

# Open Educational Resources for human-centric IEM

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



### 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.

### 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 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 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 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.

### 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.

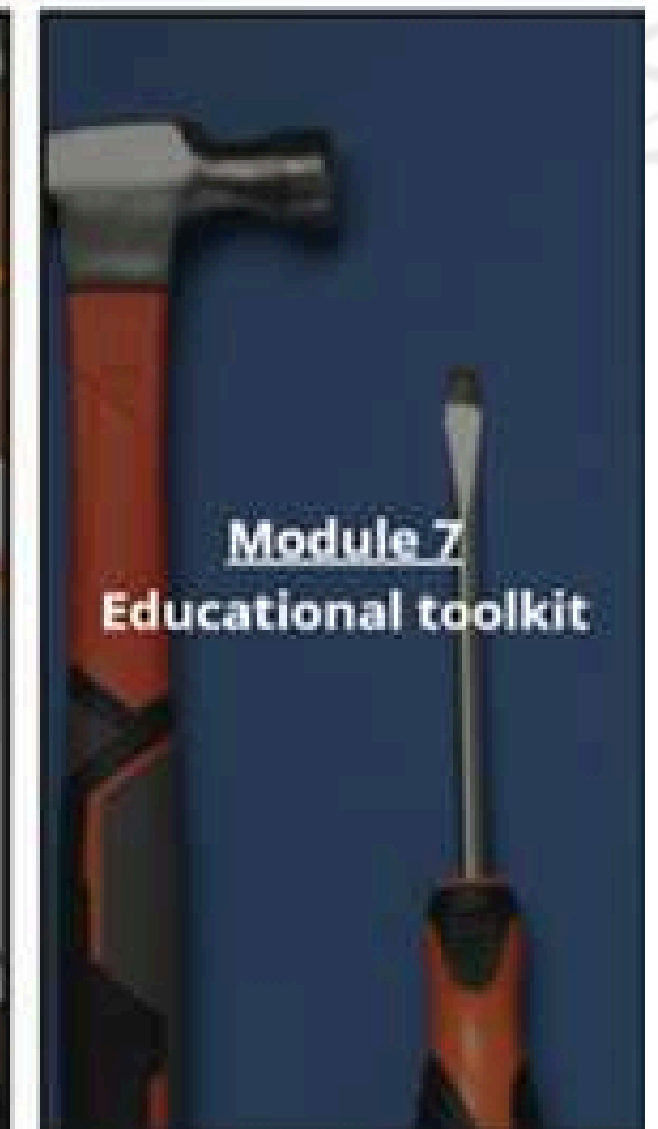
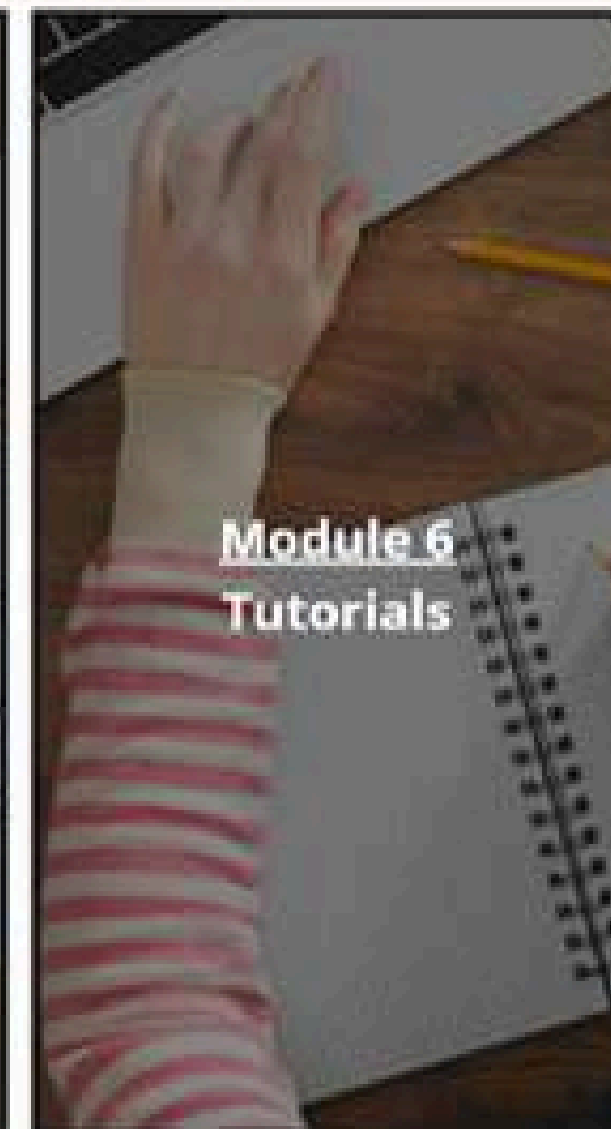
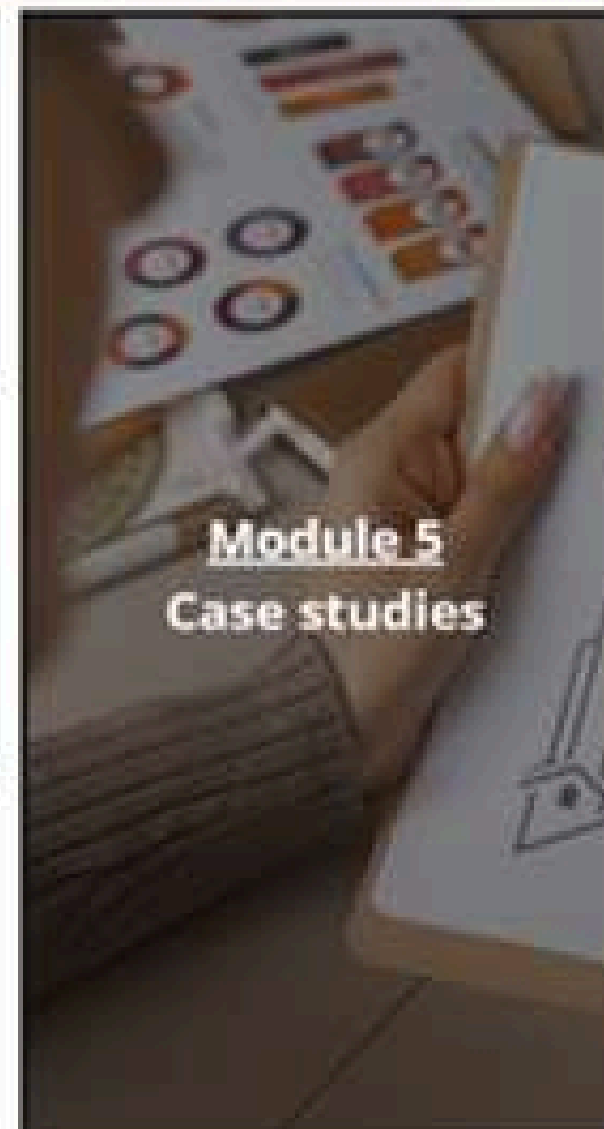
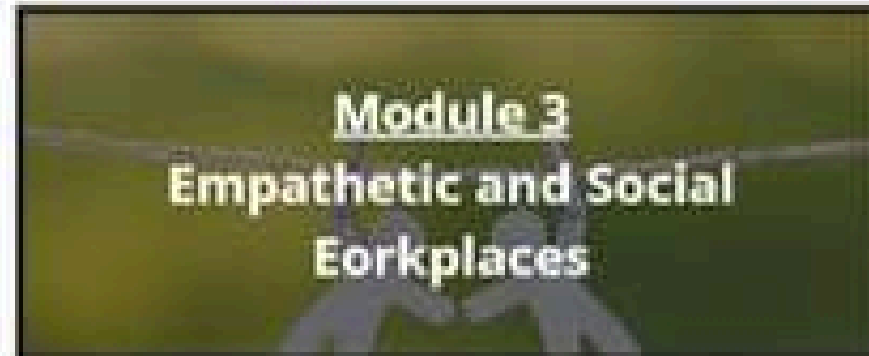
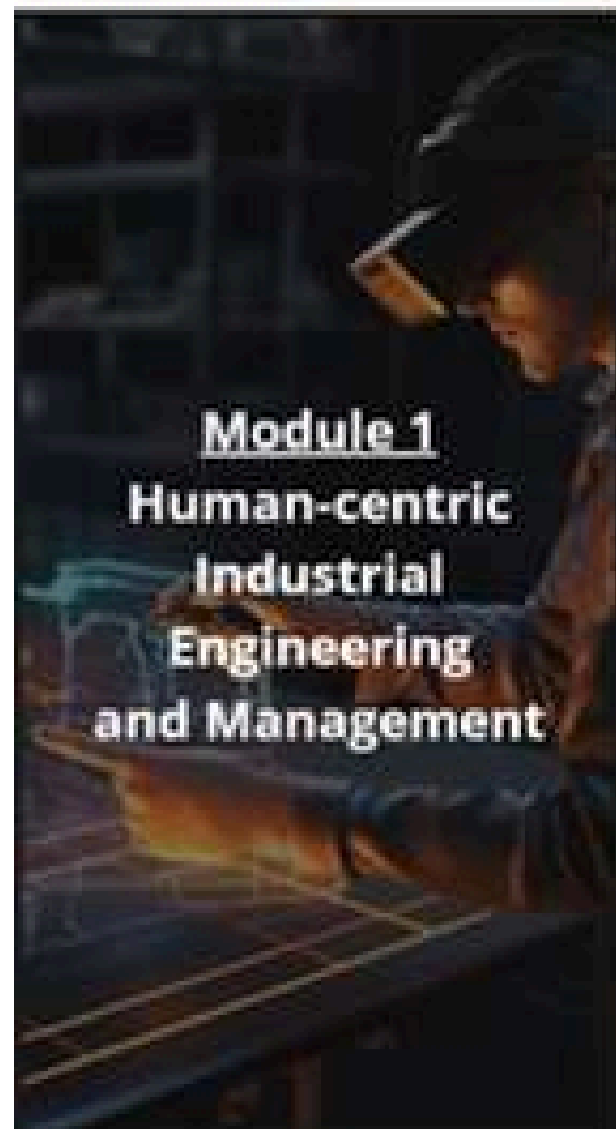
# Open Educational Resources for human-centric IEM

LEONARDO Curriculum

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Welcome



# Open Educational Resources for human-centric IEM

## Recommendations for a syllabus design

### Course content

Topics	Sub-topics	ECTS	Lecture hours		
0	Human-centered Production	2	16	0.1 Human-centricity: motivation and vision	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	3	25	1.1 Introduction to inclusive workspaces and empowered operators	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	3	25	2.1 Introduction to empathetic and social workplaces	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	25	3.1 Introduction to ethical and responsible design and use of technology	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	1	9	4.1 Case Study 1 (Empowerment and inclusivity)	3
				4.2 Case Study 2 (Empathetic and Social Interaction)	3
				4.3 Case Study 3 (Ethical and Responsible Technology Engineering)	3
		12	100		



### 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.



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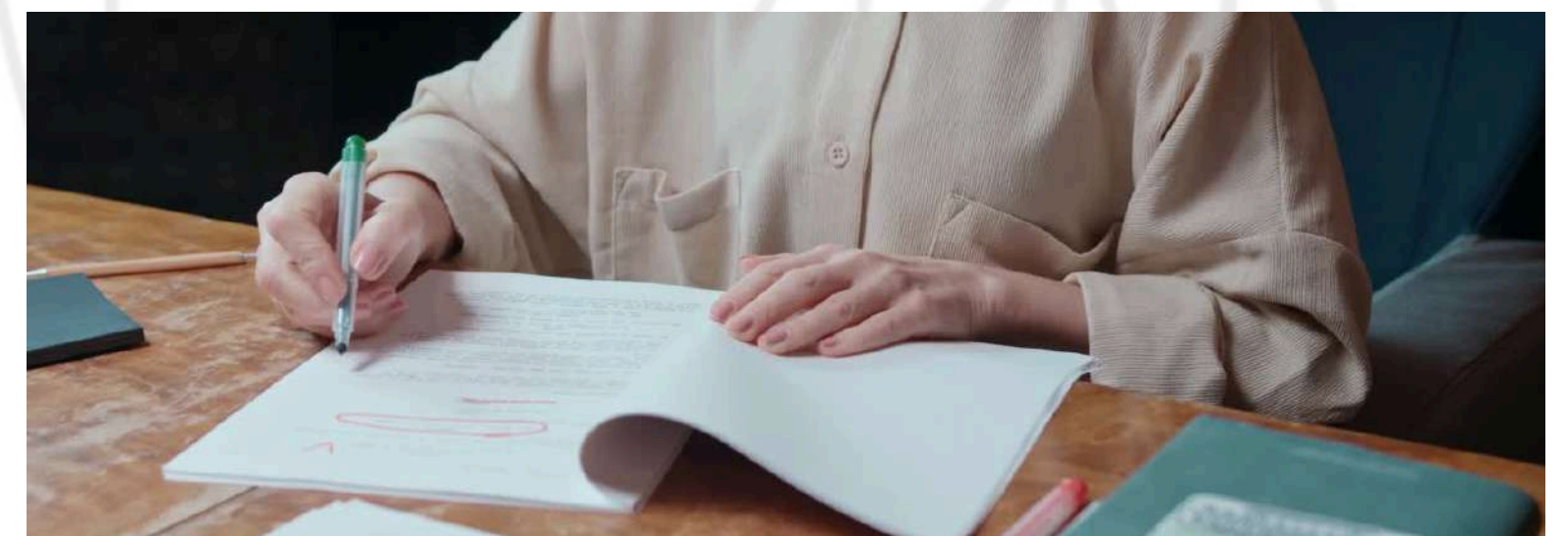
Recommendations for a syllabus design

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## KEY EXPERT RECOMMENDATIONS FOR HUMAN-CENTRIC IEM EDUCATION

*based on the feedback from 13 experts*

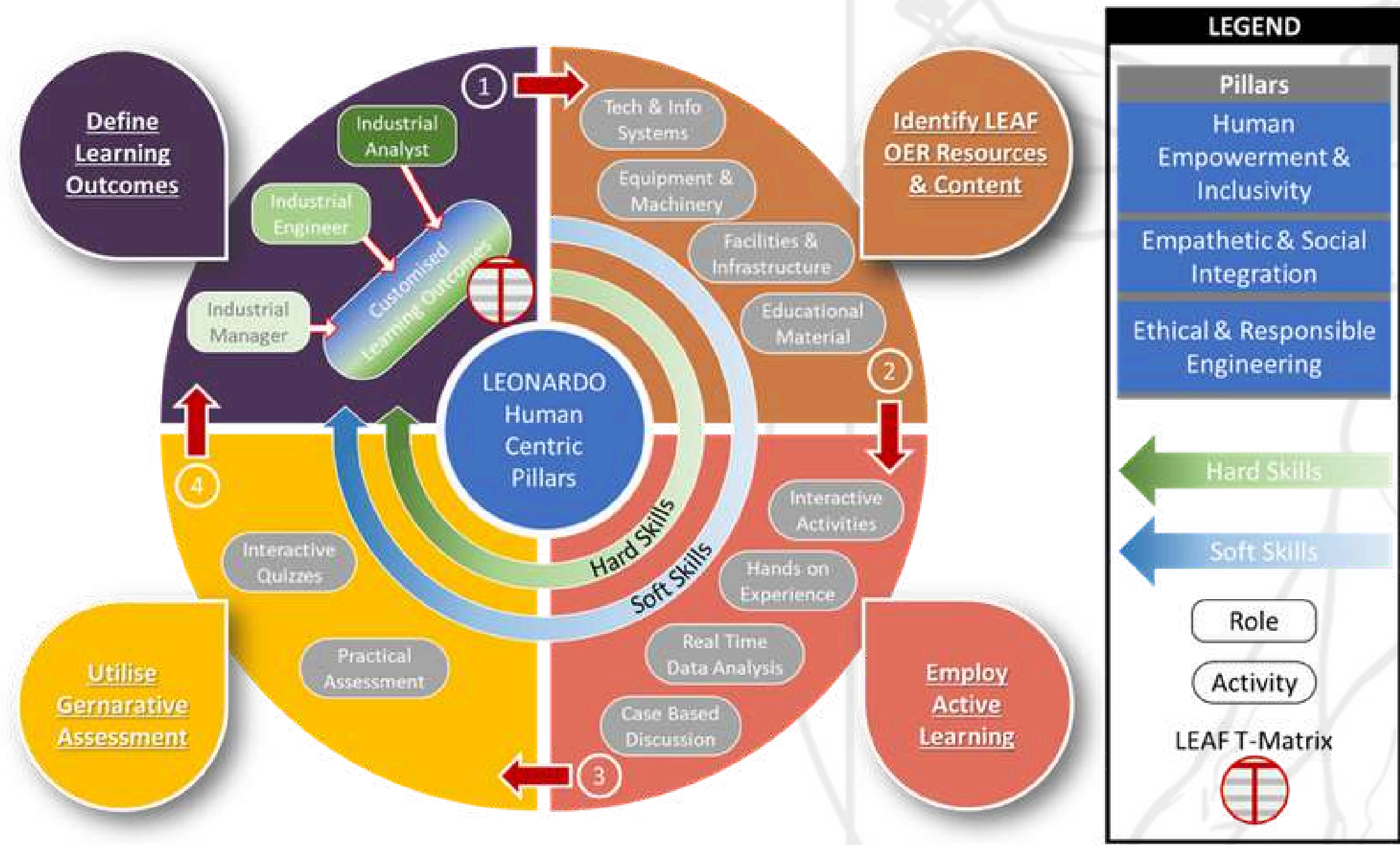
1. Formulate Intended Learning Outcomes with **observable, action-oriented verbs** (e.g. analyze, design, evaluate, apply).
2. Indicate **how learning is evaluated**, including formative and summative approaches, reflective tasks, peer assessment
3. Make use of **synchronous and asynchronous activities** 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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Pedagogical framework

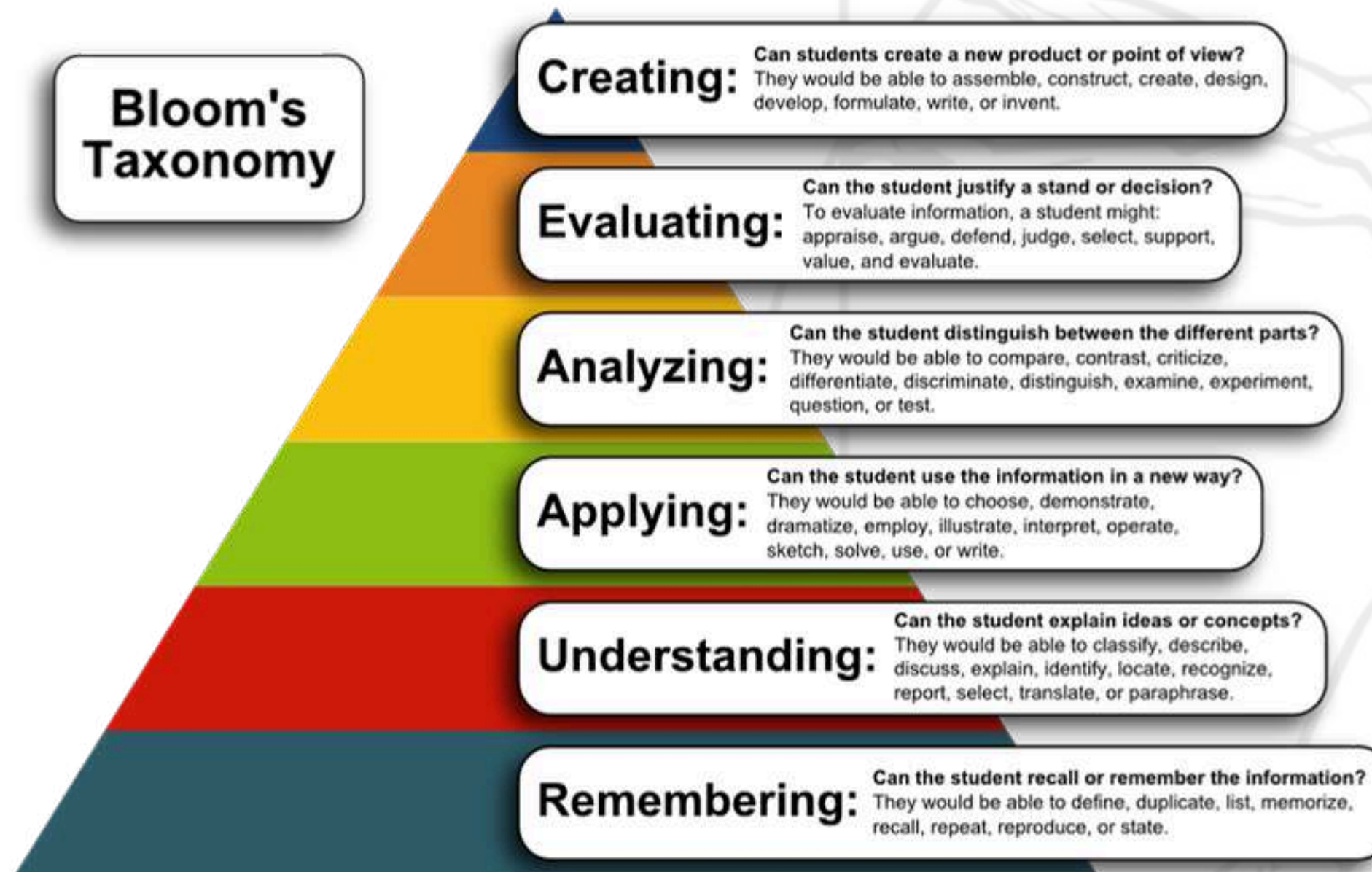
# LEONARDO



# Open Educational Resources for human-centric IEM

Pedagogical framework

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# Open Educational Resources for human-centric IEM



## LEONARDO Intended Learning Objectives (ILO) Framework

LEONARDO comprises **28 ILOs organised into five thematic domains**. The framework is grounded in Bloom's revised taxonomy and is explicitly mapped to the LEONARDO Human-Centric Pillars (LHCP). Each sub-topic in the curriculum addresses a subset of these ILOs:

### Domain A – Human-Centric Production Foundations (ILO 1–5)

These ILOs establish the conceptual and systemic foundations of human-centric production, Industry 5.0, and human-centered design. They are primarily addressed by the Pillar 0 module and recur as prerequisite knowledge throughout the other pillars.

- **ILO 1** – Describe the key principles, historical evolution, and societal drivers of Industry 5.0 and human-centric manufacturing, distinguishing them from the techno-centric paradigm of Industry 4.0. **[Knowledge / Comprehension]**
- **ILO 2** – Explain the concept of human-centered design (HCD) and articulate how placing human needs and well-being at the centre of production processes generates value for workers, organisations, and society. **[Comprehension]**
- **ILO 3** – Compare Industry 4.0 and Industry 5.0 frameworks in terms of their technological, organisational, and human implications, identifying the skills and competences required to operate effectively in each paradigm. **[Analysis]**
- **ILO 4** – Apply human factors and ergonomics principles — including physical, cognitive, and organisational ergonomics — to analyse and redesign production workstations and processes for improved worker safety, well-being, and productivity. **[Application / Analysis]**
- **ILO 5** – Evaluate the holistic well-being of workers in a given production environment by integrating physical, psychological, and social dimensions, and propose actionable improvements consistent with Industry 5.0 goals. **[Evaluation]**



# Open Educational Resources for human-centric IEM

## LEONARDO Intended Learning Objectives (ILO) Framework

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### Domain B – Empowerment, Diversity and Inclusivity (ILO 6–10)

These ILOs target the competences required to design, evaluate, and advocate for inclusive production systems that empower a diverse workforce. They are the primary focus of the Pillar 1 module and connect with Domain A ILOs on ergonomics and human factors.

**ILO 6** – Articulate the business, ethical, and societal case for workforce diversity and inclusion in industrial environments, referencing relevant European policies (EU Disability Strategy, Skills Agenda) and demonstrating awareness of intersectional barriers to inclusion. **[Comprehension / Evaluation]**

**ILO 7** – Design manufacturing workstations, tools, and processes that comply with Universal Design principles and address the physical, cognitive, and socioeconomic diversity of operators, including people with disabilities, different anthropometries, and varying experience levels. **[Synthesis / Creation]**

**ILO 8** – Select and justify appropriate Industry 4.0 and Industry 5.0 technologies — including collaborative robots, AR/VR, exoskeletons, and assistive communication systems — for augmenting the physical and cognitive capabilities of a diverse workforce. **[Application / Evaluation]**

**ILO 9** – Assess the usability and accessibility of a production system using quantitative (anthropometric measurements, RULA/REBA scores) and qualitative (user feedback, heuristic evaluation) methods. **[Analysis / Evaluation]**

**ILO 10** – Construct a personal and organisational skills development plan that integrates lifelong learning, continuous upskilling, and the ability to adapt to technological change in high-tech production environments. **[Synthesis / Creation]**



# Open Educational Resources for human-centric IEM

## Curriculum mapping



Pillar	Sub-Topic	ILOs	OER Suggestions	Hard Skills Enhanced	Soft Skills Enhanced
<b>PILLAR 0: Human-Centered Production   Module 0: Foundations of Human-Centric Industrial Engineering</b>					
Pillar 0 Human-Centered Production	1.1 The LEONARDO Vision for Human Centricity	ILO 1, 2	Lecture slides + introductory video; LEONARDO project factsheet and vision document; European Commission Industry 5.0 report (2021); In-class discussion: what does 'human-centric' mean to you?	General Systems Theory; ICT (introductory)	Communication; Creativity; Life-long Learning
	1.2 Introduction to Human-Centered Production and Industry 5.0	ILO 1, 3	Lecture slides; EC Industry 5.0 White Paper; Comparative infographics (I4.0 vs I5.0); Short video: evolution of industrial paradigms; Online quiz (Mentimeter)	General Systems Theory; Factory / Process Simulation (conceptual introduction)	Critical Decision Making; Problem Solving; Communication
	1.3 Human-Centered Design	ILO 2, 3, 4	Lecture slides on HCD principles (ISO 9241-210); Case studies: HCD in automotive and food production; Design thinking workshop activity; Visual aids (process maps, empathy maps)	HMI Design; Human Simulation; CAD Modelling (introductory)	Creativity; Problem Solving; Inclusiveness & Diversity; Receiving Feedback
	1.4 Human Factors and Ergonomics in Production Systems	ILO 3, 4, 5	Lecture slides on physical and cognitive ergonomics; Ergonomics standards (ISO 9241 series, EN 614); RULA/REBA assessment tool demonstration; LEAF shopfloor walkthrough (live or virtual); Group exercise: ergonomic risk identification at a brewing workstation	Physical Ergonomics; Cognitive Ergonomics; Human Simulation	Problem Solving; Critical Decision Making; Responsibility
<b>PILLAR 1: Empowerment and Inclusivity   Module 1: Inclusive Engineering Design and Empowered Workforces</b>					
Pillar 1 Empowerment & Inclusivity	2.1 The LEONARDO Vision for Inclusive Workspaces and Empowered Operators	ILO 1, 6	Lecture slides + LEONARDO vision video; EU Disability Strategy 2021-2030 factsheet; Testimonial videos from inclusive manufacturing companies; In-class discussion: barriers to inclusion on the shopfloor	Human-Machine Interface Design	Inclusiveness & Diversity; Communication; Life-long Learning
	2.2 Inclusivity by Design: Diversity in Production Systems	ILO 6, 7	Lecture slides on Universal Design (7 principles); Case studies: inclusive workstation design in automotive and food industries; Brainstorming activity: UD principles applied to the brewing LEAF; Infographics on workforce diversity statistics	CAD Modelling; Human Simulation; Physical Ergonomics	Creativity; Inclusiveness & Diversity; Team Work & Leadership Skills; Problem Solving



# Open Educational Resources for human-centric IEM

## Curriculum mapping



Pillar	Sub-Topic	ILOs	OER Suggestions	Hard Skills Enhanced	Soft Skills Enhanced
	<b>2.3 Technologies Augmenting Physical and Cognitive Capabilities</b>	<b>ILO 7, 8</b>	Lecture slides on AAC, exoskeletons, AR/VR, cobots; Live or video demonstrations of assistive technologies; Interactive technology-ranking group activity (match technology to user need); Literature case studies on inclusive manufacturing design	Augmented Reality; Virtual Reality; Human-Robot Collaboration; Smart Systems / Sensors	Critical Decision Making; Team Work & Leadership Skills; Creativity; Receiving Feedback
	<b>2.4 Anthropometry, Biomechanics and Usability Engineering</b>	<b>ILO 4, 5, 7</b>	Lecture slides on anthropometric data and population percentiles; Digital human modelling software demonstration (e.g. JACK, DELMIA); Usability testing protocol (heuristic evaluation); LEAF workstation measurement exercise	Physical Ergonomics; Cognitive Ergonomics; Human Simulation; Digital Twins	Problem Solving; Life-Cycle Thinking; Critical Decision Making; Inclusiveness & Diversity
	<b>2.5 Lifelong Learning and Skills Development in High-Tech Production Environments</b>	<b>ILO 6, 8, 23</b>	Lecture slides on upskilling, reskilling and T-shaped competences; EU Skills Agenda factsheet; Case study: continuous learning programmes in brewing and manufacturing SMEs; Reflective journal prompt: personal skills development plan	ICT; AI (introductory awareness)	Life-long Learning; Supervisory & Organizational Skills; Responsibility; Team Work & Leadership Skills
<b>PILLAR 2: Empathetic and Social Interaction   Module 2: Social Engineering Design and Human-AI Collaboration</b>					
<b>Pillar 2 Empathetic &amp; Social Interaction</b>	<b>3.1 The LEONARDO Vision for Empathetic and Social Workplaces</b>	<b>ILO 1, 11</b>	Lecture slides + LEONARDO vision video; Reading: Industry 5.0 and the Human in Human-Centric Manufacturing (Briken et al., 2023); Discussion prompt: what does empathy look like in a factory?; In-class reflective activity	Human Simulation	Emotional Intelligence; Communication; Life-long Learning
	<b>3.2 Introduction to Social Engineering Design</b>	<b>ILO 11, 12</b>	Lecture slides on social engineering in societal and workplace contexts; Short videos on H2H and H2M dynamics; Notes and reading list (psychology of social influence); Online discussion forum activity	Human Simulation; Human-Machine Interface Design	Communication; Emotional Intelligence; Inclusiveness & Diversity; Creativity
	<b>3.3 Social Engineering Design in the Workplace</b>	<b>ILO 12, 13</b>	Case studies: HCD applied to collaborative manufacturing systems; Role-play exercise: redesigning a brewing workstation for social inclusion; Hands-on LEAF-based team session; Published frameworks (ISO 9241-210, Value-Sensitive Design)	Human-Robot Collaboration; Human-Machine Interface Design; Physical Ergonomics; Cognitive Ergonomics; Human Simulation	Supervisory & Organizational Skills; Team Work & Leadership Skills; Receiving Feedback; Giving Feedback



# Open Educational Resources for human-centric IEM

## Curriculum mapping



Pillar	Sub-Topic	ILOs	OER Suggestions	Hard Skills Enhanced	Soft Skills Enhanced
	3.4 Generative AI and Human-AI Collaboration in the Workplace	ILO 14, 15	Lecture slides on GenAI, LLMs, and copilot systems in manufacturing; LEONARDO LEAF Service 2: Using ChatGPT for dialoguing with machines (hands-on); Published case studies on human-AI teaming; Demo: AI-assisted process monitoring at the brewing LEAF	AI; Human-Machine Interface Design; Smart Systems / Sensors; Industrial Internet of Things (IoT)	Creativity; Critical Decision Making; Life-long Learning; Problem Solving
	3.5 Emotional Intelligence and Empathy-Driven AI Systems in Industry 5.0	ILO 11, 15, 16	Lecture slides on emotional intelligence (Goleman framework) in manufacturing contexts; Reading: Toward Artificial Empathy for Human-Centered Design (Zhu & Luo, 2023); Case study: affective computing and operator monitoring systems; Reflective exercise: mapping emotional states to production outcomes	AI; Human Simulation; Human-Machine Interface Design	Emotional Intelligence; Communication; Responsibility; Giving Feedback
	3.6 Explainable AI and Trust in Collaborative Workplaces	ILO 14, 16, 21	Lecture slides on XAI methods (LIME, SHAP) in production contexts; LEONARDO LEAF Service 3: AI-powered label inspection – explainable AI activity; Reading: Explainable AI in industrial applications; Group debate: when should workers override AI decisions?	AI; Safety & Cyber Security; Digital Twins; Smart Systems / Sensors	Critical Decision Making; Responsibility; Communication; Team Work & Leadership Skills
	3.7 Empathy and Social Bonding in Human-Robot Interaction	ILO 13, 15	Lecture slides on social robotics and affective HRI; Video demonstrations: cobot interaction in automotive and brewing settings; Reading: Empathy and social bonding in HRI (Matsuura, 2023); Hands-on LEAF cobot interaction activity	Human-Robot Collaboration; Robotic Simulation; Human Simulation	Emotional Intelligence; Team Work & Leadership Skills; Creativity; Receiving Feedback
	3.8 Social Sustainability and Social Leadership	ILO 11, 16, 23	Lecture slides on social sustainability frameworks and social leadership models; Case study: Stellantis / STMicroelectronics workforce transformation; Group project: social leadership action plan for a LEAF-based scenario; Reading: World Economic Forum 2024 – Workers' Insights on New Technology	Factory / Process Simulation	Supervisory & Organizational Skills; Team Work & Leadership Skills; Inclusiveness & Diversity; Life-long Learning; Communication
<b>PILLAR 3: Ethical and Responsible Technology Engineering   Module 3: Ethics, Governance and Responsible Innovation</b>					
Pillar 3 Ethical & Responsible	4.1 The LEONARDO Vision for Ethical and	ILO 1, 17	Lecture slides + LEONARDO vision video; EC Industry 5.0 report: ethical technology section; Reading: Value-oriented and ethical	Ethics	Responsibility; Communication; Life-long Learning



# Open Educational Resources for human-centric IEM

## Curriculum mapping



Pillar	Sub-Topic	ILOs	OER Suggestions	Hard Skills Enhanced	Soft Skills Enhanced
Technology Engineering	Responsible Use of Technology		technology engineering (Longo, Padovano & Umbrello, 2020); Discussion: what ethical challenges arise in smart breweries?		
	4.2 Introduction to Ethical and Responsible Technology Engineering	ILO 17, 18	Lecture slides on ethical theories (utilitarianism, deontology, virtue ethics); Documentary / TED Talk clips on technology ethics dilemmas; Introductory reading list; In-class ethical dilemma scenario cards	Ethics; Safety & Cyber Security	Critical Decision Making; Responsibility; Communication; Life-long Learning
	4.3 Ethical Implications of Human Augmentation and Enhancement of Workplaces and Technologies	ILO 17, 18, 22	Lecture slides on exoskeletons, brain-computer interfaces, AR overlays in production; Case study: ethical risks of worker augmentation in automotive assembly; Group debate: enhancement vs. intrusion of worker autonomy; Reading: Human-centric zero-defect manufacturing	Human-Robot Collaboration; Augmented Reality; Smart Systems / Sensors; Ethics	Critical Decision Making; Responsibility; Inclusiveness & Diversity; Communication
	4.4 Ethical Audits and Risk Assessments	ILO 19, 22	Lecture slides on ethical risk frameworks and audit methodology; Ethical audit checklist template (project deliverable); Risk register exercise applied to the LEAF brewing process; ACM/IEEE Code of Ethics as reference standard	Safety & Cyber Security; Factory / Process Simulation; Digital Twins	Critical Decision Making; Responsibility; Entrepreneurial Thinking; Life-Cycle Thinking
	4.5 Ethical and Human-Centered AI	ILO 20, 21	Lecture slides on EU AI Act, human-in-the-loop systems, AI fairness; LEONARDO LEAF Service 3: AI-powered quality inspection (ethics perspective); Reading: Ethical and human-centered AI in manufacturing; Case study: bias in AI-driven quality control systems	AI; Digital Twins; Safety & Cyber Security	Critical Decision Making; Responsibility; Creativity; Communication
	4.6 Ethics of Data Collection, Workplace Surveillance & Privacy in Industrial Systems	ILO 18, 20	Lecture slides on GDPR, data minimization, and worker privacy rights; Case study: sensor-based performance monitoring in breweries and implications for worker dignity; Role-play: data controller vs. worker advocate negotiation exercise; EU GDPR regulation extract	Safety & Cyber Security; Industrial Internet of Things (IoT); Smart Systems / Sensors	Responsibility; Communication; Critical Decision Making; Inclusiveness & Diversity
	4.7 Well-being and Work-Life Balance	ILO 5, 17, 24	Lecture slides on psychological and physical well-being in manufacturing (WHO framework); LEONARDO LEAF Service 1: flexible simulation-based shift planning activity; Reading: WEF 2024	Factory / Process Simulation; Cognitive Ergonomics	Emotional Intelligence; Responsibility; Life-Cycle



# Open Educational Resources for human-centric IEM

## Curriculum mapping

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Pillar	Sub-Topic	ILOs	OER Suggestions	Hard Skills Enhanced	Soft Skills Enhanced
			– Workers' Insights on New Technology; Reflective journal: personal and organizational well-being audit		Thinking; Supervisory & Organizational Skills
	4.8 Ethical Governance and Technology Regulation, Fairness and Accountability in Technology Development	ILO 18, 19, 21	Lecture slides on regulatory frameworks (EU AI Act, Digital Services Act, ISO 26000); Case study: corporate accountability in AI deployment in manufacturing; Reading: Ethical Governance and Technology Regulation (WP3 reference); Group analysis: evaluating fairness and accountability in a real AI product recall	Safety & Cyber Security; AI; Digital Twins	Critical Decision Making; Responsibility; Entrepreneurial Thinking; Communication
	4.9 Ethical Design: Value Sensitive Design and Tarot Cards	ILO 20, 22, 25	Lecture slides on Value Sensitive Design (VSD) methodology and Privacy by Design; Tarot Cards of Technology design tool (hands-on workshop activity); Published VSD case studies in manufacturing and smart systems; LEAF design challenge: apply VSD to a sensor deployment scenario	Digital Twins; Smart Systems / Sensors; AI; Ethics	Creativity; Life-Cycle Thinking; Responsibility; Entrepreneurial Thinking; Critical Decision Making



# Open Educational Resources for human-centric IEM

## 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

# Open Educational Resources for human-centric IEM

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



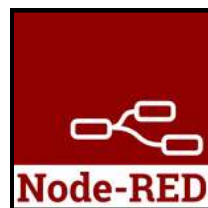
# Open Educational Resources for human-centric IEM

## 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 >](https://github.com/usslaboratory/leonardo)

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

# 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?

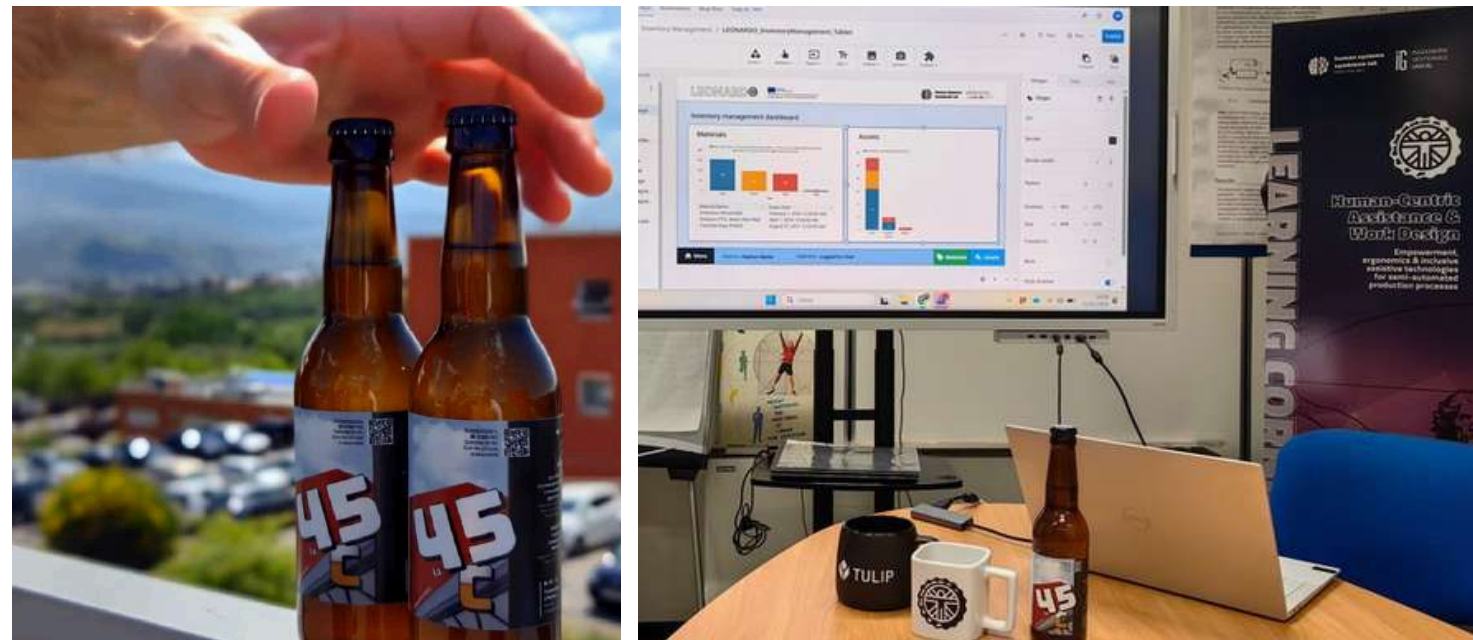
# Open Educational Resources for human-centric IEM

LEAF-based educational strategies



## 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.



LEARNING CORNER 1

Adaptive Operations Planning & Warehouse Management

Towards human-technology collaboration under uncertainty for resilient and efficient warehouse and order management

LEONARD

LEARNING CORNER 2

Smart Interaction & Process Automation

Enabling intuitive and responsible control, monitoring, and adjustment of automated brewing processes through innovative human-machine interaction

LEONARD

LEARNING CORNER 3

Human-Centric Assistance & Work Design

Empowerment, ergonomics & inclusive assistive technologies for semi-automated production processes

LEONARD

LEARNING CORNER 4

Augmented Governance & Collective Intelligence

Exploring human-AI collaboration for responsible operations and supply chain management

LEONARD

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

# Open Educational Resources for human-centric IEM

LEAF-based educational strategies






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## 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

 <p><b>TECHNOLOGY TO SUPPORT LEARNING BY DOING</b> <b>Am I doing right?</b></p>	 <p><b>TECHNOLOGY TO SUPPORT (NON-)REPETITIVE TASKS</b> <b>Is the same beer?</b></p>	 <p><b>TECHNOLOGY TO AVOID DISTRACTIONS</b> <b>Did I?</b></p>	 <p><b>TECHNOLOGY TO SUPPORT AWARENESS AND RESPONSIBILITY</b> <b>How much is enough?</b></p>	 <p><b>TECHNOLOGY TO SUPPORT CONTINUOUS IMPROVEMENT</b> <b>Did I ruin everything?</b></p>
<p><b>LESSON</b> M1 - Empowerment and Inclusivity L1.3 - Technologies augmenting physical and cognitive capabilities</p>	<p><b>LESSON</b> M2 - Empathetic and Social Interaction L2.4 - Generative AI and Human-AI Collaboration in the Workplace</p>	<p><b>LESSON</b> M0 - Human Centred Production L0.4 - Human Factors and Ergonomics in Production Systems</p>	<p><b>LESSON</b> M3 - Ethical and Responsible Engineering L3.4 - Ethical Audits and Risk Assessments</p>	<p><b>LESSON</b> M1 - Empowerment and Inclusivity L1.5 - Lifelong Learning &amp; Skills Development in High-Tech Production Environments</p>
<p><b>ACTIVITY</b> <a href="#">Watch the video &gt;</a></p>	<p><b>ACTIVITY</b> <a href="#">Watch the video &gt;</a></p>	<p><b>ACTIVITY</b> <a href="#">Watch the video &gt;</a></p>	<p><b>ACTIVITY</b> <a href="#">Watch the video &gt;</a></p>	<p><b>ACTIVITY</b> <a href="#">Watch the video &gt;</a></p>
<p><b>QUIZ AND ASSESSMENT</b> <a href="#">Link to the quiz &gt;</a></p>	<p><b>QUIZ AND ASSESSMENT</b> <a href="#">Link to the quiz &gt;</a></p>	<p><b>QUIZ AND ASSESSMENT</b> <a href="#">Link to the quiz &gt;</a></p>	<p><b>QUIZ AND ASSESSMENT</b> <a href="#">Link to the quiz &gt;</a></p>	<p><b>QUIZ AND ASSESSMENT</b> <a href="#">Link to the quiz &gt;</a></p>



# Open Educational Resources for human-centric IEM

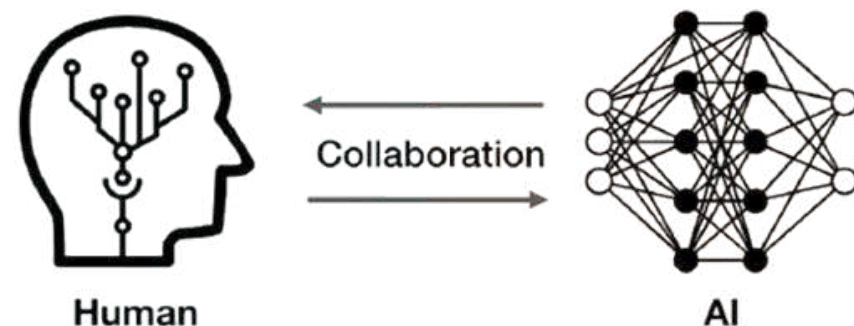
LEAF-based educational strategies



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



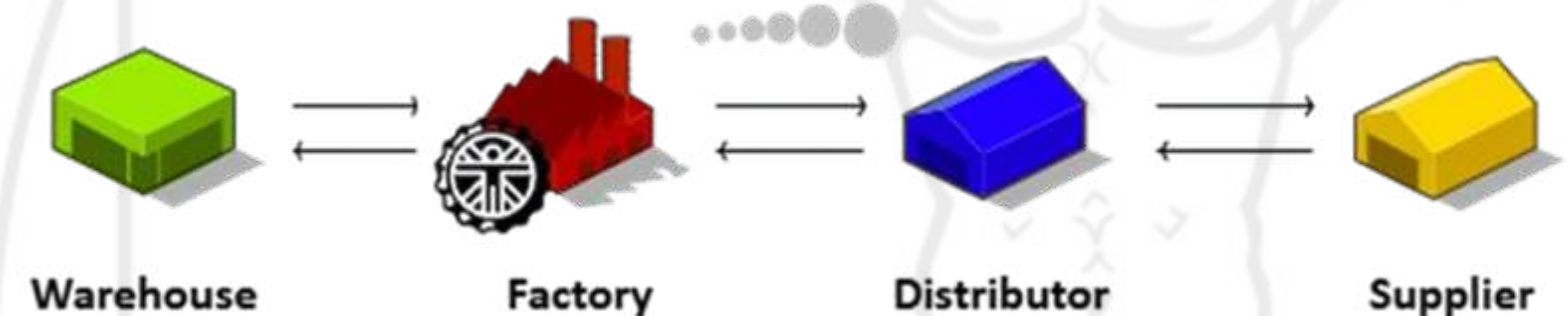
- **Shared Decision-Making:** *If AI is smarter, shouldn't it just decide for us?*
- **Transparency and Explainability:** *Are you using the AI because you understand it, or because it gives you a quick answer (blind trust)?*
- **Shared accountability and traceability:** *How can a decision be ethical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



# LEONARDO

## 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?

# Open Educational Resources for human-centric IEM

## 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.



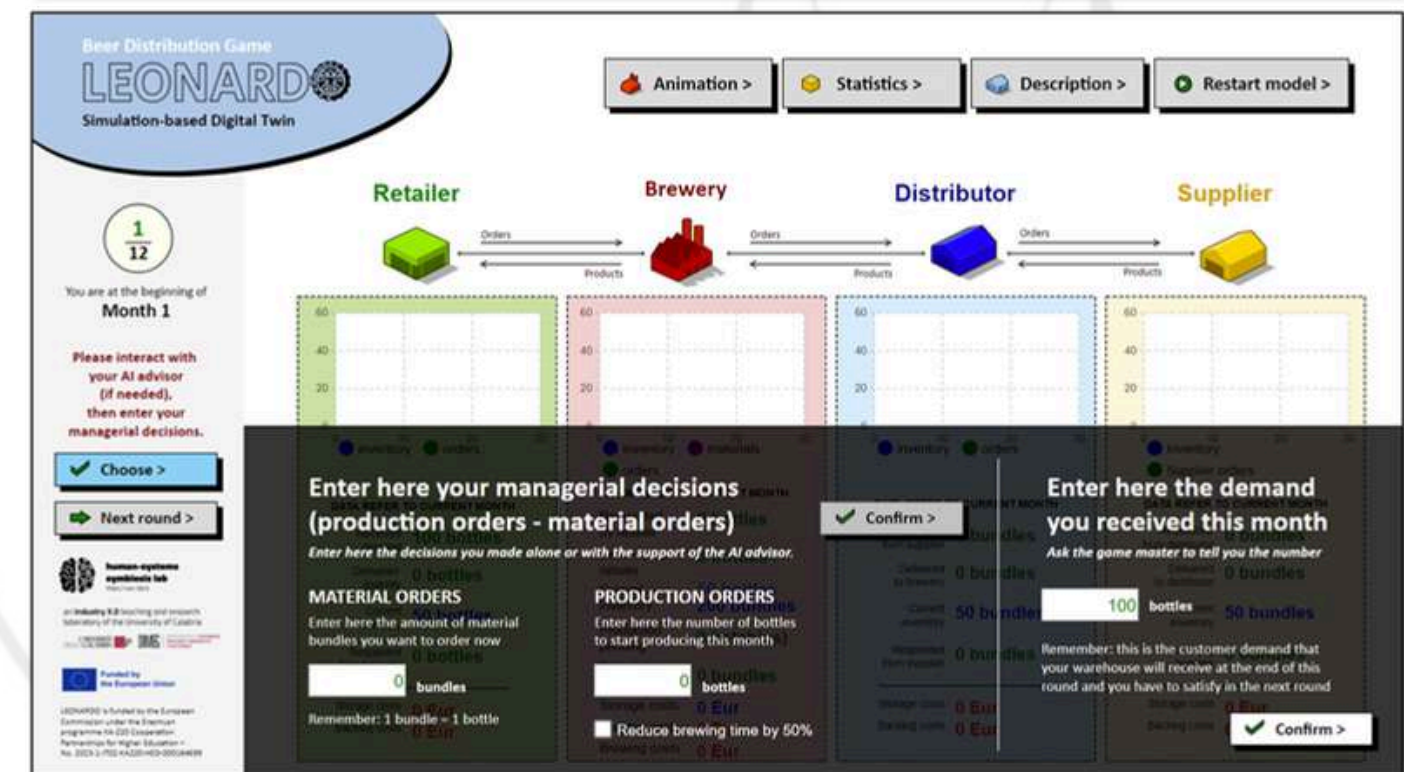
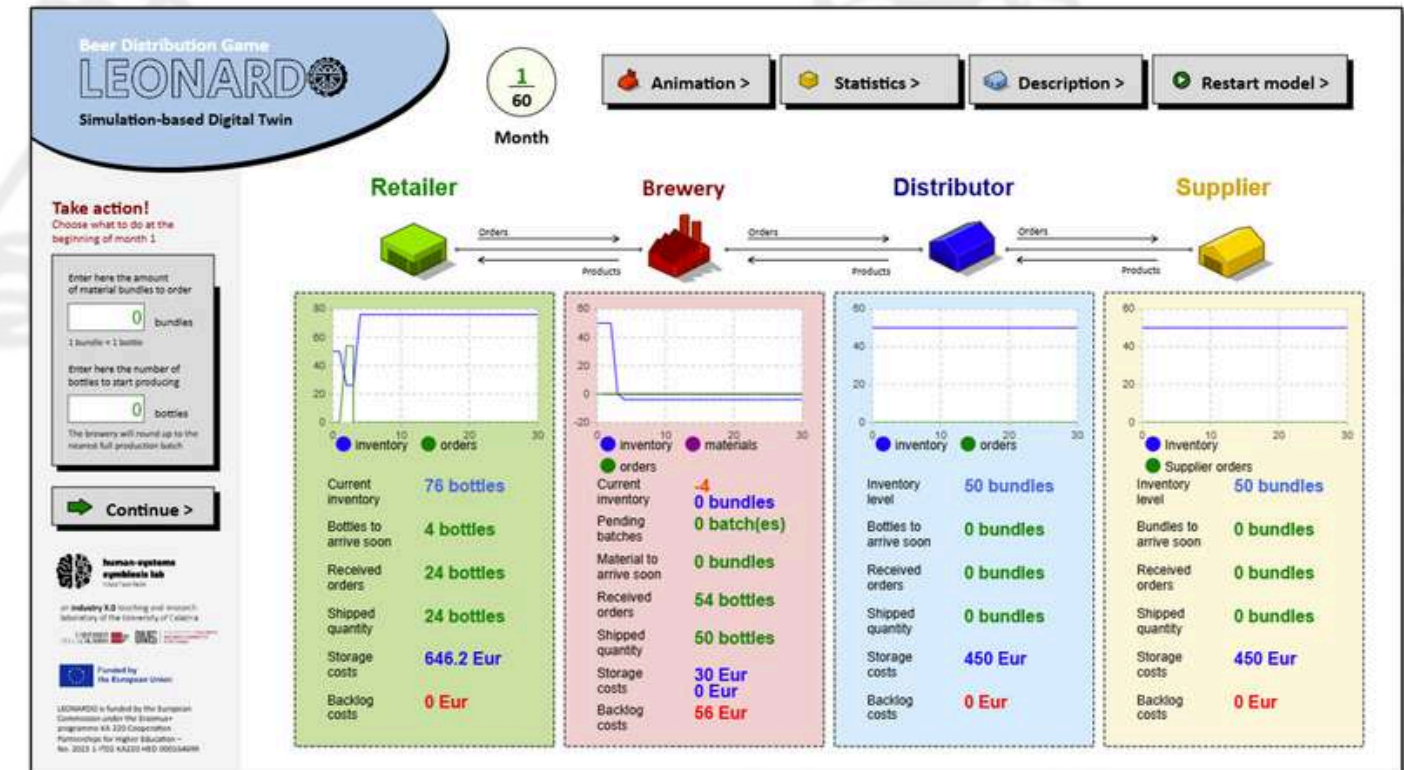
**Ethical AI advisor**

**Unethical AI advisor**



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

# LEONARD

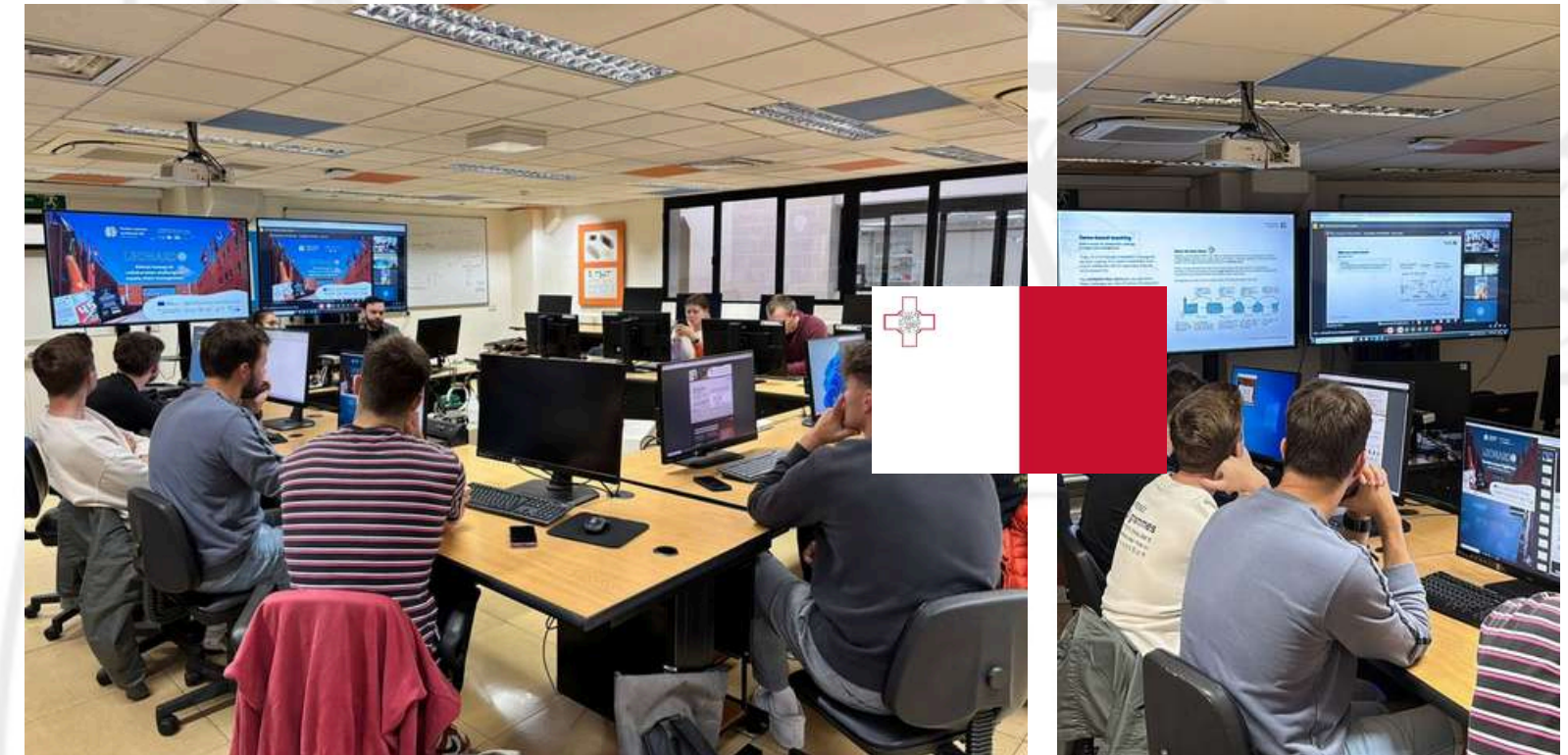
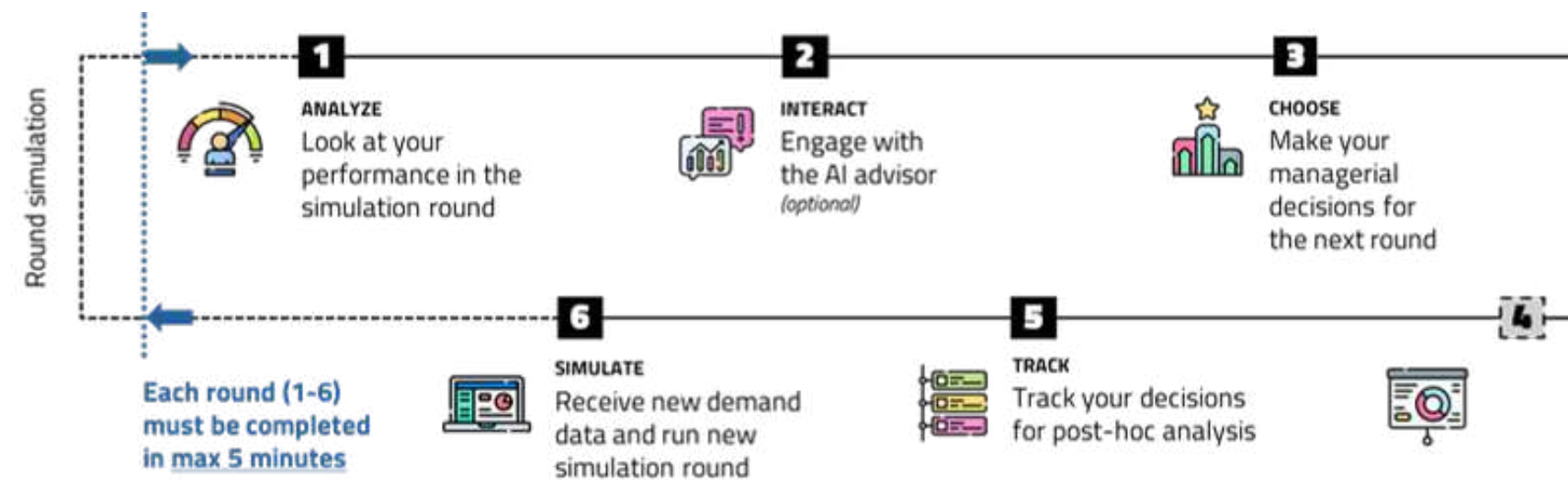


# Open Educational Resources for human-centric IEM

LEAF-based educational strategies



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



Planning the **2<sup>nd</sup> edition** of the international competition for **December 2026**:

**want to join?**



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



# Open Educational Resources for human-centric IEM

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/>

UNIVERSITÀ DELLA CALABRIA | DIPARTIMENTO DI INGEGNERIA MECCANICA, ENERGETICA E GESTIONALE | DIMEG | human systems symbiosis lab  
Confartigianato Imprese Calabria | e con il patrocinio della REGIONE CALABRIA  
30 Gennaio 2026  
**HUMANMADE+**  
Reimmaginare l'artigianato nell'era della simbiosi tra **innovazione e tradizione**  
Villa Rendano, Cosenza  
Vieni a scoprire come tecnologie, sapere e visioni stanno trasformando i mestieri: il futuro dell'artigianato inizia qui.  
SCOPRI IL PROGRAMMA e REGISTRATI SU <https://www.uss-lab.it/humanmadeplus/>  
INGRESSO GRATUITO | POSTI LIMITATI



# Open Educational Resources for human-centric IEM

## The edu-force 5.0

The Eduforce 5.0 is a transnational community of professors, lecturers, researchers, and trainers at Higher Education Institutions who are equipped — technically, pedagogically, and professionally — to teach human-centric industrial engineering and management (H-IEM) in the context of Industry 5.0.

Members of the Eduforce 5.0 share a common knowledge base covering both the technical domains of Industry 5.0 (AI, digital twins, HRC, ergonomics, IoT, ethics) and the pedagogical approaches that make that knowledge accessible, engaging, and practically relevant to the next generation of IEM students.

The Eduforce 5.0 is a community of practice — one that LEONARDO aims to seed through this skills characterisation, the Teacher's Handbook (T4.5), and the Train the Trainers programme (T4.6), and that is intended to grow, self-sustain, and evolve beyond the lifetime of the project.



Soft Skill	Priority Level	Strategic Rationale for Future Importance
Adaptability and Curriculum Agility	★★★★★ Highest	Industry 5.0 technologies are evolving faster than curriculum review cycles. Educators who cannot adapt their content in real time will systematically under-prepare their students.
Critical Thinking and Analytical Reasoning	★★★★★ Highest	As AI and automation take over routine technical tasks, the premium placed on human reasoning, judgment, and interpretive intelligence grows. Educators must develop this capacity explicitly.
Ethical Judgment and Responsible Practice	★★★★★ Highest	Emerging regulatory frameworks (EU AI Act, GDPR, digital product passports) are making ethics a professional obligation for engineers. Educators who cannot teach applied ethics will produce graduates unfit for compliance requirements.
Technological Fluency and Continued Upskilling	★★★★★ Highest	Educators who lose contact with the technological frontier cannot teach it authentically. Continuous upskilling is a professional obligation in the Eduforce 5.0 community.
Innovative and Experiential Teaching Methods	★★★★☆ Very High	The passive lecture format is insufficient for developing the human-centric, sociotechnical competences demanded by Industry 5.0. Active, LEAF-based, experiential methods are the primary pedagogical vehicle for Eduforce 5.0.
Interdisciplinary Communication	★★★★☆ Very High	Future factories are multi-disciplinary environments. Educators who can model and reward cross-disciplinary thinking produce graduates who can navigate them.
Collaboration and Community of Practice	★★★★☆ Very High	The Eduforce 5.0 is defined as a community. Its collective intelligence and shared resource base multiplies the effectiveness of each individual educator beyond what any individual can achieve in isolation.
Commitment to Lifelong Learning	★★★★☆ High	Modelling lifelong learning is both a pedagogical strategy and a professional norm. Students who observe educators who continue to learn are more likely to adopt the same posture.
Empathy and Human-Centered Pedagogy	★★★★☆ High	As H-IEM expands to include well-being, inclusivity, and psychological safety as engineering concerns, educators who practice these values in their teaching are the most credible carriers of the message.



# Open Educational Resources for human-centric IEM

Stay in touch and use the resources

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Visit [www.uss-lab.it/projects/leonardo/](http://www.uss-lab.it/projects/leonardo/) for more information

THE ARCHITECTS OF FUTURE TALENTS

**open resources for *educators and trainers***

It is no longer enough to teach technical proficiency; we must foster critical thinking, ethical reasoning, and adaptability. Our resources are designed to help teachers guide students through the intersection of advanced technology and human values.

### Teacher's Handbook

The LEONARDO Teacher's Handbook is the capstone educator resource, consolidating all project results, best practices, and teaching recommendations into a single comprehensive guide for professors, lecturers, trainers, and instructors wishing to teach human-centric IEM in the context of Industry 5.0.

[Download now →](#)

### Classroom Resource Kit

The LEONARDO classroom resource kit provides IEM professors and instructors with a practical, ready-to-use collection of teaching materials for human-centric IEM courses. It comprises lecture slides covering Industry 5.0 and H-IEM concepts, LEAF-based business cases illustrating human-centric factory scenarios, a use manual for LEAF educational services, and group and team project examples.

[Download now →](#)

**watch the *webinar***



# LEONARDO



**ERASMUS+ KA220 LEONARDO**

## Contacts



Visit [www.uss-lab.it/projects/leonardo/](http://www.uss-lab.it/projects/leonardo/) for more information



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