LEARNING FACTORIES for VET

FRAMEWORK FOR INTERDISCIPLINARY TRAINING IN LEARNING FACTORIES

WP2 Pedagogic of the Learning Factories

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1. GLOSSARY AND/OR ACRONYMS

AR Augmented Reality
AGV - Automated Guided Vehicles
AR - Augmented Reality
ARI - Automation and Industrial Robotics
BI - Business Intelligence
CBL - Challenged-Based Learning
CLF - Collaborative Learning Factory
CNC - Computer Numerical Control
CoVE – Centres of Vocational Excellence
ERP - Enterprise resource planning
ESCO European Skills, Competences, Qualifications and Occupations
ENSAM - Ecole Nationale Superieure D'arts Et Metiers
EQF – European Qualification fFamework
FHJ – FH Joanneum
HC-R-S - Human-centred, Resilience, and Sustainable
HVET High Vocational Education and Training
I4.0 - Industry 4.0
I5.0- Industry 5.0
IALF - International Association of Learning Factories
IoT - Internet of Things
IT - Information Technologies
LF - Learning Factory
MA CIFP Miguel Altuna LHII
SAT - Self Assessment Tool
SOP Standard Operating Procedures
SWOT – Strengths, Weaknesses, Opportunities, and Threats
TFCC – Teaching Factory Competence Center
VET - Vocational Education and Training
VR - Virtual Reality
WP - Work Package
WS - Workstation

CONTENT TABLE

EXECUTIVE SUMMARY

This report presents a structured and comparable way to describe Learning Factories by applying the *Framework for Interdisciplinary Training in Learning Factories*. The framework brings together two complementary dimensions: the **regional context**, which explains the industrial, economic and educational environment of each centre, and the **technical and pedagogical elements**, which define how Learning Factories are designed and operated.

Using this common structure, the report documents four Learning Factories participating in LF4VET: FH JOANNEUM's Smart Production Lab (Austria), CIFP Miguel Altuna's *Ikas Fabrika* (Basque Country), ENSAM's Evolutive Learning Factory (France), and the Teaching Factory Competence Centre (Greece). Each monography highlights the specific socio-economic context, institutional characteristics, training programmes, and workplace-relevant learning environments of the respective centre.

Together, these analyses show how diverse institutions across Europe are advancing hands-on, interdisciplinary, and industry-aligned training to address skills shortages and support digital, sustainable and human-centric industrial transitions. The framework offers a scalable tool for benchmarking, strategic development and collaboration within the growing Learning Factory ecosystem.

1. INTRODUCTION

The LF4VET frameworks is a generic, simple, adaptable framework that any VET centre or University of Applied Sciences in Europe can use to describe and benchmark their Learning Factory (LF) in a consistent way. Designed to be used across Europe, the framework brings together two essential dimensions: the **regional context**, which explains the industrial, economic and educational environment in which each centre operates, and the **learning actory elements**, which outline the technical infrastructure, pedagogical approach and training programmes that shape handson, futureready learning.

Section 2 of this report presents the structure of the framework, summarising what readers will find when exploring any Learning Factory description developed using this model.

Sections 3 to 6 provide detailed descriptions of four Learning Factories: CIFP Miguel Altuna's Ikas Fabrika (Basque Country), FH Joanneum's Smart Production Lab (Austria), École Nationale Supérieure des Arts et Métiers' (ENSAM) Evolutive Learning Factory (France), and the Teaching Factory Competence Centre's Teaching Factory (Greece).

2. FRAMEWORK FOR INTERDISCIPLINARY TRAINING IN LEARNING FACTORIES

The following tables outline a structured framework designed to guide the development of interdisciplinary training within Learning Factories. Block 1 focuses on understanding the regional context to ensure that the Learning Factory responds to real socio-economic needs, labour-market demands, and VET system dynamics. Block 2 details the essential technical and pedagogical elements required to design, implement, and operate an effective and future-ready Learning Factory ecosystem.

Table 1: Block 1 – Regional Context Elements

Section	Description / What the Centre Should Provide
1.1 Socio-Economic & Industrial Profile	Key sectors, transitions, and industrial strategies.
1.2 Labour Market Signals & Skills Gaps	Shortages, qualification levels, skills mismatches.
1.3 VET System Features & Partnerships	Collaboration models and excellence networks.
1.4 Rationale for Implementing a Learning Factory	Why an LF is needed in the region.

Table 2: Block 2 – Learning Factory Elements

Section	Description / What the Centre Should Provide
2.1 Technical aspects	
2.1.1 LF field and Value-Chain Coverage	Describe stages represented in the LF value chain.
2.1.2 Enabling Technologies	List I4.0/5.0 technologies included.
2.1.3 Data Architecture & Governance	Describe data capture, dashboards, cybersecurity.
2.1.4 Industry 5.0 Design Features	Explain human-centricity, sustainability, resilience elements.
2.2 Pedagogical aspects	
2.2.1 Program integration	Curricular coverage across EQF levels
2.2.2 Learning Model	Describe challenge-based and interdisciplinary methods.
2.2.3 Competences & Assessment	List technical, digital, transversal competences.
2.2.3 Program Integration	Specify EQF levels and programmes using the LF.
2.2.4 Teacher Collaboration & Capability	Describe teacher roles and LF governance.
2.2.5 External Stakeholders & Ecosystem	List companies, clusters, networks.

2.1. BLOCK 1 – REGIONAL CONTEXT ELEMENTS

Why a Learning Factory is needed and how it must be shaped by the context.

2.1.1. SOCIO-ECONOMIC AND INDUSTRIAL PROFILE

Purpose: Position the learning factory within the local industrial fabric and transformation agenda.

Provide:

- Key sectors served by your centre (e.g., metal, automotive, machining, mechatronics). Note dominant transitions (digital, green) influencing firms.
- Any regional smart specialisation / industrial strategies relevant to advanced manufacturing (e.g., RIS3 Smart Industry; national I4.0 programmes).

2.1.2.LABOUR MARKET SIGNALS AND SKILLS GAPS

Describe shortages, qualification levels, and skills mismatches.

Purpose: Show demand pressure and skills mismatches your LF addresses.

Provide:

- Shortage occupations and qualification levels in demand (EQF 4–6 technicians/engineers; mechatronics, automation, robotics, CNC, maintenance).
- Evidence of skills mismatch (firms struggling to hire tech/digital profiles; replacement demand due to ageing)

2.1.3.VET SYSTEM FEATURES AND PARTNERSHIPS

Purpose: Explain how your LF fits VET governance and collaboration models.

Provide:

- Modes of industry collaboration (dual training, applied projects, internships, competence centres).
- Participation in excellence and LF networks (e.g., CoVE, LCAMP/IALF/SCLF) and how they influence the LF design.

2.1.4.RATIONALE FOR AN INDUSTRY 5.0 LF

Purpose: Connect context to your LF's mission. Summarize why an LF is needed in the region.

Provide:

- The main topic of the LF and why a holistic value-chain learning environment is required (real processes, authentic challenges).
- How the LF will **reduce skills gaps** and support regional industrial transitions.

2.2. BLOCK 2 – LEARNING FACTORY ELEMENTS

2.2.1. TECHNICAL ASPECTS

- LF main field such manufacturing, energy, aerospace, etc. Value-Chain Coverage. Describe stages represented in the LF value chain.
- Enabling Technologies. List I4.0 technologies included.
- Data Architecture and Governance. Describe data capture, dashboards, cybersecurity.
- Industry 5.0 Design Features. Explain human-centricity, sustainability, and resilience elements.

2.2.2. PEDAGOGICAL ASPECTS

PROGRAM INTEGRATION

Purpose: Show curricular coverage across EQF levels.

Provide:

- EQF 4: e.g., Machining Technician; Electrical & Automatic Installations.
- EQF 5: e.g., Industrial Mechatronics; Automation & Robotics; Production Management; Specialisations (Smart Manufacturing; AI & Big Data; process-specific).
- EQF 6: e.g., Industrial Management (FT/PT), Smart Production & Services.
- Lifelong learning / Upskilling-Reskilling: company training, applied innovation, short courses.

LEARNING MODEL

Purpose: Clarify how learners acquire competences in the LF. Describe challenge-based and interdisciplinary methods.

Provide:

- Challenge-based, interdisciplinary teams mapped to value-chain roles (manufacturing, maintenance, quality, logistics, design).
- Balance between hands-on practice and data-driven decision-making (dashboards, KPIs, problem-solving).
- How human-centricity, sustainability, resilience are made explicit in tasks and reflection.

COMPETENCES & ASSESSMENT

Purpose: Make outcomes explicit and assessable.

Provide:

- Competences: Technical (automation, robotics, CNC, additive, metrology), digital/data (MES/ERP, dashboards, analytics), and transversal (communication, teamwork, decision-making)
- Assessment approach (e.g., competence-based/ETHAZI, project rubrics, dual-learning evidence).

TEACHER COLLABORATION AND CAPABILITY

Purpose: Ensure delivery capacity at scale.

Provide:

- Interdepartmental teaching teams; teacher training in I4.0/5.0 tech and LF pedagogy; time/role allocation (LF coordinator, technical lead, industry liaison).

EXTERNAL STAKEHOLDERS AND ECOSYSTEM

Purpose: Keep the LF aligned with real industrial needs. List companies, networks, and partnerships.

Provide:

- Companies (dual training, projects), competence centres (e.g., TFCC), VET excellence networks (CoVEs, LCAMP, SCLF, IALF), and how they contribute to curriculum and equipment roadmaps.

3. MONOGRAPHY FH JOANNEUM (AUSTRIA)

This section provides an in-depth monography of FH JOANNEUM and its Smart Production Lab, situating the Learning Factory within the regional, economic and educational landscape of Styria and Austria. It outlines the key industrial characteristics, labour-market dynamics, institutional profile, and study programmes that shape the role and evolution of this Learning Factory. Together, these elements demonstrate how FH JOANNEUM aligns its pedagogical and technological strategy with regional industrial needs.

3.1. GEOGRAPHY, REGIONS AND SOCIO-ECONOMIC PROFILE

Austria covers about 84,000 km² and is dominated by the Alps in the west and south, with more lowlands and basins in the east and northeast where most people and industries are located. Austria is a highly industrialized, export oriented economy in Central Europe whose geography, regional structure and labour market shape a specific context for industrial work and for graduates in industrial management and related fields. Industry remains central for value creation and exports. (Advantage Austria, 2024)

Regionally, industrial specialization is marked: Upper Austria is a core industrial region with iron and steel, chemicals and mechanical engineering and plays a central role in exports. Styria is strong in automotive, steel and advanced manufacturing along the Mur–Mürz axis, supported by dense supplier networks. Vorarlberg has niches in textiles, clothing and precision manufacturing, while Tyrol and Carinthia emphasize wood, pulp, glass and related sectors; Vienna is more service-dominated but hosts many headquarters and R&D units of industrial groups. (Advantage Austria, 2024)

Socio-economically, Austria is a high-income country where industry and related services underpin employment and exports, but structural and cyclical pressures (energy prices, international competition, decarbonisation) are forcing firms to upgrade technology and skills. (Weichselbaumer, 2025; Austrian National Bank, 2025)

Recent data show a cyclical downturn with falling manufacturing employment and turnover, while demand for highly qualified technical and management profiles remains structurally strong and appears explicitly on shortage-occupation lists. (Weichselbaumer, 2025) Thus, structural change at firm and sector level takes place mainly from production to service orientation (Weichselbaumer, 2025):

- Employment has gradually shifted from goods production toward services and public services; a 2025 structural change report notes employment losses in industry and construction, while public services expanded.
- Many manufacturing firms increase their service content (maintenance, engineering, digital services), becoming “hybrid producers” that invest more in intangible assets and higher skilled labour but often employ fewer traditional production workers.

Austria’s industrial base is also characterized by high automation: in automotive manufacturing, Austria ranks among the countries with the highest robot density worldwide, with about 1,412 robots per 10,000 factory workers in this segment, well above global averages. This high robot density supports productivity but shifts the skill mix toward engineering, automation and management of complex systems. (FH Wien der WKW, 2025)

Labour structure and quantitative labour-market indicators

The Austrian labour market has been relatively resilient overall, but manufacturing has experienced a notable contraction. According to Statistik Austria, in 2024 total employment was almost unchanged compared with 2023, yet the number of employees in manufacturing fell by 38,400 persons, with “production of goods” alone losing 33,400 employees. (Statistik Austria, 2025a; Austrian National Bank, 2025)

Despite the downturn, there is still substantial recruitment activity. On average in 2024, around 40,600 job vacancies were recorded in the manufacturing sector, while trade and services accounted for about 100,000 vacancies, corresponding to 57.5% of all advertised vacancies. (Statistik Austria, 2025b)

From a structural perspective, industrial labour in Austria is characterized by (FH Wien der WKW, 2025):

- A strong dual vocational education system: many workers are skilled bluecollar employees with apprenticeships in metal, mechatronics, electrical and process professions, complemented by high school- and university-trained technicians and engineers.
- Growing weight of higher qualified functions in planning, R&D, quality, supply chain, IT/OT integration and industrial engineering, as automation, digitalization and internationalization proceed.
- An internal differentiation between classic shopfloor jobs and knowledge intensive roles at the interface of technology, data and management. This leads to a combination of employment decline in manufacturing and persistent vacancies in high skill positions.

3.2. DEMAND FOR INDUSTRIAL MANAGEMENT GRADUATES AND SHORTAGE OCCUPATIONS

Interdisciplinary industrial engineering and industrial management programmes in Austria are described as having good career prospects, because graduates combine technical understanding with business, legal and international skills. Official shortage occupation lists confirm sustained demand for such profiles: Nationwide shortage occupation lists for 2026 include 64 occupations, up from 58 in 2025, with a strong presence of engineering and hightech roles. (Austrian Federal Government, 2025)

Because industrial production becomes more automated and data driven, industrial engineers and industrial management graduates who combine engineering knowledge with management, digital and green transition skills are in a favourable position despite stagnating or falling aggregate manufacturing employment. The coexistence of 38,400 lost manufacturing jobs in 2024 and 40,600 vacancies in manufacturing underlines the importance of skill level and profile: low skilled roles are being reduced, while firms struggle to recruit highly qualified staff. (Edstellar, 2025)

In this context, the skills expected from industrial management graduates in Austria can be grouped as follows (Edstellar, 2025; FH Wien der WKW, 2025; Klausner, 2025):

- Technical--economic skills
  - Solid grounding in industrial or mechanical engineering combined with business administration, finance and management, as reflected in Austrian master programmes in industrial engineering and business.
  - Knowledge of production systems, supply chains, quality management and industrial cost structures, including the ability to work in international, export-oriented settings.
- Digital and data competences
  - Familiarity with automation, robotics and AI in production, including understanding of how machine learning and data analytics support quality, planning and maintenance.
  - Data literacy (KPIs, dashboards, basic analytics) and awareness of cloud and digital platforms used in industrial environments.
- Green and regulatory competences
  - Knowledge of environmental management, energy efficiency and climate policy, as green technologies and environmental goods and services already contribute about twice as much to Austria's GDP and employment as in the EU-27 on average.
  - Ability to align operations with sustainability targets, ESG requirements and relevant EU and national regulations (e.g. energy, environment, AI related frameworks).
- Management and social skills
  - Leadership, team coordination and change management abilities to steer automation, restructuring and cross functional projects, including agile project management methods.
  - Strong communication across hierarchical levels and disciplines, negotiation skills and intercultural competence for work in export-oriented firms and international value chains.

3.3. ORGANISATION CONTEXT

FH JOANNEUM is one of Austria's largest universities of applied sciences, with a strong engineering and management focus and an over 30 years longstanding profile in industrial management at its Kapfenberg campus. The Institute of Industrial Management and the Smart Production Lab in Kapfenberg together form a regional hub for Industry 4.0 and Industry 5.0 teaching, applied research and cooperation with industrial networks, especially for Styrian manufacturing SMEs.

3.3.1. FH JOANNEUM: BRIEF PROFILE AND HISTORY

FH JOANNEUM University of Applied Sciences was founded in 1995 and has since grown into one of the largest UAS institutions in Austria, with around 5,000 students and approximately 750 employees across four Styrian campuses. The operating company FH JOANNEUM Gesellschaft mbH is majority owned by the Styrian government, and the university positions itself as a practice oriented, research active institution that "helps to shape the future" through applied projects and close cooperation with business and public partners.

The university offers a broad portfolio of bachelor's and master's programmes (full time, part time, dual) as well as certified vocational courses in the areas engineering, management, health, media and design, IT and social and ecologic studies.

3.3.2.INSTITUTE INDUSTRIAL MANAGEMENT (KAPFENBERG)

The Institute Industrial Management at FH JOANNEUM in Kapfenberg is one of the university's oldest institutes and has been training industrial engineers (Wirtschaftsingenieur:innen) since 1995, combining business, engineering and IT/digitalization in an interdisciplinary curriculum. The institute emphasizes practice oriented learning, extensive knowhow and the use of modern technologies, offering high-quality teaching, top equipped laboratories and a "familial" atmosphere according to graduate testimonials.

Teaching activities include bachelor's and master's programmes in Industrial Management full time and part time, with content such as operations management, tools for data analytics, leadership, or process technology. Within the bachelor's programme, students can choose a deep dive in sustainability, digitalisation or international affairs. On master's level there are three majors: Business Transformation, Supply Chain Engineering and Smart Production & Services. Students work on "Industrial Research Projects", where they lead project teams and solve real tasks for national or international companies, thereby strengthening links to industrial partners and networks.

In research and transfer, the institute focuses on digitalization, Industry 4.0 and smart production, closely linked to its Smart Production Lab and regional, national (f. e. Platform Industry 4.0) and international (f. e. prime network) networks. As a longstanding industrial engineering faculty in Styria, it cooperates with manufacturing firms and technology providers in five main research areas: future of work, supply chain management, digital technologies, ERP & MES and Management & Controlling.

3.4. SMART PRODUCTION LAB KAPFENBERG: ROLE AND VISION

The Smart Production Lab in Kapfenberg is a 600 m² teaching and research factory dedicated to digitalization and Industry 4.0, conceived and implemented by the Institute Industrial Management. Its aim is to accelerate digital transformation processes in production, particularly supporting medium sized companies, by providing a realistic but controllable environment in which new manufacturing technologies and networking concepts can be tested and demonstrated. Lately the lab was further developed to an Industry 5.0 lab focussing on sustainable, human centric and resilient aspects of production.

The lab is designed as a "Learning Factory" in which tomorrow's specialists qualify for the requirements of digitalization using hands-on use cases. It acts as a regional demonstration and transfer centre for "smart production", i.e. the networking of machines, humans and services across the entire production chain, and explicitly positions FH JOANNEUM Kapfenberg as an expert hub for digital production in Styria.

Equipment and research fields in the Smart Production Lab

Within its 600 m², the Smart Production Lab houses a range of high-tech equipment representing a modern, networked factory environment, including industrial controllers, IIoT infrastructure, sensor technology, collaborative robots, immersive data glasses, AGVs, exoskeletons and digital shop-floor systems. The lab's research field "Digital Shopfloor" concentrates on networking machines and systems, optimization of vertical IT integration along the automation pyramid and the use of industrial IoT scenarios and AI methods for predictive and prescriptive applications in an industrial context.

These use cases are used both in teaching (e.g. student projects, labs in Smart Production & Services or Operations Management modules) and in cooperation projects with industrial partners, which can test and prototype digitalization steps before rolling them out in their own plants.

Industrial networks, teaching–research integration and regional role

The combination of the Institute Industrial Management and the Smart Production Lab positions FH JOANNEUM Kapfenberg as a key node in industrial and regional networks in Upper Styria, serving as a bridge between research, teaching and company practice. Through industrial research projects, theses, applied research in fields like digital shopfloor management and smart production, and lab based demonstrators, the institute contributes to the digital transformation and competitiveness of the regional manufacturing base.

For students, this integration offers a practice oriented- education in industrial management that combines classic industrial engineering- content with concrete Industry 4.0 technologies and Industry 5.0 use cases, preparing graduates for roles in production and operations management, smart factory projects, -supply chain- engineering and industrial consulting.

3.5. STUDY PROGRAMS SAMPLE)

The aim of the project is to analyse and improve mainly the part time bachelor's degree in industrial management (EQF 6). In our understanding, part time means that the students are both, students and workers in industry. Thus they directly link the gained knowledge to their daily business and also bring in practical examples, and issues from their firms.

The part-time Bachelor's programme in Industrial Management at FH JOANNEUM is a 6 semesters program with, 180 ECTS that targets working professionals and balances business management (50%), engineering/technology (25%) and IT/digitalization (25%), with a strong emphasis on practical application, soft skills and interdisciplinary projects. Classes are scheduled on Friday afternoons, Saturdays and occasional block weeks or online evenings to fit professional schedules, allowing immediate transfer of learned content to the workplace.

In addition, at FHJ we provide knowledge transfer to other EQF levels in a non systematic way. We provide workshops and trainings for companies within our lab – combining theoretical background with practical exercises. Also we provide workshops for schools to get more involved with industry, research and digital technologies. There are also some regional events organized such as “lange nacht der Forschung” to get together public and science. Furthermore, we have a FABlab installed in our lab which means, that every second week public can come to the lab, use the machinery and work with that under support of researchers.

Core skills acquired

Graduates develop a versatile industrial engineering profile with the following key competences:

- Management and economic skills: Strategic and operational management, accounting (financial and management/controlling), corporate governance, production and process management, logistics/supply chain (including procurement, transport, inventory), marketing, project management.

- Technical and engineering skills: Production engineering (machine elements, energy systems), automation (fundamentals and advanced), electrical engineering, materials science/technology.
- IT and digital skills: ERP systems, applied IT (AI, basics/advanced, business solutions, programming/physical computing), business intelligence, digitalization in production (e.g., IoT retrofits, process optimization).
- Soft and intercultural skills: Communication, team training, cross-cultural communication, scientific working methods, business English (four levels), leadership/personal development.

3.5.1. LEARNING CONTENT BY FOCUS AREA

The curriculum is structured across 6 semesters (30 ECTS each), with integrated courses (IL) combining theory, exercises and practice. Key modules include:

Business/Management (e.g., semesters 1–6):

- Accounting I/II (7 ECTS total), Management Accounting/Controlling I/II (8 ECTS), Corporate Management I–III (13 ECTS), Business Administration I/II (10 ECTS), Logistics & Supply Chain Management (4 ECTS), Marketing I/II (7 ECTS), Process Management I/II (6 ECTS).

Engineering/Technology:

- Production Engineering I–IV (17 ECTS), Machine Elements I/II (6 ECTS), Energy Engineering (2 ECTS), Automation I/II (9 ECTS), Electrical Engineering I/II (7 ECTS), Science Tech I/II (6 ECTS).

IT/Digitalization:

- Mathematics Basics I/II & Advanced (13 ECTS), IT (ERP) I/II (7 ECTS), Applied IT Basics I/II & Advanced (11 ECTS).

Projects, Thesis and Transversal:

- Industrial Project (10 ECTS), Bachelor's Thesis 1/2 (17 ECTS), Communication I/II (4 ECTS), English 1–4 (8 ECTS), Tools for Scientific Work (2 ECTS).

Practical elements like industrial research projects (e.g., real company tasks in small groups) ensure hands-on experience in digital production, ERP implementation and process optimization.

3.6. REPRESENTATIVE WORKPLACE SITUATIONS

3.6.1. WORKPLACE SITUATION 1: PROCESS OPTIMIZATION IN A STYRIAN METALWORKING SME

In a medium-sized steel processing company (~200 employees) in the Mur–Mürz region of Styria, Austria, production follows a lean, shift-based organization with small, cross-functional teams (5–8 members) responsible for defined production cells along the value chain from material intake to final inspection.

Profession: Industrial Mechatronics Technician with additional process coordinator training, acting as shift team leader on the shopfloor or technical oriented industrial management student.

Goals:

- Achieve a 15% reduction in setup times (from 20 to 17 minutes average) for batch changes on CNC machining centers to increase overall equipment effectiveness (OEE) from 78% to 82%.
- Minimize defects in welded assemblies (<1% scrap rate) through improved first-piece inspection and operator feedback loops.
- Implement a digital retrofit for one legacy machine to enable real-time data capture for predictive maintenance.

Equipment used:

- 5-axis CNC milling centers (e.g., DMG Mori with Siemens Sinumerik 840D controls).
- welding robots (ABB IRB 2600 with IRC5 controllers) integrated into a manual-robot hybrid cell.
- Collaborative robot (Universal Robots UR10e) for automated part handling and quality checks (vision system + force-torque sensor).
- B&R X20 PLCs and industrial PCs for IIoT edge computing, connected via OPC UA to a central MES (Manufacturing Execution System).
- Mobile tablets for Andon visualization, digital work instructions and real-time dashboards (e.g., OEE, cycle times, defect rates).
- Standard shopfloor tools: digital calipers, torque wrenches, first-piece inspection gauges and safety equipment.

Problem to solve:

During recent batch changes for a new customer order (precision steel components for automotive suppliers), setup times have exceeded targets by 25% due to manual data entry errors, missing digital work instructions and non-standardized tool presetting. This causes delays in the downstream welding cell (backlog of 2 hours) and increases scrap risk from incorrect first-piece setups (current scrap rate 1.8% vs. target <1%).

3.6.2. WORKPLACE SITUATION 2: ASSEMBLY WORKER IN A STYRIAN METALWORKING COMPANY

Context: In a large-sized steel processing company (<1.000 employees) in Styria's Mur–Mürz region, a new customer order for precision automotive components requires assembling 500 welded steel sub-assemblies per shift in a manual-robot hybrid cell. Production follows lean principles with small teams (6–8 members) rotating across tasks in a U-shaped cell layout to balance workload and enable quick changeovers.

Organisation type: large company with shift-based production (2 shifts, 38.5h/week), organized in autonomous cells combining manual assembly, robot support and quality checks, supervised by a mechatronics technician/process coordinator.

Profession: assembly worker with 2 years experience, trained on-site in manual assembly, basic machine operation and quality control (no formal apprenticeship required, but forklift certification and welding safety training).

Goals:

- Assemble 125 sub-assemblies per shift (target cycle time 4.8 min/unit) while maintaining <1% defect rate.
- Support setup changeover for new batch (reduce from 23 to 18 min using standardized checklists).
- Perform first-piece inspection and report deviations via tablet to prevent scrap (current scrap 1.8%).

Equipment used:

- Manual assembly station with pneumatic tools (cordless nutrunners, torque wrenches for M8–M12 bolts).
- Collaborative robot (UR10e) for repetitive pick-and-place of heavy steel brackets (15–20kg) into welding position.
- Welding robot cell (ABB IRB 2600) for automated seams; worker loads/unloads parts and monitors via safety light curtain.
- Digital inspection gauges (calipers, thread gauges, surface testers) and barcode scanner for traceability.
- Mobile rugged tablet for work instructions, digital checklists, photo documentation of first-piece and Andon call button.
- Forklift truck (for material transport) and overhead crane for heavier assemblies.
- Standard PPE: welding helmet, gloves, safety shoes, hearing protection.

Problem to solve: During the batch changeover, inconsistent fixturing of steel brackets leads to misalignment in the welding robot cell, causing 12% rework (weld defects from 2–3mm offsets).

3.6.3. WORKPLACE SITUATION 3: MIDDLE MANAGEMENT – PRODUCTION SHIFT SUPERVISOR IN A STYRIAN AUTOMOTIVE SUPPLIER (PLASTIC INJECTION MOLDING)

Context: In a medium-sized automotive parts supplier (~150 employees) near Graz, Styria, production of dashboard components faces delays for a major OEM order (2,500 units/week). Two injection molding lines run 3 shifts, but cycle time variations and frequent mold changeovers cause 15% output shortfall and rising reject rates from cooling inconsistencies.

Organisation type: SME with lean production cells; middle management oversees 2 shifts (12 operators/line), reports to plant manager, coordinates with maintenance, quality and tool shop.

Profession: Production Shift Supervisor, trained engineer with technician certification, 12 years experience, responsible for shift output, quality, safety and team leadership on injection molding line 1+2.

Goals:

- Increase output from 85% to 89% capacity (220 parts/shift/line) by optimizing changeover and cycle times.
- Reduce reject rate from 3.2% to <2,0% through process stabilization.
- Coordinate unscheduled mold repair (downtime 4h yesterday) to prevent repeat failures.

Equipment used (for monitoring/supervision):

- Injection molding machines (Arburg Allrounder 570H, 4-cavity molds for PP/ABS parts).
- MES/ERP terminal (e.g., MPDV HYDRA) for real-time cycle times, reject rates, OEE tracking.

- Thermal imaging camera and pyrometer for barrel/mold temperature verification.
- Tablet with digital SOPs, defect photo documentation, Andon system.
- Robot arms (Epson SCARA) for part demolding/handling, supervised via HMI panels.
- Shopfloor printer for labels, wireless headset for team communication.

Problem to solve: Mold #3 shows 25% longer cycle times (38s vs. target 30s) due to inconsistent cooling channel performance after 4h downtime, causing sink marks (2.8% reject rate). Furthermore, there is a lack of skilled workers and there is a huge range from people that are not willing to include themselves in terms of responsibility to people that want to collaborate in decision making processes.

3.6.4. WORKPLACE SITUATION 4: PURCHASING CLERK IN A STYRIAN AUTOMOTIVE SUPPLIER (PLASTIC INJECTION MOLDING)

Context: In a medium-sized automotive parts supplier (~150 employees) near Graz producing dashboard components, production urgently needs 8 tons of ABS masterbatch within 48 hours due to supplier delays threatening €25k/day downtime on two injection molding lines. The purchasing team processes 15 urgent RFQs daily amid +18% global PP resin price spikes.

Organisation type: SME with centralized purchasing department (4 FTE); purchasing clerk supports purchasing manager, handles operational procurement (€2-5k POs), coordinates with production planners and logistics.

Profession: Purchasing Clerk, completed commercial apprenticeship or business informatics or industrial management, 5 years experience, responsible for operational procurement of raw materials and indirects (€3M annual value), PO processing and supplier coordination.

Goals:

- Process 3 emergency RFQs for ABS masterbatch and secure 8-ton delivery within 48 hours.
- Update 25 open POs with revised pricing/delivery dates from supplier portal.
- Maintain 98% on-time delivery rate to production while documenting price variances.

Equipment used (office-based operational tools):

- ERP terminal (SAP MM) for PO creation, goods receipt booking, stock level checks, consumption reports.
- MS Excel for supplier price comparisons, delivery tracking, freight cost calculations.
- Email/Teams for supplier coordination, production status updates, internal approvals.
- Procurement portal login (supplier extranet) for order confirmations, delivery notes, certificates.
- Dual-monitor workstation with article master data, Incoterms reference, logistics tracking.
- Office phone/scanner for PO printing, invoice matching, urgent calls.

Problem to solve: Primary supplier delays 8-ton ABS masterbatch (ETA now +3 days), risking complete line stoppage.

3.6.5. WORKPLACE SITUATION 5: HR MANAGER AT A LARGE CAR MANUFACTURER IN AUSTRIA

Context: The company is a large car manufacturer in Austria (largest vehicle contract manufacturer worldwide, ~10,000 employees), Industry 4.0/5.0 transformation (flexible EV/ICE lines, cobots, digital twins) collides with acute skilled labor shortages (mechatronics techs, automation engineers on AMS shortage list) and generational tensions: Gen Z demands purpose-driven roles/sustainability, while aging workforce (avg. 47y) resists reskilling. Turnover hit 14% in 2025; 120 skilled vacancies open across 3 shifts.

Organisation type: Large multinational with corporate HR (25 FTE), regional/global coordination; HR reports to VP HR EMEA, partners with works council, global talent center; manages recruiting, up-/reskilling for 37 vehicle models (G-Class, Supra, XPeng EVs).

Profession: HR Manager, Master Industrial Management or HR specific Master, 10 years manufacturing HR, responsible for plant talent strategy (2,500 indirects), Industry 4.0 academy, retention analytics, AMS Red-White-Red+ approvals.

Goals:

Fill 35 skilled vacancies (mechatronics, automation) within 60 days (92% fill rate target).

- Roll out "companies Digital Worker" program: upskill 800 operators on cobots/MES/AI (95% completion).
- Cut voluntary turnover 14%→9% via Gen Z retention (hybrid flex, mental health, EV project rotations).

Equipment used (corporate HR tools):

- SAP SuccessFactors for global ATS, skills ontology, succession planning, turnover prediction AI.
- Power BI dashboards: vacancy heatmaps, training ROI, demographic churn models.
- Workday LMS for 50+ Industry 4.0 modules (cobots, digital twin, human-AI collab).
- AMS Jobbörse/LinkedIn Recruiter for shortage occupation postings (€3k signing bonuses).
- SurveyMonkey/Qualtrics for NPS, pulse checks (monthly Gen Z focus groups).

Problem to solve: 120 skilled vacancies persist despite 2,500 applications (qualified rate 8%) as Gen Z rejects 3-shift models (prefer "smart shift" with flex/AI training) and skilled migrants need fast-track Red-White-Red+ visas. Aging workforce resists cobot reskilling (35% >50y).

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4. MONOGRAPHY CIFP MIGUEL ALTUNA LHII (BASQUE COUNTRY)

This section presents the monography of CIFP Miguel Altuna LHII built following the Framework for Interdisciplinary Training in Learning Factories , describing the regional labour context, the advanced manufacturing sector, and the VET ecosystem that supports the development of its Learning Factory, Ikas Fabrika. It details the centre's organisational model, pedagogical approach, technological infrastructure and ongoing initiatives. The analysis shows how Miguel Altuna integrates innovation, collaboration and Industry 5.0 principles into its learning environment.

4.1. LABOR CONTEXT OF THE ADVANCED MANUFACTURING SECTOR IN THE BASQUE COUNTRY.

4.1.1.STRATEGIC DEVELOPMENT MODEL AND REGIONAL VISION

The labor dynamics of the Basque Country's advanced manufacturing sector are inseparable from the region's distinct and deliberate policy framework, which serves as the architecture for its economic resilience and industrial ambition. The Basque government has cultivated a comprehensive approach that tightly integrates industrial policy, technological innovation, and vocational training to navigate profound global transitions.

At the core of the Basque development model is the principle of "Sustainable Human Development," a vision that seeks to balance economic competitiveness with social well-being and environmental responsibility (Basque Government, 2021b). This guiding philosophy is operationalized through a commitment to navigating a **"Triple Transition"**:

- **Technological-Digital Transition:** Embracing digitalization, artificial intelligence, and other Industry 4.0 technologies to enhance productivity and create new value.
- **Energy-Climatic Transition:** Shifting towards a carbon-neutral economy through renewable energy, circular economy principles, and sustainable industrial practices.
- **Social-Sanitary Transition:** Responding to demographic shifts, such as an aging population, by promoting healthy living and adapting social and healthcare systems.

These three interconnected transitions are not pursued in isolation but are woven into the fabric of the region's core economic strategies, most notably the Research and Innovation Strategy for Smart Specialisation, RIS3 Euskadi 2030 (Basque Government, 2021b). This integrated approach ensures that investments in science, technology, and industry are aligned with the region's long-term societal goals.

A critical enabler of this vision is the Basque Vocational Education and Training (VET) system as described in the VI Basque plan for VET (Department of Education of the Basque Government, 2022) and in the recently approved Basque Strategy for VET 2030 (Department of Education of the Basque Government,2026). Recognized for its close alignment with industrial needs, the VET system is strategically positioned to be an international benchmark in workforce development (Homs, 2023). Its proactive engagement in European innovation projects and participation in national excellence networks, such as the Spanish Network of Centres of VET Excellence on Automated Manufacturing (CEX-FA), underscores its advanced status and commitment to shaping a skilled workforce capable of leading the region's industrial transformation (Homs, 2023; Ziarsolo et al., 2024). This strategic alignment between high-level policy and educational infrastructure is fundamental to confronting the region's demographic and labor market realities.

4.1.2. DEMOGRAPHIC CHALLENGES AND LABOR MARKET QUALITY

The Basque Country's ambitious strategic vision is implemented against a backdrop of significant demographic pressures and complex labour market characteristics. These factors both challenge the region's growth trajectory and define the specific nature of its workforce development needs, reflecting broader European trends where skills shortages are a primary obstacle to investment (Eurofound & Cedefop, 2025).

The most pressing challenge is the progressive aging of the population. In 2019, individuals over the age of 65 already constituted 22.2% of the total population, a figure among the highest in Europe (Basque Government, 2021b) (EUSTA, 2024). This demographic trend has a direct and tangible impact on the labour market, creating widespread concern among companies about their ability to find sufficient qualified local labour to replace retiring workers and fill new roles (Homs, 2023). This looming skills gap places immense pressure on the region's educational and industrial systems to attract, train, and retain talent, a challenge particularly acute for SMEs which often face greater difficulties accessing skills (Eurofound & Cedefop, 2025). (European Commission, 2020).

Simultaneously, the Basque labour market is characterized by a high and improving level of quality. The manufacturing workforce has seen a consistent increase in professional qualifications, with a growing share of employees holding VET and university degrees (Homs, 2023). However, this positive trend is counterbalanced by the persistent issue of overqualification. A recent analysis reveals that in occupations theoretically aligned with Higher VET qualifications (CNO Group 3), nearly a third (29.8%) of positions are held by individuals with university degrees (Orkestra & CaixaBank Dualiza, 2024). This significant level of overqualification suggests a structural misalignment between the outputs of the university system and the technical needs of the RIS3-driven industrial strategy. It represents an inefficiency in human capital that directly challenges the region's goal of 'Sustainable Human Development' by potentially leading to professional frustration and underutilization of advanced skills. These broad regional challenges directly shape the specific human capital needs of the advanced manufacturing sector.

4.2. LABOR STRUCTURE AND DEMAND IN THE ADVANCED MANUFACTURING SECTOR

4.2.1.DEFINING THE KEY INDUSTRIAL SECTOR

This analysis focus on the Advanced Manufacturing sector, a cornerstone of the Basque Country's economic strategy and a primary driver of its future competitiveness. The region has strategically prioritized this sector to maintain its industrial leadership while navigating the global shifts toward digitalization and sustainability, a process rooted in the broader "Industria 4.0" concept that has shaped Spanish industrial policy for the last decade (Secretaría General de Industria y de la Pequeña y Mediana Empresa, 2015).

Advanced Manufacturing in the Basque context is synonymous with the **"Industria Inteligente" (Smart Industry)** priority established within the RIS3 Euskadi strategy (Basque Government, 2021b). This framework aims to transform the region's industrial fabric by deploying specific "palancas tecnológicas" (technological levers), including artificial intelligence, 5G connectivity, quantum computing, and cybersecurity, to create a more automated, interconnected, and resource-efficient industrial ecosystem (Basque Government, 2021a).

This industrial strategy is critically articulated with the Basque VET system, which functions as its direct implementation partner for workforce development Department of Education of the Basque Government. (2022), (Ley Orgánica 3/2022, 2022). The VET system proactively supports the Smart Industry agenda through targeted initiatives designed in close collaboration with industry stakeholders and also included in the Spanish organic law for FP (Ley Orgánica 3/2022, 2022). Key examples include the establishment of **Centres of VET Excellence (CoVEs)**, (European Commission, 2023) which act as hubs for innovation and specialized training, and the creation of post-graduate **Specialization Programs** (Real Decreto 279/2021, 2021) that equip VET graduates with cutting-edge skills in areas like smart manufacturing and artificial intelligence (LCAMP Consortium, 2024; Ziarsolo et al., 2024). This tight coupling between industrial strategy and the VET system translates directly into a specific and evolving set of labour demands, centered on the highly technical roles required to build a "Smart Industry" from the ground up.

4.2.2. CURRENT LABOR DEMAND AND QUALIFICATION LEVELS

To understand the practical implications of the region's strategic focus, it is crucial to analyse the current labour demand within the Advanced Manufacturing sector. This examination reveals the precise skills, roles, and qualifications that companies require to implement smart industry principles on the ground.

Labor demand is highly concentrated in technical profiles with specialized VET qualifications. According to industry analyses, mechanical manufacturing is the most demanding speciality at VET (Basque Government. (2024) and within that speciality the most sought-after profiles include **assembly technicians, mechanical engineers, and automation technicians** (Ziarsolo et al., 2024).

In addition to these core roles, recent labour market studies identify several emerging job profiles driven by industrial digitalisation. These include robotics technicians, industrial cybersecurity assistants, dataenabled process technicians, and AI/algorithm support operators, reflecting the deep integration of automation and connected systems into production environments (CEDEFOP, 2025; AFM Cluster, 2025). These roles complement the traditional occupations and illustrate the sector's transition towards more hybrid human–machine interactions. market studies identify several emerging job profiles driven by industrial digitalisation. These include robotics technicians, industrial cybersecurity assistants, dataenabled process technicians, and AI/algorithm support operators, reflecting the deep integration of automation and connected systems into production environments (CEDEFOP, 2025; AFM Cluster, 2025). These roles complement the traditional occupations and illustrate the sector's transition toward more hybrid human–machine interactions.-market studies identify several emerging job profiles driven by industrial digitalisation. These include robotics technicians, industrial cybersecurity assistants, data-enabled process technicians, and AI/algorithm-support operators, reflecting the deep integration of automation and connected systems into production environments (CEDEFOP, 2025; AFM Cluster, 2025). These roles complement the traditional occupations and illustrate the sector's transition toward more hybrid human–machine interactions.

This demand translates into the need for graduates from specific VET professional families, with the following continuing to be the most critical for the advanced manufacturing sector: Mechanical Manufacturing, Electricity and Electronics, and Installation and Maintenance (Basque Government, 2024). These families also consistently show some of the highest employability rates within the Basque VET system.

A more detailed analysis of job vacancies and company needs identifies a set of core technical roles, primarily at the European Qualification Framework (EQF) Level 5, that are central to the functioning of modern manufacturing environments (Ziarsolo et al., 2024):

- CNC technician (operator + programmer)
- Maintenance operator (electrical, mechanical, and mixed mechatronic profiles)
- Automation technician & robotics
- Technical office assistant
- Quality control assistant

Industry-level sources further underline that companies increasingly require mechatronics profiles, capable of combining mechanical, electrical, and digital competencies to operate and maintain advanced equipment (AFM Cluster, 2025). The introduction of more connected machinery is also generating demand for maintenance profiles familiar with data acquisition systems, sensor networks, and condition-monitoring tools, expanding the boundaries of traditional maintenance work (CEDEFOP, 2025).

Finally, structural elements of the Basque labour market influence these needs. Manufacturing employment remains stable and robust in the Basque Country (Eustat, 2024), yet demographic ageing and a high replacement demand create growing recruitment pressures. This situation is particularly challenging for SMEs, which consistently report difficulties in hiring qualified VET technicians (Eurofound & CEDEFOP, 2025).

4.2.3. THE EVOLUTION OF PROFESSIONAL ROLES AND REQUIRED SKILLS

Professional roles within Basque Advanced Manufacturing are undergoing a significant transformation, actively reshaped by the powerful forces of the triple transition. The skills required today are expanding beyond traditional boundaries, demanding hybrid competencies and greater adaptability from the workforce.

The primary "levers of change" driving this evolution are the twin digital and green transitions. Digitalization is a dominant force, motivated by the industrial imperative to improve production efficiency. This is practically achieved through the widespread implementation of **data acquisition systems** and the continuous **monitoring of equipment**, often involving connections to Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP) software (Ziarsolo et al., 2024). As a result, workers are increasingly expected not only to operate machinery but also to interact with and manage the data associated with production processes.

Across Europe, forecasting evidence confirms this trend: **science, engineering and ICT technicians** are among the occupations with the strongest projected growth to 2035, propelled by automation, AI, connectivity, and sustainability requirements (CEDEFOP, 2025). This aligns directly with the evolution of roles in Basque industry, where technicians increasingly require skills in robotics, AI-supported diagnostics, and cyber-physical system operation.

The practical evolution of job profiles can be illustrated through the case of the **Maintenance Operator**. Traditionally mechanical or electrical, this role is now shifting toward a **mechatronic and data-driven profile**, integrating robotics programming, IT-based diagnostics, and predictive maintenance based on sensor data (LCAMP Consortium, 2024). The green transition is also adding responsibilities such as monitoring energy consumption, ensuring equipment efficiency, and complying with environmental regulations (Orkestra & CaixaBank Dualiza, 2024).

Beyond technical abilities, companies are placing growing emphasis on **transversal skills** such as problem-solving, communication, decision-making, teamwork, and adaptability. These competencies are considered essential for operating in complex, cyber-physical production environments (Homs, 2023; Ziarsolo et al., 2024).

In response to these evolving industrial needs, the Basque VET system is developing **post-graduate specialization programs (EQF 5 Specialization Courses)**, such as “Smart Manufacturing” and “Artificial Intelligence & Big Data”. These programs aim to build the hybrid technician profiles demanded by industry and to ensure alignment between VET curricula and technological trends (LCAMP Consortium, 2024).

4.3. ORGANISATION CONTEXT: CIFP MIGUEL ALTUNA LHII

Public VET centre created in 1928 whose activities involve Initial VET, Continuous VET and applied innovation. Currently there are around 800 students and 100 staff members. Training activities are carried out in collaboration with industrial partners with more than 150 agreements related to DUAL training, internships and applied innovation projects.

At MA, we provide training at EQF levels 4 and 5, covering various professional fields

- Mechanical Manufacturing (EQF 5): Production Management, Design in manufacturing processes, Industrial Mechatronics,
- Machining technician (EQF4)
- Industrial Automation and Robotics (EQF 5) Electrical and Automatic Installations (EQF 4).
- Computer Science (EQF 5): Web Applications Development and
- Administration and Finance (EQF 5): Administrative Management, and Management Assistance, Administration and Finance (EQF4)
- Specialization programs for EQF5 graduates: Smart Manufacturing, Cold Forging Technologies, Artificial Intelligence and Big Data.

The training catalogue also includes the Continuous Training with upskilling and reskilling programs: workforce training, retraining and professional development, training for unemployed people, access to university courses.

CIFP Miguel Altuna LHII follows the combined Basque VET model, which integrates education, innovation, entrepreneurship and internationalisation as fundamental pillars.

Pedagogical Model. All study programs are based on the ETHAZI pedagogy framework (Aranguren, M. J., & Navarro, I. 2016; TKNIKA, 2024). This approach emphasizes collaborative learning, student autonomy, and the integration of real-world problem-solving.

Besides the forementioned educational provision, innovation, both technological and methodological, is another key axis, promoting transformative approaches adapted to the demands of the environment. Within this umbrella, MA is involved in several regional, national and international projects.

Entrepreneurship programs to support the creation of start-ups and new business initiatives is the third main strategic pillar. Finally, the internationalisation opens opportunities to connect with global markets and experiences, strengthening the projection of the students and the centre.

MA is involved in Basque, national and international collaboration networks, which reinforces its leadership in advanced vocational training and innovation.

MA is member of the

- Basque VET network, where it collaborates closely with TKNIKA (TKNIKA, n.d.).
- Ikaslan, network of Basque Public Vet centres (Ikaslan, n.d.).
- Spanish network of Centres of VET Excellence as a Basque Centre of Excellence in Automated Manufacturing (since 2022) (Red de Centros de Excelencia de Formación Profesional. n.d.).
- LCAMP, European Centre of Vocational Excellence (CoVE) for the advanced manufacturing sector (since 2022) (LCAMP, n.d.), previousy part of EXAM4.0 (2019) (EXAM 4.0, n.d.)
- FPempresa, network of Spanish Vet centres, (FPempresa, n.d.).

We also collaborate with Industry associations and clusters: Confebask, AFM, Adegi, Asefi, SIfe. These alliances boost our educational offer, ensuring that it responds to the needs of industry and contributes to the sustainable and competitive development of the region.

Networks related to learning factories and/or industry 5.0:

- LCAMP- alliance (LCAMP, n.d.),
- Basque network of LF: SCLF (Tknika, n.d.).
- Bridges 5.0, learning factories 5.0 (Bridges 5.0, n.d.).
- Participation in Conference on Learning Factories (International Association of Learning Factories, n.d.).

4.4. Learning factory at CIFP Miguel Altuna LHII. Ikas Fabrika

4.4.1.CONCEPT AND BACKGROUND

Miguel Altuna's *Ikas Fabrika* is a dynamic learning environment inspired by the Learning Factory concept developed by several authors (Abele, 2015; Roll, 2021; Scheid, 2018). It recreates real industrial production settings within an educational context, meeting industry-level standards to support the development of students' technical competencies (LCAMP, 2023).

The learning factory represents a qualitative leap forward from the traditional hand -on-based model commonly used in vocational education. Rather than working on subjects or modules in isolation, students engage in interdisciplinary collaboration within a semi real scenario. This fosters synergies between different educational domains and, by enabling product-oriented production operations, reproduces organizational practices typical of real industrial environments. As a result, interaction between workstations and departments becomes essential. Experiencing such real-world scenarios encourages students to make informed decisions and promotes the development of a wide range of transversal skills. Furthermore, the students reach a holistic view of the overall production process.

Because the learning factory integrates various Industry 4.0 technical features, full immersion in the production process provides an excellent context for developing transversal competencies, personal values, and the key dimensions of Industry 5.0 (European Commission, 2021): human-centricity, resilience, and sustainability. Within this framework, Ikas Fabrika becomes a highly suitable environment in which to explore and cultivate these emerging priorities.

The Ikas Fabrika initiative began in 2020 as a continuation of the earlier digitalisation of the mechanical manufacturing workshop. The LCAMP project (2022–2026) (LCAMP, n.d.). has been a major catalyst for its evolution. As new infrastructure and technical resources were incorporated, the first student-participation pilots were launched during the 2023–2024 academic year. During the 2024–2025 academic year, collaborative activities with international students were launched through the *Blended Intensive Program (BIP*) and Erasmus+ mobility initiatives (Miguel Altuna LHII, n.d.).

In 2024, the Vice-Ministry of Vocational Education of the Basque Country introduced an initiative to implement and strengthen Learning Factories in vocational education centres. Within this framework, Miguel Altuna LHII is a member of the Smart Collaborative Learning Factory (SCLF) network, together with 22 other vocational training centres. This network promotes collaboration among Basque VET centres to expand Learning Factories across institutions (Tknika, n.d.).

Technological and pedagogical developments have progressed in parallel, with multiple configurations and approaches being tested. It is worth noting that a project such as the learning factory is, by nature, a living and evolving system—one that grows through continuous adjustment and, frequently, through trial and error.

4.4.2.LAY OUT OF THE IKAS FABRIKA

The Ikas Fabrika is located within Miguel Altuna LHII's 2,000 m² manufacturing workshop, concentrated in a 250 m² area and fully integrated into the centre's digitised infrastructure. Within the Ikas Fabrika production process, there is currently capacity to manufacture two products: the MA Skate and the LCAMP mobile robot.

In terms of organisation, students are divided into departments within the Ikas Fabrika to carry out cross-programme collaborative work (see figure 1):

- **Manufacturing:** responsible for production planning, product manufacturing, quality, and maintenance.
- **Administration and Finance:** responsible for human resources management, finance, purchasing and sales, marketing, and logistics.
- **Technical Development:** responsible for product design, production process engineering, production automation, and digitalisation.

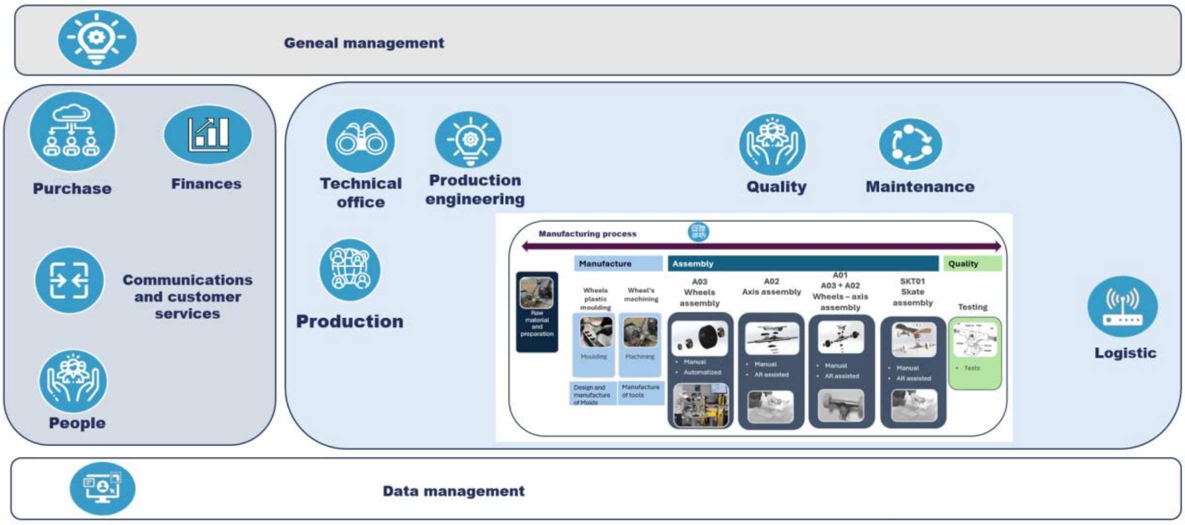

Figure 1 Value chain of the skate manufacturing learning factory

The physical layout of the production areas in the Ikas Fabrika workshop is based on flexible production lines (see figure 2). The layout consists of the following zones:

- **Component manufacturing areas:** machining, additive manufacturing, and casting (distributed across the school workshop).
- **Assembly lines:** an automated assembly station, two AR-assisted assembly stations, and a manual assembly station.
- **Quality:** integrated within the production lines or located in a dedicated area, depending on the sub-product.

Logistics: including raw-material storage, tool storage, and intermediate stock areas.

Across the assembly lines, workstations integrating **Industry 4.0 enabling technologies** are combined with manual assembly zones, incorporating lean manufacturing principles, human-centric design, and well-being considerations.

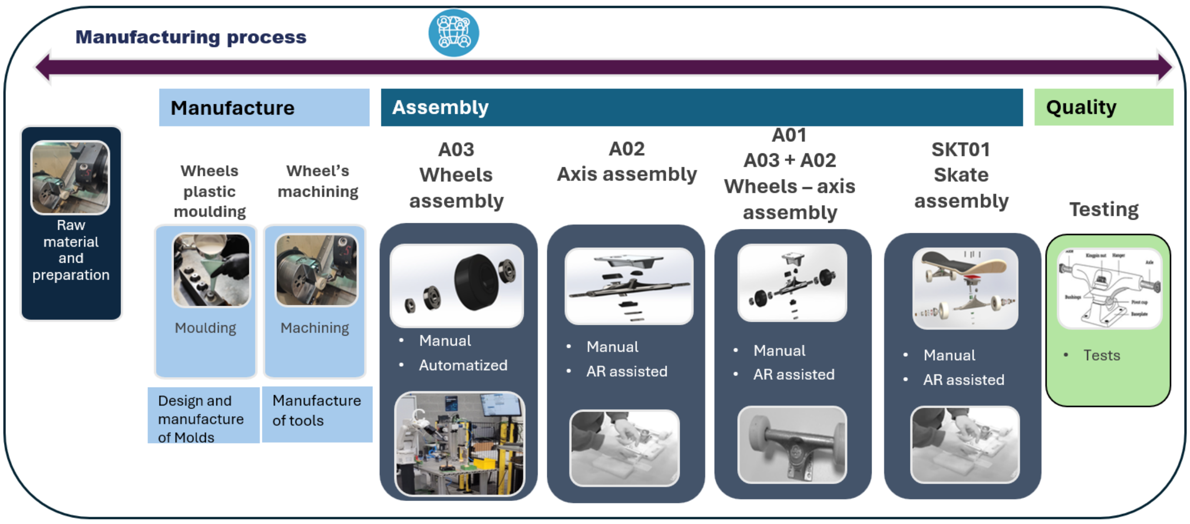

Figure 2 Manufacturing process for the Skate production

4.4.3.TECHNOLOGIES IN THE IKAS FABRIKA

Data management

Integration with the school's system, embedded within the connected workshop. Comprehensive data management includes:

- Managed information: users (students, groups, subgroups, schedules), machines, resources, challenges, parts, task times, and real-time status.
- Manufacturing information: work orders, production KPIs, cycle times, machine data, downtimes, maintenance parameters, quality data, warehouses and stock levels, traceability, and generated waste.
- Energy efficiency: monitoring of energy consumption.
- Data-driven decision-making dashboards.
- Cybersecurity in OT/IT environments, including segmentation, access control, password policies, and secure network design.

Industry 4.0 enabling technologies

IoT systems, CPS, robotics (cobots and AGVs), additive manufacturing, artificial vision, augmented reality (AR), cloud computing, big data, and AI.

G-Cloud: monitoring of challenges and learning processes, as well as individual student tracking systems.

Human centricity, resilience, and sustainability

Several initiatives are underway in the Ikas Fabrika to place people at the centre. One of them is a Vice-Ministry project aimed at evaluating workstations.

- The LF4VET project.
- Bridges5.0 and the Kiribil Laboratory.

What is missing or in progress

- Actions for data-driven production.
- Didactic personalisation (inclusive education, challenges adapted to different competence levels, personalised assessment…).
- Governance and organisation of digitalisation (centre-level): how the Ikas Fabrika connects to the VET centre's governance structure and module curricula.
- Adaptability for sustainable change: explicit activities to help students adapt to new situations, such as technological changes, new software versions, and process modification simulations.

4.4.4.PEDAGOGY

The operation of the Ikas Fabrika is designed to foster interdisciplinary learning.

In the 2025–2026 academic year, the main users of the Ikas Fabrika are the students enrolled in the Ikas Fabrika elective module. This initiative involves 6 higher-level vocational programmes, with a total of 10 groups, 80 students, and 9 teachers participating: PM (3 groups), MKT (2 groups), ARI (2 groups), DFM, AF, and ZL.

In addition to the elective module jointly developed by the different programmes, the Ikas Fabrika also has other user groups, such as the students of the Advanced Manufacturing Specialisation Course (15 students). Moreover, specific challenges belonging to the DFM, AF, PM, or MKT programmes are also carried out in the Ikas Fabrika, with varying durations.

Regardless of the modality used, the challenges developed in the Ikas Fabrika are linked to the learning outcomes of each corresponding programme, working on the contents described in their respective curricula. Student assessment follows the same system defined within the ETHAZI framework, addressing multiple dimensions such as communication, critical analysis, problem-solving, digital ethics, among others. The use of the Ikas Fabrika has been aligned with the school's pedagogical model.

To optimise the use of the Ikas Fabrika, in addition to interdisciplinary projects, other specific programme-related challenges and innovation projects are also carried out. Training sessions related to the technologies integrated into the Ikas Fabrika are also offered or incorporated into various courses.

External stakeholders also make use of the infrastructure, especially companies. The aim is to maximise the occupancy and utilisation hours of the Ikas Fabrika.

Figure 3 Students from Miguel Altunako working in the learning factory: 1) automated assembly (2),(3),(4),(7) AR-based assembly workstations, (5) Programing automated machining (6) machining (8) (9) programming of AR smart glasses,

4.4.5.ONGOING INITIATIVES AND CHALLENGES

The open lines of work and current challenges include:

- Sequencing the timelines required to carry out cross-programme manufacturing, ensuring coordination in the integration of curricular content and teacher collaboration.
- Digital and operational management of production within the Ikas Fabrika.
- Embedding a human-centric culture, values, and actions, and ensuring that users adopt a systemic perspective.
- Expanding data-driven production practices.
- Advancing didactic personalisation (inclusive education, challenges adapted to different competence levels, personalised assessment…).
- Strengthening the governance and organisational model of digitalisation at centre level: How is the Ikas Fabrika connected to the VET centre's governance structure and module curricula?
- Enhancing adaptability for sustainable change, including explicit activities that help students adjust to new situations (technology updates, new software versions, simulations of process changes).

- Incorporating Industry 5.0–related dimensions into the curriculum.

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5. MONOGRAPHY -ECOLE NATIONALE SUPÉRIEURE DES ARTS ET MÉTIERS (FRANCE)

This section explores the regional context of Auvergne-Rhône-Alpes and the organisational environment of Arts et Métiers, providing the foundation for understanding the evolution of the Evolutive Learning Factory (ELF). It outlines the region's industrial profile, labour-market trends, and the institute's training offer and research specialisation. The section demonstrates how ENSAM's Learning Factory model supports sustainable design, circular economy practices and advanced engineering education. The section is built following the Framework for Interdisciplinary Training in Learning Factories.

5.1. REGIONAL HISTORICAL AND GEOGRAPHICAL INFORMATION

5.1.1.OVERVIEW OF THE AUVERGNE-RHONE-ALPES REGION

With 8 million inhabitants, an area of approximately 70,000 km², equivalent to the size of Ireland, or 12.8% of France's total area (Auvergne-Rhône-Alpes Chambre de Commerce et Industrie [CCI], 2025) and a GDP equivalent to that of Denmark, the Auvergne-Rhône-Alpes region is one of the largest in Europe. It comprises 12 departments, including Savoie, where the city of Chambéry is located, and four urban areas (Lyon, Grenoble, Saint-Etienne and Clermont-Ferrand). AURA is considered the leading region in France in terms of industrial jobs: 490,000 out of a total of 3.3 million jobs.

From a geographical point of view, the natural heritage is diverse (high mountains, plains, large lakes) and the territory is made up of areas with significant disparities and specific sustainable development challenges: on the one hand, rural areas corresponding to one third of the territory, some of which are located in the mountains, and on the other hand, large urban areas.

5.1.2.DEMOGRAPHIC COMPOSITION: A GROWING REGION

Auvergne Rhône Alpes is the second most populous region in France. Its population grew by an average of 0.6% per year between 2012 and 2017, which is above the national average. Its population is also younger than the national population. Its economic dynamism attracts executives and middle-level professionals from other French regions (INSEE, 2021). Four multidisciplinary university clusters structure higher education in the region (Lyon, Clermont-Ferrand, Grenoble and Savoie Mont-Blanc) and attract and retain students: 300,000 are enrolled in one of the region's institutions. These areas also offer a full range of local training courses (INSEE, 2021).

By 2050, population growth is expected to be between 8% and 16%, due to the region's attractiveness to young people (which would have an impact on the birth rate) and positive net migration.

5.1.3.THE REGION'S MAIN ECONOMIC ACTIVITIES

Today, Auvergne-Rhône-Alpes is France's second largest economic hub after Île-de-France. Its gross domestic product (GDP) exceeds €300 billion, representing 11.6% of France's GDP.

Auvergne-Rhône-Alpes is France's leading industrial region in terms of employment. With more than 533,000 industrial jobs out of a total of 3.3 million, the region's industrial fabric is mainly composed of small and medium-sized establishments. Only 2% of establishments have more than 200 employees (Panorama Régional, 2025).

Industrial activity is structured around eight main sectors: machinery and equipment, metallurgy (and manufacture of metal products), rubber and plastics, electrical and electronic products, textiles and leather, and chemicals. The importance of the metallurgical industry in AURA compared to other French regions makes it a major industrial subcontracting region.

Training programmes for senior technicians specialising in production are linked to industrial areas (Maurienne, Arve Valley, Oyonnax). Research and development activities, mainly carried out by businesses, are significant in the region in terms of GDP (2.7%).

Jobs associated with industrial activity have been declining since the 1990s. This regional phenomenon is part of a national trend of deindustrialisation that has been ongoing since the 1980s, coinciding with the growth of the market services sector. The share of jobs in manufacturing has fallen in France from 21% to 11% since 1990 and from 26% to 14% in the Aura region.

Since 2016, a reindustrialisation drive has been underway, characterised in the region by strong growth in industrial jobs, twice as fast as in France (+6% compared to +3.2%) (INSEE,2020). For example, between 2016 and 2026, six new factories have opened in the region. Electronics, medical equipment, jewellery, waste collection and treatment, and the pharmaceutical industry are among the most promising sectors (Panorama Régional, 2025).

5.1.4.THE REGION'S STRATEGY FOR 2028

The Auvergne-Rhône-Alpes region's strategy for 2028 focuses on strengthening industrial sovereignty, spreading innovation among businesses, and rolling out tailor-made offerings that adapt to businesses' needs. In this context, training plays an essential role: training more engineers (EQF level 7), senior technicians (EQF level 5) and scientists by creating new training programmes, increasing the visibility of professions and supporting their deployment through secure support.

Considering that the economy, employment, training and innovation are closely linked, the Auvergne Rhône Alpes plan outlines five major strategic priorities:

1- Relocate production and strengthen industry with the major objective of creating

30,000 industrial jobs and supporting 700 business relocation projects by 2028.

2- Accelerate the digitalisation and decarbonisation of businesses with the objective of supporting 50,000 micro-businesses and SMEs in their digital transformation by 2028 and supporting relocation projects, 50% of which must have a positive impact in terms of reducing CO2 emissions.

3- Provide guidance and training by anticipating skills needs and adapting vocational training programmes so that by 2028, 30,000 people will be enrolled in training programmes for industrial professions.

4- Make Auvergne-Rhône-Alpes the region for engineers, senior technicians and scientists by providing more training courses whose curricula best meet the skills needs of manufacturers. The aim is to strengthen the link between businesses and schools with the goal of training 2,000 additional engineers in the region by 2028.

5- Rely on research and higher education to strengthen innovation by developing public-private partnerships and promoting technology transfer to businesses. Among other things, the region has set itself the goal for 2028 of supporting 200 multi-partner public/private research and innovation projects and having 12 projects carried out by local higher education institutions (recognised and high-performing higher education in the region).

Finally, the region's plan is based on several sectors of excellence that constitute regional competitive advantages: the health industries, sustainable materials, microelectronics and artificial intelligence, and hydrogen.

5.1.5.THE SAVOIE DEPARTMENT

Covering an area of 6,028 km², Savoie has a population of around 431,000 and saw its population grow by 0.5% per year between 2012 and 2017. Its main activity is linked to tourism, particularly mountain tourism (15%). However, 11% of jobs are in industry, mainly in metallurgy, metalworking and machining, and the agri-food industry. In Savoie, 47.1% of the working population aged 25 to 54 hold a higher education qualification (a rate close to that of the Auvergne-Rhône-Alpes region, at 48.7%). The department has nearly 15,000 students spread across various establishments in Bourget du Lac, Jacob-Bellecombette and Chambéry.

5.2. JOB MARKET AND ITS EVOLUTIONS

The manufacturing industry is the economic sector targeted by the LF4VET project. More specifically, it covers metallurgy and metal products; rubber and plastic products and other non-metallic mineral products; agri-food; textiles, clothing, leather and footwear; wood, paper and printing; transport equipment; machinery and equipment.

In terms of labour market movements between 2016 and 2023, nine sectors created jobs in the region: agri-food industry (+8,029 jobs); other manufacturing industries, repair and installation of machinery (+5,031 jobs); textiles, leather and leather goods (+2,470 jobs); IT, electronic and optical products (+2,168 jobs); the chemical industry (+1,392 jobs); the pharmaceutical industry (+1,331 jobs); transport equipment (+791 jobs) and electrical equipment (+122 jobs) (Panorama Régional, 2025).

Luxury leather goods, luxury jewellery, medical technology, electronics and optics are the sectors that have seen the highest net job creation since 2016.

Four factors will have a significant impact on the outlook for the labour market between now and 2030:

- The acceleration of the ecological and energy transition
- The transformation of professions through robotisation, digitalisation and artificial intelligence
- Changing lifestyles and consumption patterns: the rise of e-commerce and the growth of the collaborative economy will have an impact on skills requirements. Sustainable mobility advisers and circular economy specialists are emerging professions.
- The ageing population and retirements

In general, job creation will mainly target higher education graduates (47% of jobs in 2030). In the industrial sector, there will be a significant decline in the number of jobs held by people with a secondary school diploma or lower.

Recruitment needs will amount to 1.1 million jobs by 2030, mainly due to retirements (83%) and, to a lesser extent, net job creation (17%) (Via Compétences, 2024). Strong growth in research and development activities is expected, as well as continued reindustrialisation. These vacancies would be filled partly by young people entering the labour market and partly by workers from other regions. However, the balance between needs and recruitment would be negative, with 5% of positions remaining unfilled.

In the industrial sector, the occupations that would be most difficult to recruit for and that would recruit the most are:

- Skilled warehouse worker. This is a low-skilled job that could benefit from upward mobility.
- Textile and leather worker: this is a job that is deeply rooted in the region's culture.
  The occupations that would create the most jobs and recruit the most:
- Industrial engineers and managers: the region's industrial diversity, the importance of high-tech industry and the presence of European factories make this one of the occupations that creates the most jobs. The requirement for advanced technical skills should be met through specific training.

Research and development personnel would be one of the professions creating the most jobs in the region, but due to its attractiveness, recruitment needs would be met.

Industrial companies have identified four short-term priorities:

- Increasing the performance of production facilities
- Innovating: developing new products and services and innovating on existing products
- Improve quality of life at work and the company's image
- Improve the environmental impact of the production process, design and develop more sustainable products, and improve the energy impact of the production process.

These priorities are accompanied by discrepancies between the training system and the needs of businesses. Businesses are increasingly looking for employees with CAP and Bac qualifications, whereas the level of training provided is Bac+2 (BTS/BUT). Furthermore, school-based training is generalist and not particularly geared towards professional challenges. The geographical dispersion of specific profiles also poses a difficulty (L'observatoire compétences industries 2i, 2025).

5.2.1.FOCUS ON THE PROFESSIONS COVERED BY LF4VET (Panorama Emploi, 2025)

- - Design, research and development: design office technician, renewable energy research and development engineer

This family of professions will see a significant evolution in skills over the next three years. This is particularly true with regard to the integration of digital technology and artificial intelligence into research and design processes: digital simulation and biostatistics. In terms of ecological and environmental transitions: changes in mobility (batteries, new materials to make vehicles lighter, hydrogen, new engines, etc.), recycling (textiles, composites, batteries, etc.), innovation by suppliers of materials (wood, aluminium, PVC, glass, etc.) and equipment (heating, paints, etc.) to offer high-performance solutions in line with regulatory changes.

- In terms of digital transition: integration of embedded software and systems, smart cities, telemedicine, automation and robotisation.

Design office technician: Main activities: reviewing specifications and documents provided by the client, analysing the technical file for the project and its constraints, and developing proposals to ensure their feasibility, taking into account environmental constraints; producing models, drawings, plans and diagrams in 2D or 3D, using CAD/DA tools in particular.

Renewable energy research and development engineer: translating functional requirements into technological hypotheses, carrying out technical and economic feasibility studies for projects, participating in the monitoring of the manufacturing and assembly phase of renewable energy installation projects.

- Planning and QHSE: methods technician, industrialisation engineer, HSE engineer

Methods technician: Studies and determines the procedures to be followed for each manufacturing process; formalises the processes and procedures necessary for the organisation to function; compiles manufacturing files; establishes provisional production schedules.

Industrialisation engineer: Analyses technical data for the implementation of industrial methods; centralises and analyses issues in order to optimise industrialisation; defines the manufacturing phases and the distribution of tasks; proposes corrections to procedures or improvements to production performance.

HSE Engineer: Develops and implements HSE policy; assesses and manages occupational and environmental risks; coordinates relations with authorities, professional organisations and regulatory bodies to ensure regulatory compliance; monitors regulations.

5.3. ORGANISATIONAL CONTEXT

5.3.1.GENERAL PRESENTATION OF ARTS ET MÉTIERS

The École Nationale Supérieure d'Arts et Métiers, founded in 1780, is one of the oldest engineering schools in France. Today, Arts et Métiers has 14 sites, 13 in France and 1 abroad (Morocco), hosting 15 research laboratories, which train 6,000 students per year across all courses, including 331 doctoral students and 2,000 continuing education students, in 11 engineering programmes (1 generalist, 10 apprenticeship programmes), one bachelor's degree in technology, 20 research master's degrees, and 17 specialised master's degrees. The entire spectrum of technological training in higher education, from bachelor's to master's degrees, is thus covered to meet all needs and expectations. The scientific teams are engaged in five major strategic areas, corresponding to five economic sectors: transport, energy, health, housing, and production. These fields are divided into 20 areas of research, such as digital engineering, biomechanical design, thermal energy and collaborative robotics. Researchers and students can work on the entire life cycle of a product: from design to production and recycling.

5.3.2.THE CHAMBÉRY INSTITUTE AT SAVOIE TECHNOLAC

Located in Le Bourget du Lac in the Savoie department and covering a total area of 150 hectares, Savoie Technolac is an ecosystem of businesses, research centres and higher education institutions. This business park is home to 230 innovative companies, half of which are in the energy sector, providing 3,500 jobs and offering an incubator and growth accelerator for innovative companies in the region. The hub also hosts 1,000 researchers and 5,000 students. The Institut des Arts et Métiers de Chambéry has been based on this site since 1995. It is a design, mechanical engineering and environmental institute, making it a pioneer in sustainable design. Its aim is to train future engineers and senior technicians, but also to support the industrial fabric in its transformation towards sustainability and robustness at the local level in order to cope with socio-ecological fluctuations.

The institute specialises in the circular economy, eco-innovation, sustainable design, recycling and recovery channels, regional sustainability, sustainable value assessment and low-tech solutions.

The approach it takes is one of sustainable design: design of goods and services, life cycle engineering, environmental impacts, reuse and eco-innovation. A circular economy approach is also targeted with the environmental assessment of products and services.

The Chambéry Institute offers training programmes ranging from Bac+3 to Bac+8:

- Bachelor's degree in Science and Technology, sustainable design courses. EQF5
- General engineering programme. Third-year specialisation: Eco-design of goods and services.
- Specialised engineering programme: Environment and risk management EQF7

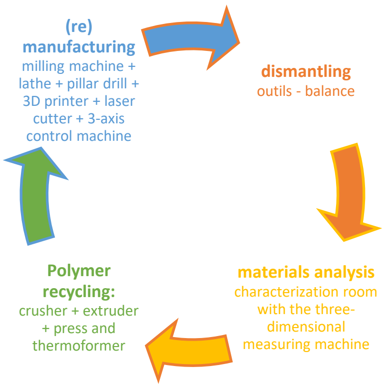
These engineering programmes are aimed at careers in health, safety and environmental engineering, environmental and sustainable development engineering, design engineering, risk management and prevention consulting and auditing, and product and process eco-design engineering.

- Specialised Master's degree: Expert in sustainable construction and housing; Manager of change and sustainable innovation EQF7
- Doctorate - EQF8

5.4. LEARNING FACTORY HISTORY AND DESCRIPTION

In its ambition to be the engineering school of tomorrow's industry, Arts et Métiers has undertaken a process of renewing its educational and technological approach by proposing the concept of the Evolutive Learning Factory (ELF). The aim is to bring together in one place and in a comprehensive approach the equipment, processes and methods encountered during the stages of an industrial product's life cycle: ideation, design, modelling, prototyping, production and ‘end of life’. The facilities will aim to integrate different industrial processes, digital tools, and individual and collective spaces.

In Chambery, the ELF comprises various machine tools adapted to different training programmes, research and companies in the sector. The following cycle is therefore used, with the machines associated with each stage:



The equipment already purchased is: milling machine, a lathe, a pillar drill, a 3D printer, a laser cutter, a three-dimensional measuring machine, a crusher, an extruder.
The equipment currently being financed and purchased is:
a press, a thermoformer, another 3D printer, a three-dimensional measuring machine, a 3-axis control machine

Figure 4 Educational renewal and spin-offs

The main educational objective of the ELF is to renew the training of industrial transition engineers and manufacturing professionals (in the three areas of design, manufacturing and organisation). These professionals will need to be able to integrate technological innovations, particularly those related to Industry 4.0, and to support companies in their digital and sustainable transformation. Supported by state-of-the-art technical platforms representative of Industry 4.0, the teaching methods developed will reduce the gap between training situations and work situations, thus facilitating the transfer of knowledge. The definition of objectives using a skills framework, in particular the CDIO (Conceive Design Implement Operate) approach, strengthens the links between the training context and the work context.

The Evolutive Learning Factories (ELF) project is one of the structuring projects of the École Arts et Métiers. As such, its progress is systematically presented to the School's governing bodies: the Territorial Council, the Scientific Council, the Council for Studies and Student Life, the Management Committee, the Executive Committee and the Board of Directors.

To ensure the effective deployment and monitoring of the ELF project, the management has set up specific bodies such as the School's Deputy General Management: its mission is to make the ELF project operational and to liaise with the school's management bodies. The ELF committee on each campus: implements the national strategy by integrating the national ecosystem.

5.5. STUDY PROGRAMMES

As part of the LF4VET project, two degrees will be studied in depth:

1. The Bachelor's degree in Science and Technology, sustainable design courses. This is an EQF level 5 degree, the target audience is high school graduates and the system is work-study.

- Year 1:

- Scientific and technological teaching based on the design and production of innovative technological products (3DEXPERIENCE CAD software, machining and rapid prototyping machines)
- Case studies and project-based activities (simulation of an electric battery production line)
- Practical training in industrial environments

- Year 2:
  - Teaching focused on product, process and energy engineering (Ansys Granta software)
  - Eco-design tools to reduce the environmental impact of products and processes (SIMAPRO and Open LCA environmental assessment software)
  - Projects related to battery life cycles with industrial partners

- Year 3:
  - Development of scientific and technical skills
  - Teaching on eco-innovation, sustainable development and the circular economy
  - Project leadership and management

Career opportunities

Intermediate management positions:

- production or maintenance team leader,
- eco-design project manager,
- industrial technician,
- production technician,
- maintenance technician,
- design office technician…

Targeted skills

- SKILL SET 1: Designing and manufacturing innovative products
  - Skill 1: Develop specific specifications to meet stakeholder needs
  - Skill 2: Select materials and manufacturing methods to meet specifications
  - Skill 3: Design parts and assemblies to meet specifications
  - Skill 4: Manufacture parts and assemblies to meet specifications
- SKILL SET 2: Implementing and optimising the operation of an industrial system
  - Skill 1: Implementing an industrial system to enable the production, management in use and end-of-life recovery of products and their raw materials
  - Skill 2: Ensure the continuous improvement of production methods and processes to guarantee production quality, operator safety, cost and deadline compliance, and consideration of socio-environmental issues
- SKILL SET 3: Deploy tools and approaches aimed at reducing the socio-environmental impacts of products and services throughout their life cycle from a systemic perspective
  - Skill 1: Integrate systemic socio-environmental issues when framing a project to meet current and future challenges
  - Skill 2: Analyse the entire life cycle of a product or service in order to improve its socio-environmental impacts
- SKILL SET 4: Integrating into a technical industrial project within a multidisciplinary team

- Skill 1: Supporting an engineer in managing a multidisciplinary team to achieve the objectives set
- Skill 2: Supporting an engineer in steering an industrial project to meet customer needs

Scope of application

All stages of designing and manufacturing innovative products; setting up and optimising the operation of an industrial system; deploying tools and approaches aimed at reducing socio-environmental impacts; integration into a technical industrial project within a multidisciplinary team.

Target sectors

All companies designing or manufacturing products, or design offices.

2. The Eco-design of Goods and Services programme, third-year specialisation of the general engineering degree. The EQF level is 7, and the target audience is engineering students at the school.

- Module 1 - Overview of environmental issues and resources in our modern societies. Interactions between the economy, the environment and society. Consequences and prospects for economic actors in product development models.
- Module 2 - Environmental assessment of products and services: Develop a carbon footprint (CF) and/or life cycle assessment (LCA) for a product or service, assess the impacts in order to improve the company's environmental performance.
- Module 3 - Eco-innovation and eco-design methods and tools: Acquire methods and tools for integrating environmental parameters into the different phases of product design in order to reduce its environmental impact throughout its life cycle.
- Module 4 - The different levers of eco-design: Reflect on the management of the materials that make up the product in order to optimise production through sustainable processes and anticipate end-of-life (recycling, recovery, etc.). Low-tech approach. New business models.

Career opportunities

- Eco-design engineer
- Sustainable innovation engineer
- Sustainable product development engineer
- Industrial strategy consultant
- Environmental analysis consultant

Targeted skills

Engineers who choose the ‘EcoBS’ option have the following specific skills:

- • Selecting and implementing methods for assessing the environmental impact of products and services in order to take into account, from the design stage onwards,
- • Reduce these impacts throughout the entire life cycle,
- • Integrate tools into a company and its design process that enable the sustainable application of eco-innovation and eco-design approaches,
- • Lead an eco-innovation and eco-design initiative,
- • Implement the concepts of functional economy and circular economy.
- • Create and develop eco-innovative companies.

Scope of application

All stages of design, production, development and deployment of goods and services.

Target sectors

All companies that design or produce products and services. Research organisations, technical centres, chambers of commerce, organisations.

5.6. WORKPLACE SITUATIONS

5.6.1.GENERAL INGENEER PROGRAM ECOBS 3RD YEAR TRAINING AS PART OF THE CORE PROJECT: DISMANTELING

During a practical entitled 'TP de démantèlement' (Dismantling Practical), students will have to dismantle an end-of-life product, which will require them to:

- Use the various machines/tools available to them in the training factory, depending on the object chosen, and also;
- Mobilise several skills across different disciplines (multidisciplinarity).

OBJECTIVES:

- Dismantle an end-of-life product from A to Z (using the necessary tools and machines in the training factory)
- Produce data for more in-depth studies:
  - Deliverable 1: Dismantling tree (link to the eco-design course)
  - Deliverable 2: Parts list (link to the life cycle analysis course)
  - Deliverable 3: End-of-life sector diagram (link to the course on product end-of-life)
- Identify barriers to circularity and recyclability
- Propose areas for improvement/development in design and for the sector

SKILLS DEVELOPED (and assessed using skills assessment grids):

Product studied: Waste Electrical and Electronic Equipment (WEEE)

Main skill:

• Study the circularity of end-of-life waste electrical and electronic equipment (WEEE) by dismantling it, creating a dismantling tree and a parts list, in order to assess its current and potential recycling rates and their regulatory compliance, and to suggest ways to improve the barriers to circularity

Targeted learning outcomes:

- Dismantle waste electrical and electronic equipment (WEEE) in accordance with safety instructions (wearing PPE, using appropriate tools, behaving responsibly) to separate it into sub-assemblies, then single-piece and single-material parts
- Collect data useful to end-of-life and recycling stakeholders, such as dismantling time, types of connections (removable, non-removable, destructive), the functions of sub-assemblies and the identification of materials
- Create a dismantling tree that summarises this data in a clear and structured manner, in order to identify the variety of materials and connections, as well as the obstacles to circularity that could be addressed through eco-design
- Create a nomenclature (parts, materials, masses, processes) that will be used as the basis for a complete life cycle analysis

- Calculate the different recycling rates for the current product (collection, treatment, reuse) using literature from eco-organisations and ADEME, and compare them with potential recycling rates using improved dismantling scenarios
- Explain and justify current and potential end-of-life scenarios by verifying their compliance with regulations
- Identify the main pollutants and critical materials (flame retardants, Critical Raw Materials Act, etc.) to study their possible targeted extraction

5.6.2. BACHELOR'S DEGREE IN SCIENCE AND TECHNOLOGY, SUSTAINABLE DESIGN

Each semester corresponds to an object to be created from scratch by students using the machines in the teaching workshop (laser cutting, 3D printer, etc.) and in line with the resources mobilised (disciplines), the skills targeted and taking into account the different levels of difficulty.

This diagram summarises this authentic assessment situation over a semester:

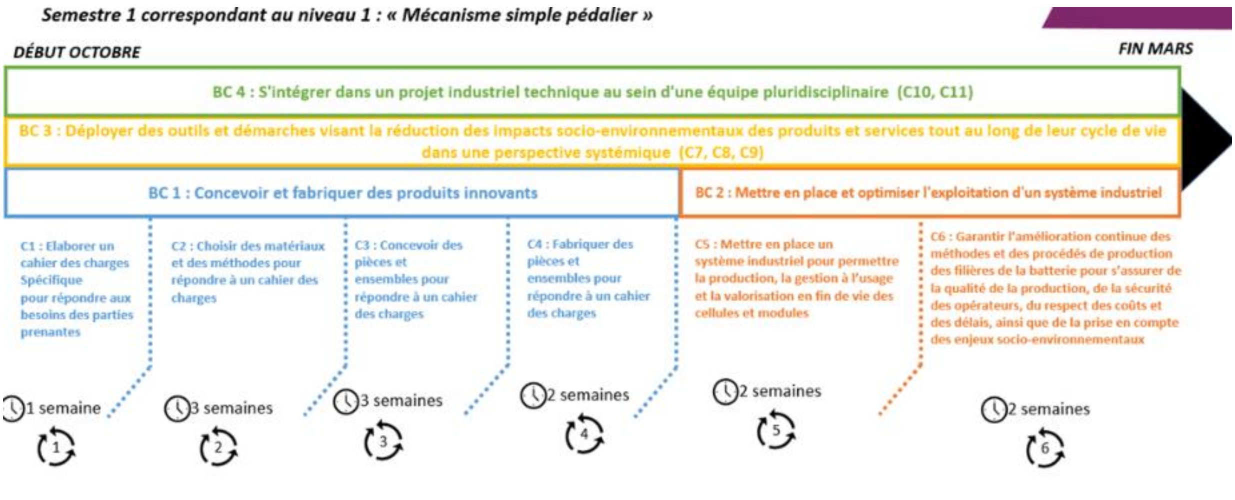


Figure 5 Assessment situation over a semester

In order to create this pedal set, students will need to use skills appropriate to the level of difficulty required and make use of tools/machines. These skills will be assessed using assessment grids. If the required level is not achieved for one or more skills, it will be possible to re-validate the semester the following semester, as the cycle starts again but with a new, more complex object.

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6. MONOGRAPHY TEACHING FACTORY COMPETENCE CENTRE (GREECE)

This section describes the geographic, socioeconomic and industrial characteristics of Greece and, more specifically, the Region of Western Greece, to contextualise the Teaching Factory Competence Centre (TF-CC). It highlights the country's digital transformation priorities, labour-market dynamics and the emergence of Learning Factory initiatives. The section then introduces TF-CC's mission, technological facilities and programme portfolio, illustrating its role in strengthening industry-education collaboration in advanced manufacturing. The monography is built following the Framework for Interdisciplinary Training in Learning Factories

6.1. GEOGRAPHICAL AND LABOUR STRUCTURE CONTEXT

Greece is situated in Southeastern Europe and features a mixed economy where the service sector contributes the largest share of gross domestic product (GDP) (Statista, n.d.), but manufacturing and industrial activities remain strategically important for regional development and technological transformation (International Trade Portal, n.d.). In recent years, national strategies and European funding programmes (The Digital Europe Programme, n.d.) have made efforts to accelerate the digital transformation and competitiveness of Greek industry, placing emphasis on digital and advanced manufacturing technologies, as well as the development of the workforce to support these transitions (Digital Transformation Programme 2021-2027, n.d.).

Greece faces ongoing challenges related to skills mismatches between labour supply and industry needs(Skills Mismatch in the Greek Labour Market, 2021), particularly in technical and digital areas. Employer surveys indicate that a significant share of firms struggle to find workers with the required specialised skills, in manufacturing and production as well as in engineering roles, highlighting the need for improved upskilling and reskilling measures across the economy(EKathimerini.Com, n.d.).

6.1.1.GEOGRAPHICAL & LABOUR STRUCTURE CONTEXT - WESTERN GREECE

The Region of Western Greece is an administrative region in the western part of mainland Greece, composed of Achaea (with Patras as its capital), Aetolia-Acarnania and Ilia. It covers about 11,350 km² and has a regional population of roughly 640 000 inhabitants. Economically, Western Greece has traditionally relied on primary and tertiary sectors, with agriculture and services dominating value added and employment. The manufacturing sector exists but is relatively limited, concentrated in low- to medium-technology industries such as food and beverages, construction materials and basic chemical products. SMEs (micro, small, medium enterprises) make up over 97 % of the business base, yet productivity and innovation remain constrained(CTI, n.d.).

The labour market in Western Greece reflects broader Greek labour trends: employment rates sit around 45 % of working-age adults, slightly below the national average but with lower unemployment (≈ 9.8 % in 2023). Youth and female employment rates remain particularly low(EURES, 2025). Patras, the regional capital and third-largest city in Greece, functions as a commercial and transport hub due to its port and the Rio-Antirrio bridge, and hosts three universities contributing to a significant student population and scientific/technological activity.

While services dominate the city's economy, manufacturing persists in sectors such as cement, timber, paper, packaging, industrial equipment, and food processing (including breweries, soft drinks and dairy). Export-oriented firms like bike manufacturing and industrial equipment underscore Patras's industrial presence.

6.1.2.REGIONAL HISTORICAL & SOCIO-ECONOMIC CHARACTERISTICS

Historically, the region's economy has been less industrialized than other European regions, with much of the workforce employed in agriculture or services. The industrial base has struggled to scale up due to structural issues such as outdated infrastructure, skills gaps, and limited innovation integration. Economic strategies at the regional and national level have sought to reverse this by promoting digital transformation, innovation and smart specialization policies (e.g., Regional Smart Specialization Strategy "RIS3") focusing on agri-food & advanced manufacturing as priority sectors(Εθνική Στρατηγική Έξυπνης Εξειδίκευσης, 2024). Development programmes under the Greece 2.0 Recovery Plan and regional operational programmes have dedicated funds to support modernizing manufacturing, digitalization, automation and industry-oriented skills development, reflecting the perceived need to align regional employment with evolving technological demands("Next Generation EU," n.d.).

6.1.3.CHOICE OF ECONOMIC SECTOR: MANUFACTURING

Given the regional context, the manufacturing sector is a critical choice for analysis, notably due to its role in socio-economic development, labour absorption and links to educational pathways such as vocational training and technical education. Manufacturing in Greece constitutes about 8% of national GDP, which is lower than the European average but still significant in terms of employment and economic impact. It has been identified as a vital sector that offers stable employment, higher salaries relative to some other sectors and strong multiplier effects in the wider economy(HELLENIC PRODUCTION, n.d.). Manufacturing, at national level, accounts for approximately 11-12% of total employment and remains one of the core productive sectors after trade and tourism.

In the Western Greece, the industrial base of the region is characterised primarily by food and beverage manufacturing linked to agricultural production (olive oil, wine, fruit processing and packaging), cement and construction materials, metal products, energy supply and oil refining. The sector's structure is also characterised by small and medium enterprises (SMEs), family-owned businesses, and some larger firms in strategic locations(BBioNets Platform, n.d.). A flagship industrial installation in the region is the Motor Oil Hellas refinery in Corinth, one of the largest industrial complexes in Greece and a major employer both directly and indirectly. Industrial representation and coordination are supported by organisations such as the Federation of Industries of Peloponnese and Western Greece, which promotes competitiveness, investment and innovation across the wider regional industrial ecosystem.

Over the past years, the evolution of the sector has been shaped by three main dynamics. First, there has been gradual stabilisation and recovery following the financial crisis period, with renewed investments supported by European Structural Funds and national development programmes. Second, there is increasing integration of digital tools, automation systems and optimisation technologies within production processes. Third, the sector is progressively aligning with sustainability requirements, including energy efficiency improvements, environmental compliance and circular economy practices. Manufacturing labour demand in the region has experienced fluctuations due to broader economic trends, demographic shifts, and the ongoing digital transformation of production processes. Across Greece, employment in manufacturing saw declines during the economic crisis period but has recently experienced relative stabilisation and modest growth, particularly in sectors aligned with export markets and industrial services.

From a labour skills perspective, manufacturing increasingly requires a combination of technical and digital competencies. Skills related to advanced production technologies, automation, quality control, supply chain management, and sustainability practices are becoming progressively more important, especially as firms adopt Industry 4.0 and Industry 5.0 paradigms. This trend underscores the importance of targeted training and education to bridge existing skills gaps within the regional workforce. Academic and policy literature emphasises the need for upskilling initiatives and integration of digital manufacturing curricula in vocational and higher education to enhance employability and firm competitiveness (Gwen, 2025).

6.1.4.INDUSTRY 4.0 AND DIGITAL SKILLS IN GREECE

Digital transformation has been identified as a key priority for economic competitiveness in Greece. According to data from the Digital Skills and Jobs Platform, Greece's share of individuals with basic digital skills remains slightly below the EU average, and the proportion of ICT specialists in employment is lower than the European benchmark, though there is gradual progress in digitalisation among SMEs (*Greece | Digital Skills and Jobs Platform*, n.d.). National initiatives such as the Greece National Digital Decade Strategic Roadmap seek to increase digital skill levels throughout the population and the workforce, underscoring the need to strengthen both basic and specialised digital competences to support industrial transformation(National Digital Decade Strategic Roadmap, n.d.).

At the policy level, the Greek Ministry of Labour has also introduced a national skills strategy aligned with European priorities, stressing the importance of improving digital skills, fostering innovation and supporting the circular economy. A key objective of this strategy is to reduce skills mismatches by addressing skills needs at sectoral and regional levels(CEDEFOP, 2024). Initiatives such as **Greece4.0**, a national excellence network for digital transformation in manufacturing, demonstrate ongoing efforts to promote the adoption of Industry 4.0 technologies, such as digital twins, industrial IoT, robotics and advanced data analytics, within Greek industry. These initiatives complement the skills development agenda by fostering collaboration between industry, research institutions and training providers to address the needs of modern manufacturing.

Overall, the Greek industrial and labour market context is characterised by **growing digitalisation**, an increasing demand for technical and digital skills, and **persistent mismatches** between the skills supplied through existing education and training pathways and those required by employers. These conditions underscore the importance of strengthening vocational education and training, especially in manufacturing-related fields, and aligning it more closely with real industrial needs.

6.1.5.LABOUR MARKET TRENDS AND DEMAND FOR TECHNICAL SKILLS

Forecasts for future employment patterns in Greece emphasise a growing demand for **medium- and high-level qualifications**. By 2035, a majority of job openings are expected to require at least medium-level technical and specialised skills, while demand for low-qualified roles continues to decline. This trend reflects structural changes in the economy that favour **technology-intensive and digital-enabled occupations**, reinforcing the need for targeted skills development pathways in technical education and training(CEDEFOP, 2025). In addition to high-level skills projections, surveys of Greek employers show that around one-third of companies have difficulty hiring employees with the right manufacturing, production and engineering skills, confirming a **persistent skills gap** in sectors directly linked to Industry 4.0 and advanced production environments.

The evolution of labour demand in the Region of Peloponnese is increasingly shaped by the dual pressures of digitalisation and sustainability, in alignment with the Regional Smart Specialisation Strategy (RIS3)(Οριζόντιοι Υποστηρικτικοί Τομείς – RIS3, n.d.). The Region prioritises the development and deployment of automation systems, optimisation tools, Life Cycle Assessment (LCA) methodologies, energy management systems, Building Energy Management Systems (BEMS), digital tools and value chain optimisation mechanisms to support the agro-food and tourism sectors. The adoption of these technologies directly reshapes occupational roles and required competences.

Maintenance technicians are increasingly required to interact with automated production systems, condition monitoring technologies and digital dashboards. Their role now includes interpreting sensor data, supporting predictive maintenance strategies and contributing to system optimisation processes. Production operators are expected to understand quality analytics, operate digitally controlled machinery, and perform basic system configuration tasks within integrated cyber-physical production environments(CNN.Gr, 2025). The use of optimisation systems and digital performance monitoring tools requires a higher level of data literacy than in traditional production settings.

Technical staff must combine mechanical, electrical and digital competences, reflecting a transition toward hybrid mechatronic profiles. The implementation of energy systems, BEMS, environmental monitoring tools and LCA-based sustainability assessment frameworks requires personnel capable of understanding both technical infrastructure and environmental performance metrics. Moreover, the introduction of value chain optimisation tools and logistics optimisation systems expands skill requirements beyond production processes to include supply chain analysis, resource efficiency assessment and sustainability-oriented decision-making.

Beyond technical expertise, transversal competences are increasingly critical. The complexity of automation systems and cyber-physical infrastructures requires strong problem-solving abilities, adaptability to technological change, teamwork in interdisciplinary environments and continuous upskilling. Evidence from Eurofound and Cedefop (2025) indicates that SMEs across Europe identify skills shortages as a major barrier to investment and digital transformation. Given that the productive structure of Western Greece is dominated by SMEs, this challenge is particularly relevant for the region.

6.2. HISTORY OF LEARNING FACTORIES IN GREECE

In Greece, the concept of **Learning Factories** has gradually emerged over the past decade as part of broader efforts to modernise technical and vocational education and to better align it with the needs of industry. The Learning Factory paradigm builds on the idea of applied, practice-oriented learning environments that simulate real industrial systems and processes, enabling learners to acquire hands-on experience with contemporary manufacturing technologies.

The **Teaching Factory** concept, in particular, has been introduced and discussed in the Greek educational and industrial ecosystem as an approach inspired by the "teaching hospital" model, aiming to bring students, educators and industrial stakeholders together around real production challenges. This approach has been highlighted as a means to strengthen the connection between education and manufacturing practice, especially in the context of Industry 4.0 and digital transformation(Business Daily, 2021).

Initial Learning Factory-related initiatives in Greece were primarily developed within **universities and applied research laboratories**, often supported by European funding instruments, where pilot manufacturing environments focusing on automation, robotics and digital production were integrated into engineering education. Over time, these initiatives evolved to include structured collaboration with industry and participation in European networks and projects addressing advanced manufacturing skills.

More recently, the establishment of dedicated structures such as the **Teaching Factory Competence Center (TF-CC)** has contributed to consolidating the Learning Factory framework in Greece. TF-CC operates as a competence centre explicitly oriented towards the Teaching Factory paradigm, facilitating collaboration between academia, industry and training providers and supporting the dissemination of advanced manufacturing technologies and skills through hands-on training and pilot activities(TeachingFactory-CC, n.d.). Overall, while Learning Factories in Greece are still evolving, there is a clear trajectory toward their increased adoption as effective tools for vocational and professional training.

6.2.1.ORGANISATION CONTEXT - TEACHING FACTORY COMPETENCE CENTER

Teaching Factory Competence Center (TF-CC) is a Greek competence center focused on strengthening the connection between education, research and industry in the field of manufacturing and advanced technologies. TF-CC operates as a **Teaching Factory**, a model designed to integrate **innovative Industry 4.0 technologies** into training and industrial practice by enabling knowledge exchange between academia and industry stakeholders and by exploiting research results towards industrial applicability in pilot settings.

Organisation Profile

TF-CC's core mission is to create **added value for services and products of manufacturing companies** through research-driven innovation and education. This is achieved by fostering collaboration between academic institutions and industrial partners, including end-users, manufacturers, machine builders, system integrators and software providers, which together form a broad ecosystem of expertise under the TF-CC umbrella. Its activities aim to promote technological adoption, problem-solving and workforce development in areas critical to the digital transformation of manufacturing.

TF-CC's strategic objectives include:

- **Enabling knowledge sharing** between academia and the national industry
- **Integrating Industry 4.0 technologies** such as Artificial Intelligence (AI), robotics, digital twins and Internet of Things (IoT) into manufacturing
- **Supporting upskilling and reskilling** of professionals to meet current and future industry demands
- Translating research results into industrially applicable solutions through pilot activities and consulting services.

TF-CC also engages actively in European talent and innovation ecosystems, for example, it has pledged support to the **EIT Deep Tech Talent Initiative**, which aims to boost deep tech competency and equip the workforce with advanced technological skills relevant to modern manufacturing.

6.2.2. TEACHING FACTORY PARADIGM AND ACTIVITIES

The **Teaching Factory paradigm** implemented by TF-CC combines theoretical education with real industrial challenges. It follows a model where training is structured around **industry-relevant problems, hands-on learning and hybrid modes of instruction (both in-person and remote)**. Through this approach, the centre delivers tailored training services, familiarises learners with advanced technologies, and supports implementation of solutions in real world contexts.

TF-CC provides a portfolio of services that includes:

- **Training Services** on digital manufacturing, automation, additive manufacturing and other Industry 4.0 technologies, certified to international quality standards (e.g., ISO 29993:2018). These courses are designed to enhance participants' technical competencies and support professional development.
- **Technical Services and Consulting** to help manufacturing firms upgrade processes, adopt new technologies, and improve production efficiency.
- **Knowledge-based Support** through access to technical documentation, studies, and practical demonstrations that support both learners and industry professionals.

6.2.3. TEACHING FACTORY FACILITIES

TF-CC's facilities are based on the **Teaching Factory concept originally developed by the Laboratory for Manufacturing Systems and Automation (LMS)** and include technology areas such as robotic assembly and handling cells, additive manufacturing cells, and digital twin platforms. These environments are used both for training and for conducting pilot activities that bridge education and industrial practice. Such facilities allow learners to gain **practical experience with real industrial equipment**, while enabling the centre to work closely with companies to identify technological needs and co-design solutions tailored to sectoral challenges.

6.3. SAMPLE OF STUDY PROGRAMMES

Below, four representative training programmes have been selected from the Teaching Factory Competence Center portfolio. The selected programmes address both technical and human-centric competences and respond to regional labour market needs in digital manufacturing, automation, and occupational safety.

6.3.1. INDUSTRY 4.0 TECHNOLOGIES FOR HEALTH AND SAFETY IN WORKPLACES

This programme focuses on the integration of advanced digital technologies into occupational health and safety practices within industrial environments. It addresses the growing need for engineers and technical staff capable of combining digitalisation strategies with ergonomic and safety-oriented workplace design. The training adopts a blended learning structure (20 hours theoretical instruction, 10 hours hands-on training, and 10 hours consultancy-oriented reflection). It introduces participants to Virtual Reality (VR) systems, IoT-based sensorial technologies, and digital monitoring tools that enable the simulation and optimisation of production environments before physical implementation.

A strong emphasis is placed on human-centred manufacturing principles. Participants analyze inefficient layouts, identify bottlenecks and congestion points, and evaluate safety risks using ergonomic assessment tools. Through human tracking systems and safety-distance calculation models, they develop competences in hazard identification and preventive system design. The program primarily targets engineers, design engineers, and technically oriented students.

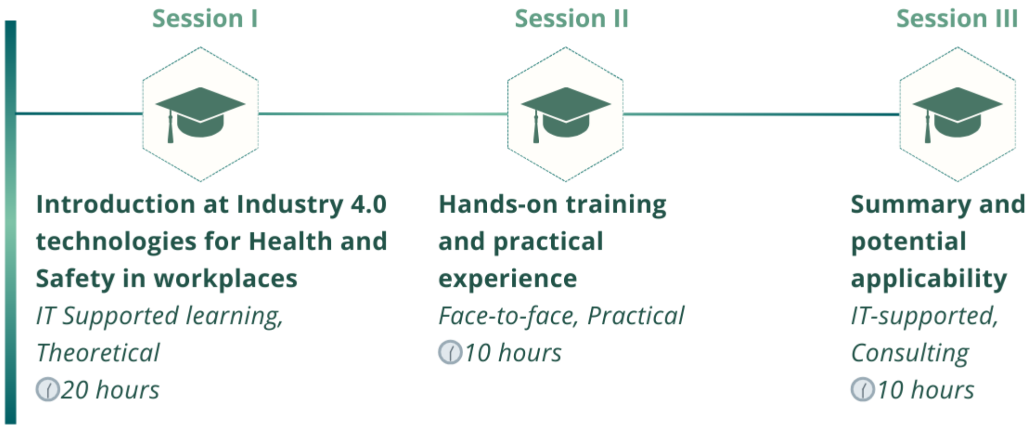

Figure 6 6.3.1. Training programme Industry 4.0 technologies for health and safety in workplaces

6.3.2.FIRST AID AT WORK

The “First Aid at Work” training programme is designed to strengthen emergency preparedness and safety culture within industrial and organisational environments. It is primarily addressed to companies wishing to train their employees in first aid provision, while individual participants may also attend upon group formation. The programme supports organisations in developing internal capacity to respond effectively to workplace incidents, contributing to safer and more resilient working environments.

The training follows a blended learning structure combining synchronous and asynchronous theoretical instruction with face-to-face practical application and consultancy support. Participants acquire essential competences in Basic Life Support (including CPR and AED use), bleeding control techniques, trauma management, safe immobilisation and transport of injured persons, and management of musculoskeletal injuries. Emphasis is placed on scene safety, rapid assessment, and appropriate response in industrial contexts.

Beyond technical first-aid procedures, the programme promotes situational awareness, responsibility, and confidence in emergency decision-making. By combining structured theoretical learning with hands-on practice using specialised equipment and guidance from qualified instructors, the training enhances both individual skills and organisational safety culture.

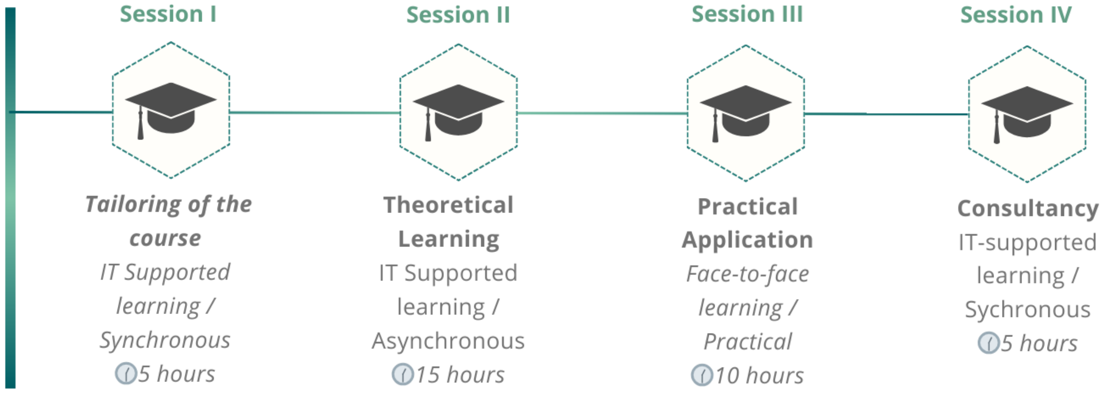

Figure 7 Training program first aid at work

6.3.3.AUTONOMOUS COLLABORATIVE ROBOTS

This training programme is designed to support industries seeking to advance their digitalisation strategies and lean manufacturing practices through the integration of collaborative robotic systems. It targets production engineers, operations managers, safety engineers, system integrators, and technically oriented students who are involved in automation projects or production system optimisation.

The programme combines theoretical instruction with hands-on practical training and consultancy-oriented sessions. It develops advanced competences in collaborative workplace design, task and motion planning, and safe human-robot interaction (HRI). Participants explore enabling technologies such as wearable devices, augmented reality, sensing systems, digital twins, data management platforms, and AI-based vision systems, including deep learning applications for perception and object recognition.

A strong emphasis is placed on safety, risk reduction, and human-centric production environments. Through practical applications, participants design and evaluate collaborative workstations, integrate decision-making tools and control devices, and assess innovative HRI solutions such as speech recognition and force-sensitive interfaces. Overall, the programme equips learners with the analytical and technical capacity to implement collaborative robotic solutions in complex industrial contexts.

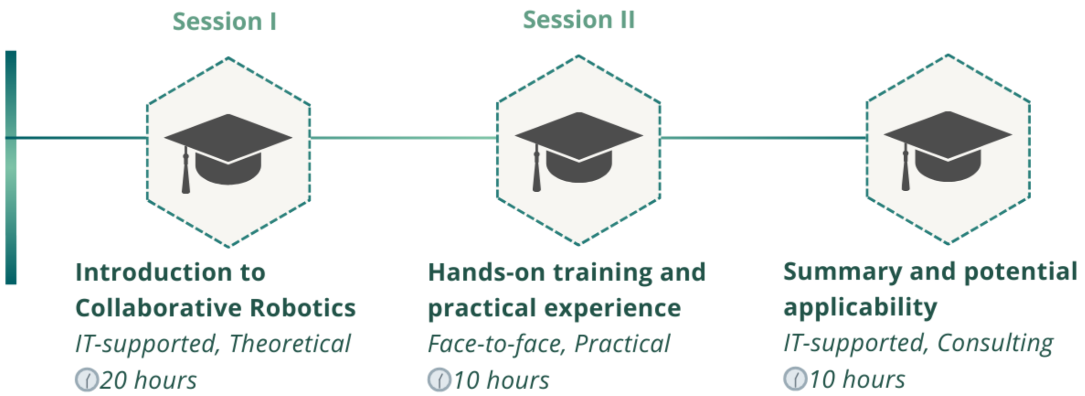

Figure 8 Training programme Autonomous collaborative robots

6.3.4.ADDITIVE MANUFACTURING

The Additive Manufacturing (AM) training programme provides a comprehensive introduction to advanced, non-conventional manufacturing technologies, combining theoretical knowledge with practical application. Structured in progressive modules, the programme guides participants from fundamental AM principles and process groups to design optimisation and real-world industrial implementation. It is addressed to production engineers, design engineers, industry professionals, and students seeking to strengthen their competences in digital and flexible manufacturing systems.

Participants are introduced to AM technologies, materials, post-processing techniques, and the business perspective of additive manufacturing. Emphasis is placed on Design for Additive Manufacturing (DfAM), simulation of part quality issues, and optimisation of process parameters. Through a hands-on pilot case, learners design, prepare, and manufacture a component using AM equipment, consolidating both technical and analytical skills. Overall, the programme equips participants with the capacity to evaluate and implement AM solutions within industrial contexts.

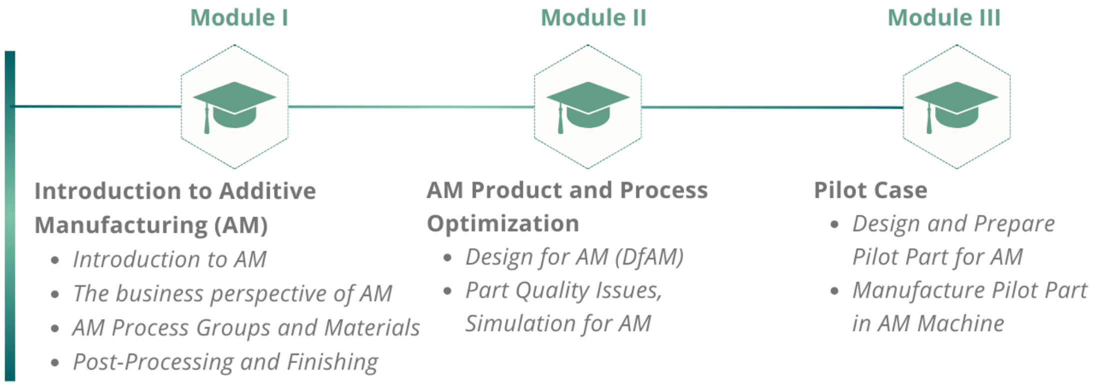

Figure 9 Training programme additive manufacturing

6.4. WORKPLACE SITUATIONS

6.4.1.HEALTH AND SAFETY IN THE CONTEXT OF INDUSTRY 4.0

The “Health and Safety in the Context of Industry 4.0” course is designed for engineers, operators, and safety professionals, seeking to incorporate or extend the digitalization and lean manufacturing concept, by enriching industrial equipment and services with cutting-edge technologies. This course focuses on the utilization of advanced technologies, such as Virtual Reality (VR) and the Internet of Things (IoT), to enhance health and safety in industrial settings. Participants gain both theoretical knowledge and practical experience, familiarizing themselves with these technologies and their potential applications. As main learning goals, learners familiarize themselves with Industry 4.0 technologies through demonstration and hands-on training of three applications: a) ergonomics-based workplace design, b) ergonomics analysis in production station using IoT sensorial system and, c) human tracking for enabling zero access areas and notify human in high-risk zones. The participants:

- gain expertise in the use of Virtual Environment for production design and training
- gain a deeper understanding of ergonomic assessment
- familiarize with technologies for human tracking for enabling zero access areas and notification in high-risk zones

- get prepared for practical, tailored solutions for specific pilot cases, that improve product design and manufacturing efficiency
- explore and evaluate solutions to innovate towards reducing working accidents, minimizing and efficiently addressing risks (especially new and emerging)

The course is conducted in hybrid mode, with online sessions for the theoretical and consulting part, and the opportunity of hands-on experience in Teaching Factory Competence Center facilities. Through the hands-on session and in-depth technical discussions, this course empowers participants to drive innovation and improve safety in their workplace, while cultivating a strong Safety Culture. This hybrid approach that Teaching Factory Competence Center provides, aims to facilitate the integration of technologies in the real industrial environment and ensure a higher impact of training.

6.4.2.TF PILOT – COLLABORATIVE MACHINE TOOL DESIGN

A "factory-to-classroom" operating scheme was envisioned involving the adoption of an industrial-driven project. The goal of this pilot was to implement a Teaching Factory between an academic and an industrial partner. The Teaching Factory pilot involved a "real-life" engineering challenge which was elaborated by engineering students. Two teams, each with four young engineers, were formed. The Teaching Factory pilot consisted of five sessions in which student teams used video conferencing equipment to communicate with expert engineers. The Teaching Factory pilot topic was the design of a Multi-Technology-Platform (MTP) machine tool, consisting of a 5-axis milling center "Mill 2000," which is equipped with a milling spindle, and two identical and simultaneously utilized working spaces "WS1" and "WS2" on either side of the milling center. Industrial work is approached through a weekly cycle of sessions, which includes support classes, project work and live interactions with the factory. A weekly cycle of sessions is used to approach industrial activity, which includes support classes, project work, and live contact with the factory. A strong interaction with the factory characterizes each work session. Depending on the problem's topic, this interaction may involve discussions, presentation sharing, live production videos, and other knowledge delivery mechanisms. Students should undertake project work in between live sessions, which may include experimenting or analysing data to come up with conclusions and new solutions. An academic supervisor oversees the support courses and is also responsible for initiating talks and offering directions for finding solutions. The pilot consisted of five collaborative cycles in which students worked with indusrty engineers to advance their designs while following the design cycle of the particular industrial practice.

The real-life industrial problem was given to both student teams at the first session, in an interactive session that included a remote video connection with the production plant so that the students could understand that concept, operation, and obstacles involved. In addition, the experts and the student teams discussed various design considerations. The second cycle focused on the definition of design specifications based on the first cycle's requirements. Both teams used specifications, which were followed throughout the design process and are given. Over the third cycle of the pilot, the student teams incorporated the feedback they got from WZL/IPT engineers during the first two cycles to produce an initial design. Each team took a very different approach. The fourth cycle focused on the selected design's detailed dynamic and thermal analysis. For mechanical and thermo-elastic study of their preliminary designs, both teams used finite element analysis techniques. Finally, both student teams presented their iterative design process based on the dynamic and thermal analysis results, resulting in their final solution as a result of this collaborative design process during the fifth cycle. The completion of the Teaching Factory pilot proved to be mutually beneficial for all parties: young engineers gained real-world product design experience, while the industrial partner gained vital knowledge and guidance at various levels. Furthermore, the approaches, methods, and solutions presented by the participating teams were vastly different, demonstrating the value of the Teaching Factory paradigm for both parties: young engineers are challenged to improve their creativity and problem-solving abilities in order to generate novel solutions, while industry gains access to novel ideas, approaches, and solutions.

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7. CONCLUSION AND OUTLOOKS

This report has presented a unified and comparable analysis of four Learning Factories, each described using the Framework for Interdisciplinary Training in Learning Factories. By applying the same structure across regions and institutions, the report demonstrates how diverse VET centres and universities can align their pedagogical, technological, and organisational strategies with regional industrial and labour-market needs. The framework has proven effective in capturing both contextual differences and shared priorities—such as digitalisation, sustainability, human-centric design, and the growing demand for hybrid technical profiles.

Across all four cases, a common pattern emerges: Learning Factories act as strategic infrastructures that strengthen the link between education and industry, enabling learners to acquire real, interdisciplinary, and future-proof competences. They also foster collaboration across departments, support innovation ecosystems, and help regions address skills shortages through authentic, challenge-based training environments. Despite differences in size, sectors, and educational models, all four institutions show that integrating Industry 4.0/5.0 technologies with pedagogical innovation creates powerful learning environments capable of supporting regional transformation.

Looking ahead, several opportunities stand out. Strengthening data-driven practices, enhancing teacher capability, embedding human-centric and sustainable design more deeply, and expanding Learning Factory networks—locally, nationally, and internationally—will be essential to scaling impact. The framework developed in this project offers a solid foundation for future benchmarking, continuous improvement, and strategic planning. As VET systems navigate rapid technological and social change, Learning Factories will continue to play a critical role in preparing learners, educators, and industries for the industrial transitions of the coming decade.

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LEARNING FACTORIES for VET

*Shaping technical skills with **human values***

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