LEARNING FACTORIES for VET

2. LABOUR CONTEXT OF THE ADVANCED MANUFACTURING SECTOR IN THE BASQUE COUNTRY.

WP2 PEDAGOGY OF THE LEARNING FACTORIES FOR VET

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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 Framework
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
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

The Basque Country's industrial strategy aims to maintain competitiveness while addressing societal and environmental challenges through a "triple transition": technological-digital, energy-climatic, and social-sanitary. Advanced manufacturing is central to this strategy, demanding technicians with hybrid skills combining mechanical, electrical, and digital competencies, alongside transversal abilities such as problem solving, teamwork, and adaptability. Demographic ageing and the retirement of experienced workers are increasing recruitment pressures, especially for SMEs.

This report presents the experience of CIFP Miguel Altuna LHII, a vocational education and training centre, focusing on its Ikas Fabrika learning factory. The facility recreates industrial production processes in an educational environment, enabling interdisciplinary collaboration across training programmes. Students engage in product design, manufacturing, logistics, and management activities while using Industry 4.0 technologies including robotics, IoT systems, additive manufacturing, artificial vision, and data management platforms.

Ikas Fabrika demonstrates how learning factories can support the development of technical and transversal skills relevant to advanced manufacturing. By combining real production challenges, collaborative learning, and digital technologies, it provides students with practical experience that reflects the complexity of modern industrial environments while fostering stronger links between vocational education and industry.

1. REGIONAL SOCIOECONOMIC CONTEXT OF THE BASQUE COUNTRY

1.1. STRATEGIC DEVELOPMENT MODEL AND REGIONAL VISION

The labour 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 labour market realities.

1.2. DEMOGRAPHIC CHALLENGES AND LABOUR 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.

2. LABOUR STRUCTURE AND DEMAND IN THE ADVANCED MANUFACTURING SECTOR

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.

2.2. CURRENT LABOUR 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.

Labour 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).

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).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.).

3. •LEARNING FACTORY AT CIFP MIGUEL ALTUNA LHII. IKAS FABRIKA

3.1. 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.

3.2. IKAS FABRIKAREN LAY OUTA

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.

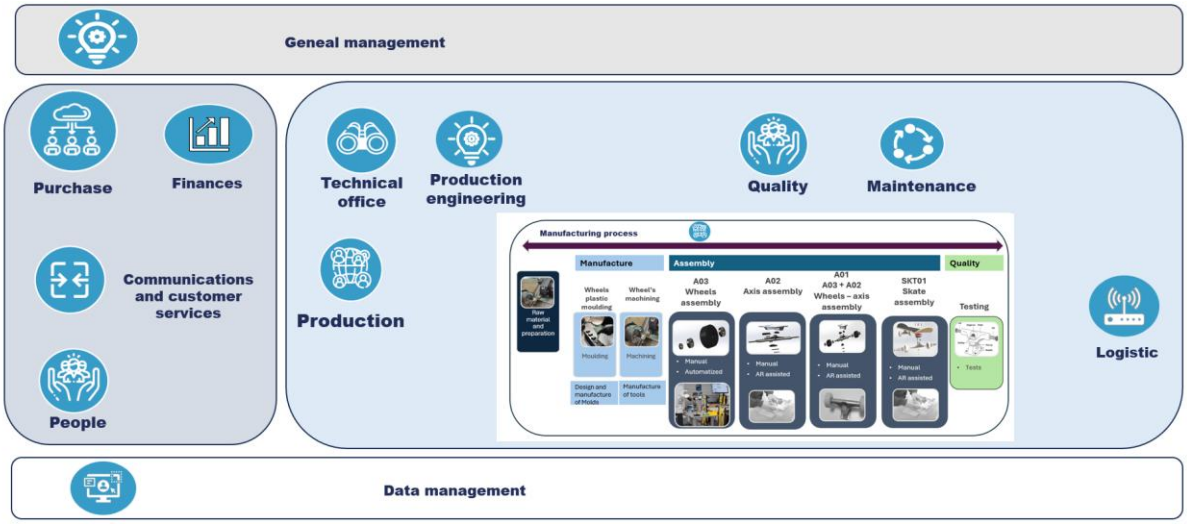

Figure 1 Value chain of the skate manufacturing learning factory

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.

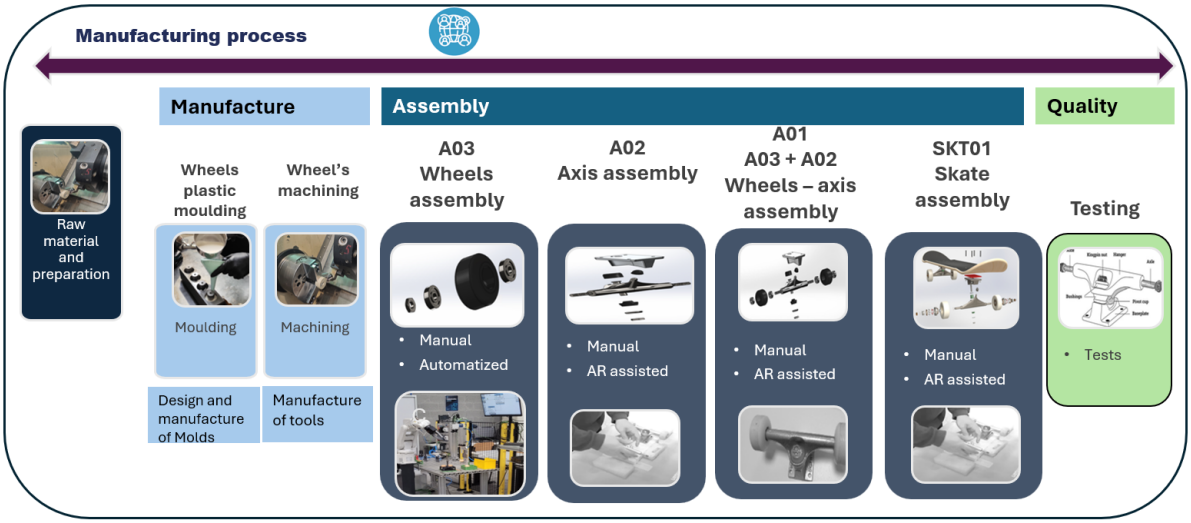

Figure 2 Manufacturing process for the Skate production

3.3. TECHNOLOGIES IN THE IKAS FABRIKA

3.3.1.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.

3.3.2.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.

3.3.3.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.

3.3.4.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.

3.4. 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) assembly workstation, (2) AR-based assembly workstation, (3) programming of AR smart glasses, (4) material preparation and storage, (5) casting control, (6) automated assembly, (7) machining, and (8) automated machining.

3.5. 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.

4. CONCLUSION AND OUTLOOKS

The Basque Country's advanced manufacturing sector, supported by a strategically aligned VET system, demonstrates a strong model for combining industrial competitiveness with social and environmental sustainability. CIFP Miguel Altuna LHII and its Ikas Fabrika exemplify this integration, providing students with interdisciplinary, hands-on training aligned with Industry 4.0 and emerging Industry 5.0 standards.

Looking ahead, several key outlooks emerge:

- **Evolving Skills Requirements:** Continuous adaptation to technological, digital, and green transitions will require VET programs to expand hybrid competencies, combining mechanical, digital, and analytical skills.
- **Data-Driven and Personalized Learning:** Greater emphasis on data management, personalized challenges, and adaptive pedagogy will enhance learning outcomes and workforce readiness.
- **Strengthened Industry Collaboration:** Ongoing partnerships with local and European networks will reinforce alignment with real-time labour market needs, innovation projects, and international best practices.
- **Sustainability and Human-Centric Focus:** Embedding resilience, sustainability, and human-centric approaches in curricula will prepare students to navigate complex industrial environments responsibly and ethically.

These perspectives position the Basque VET system and Ikas Fabrika as pivotal actors in shaping a future-ready workforce while supporting regional industrial transformation.

5. REFERENCES

Abele, E., Metternich, J., Tisch, M., Chryssolouris, G., Sihn, W., ElMaraghy, H., Hummel, V., & Ranz, F. (2015). Learning factories for research, education, and training. *Procedia CIRP*, *32*, 1–6. https://doi.org/10.1016/j.procir.2015.02.187

AFM Cluster. (2025). *Tecnologías avanzadas de fabricación: Datos definitivos 2024–2025*. https://www.afm.es/gestor/recursos/uploads/notas-prensa/2025/07_DATOS_DEFINITIVOS/EN_DATOS_DEFINITIVOS.pdf

Aranguren, M. J., & Navarro, I. (2016). Innovación y cambio en la Formación Profesional del País Vasco. El modelo ETHAZI. *Cuadernos de Gestión*, *16*(1), 153–178. https://doi.org/10.5295/cdg.140492ma

Basque Government. (2021a). *Estrategia para la Transformación Digital de Euskadi 2025*.

Basque Government. (2021b). *Plan de Ciencia, Tecnología e Innovación Euskadi 2030*. Lehendakaritza.

Basque Government. (2024). *Current situation of Basque VET: Meeting the challenges* (February 2024). https://www.euskadi.eus/contenidos/informacion/lh_euskal_plana/eu_def/adjuntos/ENG-CURRENT-SITUATION-BASQUE-VET.pdf

Bridges 5.0. (n.d.). *Teaching and learning factory interventions*. https://bridges5-0.eu/teaching-and-learning-factory-interventions/

CEDEFOP. (2025). Skills forecast: Trends up to 2035. https://www.cedefop.europa.eu/en/tools/skills-forecast

CEDEFOP. (2025). Short-term anticipation of skills and VET demand (STAS).https://www.cedefop.europa.eu/en/data-insights/short-term-anticipation-skills-and-vet-demand-stas

Department of Education of the Basque Government. (2022). *VI Plan Vasco de Formación Profesional* [VI Basque Plan for Vocational Education and Training] [PDF]. Basque Government – Euskadi. https://www.euskadi.eus/vi-plan-vasco-de-formacion-profesional/web01-a2hlanhz/es/

Department of Education of the Basque Government (2026). *Vocational Education and Training Strategy 2030*. https://www.euskadi.eus/contenidos/informacion/estrategia_2030_fp/es_def/adjuntos/ESTRATEGIA_2030_MAKETA_DND_CASTELLANO_PLIEGOS.pdf (in Spanish)

Eurofound & Cedefop. (2025). *SME digitalisation in the EU: Trends, policies and impacts*. Publications Office of the European Union.

Eustat. (2024). Jobs in the Basque Country by A-4 activity branch and province, 2022–2023. https://www.eustat.eus/elementos/tbl0014387_i.html

European Union. (2021). Regulation (EU) 2021/694 of the European Parliament and of the Council of 29 April 2021 establishing the Digital Europe Programme and repealing Decision (EU) 2015/2240. *Official Journal of the European Union, L 166*, 1–34.

European Commission. (2020). *Skills for industry curriculum guidelines 4.0: Future-proof education and training for manufacturing in Europe*. Publications Office of the European Union. https://doi.org/10.2826/519469

European Commission. (2021). *Industry 5.0: Towards a sustainable, human-centric and resilient European industry*. Publications Office of the European Union. https://doi.org/10.2777/308407

European Commission. (2023). *Centres of Vocational Excellence* (Erasmus+ Programme). European Commission. https://erasmus-plus.ec.europa.eu/programme-guide/part-b/key-action-2/centres-vocational-excellence

EUSTAT. (2024). *Population structure: The Basque population grew by 11,262 people in 2024*. Eustat Instituto Vasco de Estadística. https://en.eustat.eus/elementos/not0024469_i.html

EXAM 4.0. (n.d.). *Excellence in Advanced Manufacturing for VET 4.0*. Erasmus+ Project. https://www.exam40.eu/

FPempresa. (n.d.). *Red de centros de Formación Profesional* [Network of vocational training centres]. Asociación de Centros de Formación Profesional FPEmpresa. https://www.fpempresa.net/

Homs, O. (2023). *Detección de necesidades de formación de perfiles del sector de fabricación automatizada*. Ministerio de Educación, Formación Profesional y Deportes.

International Association of Learning Factories. (n.d.). *Conference on Learning Factories (CLF)*. https://ialf-online.com/clf.html

Ikaslan. (n.d.). *Ikaslan Bizkaia: Red de centros públicos de formación profesional*. https://www.ikaslan.eus/

LCAMP Consortium. (2024). *Alignment of VET Offer and Industry Needs in Advanced Manufacturing in the Basque Country (D3.2)*. LCAMP Project.

LCAMP. (n.d.). *About LCAMP*. Learner Centric Advanced Manufacturing Platform. https://www.lcamp.eu/about/

Ley Orgánica 3/2022, de 31 de marzo, de ordenación e integración de la Formación Profesional. Boletín Oficial del Estado, núm. 78, de 1 de abril de 2022.https://www.boe.es/buscar/act.php?id=BOE-A-2022-5132

LF4VET Consortium. (2025). *Learning factories for the pedagogical and digital transformation of VET systems (KA220-VET-4FF3397D)*. Erasmus+ Project Proposal.

Miguel Altuna LHII. (n.d.). Miguel Altuna hosts an international training as part of the Erasmus BIP program. Retrieved from https://maltuna.eus/en/miguel-altuna-hosts-an-international-training-as-part-of-the-erasmus-bip-program/

Orkestra & CaixaBank Dualiza. (2024). *La Formación Profesional ante los retos de sostenibilidad medioambiental en España*.

Orkestra – Instituto Vasco de Competitividad. (2024). Informe de competitividad del País Vasco 2024. https://www.orkestra.deusto.es/es/investigacion/informe-de-competitividad-del-pais-vasco-2024

Real Decreto 279/2021, de 20 de abril, por el que se establece el Curso de especialización en Inteligencia Artificial y Big Data y se fijan los aspectos básicos del currículo [Royal Decree 279/2021 of April 20 establishing the Specialization Course in Artificial Intelligence and Big Data and setting the basic aspects of the curriculum]. *Boletín Oficial del Estado* [Official State Gazette]. https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-7686

Red de Centros de Excelencia de Formación Profesional. (n.d.). *Centros de excelencia*. Ministerio de Educación, Formación Profesional y Deportes. https://www.todofp.es/red-centros-excelencia.html

Roll, M., & Ifenthaler, D. (2021). Learning factories 4.0 in technical vocational schools: Can they foster competence development? *Empirical Research in Vocational Education and Training*, *13*(1), Article 20. https://doi.org/10.1186/s40461-021-00125-6

Scheid, M. (2018). *Learning factories for vocational education and training – Requirements and challenges* [Conference paper]. 8th Conference on Learning Factories, Patras, Greece.

Secretaría General de Industria y de la Pequeña y Mediana Empresa. (2015). *Industria Conectada 4.0: La transformación digital de la industria española*. Ministerio de Industria, Energía y Turismo.

TKNIKA. (2024). *ETHAZI - Collaborative learning based on challenges*. Basque VET Applied Research Centre. https://ethazi.tknika.eus/en/

TKNIKA. (n.d.). *Basque VET network*. Basque VET Applied Research Centre. https://tknika.eus/en/basque-vet/

Tknika. (n.d.). *Smart Collaborative Learning Factories*. https://tknika.eus/en/cont/proyectos/smart-collaborative-learning-factories-3/

Ziarsolo, U., Araiztegui, I., Zubiaurre, A., & Llorente, J. (2024). *Analysis of the evolution of jobs in advanced manufacturing in the Basque Country*. LCAMP Project.

6. INDEX OF FIGURES

LEARNING FACTORIES for VET

Where pedagogy meets technology

Shaping technical skills with human values

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