction

2.1 | The LEONARDO Vision for Empathetic and Social Workplaces >
2.2 | Introduction to Social Engineering Design >
2.3 | Social Engineering Design in the Workplace >
2.4 | Generative AI and Human-AI Collaboration in the Workplace >
2.5 | Emotional intelligence and empathy-driven AI systems in industry 5.0 >
2.6 | Explainable AI and trust in collaborative workplaces >
2.7 | Empathy and social bonding in human-robot interaction >
2.8 | Social sustainability and social leadership >

Module 3 | Ethical and Responsible Technology Engineering

3.1 | The LEONARDO Vision for Ethical and Responsible use of Technology >
3.2 | Introduction to Ethical and responsible technology engineering >
3.3 | Ethical Implications of Human Augmentation and Enhancement >
3.4 | Ethical Audits and Risk Assessments >
3.5 | Ethical and human-centred AI >
3.6 | Ethics of Data Collection, Workplace surveillance and Privacy in Industry >
3.7 | Well-being and Work-Life Balance >
3.8 | Ethical Governance and Technology Regulation, Fairness and Accountability >
3.9 | Ethical design: Value Sensitive Design and Tarot Cards >

Module 4 | Business case studies

4.1 | Case Study 1 (Empowerment and inclusivity) >
4.2 | Case Study 2 (Empathetic and Social Interaction) >
4.3 | Case Study 3 (Ethical and Responsible Technology Engineering) >

Module 5 | LEAF tutorials

5.1 | CALABRIA LEAF Tutorials (Part 1) >
5.2 | CALABRIA LEAF Tutorials (Part 2) >
5.3 | WELS LEAF Tutorials >

PDF lecture slides are available. Click on the lecture to download it

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Group/team project examples

Human-centered design of Industry 4.0 technologies

A group/team project where students apply human-centric design principles to Industry 4.0 technologies in a smart brewing system.

Download

Human-centered manufacturing and human-centered AI design: HAX Design Guidelines for Human-AI Interaction

A group/team project where students explore the implications of AI through HAX Design Guidelines for Human-AI Interaction.

Download

Value-based engineering and responsible technology design with Tarot Cards of Tech

A group/team project where students use the Tarot Cards of Tech to brainstorm about the consequences of applying technologies from an ethical perspective.

Download

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LEAF-as-a-service educational toolkit

Remotely accessible services/apps for LEAF-based student game-based education, including IT-based services to access the LEAF remotely and experiment with it (including user manuals)

LEONARDO Simulation-based Supply Chain Digital Twin available for free on AnyLogic Cloud
Link to the web app >

Use sensor data from the FHOOE LEAF for experimentation by the students
Email Prof. Thomas Schlechter for details on how to connect >

Open source dataset of beer bottle images available on official LEONARDO GitHub Repo
https://github.com/usslaboratory/leonardo >

Equipment manuals available on official LEONARDO GitHub Repo
https://github.com/usslaboratory/leonardo >

Open Educational Resources for human-centric IEM

LEAF-based educational strategies

Educational Strategy #1:
Training through Factory-in-Action Learning

Pedagogical focus: Experiential learning, perspective-taking, role-playing
Scope: Operator/Manager X.0

Students assume key operational roles within the LEAF smart factory and manage its full production cycle through immersive roleplay. By addressing real-time challenges using digital twins and AI-supported tools, they make decisions with tangible operational consequences. The approach emphasizes cross-role coordination, leadership under uncertainty, balanced human–AI decision-making, and learning through iteration and reflection, transforming students from passive learners into active operators of complex socio-technical systems.

Educational Strategy #2:
Collective Intelligence: Learning with/against AI

Pedagogical focus: Cognitive augmentation, hybrid intelligence, reflective practice, ethical awareness
Scope: Analyst X.0

Students engage with AI as both a collaborative partner and a critical counterpart in solving manufacturing-related problems within the LEAF environment. Through alternating cooperative and competitive scenarios, they analyze digital twin simulations, co-design solutions, and challenge AI-generated recommendations. This approach strengthens students' understanding of AI capabilities and limitations, enhances problem-solving and meta-cognitive skills, and fosters responsible, ethical, and well-calibrated human–AI collaboration.

Educational Strategy #3:
LEAF Innovation Arena: Prototype, Pitch, Perform

Pedagogical focus: Agile learning, entrepreneurial mindset, interdisciplinary co-creation
Scope: Leader/Innovator X.0

Students participate in challenge-driven innovation sprints, such as design labs or hackathons, where interdisciplinary teams conceptualize, prototype, and validate new technological and organizational solutions for the LEAF environment. By leveraging AI, XR, IoT, and automation, students develop creative problem-framing, rapid prototyping, strategic communication, and ethical, human-centered design skills. The experience fosters entrepreneurial thinking, informed risk-taking, and the ability to navigate uncertainty and trade-offs inherent in real-world industrial innovation.

How to operationalize this?

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LEAF-based educational strategies

LEONARDO

Operational Immersion to Train Operators 5.0

Factory-in-Action Learning

Objective. To provide students with an authentic experience of operating a real factory - from producing a high-quality beer, to collaborating with external companies, and managing supporting processes such as procurement.

Four different **learning corners** for human-centric factories of the future

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LEAF-based educational strategies

LEONARDO

Operational Immersion to Train Operators 5.0

Factory-in-Action Learning

Digital learning objects as small bite-sized chunks of learning material for electronic delivery and use packed into micro-courses that include a lesson, an activity, and an assessment

TECHNOLOGY TO SUPPORT LEARNING BY DOING

Am I doing right?

LESSON
M1 - Empowerment and Inclusivity
L1.3 - Technologies augmenting physical and cognitive capabilities

ACTIVITY
Watch the video >

QUIZ AND ASSESSMENT
Link to the quiz >

TECHNOLOGY TO SUPPORT (NON-)REPETITIVE TASKS

Is the same beer?

LESSON
M2 - Empathetic and Social Interaction
L2.4 - Generative AI and Human AI Collaboration in the Workplace

ACTIVITY
Watch the video >

QUIZ AND ASSESSMENT
Link to the quiz >

TECHNOLOGY TO AVOID DISTRACTIONS

Did I?

LESSON
M0 - Human Centred Production
L0.4 - Human Factors and Ergonomics in Production Systems

ACTIVITY
Watch the video >

QUIZ AND ASSESSMENT
Link to the quiz >

TECHNOLOGY TO SUPPORT AWARENESS AND RESPONSIBILITY

How much is enough?

LESSON
M3 - Ethical and Responsible Engineering
L3.4 - Ethical Audits and Risk Assessments

ACTIVITY
Watch the video >

QUIZ AND ASSESSMENT
Link to the quiz >

TECHNOLOGY TO SUPPORT CONTINUOUS IMPROVEMENT

Did I ruin everything?

LESSON
M1 - Empowerment and Inclusivity
L1.5 - Lifelong Learning & Skills Development in High-Tech Production Environments

ACTIVITY
Watch the video >

QUIZ AND ASSESSMENT
Link to the quiz >

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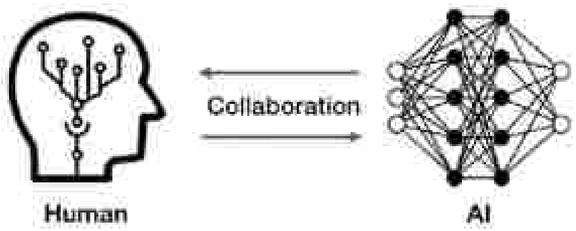
LEAF-based educational strategies

LEONARDO

Collective Intelligence: Learning with/against AI

Ethical human-AI collaboration in IEM: an international competition

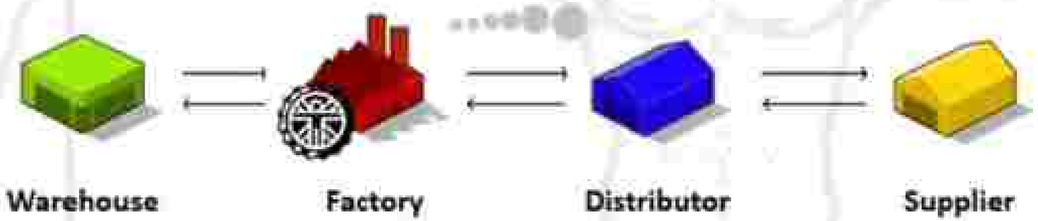
Objective. Understanding the ethical impact of AI from being a tool to a nearly full-fledged genuine teammate



- **Shared Decision-Making:** *If AI is smarter, shouldn't it just decide for us?*
- **Transparency and Explainability:** *Are you using the AI because you understand it, or because it gives you a quick answer (blind trust)?*
- **Shared accountability and traceability:** *How can a decision be ethical if no one can be held accountable for it?*

WHAT WE DID

A customized version of the **Beer Game** where the students play the role of the brewery manager



Available simulation model developed ad hoc in **AnyLogic**

Student teams competing indirectly on operational excellence and responsiveness

- How many material bundles do we order from the distributor this month?
- How many bottles should we produce this month?
- How do we report our performance to the market?

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LEAF-based educational strategies

In the game, AI use is limited, strategic, and across all these rounds, the team may consult the AI a maximum of 5 times total.

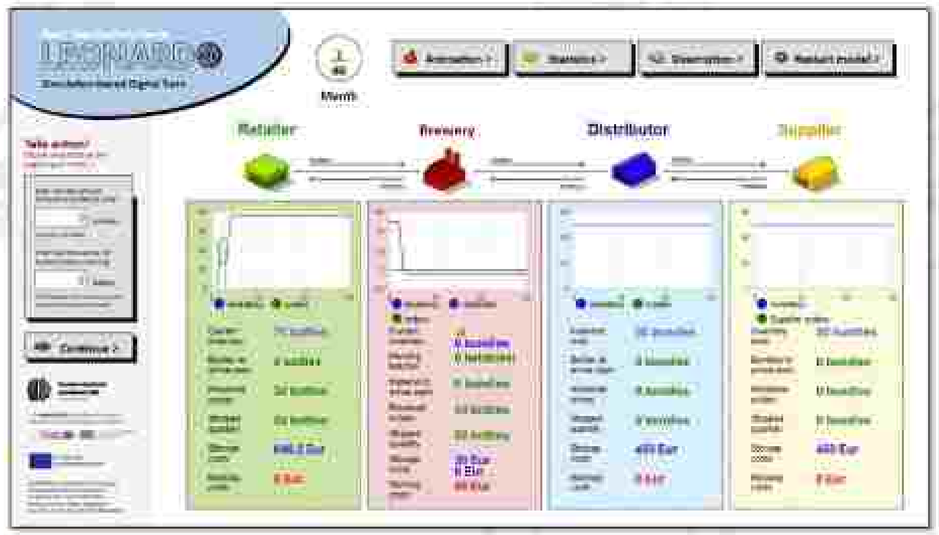
The AI advisor is **situationally intelligent**.

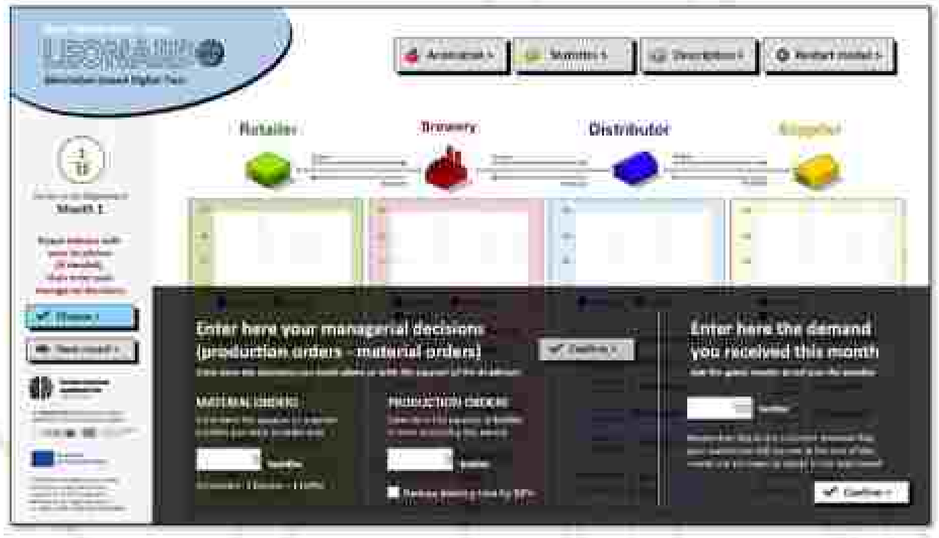
Human–AI collaboration works only when humans develop the right kind of trust. Not blind trust. Not zero trust. But **calibrated trust** - trust that matches the AI's actual capabilities.

Ethical AI advisor

Unethical AI advisor

An AI advisor was assigned to the teams but they did not know which one





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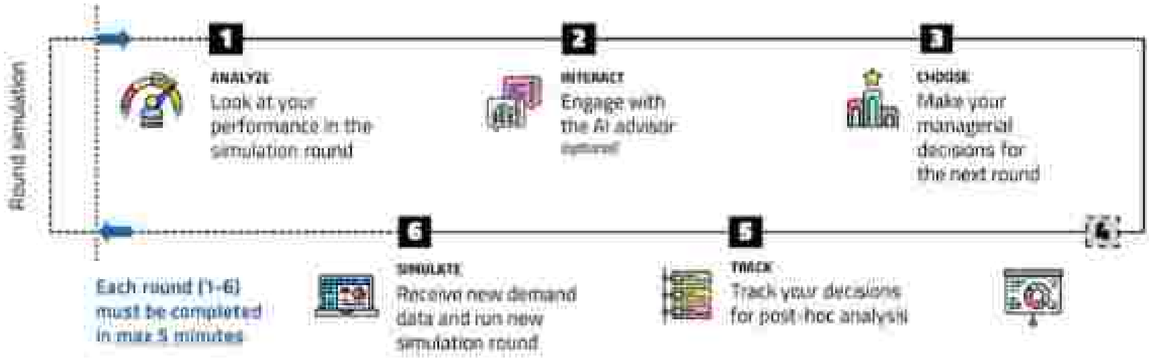
LEAF-based educational strategies

12 rounds simulated, **3-hour class** with teams connected remotely with local facilitator



Planning the **2nd edition** of the international competition for **December 2026**:

want to join?

DOWNLOAD

Game resources are available **open access** for your review

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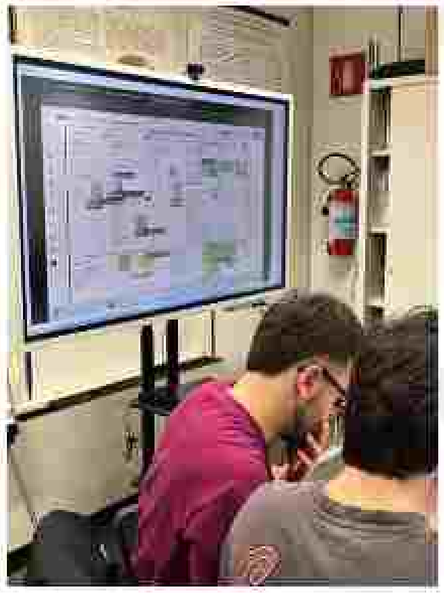
LEAF-based educational strategies

LEAF Innovation Arena: Prototype, Pitch, Perform

Design labs and innovation sprints

Task: Creating/updating the business model canvas for learning factories



LEONARDO

UNICAL students pitched their ideas at **HUMANMADE+ 2026** in Cosenza, Italy

Visit https://www.uss-lab.it/humanmadeplus/

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Stay in touch and use the resources

Visit www.uss-lab.it/projects/leonardo/ for more information

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Contacts

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