Learner Centric Advanced Manufacturing Platform

Alignment of VET Offer and Industry Needs in Advanced Manufacturing in the Basque Country

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GLOSSARY AND/OR ACRONYMS

AR - Augmented Reality
ARM- Advanced Robotics for Manufacturing
BDIH- Basque Digital Innovation Hub
BAIC - Basque Artificial Intelligent Center
CEDEFOP- European Centre for the Development of Vocational Training
CMMS- Computerised Maintenance Management Systems
CNN - Convolutional Neural Networks
CLF - Collaborative Learning Factory
CoVE - Centres of Vocational Excellence
DFMA - Design Failure Mode & Effect Analysis
EFNMS- European Federation of National Maintenance Societies
EQF - European Qualifications Framework
ERP - Enterprise resource planning
FoF- Factory of the future
HVET - Higher Vocational Education and Training
IoT- Internet of Things
IT - Information Technology
MES- Manufacturing Execution System
OECD- Organisation for Economic Co-operation and Development
VET - Vocational Education and Training
SME- Small and Medium sized Enterprises
ZDM- Zero Defect Manufacturing
MES- Manufacturing Execution System
RPL Recognition of Prior Learning
SME- Small and Medium-sized Enterprises

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EXECUTIVE SUMMARY

This report analyses from a regional perspective, four key occupational profiles in advanced manufacturing by identifying the skills gaps, assessing the alignment between VET programmes and industry needs, and evaluating how well students are prepared for real-world challenges. It reviews emerging skill needs, existing training pathways, and company strategies, and explores how collaboration between VET schools and SMEs helps strengthen the connection between education and industry in a context of evolving digital maturity.

The starting point of this report is the report Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al., 2024) published by the LCAMP observatory. Based on its findings, a more in-depth investigation has been carried out to ensure that some of the conclusions reached are valid across a broader spectrum of the industry. This study examines how vocational education and training is responding to the changes being brought about by company characteristics and certain technologies (such as artificial intelligence) in the four standard job profiles included in this research.

Some of the findings that establishes the baseline of this report are the following:

- Companies expect a solid foundational education from Vocational Educational Training (VET) graduates, while high specialized technology expertise typically takes place within the companies.
- Students who have completed a higher-level VET programs, European Qualifications Framework (EQF) level 5 qualification, and additional specialization courses (one extra year of training in specific technologies) are generally well received by the industry.
- In the segment of companies analysed (mainly small and medium-sized enterprises), the competences related to the use of certain key technologies, such as artificial intelligence, collaborative robotics, or advanced automation, Are not widely adopted.
- The Basque Country's Vocational Education and Training system is prepared to support the digitalization of companies by training students with the necessary skills and updated technologies. In this process, the one-year specialization courses offered to students who have already completed the two-year EQF5 level programme are especially important, as they allow for specific adaptation to the technological needs of the industrial sector.
- Many companies have decided to take steps towards digitalization and automation of their processes and even have a defined strategy, but some of these initiatives fail, mainly due to human factors.
- While most companies understand the importance of process digitalization and automation, and many have developed implementation strategies and taken initial steps by participating in public-funded projects and initiatives, only a small percentage of these businesses continue the digital transformation journey independently after these structured programs end. This indicates a significant gap between recognizing the need for digital transformation and sustaining long-term implementation efforts.

1. INTRODUCTION

This report, developed as part of the observatory of LCAMP project, builds upon the findings presented in the 2024 publication “Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country” (Ziarsolo et al., 2024). It explores whether those conclusions also apply to other industrial segments—such as large enterprises, high-tech startups, and digitally mature Small and Medium-sized Enterprises size MEs. Additionally, the report examines how the current Basque VET system is responding to the identified needs, what systemic tools are being deployed, and the outcomes achieved so far. Special emphasis is placed on the integration of updated competencies and skills into VET programs in the Basque Country.

The document incorporates updated insights from companies, training providers, and both regional and European sources to better understand the evolving skill needs driven by workforce transformation. To narrow the scope of the research, the analysis focuses on four representative job profiles, CNC operators, maintenance technicians, automation technicians, and quality control technicians, which serve as a sample from which broader findings can be extrapolated.

In parallel, the report explores how the Basque VET system is currently addressing the competencies required for these roles, and how well these align with companies' digital transformation strategies, considering differences based on company size and technological maturity.

Particularly, the study examines the impact of enabling technologies, such as Artificial Intelligence (AI), Cybersecurity, and the Internet of Things (IoT), on these four job profiles. It also looks at how VET institutions are integrating these technologies into their training programs and partnering with industry to better prepare students for real-world manufacturing challenges, as well as the strategies that companies employ when incorporating these technologies into their operations and workforce development.

1.1. PURPOSE AND OBJECTIVES OF THE REPORT

The main goal of this report is to corroborate the main findings of the report *“Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country”* by analysing four key occupations in advanced manufacturing, CNC Operator, Quality Technician, Maintenance Technician, and Automation Technicians, in order to complete, update, and refine their profiles. This requires defining the main tasks, responsibilities, and skills needed in the increasingly digitalized industrial environments.

The report also aims to determine the degree of integration of these skills into the VET system in the Basque Country and to evaluate the degree of correspondence between training programs and the changing needs of companies.

More specifically, the objectives of the report are:

- To analyse the skills and knowledge required for these four job profiles, considering both the current needs and the emerging trends due to digital transformation.
- To evaluate the incorporation of these skills into the VET offer, focusing on EQF and EQF level 5 programmes and specializations.

- To investigate the approaches that companies, especially SMEs, use to introduce digital technologies (e.g. AI, data analytics, collaborative robotics, MES platforms) and how they build internal competencies to support these processes.
- To examine the forms of collaboration between companies and VET centres, identifying challenges, good practices, and opportunities for improvement in the context of talent development and digitalization.

In the end, the report aims to offer a thorough analysis of how VET systems and companies are dealing with the challenges and opportunities brought about by the digital transformation of advanced manufacturing.

Moreover, the report helps to identify learning pathways that support skill development across different VET formats, from initial training to upskilling aligned with workplace needs. These pathways are crucial to promote adaptability and lifelong learning in a changing industrial context.

2. METHODOLOGY

Our investigation used the report Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al., 2024) published by the LCAMP observatory as a starting point and foundational framework for our research. The research methodology employed in this study consisted of a multi-faceted approach to gather comprehensive insights.

Interviews with VET Educators

We conducted interviews with 21 teachers from 9 VET centres. These VET professionals are involved in programs on current technologies and innovation projects developed with SMEs. Some of them also coordinate students' internships and have direct and ongoing relationships with businesses through dual education and directly supervising students working in real workplace contexts.

Industry Perspectives

Interviews were carried out with 8 companies, representing a diverse range of organizations including SMEs and technological startups that provide services to advanced manufacturing companies. Additionally, we were granted access to a comprehensive survey conducted by AFM (Spanish Association of Manufacturers of Machine Tools) among their member companies. Furthermore, we have had direct information from companies that collaborate with vocational training cents.

Desk Research

Extensive desk research was performed focusing on the four selected occupations. This involved identifying current qualification requirements, demanded skills, and future needs, primarily through analysis of European projects within the skills framework. This documentation review provided contextual information to complement the primary research findings.

3. CONTEXT & BACKGROUND

3.1. CONNECTION TO THE PREVIOUS STUDY

The first step in conducting this report was to analyse the previous study, which examined the evolution of job roles in advanced manufacturing. That study focused on identifying the key competencies associated with selected job positions and tracking their development over time.

Building on that previous research, this report focuses on a set of key occupations considered particularly relevant for the future of advanced manufacturing. For each of these profiles, the analysis explores both the evolution of their roles, and the specific skills and knowledge required. In addition, special attention has been given to assessing how well VET centres, training programmes and upskilling initiatives are currently addressing these needs, identifying gaps, strengths, and opportunities for improvement.

This analysis revealed several key findings:

1. Digitalization and sustainability are reshaping job roles, though the extent of transformation varies depending on company size, digital maturity, and business strategy.
2. Automation and digitalization primarily restructure existing jobs rather than creating entirely new ones, with notable changes observed in maintenance and automation.
3. Companies are increasingly shifting toward data-driven management and new organizational models to enhance autonomy at all levels.
4. Companies seek highly specialized profiles tailored to their manufacturing processes. This specialization is developed through in-house training and work experience, built upon the foundational knowledge acquired by individuals from VET schools.
5. While AI gaining interest, It´s adoption remains limited.
6. Robotics implementation is lower than expected despite the ongoing trend toward automation.

Moreover, based on expert recommendations, the analysis has incorporated two additional perspectives to enrich the findings:
• The inclusion of technological start-ups that possess deep know-how in the various digital technologies used in Industry 4.0, allowing for a more comprehensive understanding of real-world implementations.
• An analysis of one year specialization programs related to advanced manufacturing, as they cover a significant portion of the skills identified in previous research and serve as a crucial training pathway for future professionals.

3.2. RATIONALE FOR THE SELECTION OF KEY FOCUS AREAS

This report focuses on four strategic job profiles that serve as reference cases for analysing the transformation of work in advanced manufacturing and the adequacy of vocational education and training (VET) systems. These occupations will be used throughout the report to examine:

- The identification of emerging skills and competences for these occupations.
- The current VET offers and learning pathways available for these roles.
- The alignment between training provision and industry needs.

The selected profiles are:

- CNC Operator
- Maintenance Technician
- Automation Technician
- Quality Control Technician

These roles represent essential technical and operational occupations within manufacturing companies. Their selection is based on two main criteria:

1. *Strategic importance of these occupations for the future competitiveness of advanced manufacturing companies.*
2. *Impact of Digital Transformation and Emerging Skills on the Selected Occupations*

These profiles offer an ideal perspective to analyse how companies are adapting their workforce, which competences are becoming essential, and how VET systems need to evolve to better respond to the new demands of industrial environments.

3.3. STRATEGIC IMPORTANCE OF SELECTED OCCUPATIONS IN THE FUTURE OF ADVANCED MANUFACTURING

The selected occupations play a fundamental role in manufacturing companies due to their direct involvement in production, automation, maintenance, and quality control processes, all of which are critical for competitiveness and innovation in advanced manufacturing.

Their selection is supported by evidence gathered in the previous LCAMP report, as well as by updated regional and European studies, including:

- *Study of the Key Profiles and Competencies to Be Developed in Advanced Manufacturing* (AFM Cluster, 2025)
- *Employment and Qualification Needs of Basque Companies for 2024* (Confebask, 2024)
- *Informe de Prospectiva 2024. Tendencias de Innovación*. (Innobasque, 2024)

- *Transformation of Manufacturing Embracing Digital and Green Skills*. (CECIMO, 2024)

According to the report *"Employment and Qualification Needs of Basque Companies for 2024"* (Confebask, 2024), the manufacturing sector in the Basque Country continues to show a strong demand for technical profiles related to production, maintenance, and quality functions. The study estimates that companies will need to hire approximately 44,250 workers throughout 2024. A significant share of these expected hires, around 43%, is linked to production, assembly, and maintenance functions, while engineering and quality roles account for an additional 28% of the anticipated job openings. (figure 1)

In terms of educational background, more than 64% of the demand is directed towards profiles with higher education or advanced vocational training qualifications. The most demanded training areas include Mechanical Manufacturing, Electricity and Electronics, and Information and Communication Technologies, all of which are directly related to the occupations analysed in this report.

Although the report does not explicitly mention the occupation of *Automation Technician*, the strong demand for profiles specialised in Electricity, Electronics, and ICT reflects the growing need for workers capable of operating and managing increasingly automated and digitalised industrial environments.

Figure 1.Distribution of Expected Hiring by Department. Source: Employment and Qualification Needs 2024 (Confebask 2024)

AFM Cluster (2023) identified the most critical profiles for the future of advanced manufacturing based on a comprehensive study involving 117 companies. The study estimates that around 1,100 new hires will be needed in the next three years across the sector. The most in-demand technical roles include:

- CNC machine operators and specialised manufacturing workers
- Maintenance and service technicians
- Production managers and continuous improvement specialists
- Quality control and measurement technicians

- Automation and electronic application technicians

These profiles serve as essential elements for today's industrial operations while supporting the digital transformation of manufacturing. Companies emphasized the growing need for employees who can work in environments that combine traditional and data-intensive operations, as the industry implements new technologies while its workforce transitions between generations.

3.4. EMERGING SKILLS AND DIGITAL TRENDS IMPACT

- **Key Digital Trends Impacting These Roles**

The selected profiles analysed in this report already incorporate many of the key digital skills identified as essential for the future of advanced manufacturing, as highlighted in CECIMO's survey (2024). These include competences in areas such as Cybersecurity, Automation Control Systems, Data Analytics, Internet of Things (IoT), and Robotics Programming, all of which are crucial for driving digital transformation on the production floor. Figure 2 summarises the digital skills currently considered most important by manufacturing companies.

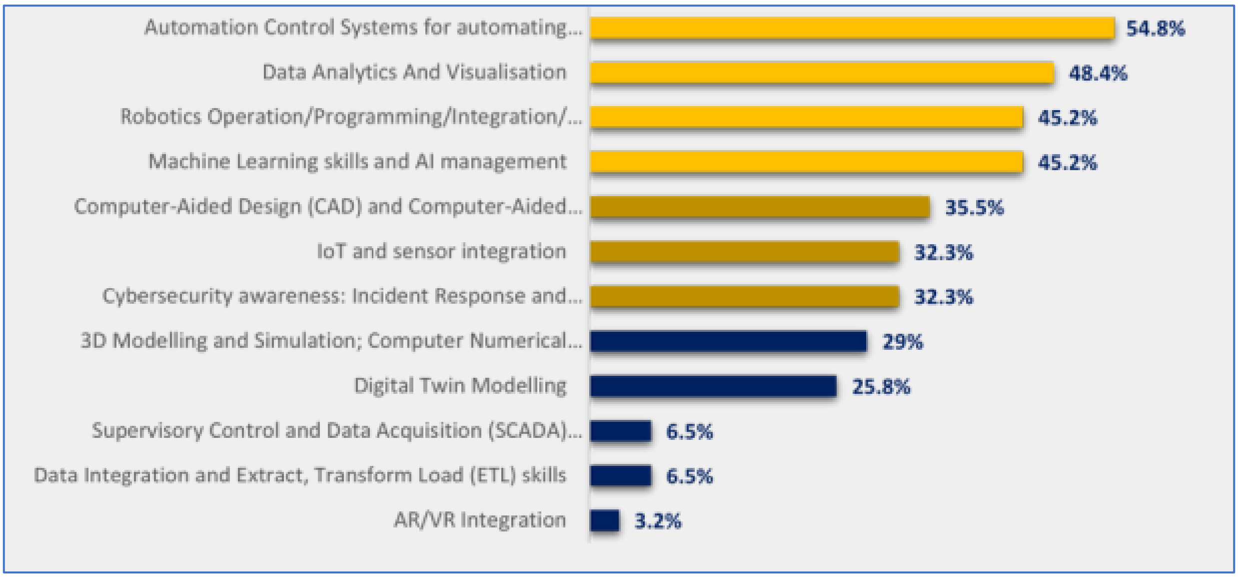


Figure 2.Digital Skills Necessary in Industry's Production Proces. Source: From survey to strategic (CECIMO 2023)

The manufacturing industry observes a growing trend of combining various roles which previously belonged to separate departments. Modern business operations require employees who can analyse and handle production process systems while demonstrating versatility across different operational areas.

Maintenance technicians now perform tasks beyond their traditional preventive and corrective maintenance duties. These professionals now have the responsibility to help optimize production line automation systems. Production workflows now incorporate quality control tasks which are carried out by machine operators and embedded automated systems. Digital tools enable real-time data collection and analysis that drives this evolutionary process.

The roles of Maintenance Technician and Automation Technician are transforming into dual-purpose positions that combine multiple functions. The industry-wide shift toward smart manufacturing environments with data-driven integration represents the broader industry trend according to (LCAMP 2024.)

The strategic importance of the chosen occupations becomes clear through these developments because they bridge technological evolution with current workforce demands.

AFM Cluster (2024) conducted the research *Estudio de Perfiles Críticos y Competencias a Desarrollar en la Fabricación Avanzada* to identify digital trends, on transform industrial operations and workforce skills needs in the sector. Businesses highlighted five key technologies namely AI, collaborative robotics, cyber-physical systems, cloud computing and big data because these technologies deeply impact task execution and monitoring operations in shop floor environments. The selected occupations experience increased involvement in data-driven production environments alongside their need to work with interconnected digital systems because of these emerging trends. The wide implementation of these technologies creates an increased demand for job profiles that blend multiple functions and demonstrates the need for advanced digital competences among core manufacturing professionals.

The previous report showed that AI technology interests manufacturing companies, yet its adoption remains restricted mostly to large enterprises instead of small and medium-sized enterprises (SMEs). The trend is transforming because AI awareness and strategic planning continues to grow.

AI functions as a transformative technology which transforms the current state of the industrial environment. The technology dominates public discourse because its influence extends across multiple sectors. The main issue now focuses on defining AI's objectives and boundaries alongside its deployment plan and security risks (Innobasque, 2024).

- **Crosscutting Skills Emerging Across Profiles**

Some skills have proven to be consistently relevant across multiple job roles and remain essential for supporting automation, data management, and systems integration. Their continued importance underlines their critical role in the digital transformation of industrial operations. (Figure 3)

Figure 3.Cross cutting Skills. Source: Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al., 2024)

The selection of the four key occupations also took into account the presence of such cross-cutting competences, as identified in the previous report, as well as the digital technologies most closely associated with them. All of these technologies are directly linked to the ongoing processes of digitalisation and automation within companies.

While many of these skills appear across different job roles, the required level of expertise and their application vary significantly depending on the role. Additionally, the importance of each skill is highly context-dependent and influenced by factors such as the company’s size, sector, product type, and level of digital maturity.

3.5. SCOPE OF THE ANALYSIS

The scope of the report focuses on three key dimensions:

- **VET Centres:** The analysis considers the experience and insights of teachers who are directly connected to companies in their local environment and actively involved in specialization programs related to the areas under study. Their perspective is essential, as these programs play a crucial role in equipping future professionals with the necessary skills for advanced manufacturing and related fields.
- **Companies:** The study focuses on the information from companies that are actively engaged in digital transformation and collaborate with VET centres, as well as insights from start-ups specialised in digital technologies, which bring an innovation-driven perspective to the analysis.
- **Key Areas & Job Profiles:** The study specifically examines roles and digital trend technologies within maintenance, automation, manufacturing, and quality.

This multi-actor approach ensures that the analysis reflects both the operational realities of companies and the evolving role of VET in supporting industrial transformation.

4. INDUSTRY PRESPECTIVE: IMPLEMENTATION OF DIGITAL TRENDS & RELATED SKILLS IN THE SELECTED AREAS

4.1. KEY APPROACHES FOR IMPLEMENTING DIGITAL TECHNOLOGIES

The manufacturing industry is undergoing a transformation towards digital manufacturing, also known factory of the future. Most companies are responding to this shift, though often cautiously. Many SMEs and large businesses, occupied with daily operations, face difficulties in understanding technological needs, setting business priorities, and defining implementation plans (Jack C Chaplin, 2021).

In a Basque context, many companies collaborating with VET centres recognizes the need to move towards digitalization and to integrate new technologies into their production and organizational processes. However, despite this awareness, the first steps towards implementation often present significant challenges. SMEs typically do not possess the required knowledge and time and financial or technological capabilities to start this transition successfully (Ziarsolo et al., 2024).

To better understand the current state of digital transformation in the industrial sector, the following figure 4 from the *Smart Industry 4.0 Report 2024* (NTT DATA, 2024) illustrates the evolution of digital adoption among companies over recent years. It shows that, although more than half of the companies have achieved positive results with their initial Industry 4.0 initiatives, the number of companies reaching advanced stages of digital maturity has declined, reflecting the complexity and challenges associated with deeper technological integration.

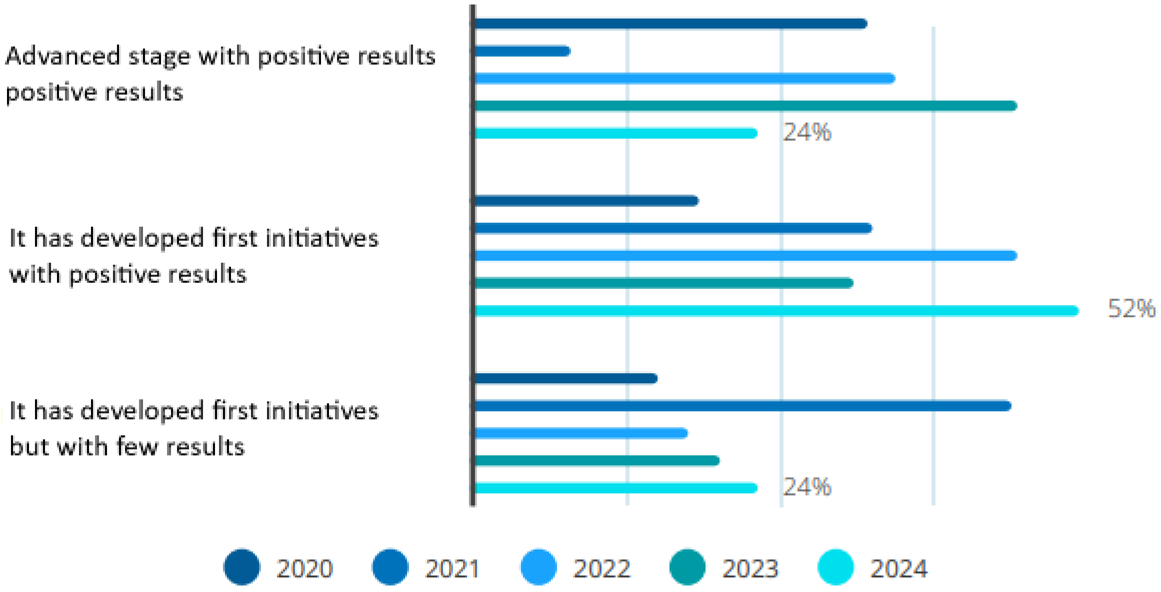


Figure 4.Trends and Digital Adoption in Industrial Companies (Source: NTT DATA, 2024

The following section explores these key approaches in more detail, highlighting common patterns, benefits, and challenges identified through interviews and fieldwork, as well as the concrete steps that local companies are taking to advance their digital transformation.

4.1.1.LEVERAGING PUBLIC FUNDING AND COLLABORATIVE INNOVATION PROJECTS

Public support is key for companies, especially SMEs, seeking to adopt digital technologies, as they are subject to significant financial and technological constraints. Several funding mechanisms exist at regional, national and European levels to finance investments in research, development and adoption of digital solutions. These programs are instrumental in helping companies overcome their initial hurdles on the road to digital transformation by providing them with the financial and technological support needed to implement new technologies.

And it's not just about funding. It often fosters collaboration on innovation projects between companies, VET centres, universities and research institutions. Companies also gain access to specialized resources and cutting-edge technologies at a fraction of the cost. And these partnerships not only limit risk and expense, but also help build internal capabilities, as well as shape a company's sense of what technology can actually do.

Below are several examples that were identified during the analytical work conducted for this report:

Taller Digital 1000

A relevant regional initiative that aligns with the LCAMP framework is the Taller Digital 1000 project, (AFM Cluster,2024) carried out in Gipuzkoa by AFM Cluster, INVEMA, and IMH Campus. The goal was to help small and micro machining companies define and implement digital transformation strategies.

The project began with digital maturity assessments of over 30 companies. Each SME received a tailored report with improvement areas. Based on these, three levels of digital maturity were identified, each with corresponding strategic priorities:

- **Basic**: Focus on IT/OT infrastructure and basic automation.
- **Ready**: Emphasis on data usage and system connectivity.
- **Digitalised**: Optimising automation and leveraging data.

SMEs participated in cross-visits, workshops, and meetings with tech providers, fostering peer learning and project ideas. The project also produced tools like a catalogue of solution providers and a funding guide to support implementation.

This hands-on, bottom-up approach helped companies move from awareness to action, despite the daily challenges they face in prioritising digitalisation.

The process began with individual digital maturity assessments of more than 30 companies. Each participating SME received a tailored diagnosis report identifying its current situation, strengths, and areas for improvement. Based on the aggregated findings, a shared analysis was developed to identify common trends and challenges across the sector.

After assessing the digital maturity of industrial SMEs and identifying tailored development opportunities based on their current level of digitalisation, three levels of digital maturity were observed, each suggesting a distinct strategic path and specific lines of action.

“Basic digitalisation” companies: Main opportunities lie in improving IT/OT infrastructure and process automation.

“Ready” workshops: With more developed IT/OT systems, the next step is enhancing data use and asset connectivity.

“Digitalised” workshops: Having achieved connectivity, the focus shifts to optimising automation and data exploitation.

Following this initial phase, companies were engaged in collaborative activities such as cross-visits, experience-sharing workshops, and matchmaking events with digital solution providers. These activities created a dynamic environment where SMEs could learn from one another, discuss challenges openly, and explore concrete project ideas.

The initiative also produced practical tools to support implementation, including a catalogue of digital technology providers (classified by areas such as robotics, data, simulation, etc.) and a comprehensive guide to public funding opportunities. These resources helped companies to move from awareness to action, by reducing uncertainty, facilitating connections with trusted suppliers, and supporting investment decisions.

While an increasing understanding of the necessity of digitalization emerges, many SMEs experience difficulties in bridging the gap from diagnosis to existence in practice. Frequently, however, both these groups have operational challenges daily that make it difficult for them to take the steps to make their businesses digital, even though they understand they need to do so.

This use case is representative of a hand on, bottom up-ecosystem approach to catalyse the digitization of industrial SMEs, approach that has an equally high level of congruence with the aims and methodologies of the LCAMP framework.

ADMA Trans4mers

ADMA Trans4mers (Trans4mers, n.d.) is a European project aimed at supporting SMEs in their digital and green transformation through tailored mentoring, capacity building, and access to innovation ecosystems.

As part of LCAMPs WP7, a series of digital readiness assessment called “scans” were conducted using the ADMA TranS4MErs methodology within 10 selected companies in the Basque Country. These scans assess seven fundamental transformation dimensions and benchmark them against the Factory of the Future (FoF). The objective of this evaluation is to ascertain strengths, gaps, and areas for improvement regarding the adoption and deployment of digital trends in varied industrial settings.

The results below summarize some of the most interesting insights from the scans on the state of play, challenges and next steps in the digitalization, smart manufacturing, the upskilling of the workforce.

- **Digital Factory Maturity Levels Vary**

Companies scored between 1.25 and 3.75 out of 5 on Digital Factory. Some companies have implemented advanced digital integration strategies, while others still rely on stand-alone, non-connected systems with limited automation.

- **Low Shop Floor Connectivity and Data Integration**

Many machines are not connected to a network, and data is still transferred manually using USB sticks or flash cards. Some equipment is linked to a company network, but data exchange is often initiated manually rather than automatically. Only a few companies have achieved full machine connectivity, using IoT sensors, gateways, and middleware solutions for seamless data flow.

- **Lack of Real-Time Data Utilization for Decision-Making**

Multiple organizations fail to achieve real-time shop floor visibility which prevents them from maximizing their production efficiency and workflow optimization. Companies that gather extensive data face challenges because they do not have standardized data structures which creates data silos and operational inefficiencies. The partial implementation of Manufacturing Execution Systems (MES) prevents organizations from achieving complete digital factory integration and real-time decision capabilities.

- **Cybersecurity Risks and Lack of Digital Security Infrastructure**

Companies that lack strong cybersecurity protocols depend on minimal security measures which creates exposure to possible threats. Organizations that handle security updates manually face risks from cyberattacks and data breaches because of their exposed position. Many organizations do not use advanced threat detection or security event monitoring systems which allows security breaches to remain undetected.

- **Resistance to Digital Adoption and Workforce Training Gaps**

Multiple organizations face employee resistance to digital transformation because their work environments continue using manual processes. Digital adoption remains limited because not all employees receive upskilling programs which results in slow transformation efforts.

BDIH KONEXIO

The Basque Digital Innovation Hub (BDIH) functions as a strategic initiative within the Basque Country to enable industrial SMEs to assess advanced manufacturing technologies before they commit to significant investments. The initiative connects industrial SMEs to a digital network of R&D facilities and pilot plants and specialized expertise through joint management by technology centres and VET centres and universities. The BDIH receives robust backing from regional public institutions which enables companies to conduct solution testing and validate use cases and develop internal capabilities in a protected environment. The approach minimizes uncertainty which enables businesses to make sure and confident choices about their digital transformation. The nine strategic technological (fig5) areas of BDIH enable industrial SMEs to access testing and validation environments for their digital transformation.

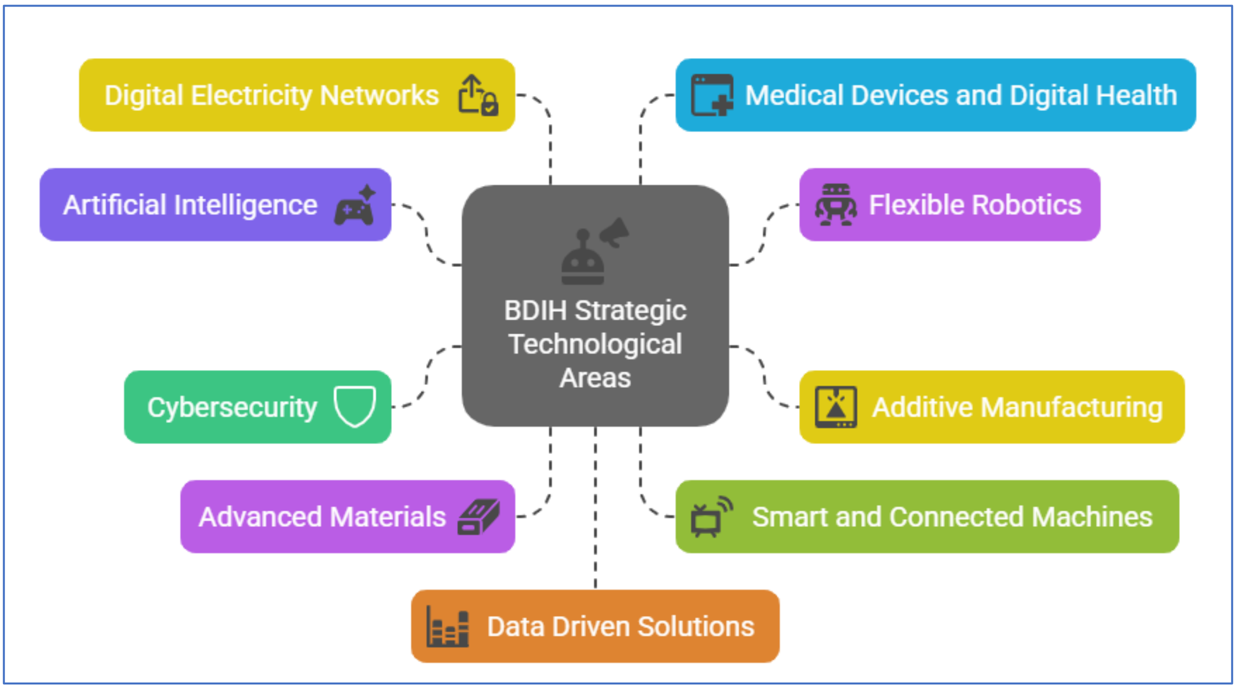


Figure 5.Strategic Technological Areas. Source: BDIH web

BDIH Konexio (SPRI 2024) is a support programme designed to connect Basque industrial companies, especially SMEs, with the assets and services of the BDIH. The initiative helps companies identify their technological needs and facilitates access to testing, validation, and implementation services across the BDIH network. By doing so, BDIH Konexioa reduces uncertainty, accelerates innovation processes, and promotes the adoption of Industry 4.0 solutions in a practical, low-risk environment.

4.1.2.OUTSOURCING TECHNOLOGICAL EXPERTISE THROUGH STRATEGIC PARTNERSHIPS

To overcome the barriers to digital transformation, companies are adopting different strategies. One common approach, particularly among SMEs, is to rely on external expertise by partnering with or hiring specialized technology providers, often innovative startups. This is especially common in areas like AI and data analytics and Cybersecurity, where rapid technological advancements make internal capacity building more difficult.

Many of the collaborating companies are technology startups or technological centres, specialising in areas such as AI and predictive maintenance. Their external support is crucial for introducing and integrating cutting-edge digital solutions into industrial environments.

The technological companies consulted highlight the importance of good communication between both parties for the successful implementation of technological solutions. In this context, technology partners emphasize the valuable role that VET technicians with knowledge of technologies such as AI or cybersecurity can play in the implementation and development process. While they are not experts in these fields, they are capable of understanding the overall logic of the processes, what is being done, why it is done, and how it fits within the broader system. They may not need to master the technical details, but having a general understanding allows them to contribute meaningfully during deployment, integration, and operation phases.

BAIC Use Cases

The Basque Artificial Intelligent Center (BAIC) is a public-private initiative that aims to drive the development, adoption, and dissemination of AI across all sectors of Basque society and industry. TKNIKA, as an innovation centre for the Basque VET system, is an active member of BAIC and contributes to its initiatives.

The report *"Casos de uso IA Euskadi"* (Basque Artificial Intelligence Centre, 2023) presents an extensive collection of real-world applications of artificial intelligence (AI) and digital technologies developed in the Basque Country.

The document classifies more than 70 use cases across sectors such as industry, energy, logistics, healthcare, retail, infrastructure, and transport. The main technologies applied include Machine Learning, Deep Learning, Computer Vision, Digital Twins, Edge Computing, Cloud Computing, Federated AI, advanced optimisation algorithms and Augmented Reality.

The use cases focus on areas such as production, logistics and resource optimisation, demand and fault prediction, product quality assurance, predictive maintenance, intelligent infrastructure monitoring, decision-support system development, process automation, and real-time connected digital twins. Applications also extend into mobility and healthcare

Emerging trends detected across the cases include the growing integration of AI and Big Data into industrial and energy processes, the use of predictive maintenance to reduce costs, the increasing need for interoperability between different systems (e.g., sensors, ERPs, IoT platforms), and the demand for hybrid professional profiles combining technical expertise (data, AI, industrial processes) with strong sector-specific knowledge. In many projects, cybersecurity and ethical data management have also been identified as critical factors.

The cases highlight the central role played by technological startups, research centres, universities, and leading companies.

4.1.3.BUILDING INTERNAL CAPACITY

Some companies, most of them larger firms, especially industrial leaders or so-called “tractor companies”, are increasingly choosing to develop internal departments dedicated to digital technologies. These units manage the implementation of solutions using their own human resources. In most cases, these companies initially participated in collaborative innovation projects or publicly funded initiatives, often in partnership with technological centres, universities, or research institutions, to test and explore new technologies. After the completion of these projects and obtaining positive results, many decided to invest further and expand their internal capabilities by developing new areas within their digitalisation strategy.

In addition, among the companies contacted for this study, there are a few isolated cases of small firms with a strong conviction and clear vision for digital transformation. These SMEs are implementing their strategies with commitment across the entire organisation. Due to their smaller size, fewer hierarchical layers, and fewer people involved, they are often able to progress more quickly in aligning all teams and operations around digitalisation goals.

These companies have typically gone through the earlier stages of working with external providers and participating in pilot or collaborative projects, and in many cases, they continue to do so. However, they are now complementing that external support with stronger in-house teams and more strategic long-term planning. Today, they see the benefit of allocating more resources and becoming more autonomous. As part of this shift, they increasingly focus on recruiting talent with university-level qualifications, particularly for more specialised and strategic areas. Cybersecurity has become both a central pillar in their digital strategies and one of their main concerns, as the growing complexity of digital systems increases the potential risks associated with data breaches and cyber threats.

However, it is important to note a significant decrease in the number of companies at an advanced stage of adoption, dropping from 46% in 2023 to 24% in 2024. This change could suggest a slower pace of evolution towards more advanced stages, or that the initial expectations were overly optimistic. The decline might also be related to the increased complexity involved in advancing these technologies, or it could reflect that many companies have completed their initial testing phases. Further investigation would be useful to better understand the reasons behind this drop.(NTT DATA, 2024)

4.2. INDUSTRY-ALIGNED VOCATIONAL JOB PROFILES

Each of the following subsections presents:

- Profile overview summarizing the fundamental skills, competencies, and key characteristics that define each professional profile.
- Summary of sources documenting the information sources and methodology used to construct the skill profile definitions. This dual structure ensures both practical understanding of required capabilities and methodological transparency.

4.2.1.MAINTENANCE

Profile overview:

Maintenance plays a crucial role in the digital transformation of industrial operations. As manufacturing systems become more interconnected and data-driven, maintenance professionals are expected to go beyond traditional responsibilities and contribute actively to the optimisation, automation, and resilience of production processes.

While conventional tasks, such as corrective and preventive maintenance, remain essential, the integration of digital technologies is shifting the focus towards predictive and condition-based approaches. These are supported by sensor networks, real-time alerts, and advanced monitoring systems aimed at reducing downtime and preventing failures before they occur.

The role of the maintenance technician can vary considerably depending on the company's size, sector, and level of digital maturity. These factors influence not only the technician’s daily tasks, but also the required proficiency in areas such as digital diagnostics, system integration, data interpretation, and predictive technologies.

Reference sources:

LCAMP

In the M24 report, the role of the maintenance technician was highlighted as one of the most critical profiles in the context of industrial transformation. Through consultations with companies and training providers, the report identified a set of key skills that reflect the evolving nature of this role in increasingly digitalised and automated environments.

These skills go beyond traditional maintenance tasks and include competences related to data interpretation, automation systems, and digital communication between machines, as well as problem-solving and adaptability. The findings showed that companies are increasingly looking for maintenance professionals who can contribute not only to equipment reliability, but also to process optimisation and technological integration for automation.

The following figure summarises the most relevant “new "skills identified in the M24 analysis for this job profile and forms the basis for the updated insights presented in the current report.

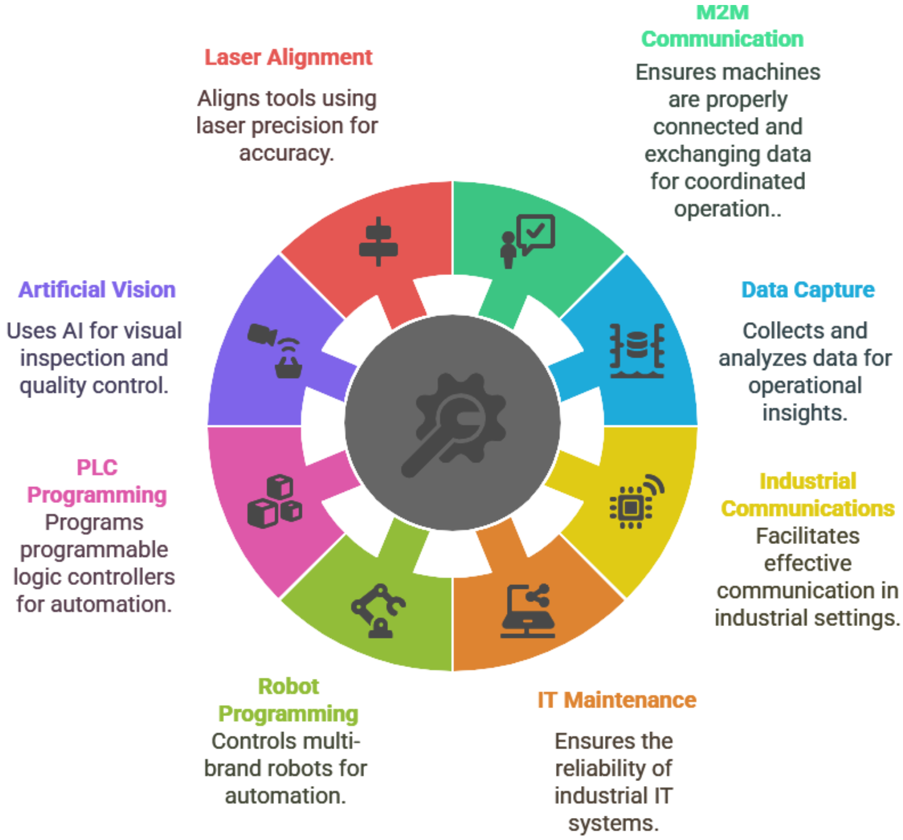


Figure 6.Maintenance Technician Skills. Source: Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al., 2024)

EFNMS Occupations

The EFNMS (European Federation of National Maintenance Societies), through the Certified European Maintenance Professionals project , aimed to establish a qualification, validation, and certification framework for maintenance personnel. The aim of the project is to develop a common qualification framework for the development of courses and connect this with validation as a quality assurance system. This structured approach ensures that maintenance professionals acquire standardized and recognized competencies that align with industry needs.

In this process, the guidelines from the European Centre for the Development of Vocational Training (CEDEFOP) have been followed, particularly those focusing on the validation of non-formal and informal learning. The recognition of total learning outcomes is of paramount importance for the development of an organization, ensuring that acquired skills, whether through formal education, workplace experience, or self-directed learning, are properly validated. EFNMS has defined four qualifications for four maintenance roles aligned with the

Considering that VET covers up to EQF level 6, four roles are directly related to VET:

- Maintenance Mechanics, Electricians & Automation Electricians (EQF4)
- Maintenance Technician Specialists (EQF5)
- Maintenance Engineers and Supervisors (EQF6)

As part of this effort, EFNMS has defined the knowledge, skills, and responsibilities for various roles in industrial maintenance. The content has been structured into seven main categories

- Maintenance within Physical Asset Management
- Maintenance Management
- Maintenance Execution
- Health, Safety & Environment in Maintenance
- Maintenance Engineering Techniques
- Maintenance Support

Within each category, specific subcategories and subjects have been defined. In the Maintenance Execution section, the required knowledge, skills, and responsibilities for each role in Predictive Maintenance are outlined (Fig7). Additionally, the knowledge, skills, and responsibilities related to Maintenance and Industry 4.0 have been described for each role (Fig.8).

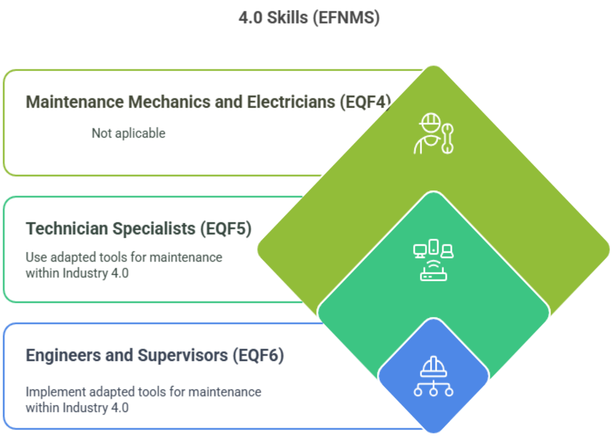


Figure 7. 4.0 Skills. Source EFNMS

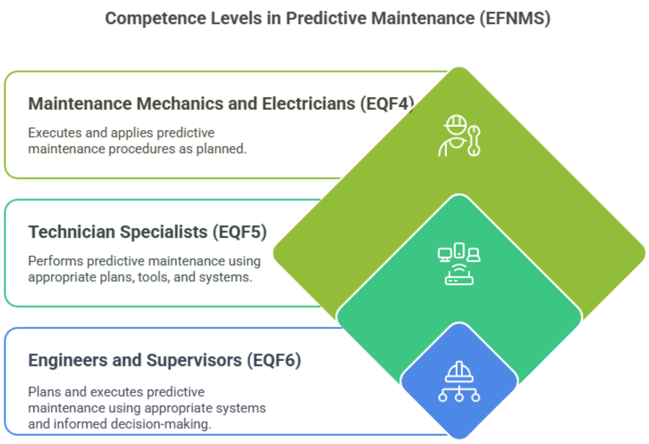


Figure 8.Competence Levels in PdM Source: EFNMS

While maintenance mechanics and electricians (EQF4) are expected to understand and apply predictive maintenance methods in practice, technician specialists (EQF5) should also be able to explain the principles behind these approaches, differentiate between predictive and non-predictive maintenance, and use adapted tools to support the process.

At a higher level, engineers and supervisors (EQF6) are expected to go further, being able to analyse and optimise predictive strategies, and manage the implementation of digital tools across systems and teams.

However, across all levels, a key takeaway is that maintenance professionals do not need to be deep technical experts in each digital technology, such as AI, IoT, or digital twins, but rather, they must understand what these tools are used for, how they impact maintenance tasks, and how to integrate them into real industrial processes. This ability to interpret and apply technology in context is essential to ensure effective collaboration with specialists and successful integration of digital systems.

In short, the focus is not on mastering the inner workings of each technology, but on understanding the logic, application, and added value they bring to maintenance operations. This competence-based approach helps define realistic, actionable learning objectives within Vocational Education and Training, adapted to the role and level of responsibility of each professional.

DRIVES framework

In the European DRIVES project, specific skill sets were defined for various industrial roles to support the transition towards Industry 4.0. For example, dedicated profiles were developed for Predictive Maintenance Technicians, distinguishing between different levels of responsibility such as Expert Technician and Engineer. These profiles include both technical and digital competences aligned with the requirements of smart and connected manufacturing environments and serve as a valuable reference for identifying the skills needed to implement predictive maintenance strategies.

However, based on the analysis of regional companies and, as well as discussions held with VET teachers closely connected to local industry, no exclusive roles dedicated just to predictive maintenance were identified. Instead, predictive maintenance is generally understood as a set of emerging tasks and competences that are integrated into broader maintenance technician roles.

In addition, DRIVES also defined comprehensive competence frameworks for the following roles in the field of automotive mechatronics:

- Automotive Mechatronics Manager (Basic Level)
- Automotive Mechatronics Expert
- Automotive Mechatronics Developer

Each of these roles incorporates a structured combination of knowledge, skills, and responsibility levels, covering areas such as diagnostics, control systems, embedded electronics, and digital communication tools. This approach supports modular training pathways and facilitates targeted upskilling and reskilling strategies in the automotive sector.

Although these profiles were originally designed for the automotive industry, they provide a useful reference for broader industrial applications. In fact, most students completing EQF level 5 programmes in mechatronics today typically enter the labour market as Maintenance Technicians, particularly in advanced manufacturing sectors. This highlights the importance of adapting and aligning training programmes with real employment pathways and occupational needs.

4.2.2. AUTOMATION-ROBOTICS

Profile overview:

Automation and robotics technicians play a key role in the design, implementation, and optimisation of automated systems in industrial environments. These professionals are responsible for ensuring that machines, robotic cells, and interconnected control systems operate efficiently, reliably, and in accordance with production goals.

Their tasks typically include the configuration and maintenance of PLCs and industrial robots, troubleshooting of automated processes, integration of sensors and actuators, and collaboration with engineering and IT teams to implement system improvements. As manufacturing becomes increasingly digitised and autonomous, these technicians are also expected to engage with data acquisition systems, human-machine interfaces (HMIs), and communication protocols such as OPC-UA or industrial Ethernet.

The exact scope of the role may vary depending on the company's size, sector, and technological infrastructure. In SMEs, automation technicians often take on multidisciplinary responsibilities, including mechanical, electrical, and software-related tasks. In larger or more specialised environments, they may work within a team focused on advanced robotics, machine learning applications, or smart manufacturing systems.

Reference sources:

LCAMP

In the M24 report, the role of the automation technician was already noted as emerging in connection with digitalisation processes, although often integrated within other roles such as maintenance or process engineering. In the current analysis, this role gains further relevance, particularly in companies with high levels of technological maturity, where automation is no longer limited to isolated systems but is increasingly interconnected with data acquisition, digital platforms, and integrated production systems.

The automation and robotics technician is responsible for designing, implementing, and maintaining automated systems, programming robots, and integrating IoT devices and communication networks that connect production equipment with MES and ERP systems. This role is essential for ensuring not only the efficiency and reliability of automated processes, but also their alignment with digital transformation strategies within companies.

The following figure presents a synthesis of the most relevant skills currently associated with this job profile, which builds upon the observations made in the M24 report and incorporates updated insights from the latest company consultations.

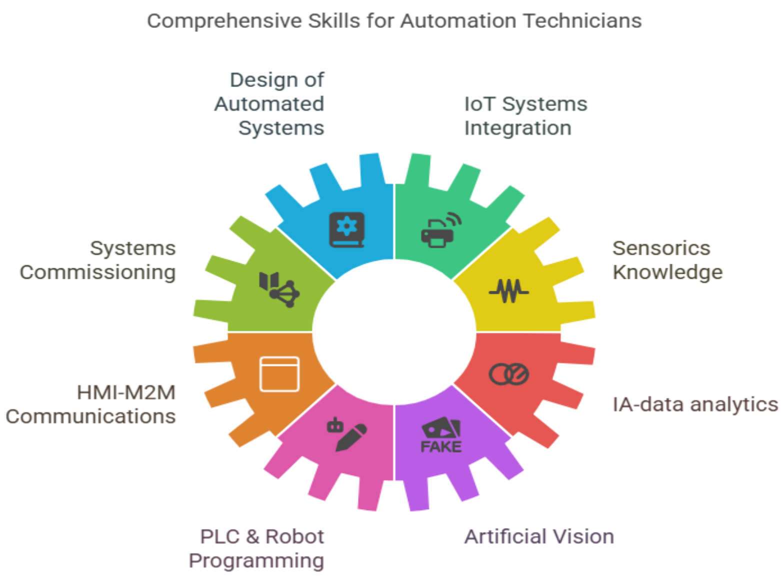


Figure 9.Automation Technician Skills. Source: Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al., 2024

DRIVES Framework

The DRIVES project developed dedicated occupational profiles for the Robotic Technician and the Robotic Engineer, recognising robotics as a strategic competence area within Industry 4.0. These profiles are structured according to the ECQA (European Certification and Qualification Association) competence model and reflect different levels of responsibility, autonomy, and technical complexity.

Robotic Technician

The Robotic Technician profile is designed for professionals who install, operate, and maintain robotic systems in industrial environments. Key competence areas include:

- Understanding and operating automated manufacturing systems
- Performing mechanical and electrical maintenance on robotic equipment
- Troubleshooting faults in robotic and automation systems
- Applying basic software tools to operate and adjust robot parameters

This profile reflects the needs of professionals working directly with robotic systems on the shop floor or in maintenance and production support roles.

Robotic Engineer

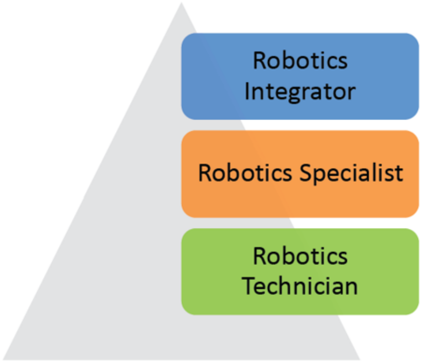
The Robotic Engineer profile focuses on the design, programming, and implementation of advanced robotic systems. Core skills defined in the DRIVES framework include:

- Designing and optimising automated robotic systems.
- Implementing predictive maintenance and advanced fault analysis.
- Developing and integrating robot control software.
- Using simulation tools for testing robotic cells and production lines.
- Incorporating new technologies such as AI and machine learning into robotic solutions.

This role is oriented towards professionals responsible for innovation, system development, and the strategic integration of robotics into production environments.

Advanced Robotics for Manufacturing (ARM) Institute

An additional reference framework worth considering is the Robotics Career Pathway developed by the ARM Institute. This U.S.-based initiative defines a structured progression of roles in robotics manufacturing, from Robotics Technician, to Robotics Specialist, and up to Robotics Integrator. Each role includes a set of clearly defined technical and transversal skills identified through a collaborative effort involving over 200 organisations from industry, academia, and government. (ARM Institute, 2020)



"The Robotics Integrator is the subject matter expert on automation and robotics. The Integrator understands how applying robots and automation to the manufacturing floor brings greater profitability to their company and will create plans for those areas ripe for automation or robotic features." (ARM Institute, 2020)
"The Robotics Specialist is the subject matter expert on the robotic system on the manufacturing floor and is responsible for proposing upgrades to the system that increase productivity for their manufacturing sector."(ARM Institute, 2020)
The Robotics Technician is the subject matter expert on the equipment and day-to-day robotic maintenance on the manufacturing floor."(ARM Institute, 2020)

Figure 10.Hierarchical Structure of Robotics Career Pathways .Source: ARM Institute 2020

Figure 10 shows the structured career path in robotics developed by the ARM Institute, highlighting the progression from Robotics Technician to Robotics Specialist and ultimately to Robotics Integrator (applied level). Each career stage is associated with a specific set of technical competencies, covering areas such as mechanical systems, robotic programming, simulation, big data, systems integration and cybersecurity-related skills, reflecting the evolving requirements of Industry 4.0.

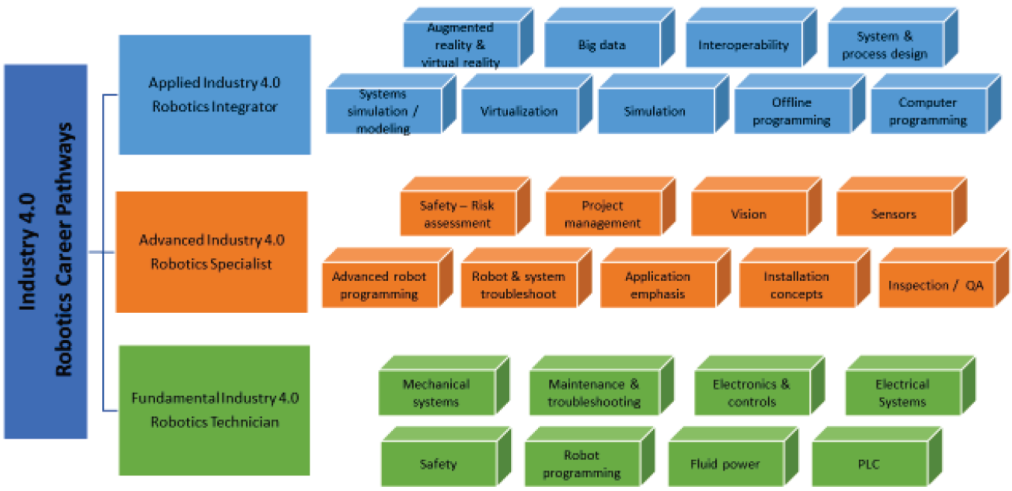


Figure 11.Industry 4.0 Robotics Career Pathways and Associated Skill Areas (Source: ARM Institute, 2020)

Although designed in the U.S. context, the ARM framework offers a valuable international perspective. It aligns well with European efforts, such as DRIVES or ESCO, in defining industry-relevant learning pathways and supporting the integration of robotics into vocational training and upskilling initiatives. Its application may serve as a useful reference when structuring modular training programmes in advanced manufacturing environments.

4.2.3. QUALITY CONTROL TECHNICIAN

Profile overview:

Quality control technicians are responsible for checking that products meet quality standards during and after the manufacturing process. They use measurement tools and inspection equipment to detect errors, ensure accuracy, and help maintain product consistency.

Their daily tasks often include inspecting parts, measuring dimensions, recording results, and reporting any defects. They also compare finished products with technical drawings and specifications and may support the calibration and maintenance of measuring instruments.

As manufacturing becomes more digital, quality control technicians are starting to use more advanced tools such as digital inspection systems, machine vision, and quality software to monitor processes and detect problems more efficiently.

Depending on the company, their role can vary in small companies, they may take on multiple responsibilities, including documentation and reporting; in larger companies, they often work as part of a quality team and focus on specific areas like incoming materials, production lines, or final inspections.

Reference sources:

LCAMP Project

In the M24 report, the quality technician was already identified as a relevant profile in most manufacturing companies, particularly in those where product conformity and traceability are strategic concerns. While this position is not new, its functions are evolving significantly due to digitalisation and increasing process integration. In many companies, traditional quality control tasks are gradually being transferred to machine or line operators, making quality a shared responsibility across production teams. However, the role of the quality technician remains essential for overseeing critical components and operations and ensuring compliance with customer specifications and industry standards.

Recent company consultations reinforce the idea that quality technicians are increasingly required to combine technical inspection skills with digital and data management capabilities. In automated and data-rich production environments, quality technicians often work with machine vision systems, 3D scanners, and digital verification tools to monitor and control quality. They also contribute to root cause analysis and process improvement initiatives using methods such as 5S, 8D, 5-Why, or Ishikawa diagrams.

Key drivers of change include the integration of production and quality systems, growing demand for product traceability, automated inspection processes, and the implementation of digital platforms for monitoring critical parameters. In this context, quality technicians must develop digital literacy, data analysis skills, and basic cybersecurity awareness, alongside solid knowledge of the production process and communication abilities to report findings and collaborate with cross-functional teams.

The following figure presents a synthesis of the most relevant skills associated with this profile, reflecting both the findings of the M24 report and updated insights from the latest interviews with industrial partners and VET providers.

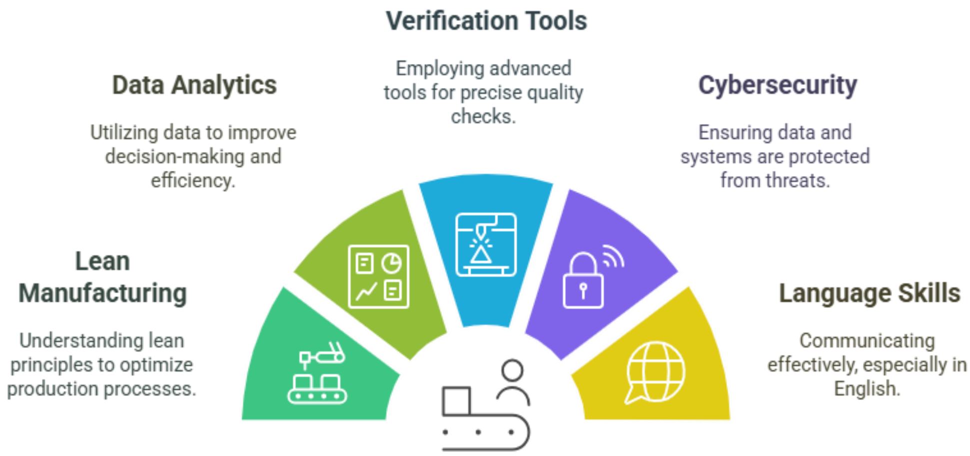


Figure 12.Quality Control Skills. Source: Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al.,)

DRIVES Project

According to the *DRIVES project – Automotive Engineer in Quality and Metrology Skills Definition* (2020), a comprehensive competence framework was developed for the role of Automotive Engineer in Quality and Metrology, recognising quality assurance and metrology as strategic domains within smart manufacturing and Industry 4.0. This role is structured according to the ECQA competence model, and divided into four main units of skills development:

- Foundations to Quality and Metrology – covering core concepts such as uncertainty, physics for metrology, and the mathematical foundations for data interpretation in dimensional measurements.
- Standards, Certification and Uncertainty – focusing on traceability, metrology standards, and assessing measurement uncertainty.
- Metrology in Product-Process Quality Engineering – including quality methodologies such as Lean Six Sigma, process capability and stability, and tools like PPAP and FMEA.
- Metrology Resources, Planning and Execution – centred on the use of dimensional metrology tools, measurement planning, drawing interpretation, and digital inspection technologies.

These units address both technical and analytical competencies and reflect the growing importance of digital tools (e.g. coordinate measuring machines, optical scanners, metrology software) and data-driven decision-making in quality control processes. The structure supports the development of a robust skill set combining theoretical knowledge, practical application, and digital integration aligned with the ECQA and EQF frameworks.

(DRIVES Project, 2020)

In addition to the technical and digital skills required for modern quality roles, the DRIVES project also provides a structured competence framework for Lean Six Sigma methodologies. These frameworks, covering Yellow Belt, Green Belt, and Black Belt levels, define role-specific skills aligned with the ECQA competence model and are particularly relevant for quality technicians engaged in continuous improvement, defect reduction, and process optimisation.

The competence matrices include areas such as:

- Problem-solving and root cause analysis (e.g. 8D, 5-Why, Ishikawa)
- Use of statistical tools and data interpretation (SPC, control charts)
- Implementation of stable and capable processes
- Project planning and teamwork in quality initiatives
- Digital support tools for Six Sigma (e.g. Minitab, process mapping software)

These skill sets align with the needs of Industry 4.0 environments, where quality control is integrated into real-time data systems and continuous improvement is driven by digital insights. (*Theisens, Harborne, & Hesp, 2020)*

OPTIMAI Project

According to the *OPTIMAI D2.3 , State of the Art Report* (2022), emerging technologies in artificial intelligence and smart manufacturing are reshaping the skill requirements for quality technicians. The report highlights the increasing use of **computer vision systems** and **convolutional neural networks (CNNs)** for defect detection, along with **deep learning techniques** applied to 3D surface measurement and anomaly recognition. It also notes the integration of **AI-based inspection tools** with robotics and industrial sensors, as well as the use of **machine learning** in process monitoring, metrology, and predictive analytics.

As a result, quality technicians are now expected to work with **digital and AI-enhanced inspection systems**, analyse data from advanced metrology and vision technologies, and participate in **zero-defect manufacturing (ZDM)** and **digital twin-based environments**. These developments represent a shift toward **data-driven, digitally integrated roles** in quality control, in line with the broader evolution of Industry 4.0.

Superior Skill set

According to Domingues et al. (2020), an international study involving 319 professionals from 61 countries identified seven key dimensions that define the skillset of a successful quality leader in the context of Industry 4.0 and Quality 4.0. The article presents the future skills expected from quality professionals, emphasizing that they must go beyond traditional tools and develop a broader set of competencies.
These include leadership, communication, adaptability, analytical thinking, and digital literacy, essential to meet emerging challenges such as product customization, advanced data analytics, automated inspection, digital traceability, and continuous improvement in smart manufacturing environments.

Importantly, the study reinforces that transversal skills and the ability to learn are not only relevant across all seven dimensions but also act as key enablers for quality professionals to adapt and thrive in rapidly evolving industrial contexts.

Figure 13.Core Skills for Quality Professionals. Source: OPTIMAI D2.3 , State of the Art Report (2022)

4.2.4.CNC OPERATOR

Profile overview:

CNC operators are responsible for using computer-controlled machines to produce precision parts, usually from metal or plastic. Their main tasks include preparing and setting up the machines, loading materials, running machining programs, and checking that the finished parts meet the required specifications.

They use measuring tools to control quality and may adjust machine settings when necessary. CNC operators must also read technical drawings and follow safety and quality rules during production.

As manufacturing becomes more digital, CNC operators are expected to work with digital interfaces, basic programming tools, and sometimes CAD/CAM software. Depending on the company, they may also support maintenance tasks or help optimise production processes.

Reference sources:

LCAMP

According to the *LCAMP D3.2*, the CNC Operator role is present in over 70% of the manufacturing companies interviewed and is considered one of the occupations undergoing the most transformation. The integration of advanced CNC machines with HMIs, data acquisition systems, and automated feeding mechanisms is driving changes in required skills and work organisation. Operators are increasingly expected to interact with MES and ERP systems, perform basic program adjustments, and understand predictive maintenance and data analysis techniques.

The report highlights that while CNC programming is often external to the operator's role, operators are now taking on more autonomous responsibilities, including problem-solving and interpreting complex technical drawings. Skills related to CAD/CAM, cybersecurity in OT environments, and lean manufacturing are also gaining relevance.

These trends reflect the shift from a purely mechanical role to a more digitally integrated, data-aware position, especially in companies investing in smart machining and product customisation technologies

The following figure 14 presents a synthesis of the most relevant skills currently associated with the CNC Operator profile.

Figure 14.CNC Operator Skills. Source: Analysis of the Evolution of Jobs in Advanced Manufacturing in the Basque Country (Ziarsolo et al.,)

Industry 4.0 CHALLENGE

According to the European project *Industry 4.0 CHALLENGE: Empowering Metalworkers for Smart Factories of the Future (4CHANGE)* (2020), the role of the CNC machine operator is being redefined to respond to the evolving needs of smart manufacturing. The project outlines three distinct qualification profiles aligned with EQF levels 3, 4 and 5, each with a specific combination of technical and transversal competences.

These profiles are structured through a set of 13 competence blocks (e.g., metal machining, CNC machining, mechatronics, CAD/CAM, robotics, etc.), and each block includes clearly defined subjects or training content relevant to the required skill level (table 1).

Table 1. CNC profesional competence blocks, Source 4CHANGE Project (2020)

SKILL AREA	DESCRIPTION
Metal Machining	Understanding of materials, cutting tools, machining processes, and traditional manufacturing techniques.
CNC Machining	Operation, setup, and basic maintenance of CNC machines, including measuring and quality control.
Mechatronics	Integration of mechanical, electrical, and control systems within industrial equipment.
Programming	Reading, understanding, and editing CNC programs, including basic G-code.
CAD/CAM	Use of design and manufacturing software to support CNC operations and digital workflows.
Networking, IT Security, Big Data	Awareness of digital connectivity, data protection, and the role of big data in manufacturing.
Robotics	Interaction with automated handling systems, robotic arms, and basic programming of robotic tasks.
Additive Manufacturing (AM)	Practical use and setup of 3D printing technologies, as well as understanding their integration in production.
Smart Production Process Management	Knowledge of planning, coordination, and optimization of manufacturing processes using digital tools.
Change Management	Capacity to deal with organizational and technological change, and to support adaptation strategies.
Innovation Management	Ability to participate in improvement projects and contribute to the adoption of new ideas and solutions.
Self-learning	Autonomy and motivation to learn new technologies and update skills continuously.
Coaching	Support and mentoring of colleagues to foster collaborative learning and skills transfer within teams.

The 4CHANGE project emphasises that CNC operators must not only master traditional machining skills, but also develop adaptability, learning capacity, and a working understanding of emerging technologies such as additive manufacturing, robotics, and digital communication systems. These elements are essential for operating effectively in increasingly automated and interconnected production environments.*(4CHANGE Project, 2020)*

5. OVERVIEW OF THE VET OFFER IN THE SELECTED AREAS

5.1. BASQUE VET FRAMEWORK REVIEW

Recent reforms in Spain's Vocational Education and Training (VET) system, established under Royal Decree 69/2025, of February 4, have reorganised the system to better respond to citizens' learning needs while aligning with European lifelong learning strategies. The new structure introduces a progressive, five-level framework (Grades A to E), enabling individuals to build flexible, modular learning pathways.

As part of this reform, Royal Decree 208/2025, of March 18, specifically regulates Grades A, B, and C for selected professional families. These grades are designed to support both initial vocational training and lifelong upskilling/reskilling. They are based on the National Catalogue of Professional Competence Standards (Catálogo Nacional de Estándares de Competencias Profesionales) and correspond to professional competence levels 1, 2, and 3, defined by the required degree of knowledge, autonomy, initiative, and task complexity.

- Grade A consists of very short training programmes that certify specific competences or learning outcomes (*micro-credentials*).
- Grade B refers to competence certificates that group related skills and validate the ability to carry out professional tasks within specific occupational functions.
- Grade C corresponds to Certificates of Professional Competence (Certificados de Profesionalidad) associated with professional competence levels 1, 2, or 3. These qualifications include compulsory modules on occupational risk prevention and environmental sustainability.

This structure promotes the recognition of prior learning, stackable qualifications, and greater permeability between education and employment, allowing individuals to personalise their training pathway according to their professional and personal development goals. (2025, January 22).

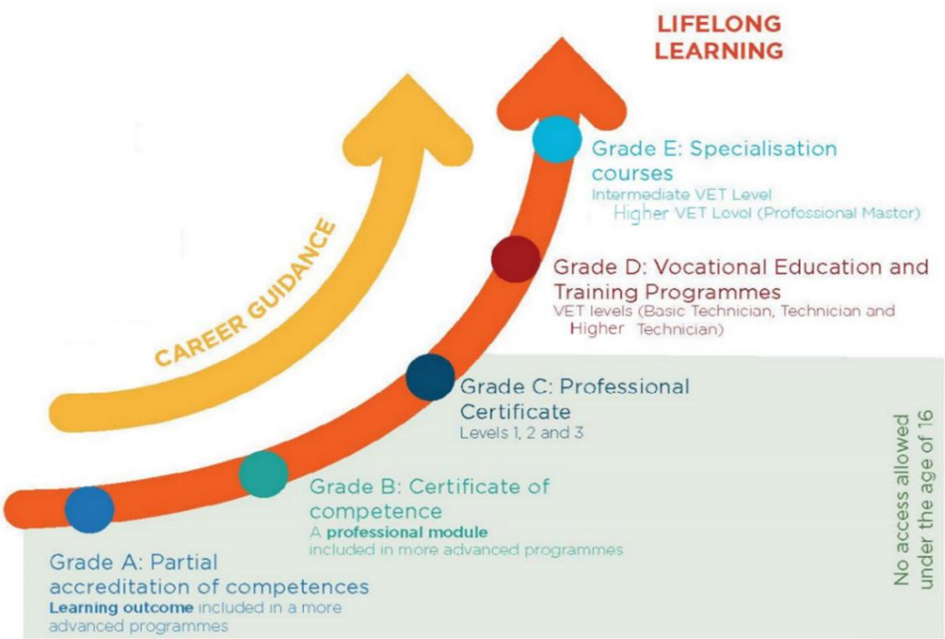


Figure 15.Spanish VET System. Source CEDEFOP

Vocational training qualifications under Grade D correspond to the official VET programmes at basic (EQF 3), intermediate (EQF 4), and advanced (EQF 5) levels. These full qualifications provide learners with a comprehensive set of technical, digital, and transversal skills required to perform complex professional activities with autonomy and responsibility. All Grade D programmes are delivered in dual modality (either general or intensive), combining learning in the training centre with practical training in companies. They are structured around professional modules and include transversal contents such as sustainability, entrepreneurship, and occupational health and safety.

Specialisation courses (Grade E) are designed to complement and deepen the skills acquired in higher-level vocational education programmes (EQF level 5). These programmes provide more specific and advanced knowledge, allowing learners to enhance their professional profiles in response to emerging technological and industry trends. In most cases, specialisation courses are closely aligned with innovation and digital transformation areas such as artificial intelligence, additive manufacturing, cybersecurity, or smart manufacturing. They aim to equip graduates with cutting-edge competencies that increase their employability, facilitate career advancement, and strengthen the connection between VET and the demands of the productive sector.

The transition to Industry 4.0 and the growing digitalisation of manufacturing requires significant updates in both technical skills and training systems. However, Technical and Vocational Education and Training (TVET) systems often struggle to keep pace with these rapid changes, resulting in a mismatch between company needs and graduate skills, particularly in areas such as data analytics, automation, and artificial intelligence (UNESCO, 2021). To address this gap, work-based learning and stronger collaboration between training providers and industry have become essential.

Since 2021, the Basque VET system has introduced several specialisation programmes aimed at helping students deepen their understanding of the digital technologies and trends relevant to their specific fields. These programmes respond to the evolving demands of the labour market and contribute to preparing a workforce that is capable of operating in highly digitised and automated industrial environments.

5.2. VET SPECIALIZATION PROGRAMS RELATED TO EACH AREA

5.2.1.SMART MANUFACTURING

This specialisation programme prepares students to lead and support digital transformation in industrial production environments. It focuses on the integration of advanced technologies to improve production performance while meeting safety, quality, and sustainability standards.

Learners develop the skills to design, manage, and optimise smart manufacturing processes, incorporating technologies such as digital control systems, smart metrology, IoT-connected environments, and virtualisation. The curriculum also places emphasis on sustainability, traceability, and cybersecurity, ensuring students can adapt production systems to meet evolving market and technological demands.

General competence: To design and manage projects that adapt production processes by identifying performance goals and applying advanced control technologies, while ensuring compliance with quality and safety requirements. *(Gobierno Vasco, 2023)*

According to the official Basque VET curriculum, students who complete this specialisation will be qualified for roles such as:

- Smart manufacturing systems expert.
- Smart manufacturing project technician.
- Advanced technology integration manager.
- Smart manufacturing technology analyst.

Graduates are expected to work in production companies with a clear commitment to the integration of digital management and operational systems.

Industry relevance: Smart manufacturing represents the future of industrial production, but current adoption remains uneven across the sector. While larger manufacturing companies show interest in digital transformation and Industry 4.0 concepts, many struggle with the complexity and investment required for comprehensive smart manufacturing implementation. Most companies are still in exploratory phases, often focusing on isolated improvements rather than integrated smart manufacturing systems. The gap between theoretical potential and practical implementation creates challenges for widespread adoption, though the pressure for increased efficiency and competitiveness is driving gradual progress.

Employability: The job market for smart manufacturing specialists is still developing, with limited opportunities as most companies have not yet reached the required level of technological integration. According to programme teachers, finding suitable internship placements remains challenging. While these profiles are increasingly necessary for digital transformation, companies often struggle to understand how to effectively integrate these specialists into their existing organizational structures

5.2.2.ARTIFICIAL INTELLIGENCE AND BIG DATA

This specialisation programme provides students with the foundational knowledge and practical skills to develop, program, and apply intelligent systems in industrial environments. With a strong focus on data analysis, automation, and optimisation, the course equips learners to contribute to the implementation of artificial intelligence and big data solutions across a variety of sectors.

The curriculum includes key modules on data processing, machine learning, intelligent system design, and ethical data use. Particular attention is given to ensuring that data-driven systems are developed in line with accessibility, usability, security, and legal standards.

General competence: To design, program, and apply intelligent systems that optimise information management and the exploitation of big data, ensuring secure data access and complying with established accessibility, usability, and quality standards, as well as ethical and legal principles. *(Gobierno Vasco, 2023)*

Job Roles:

- AI systems developer
- Big Data technician
- Machine learning assistant

As companies begin to integrate AI tools to enhance production, logistics, and decision-making, graduates of this programme will be able to support these transitions by contributing to data-driven innovation while ensuring responsible and ethical technology deployment.

Industry relevance: While there is growing interest in artificial intelligence and big data solutions, most manufacturing companies are still in the early stages of understanding and implementing these technologies. Many organisations recognise the potential benefits for production optimisation, predictive maintenance, and data-driven decision-making, but struggle with the complexity of implementation and lack of internal expertise. The adoption remains limited, with companies often unsure of where to start or how to effectively integrate AI solutions into their existing processes.

Employability: The job market for AI and big data specialists in manufacturing is still emerging. According to programme teachers, finding relevant internship placements can be difficult as most companies have not yet implemented these technologies extensively. However, students do have valuable opportunities to complete internships at technology consultancies, where they are highly sought after and often have the chance to remain as full-time employees after graduation. While some opportunities also exist with larger corporations beginning digital transformation initiatives, the widespread demand is not yet fully established in the traditional industrial sector. Nonetheless, the consulting firms specializing in digital transformation are actively recruiting these specialized graduates, creating a strong pathway from education to employment.

5.2.3. DIGITALISATION OF INDUSTRIAL MAINTENANCE

This specialisation programme has been part of the Basque VET system for the past three years, responding to the growing need for professionals capable of supporting the digital transformation of industrial maintenance processes.

Although the course is primarily focused on maintenance, it adopts a multidisciplinary approach that reflects the convergence of technologies and roles in modern manufacturing environments. Students are equipped with cross-functional skills that go beyond traditional maintenance tasks. The first module, Smart Metrology and Instrumentation, exemplifies this approach by emphasising the role of quality control as an integral part of digital maintenance.

General competence:
To implement and manage digitalisation projects in industrial maintenance environments, applying state-of-the-art technologies while ensuring compliance with quality, safety, and environmental standards. (Gobierno Vasco, 2023)

Job roles:
• Specialist in Industrial Maintenance Digitalisation
• Specialist in Industrial Automation and Digitalisation
• Industrial Digitalisation Coordinator or Manager

Industry relevance:

In increasingly digitalised industrial environments, the ability to monitor and interpret data from smart measurement systems is crucial, not only to ensure the correct functioning of equipment, but also to guarantee product quality and support predictive maintenance strategies.

This evolving context has led to the emergence of hybrid job roles that require professionals to operate at the intersection of maintenance, automation, and quality. Graduates of this programme are expected to contribute to integrated, data-informed processes where technical versatility is a key asset.

While these new professional profiles are valued, companies still tend to place more weight on candidates' prior qualifications in Mechatronics or Industrial Automation and Robotics. This is largely because many firms are only beginning their digital transformation journey and still rely heavily on conventional skill sets. In fact, some companies are not yet sure how to integrate these new profiles into their current structures or workflows. However, as digital technologies become more embedded in production environments, the need for professionals with digital maintenance expertise is expected to grow.

Employability:

Most students find employment either immediately after the course or shortly thereafter. However, teachers note that while graduates are successful in securing jobs, these positions often begin with more conventional tasks. Digital maintenance responsibilities are typically introduced gradually, as companies progress in their own digital transformation journeys.

5.2.4.COLLABORATIVE ROBOTICS

This specialisation course, part of the Basque VET system, aims to equip graduates with the necessary skills to design, implement, and maintain collaborative robotic systems, including robotic arms and mobile robots. With a duration of 600 hours, the programme combines technical modules on robotics configuration, programming, and safety with practical training on the integration of collaborative robots in production environments.

The general competence: develop collaborative robotics projects as well as assembling, commissioning, and maintaining these systems while adhering to quality, safety, accessibility, and environmental standards. (Gobierno Vaco, 2023)

Job roles:

- Collaborative Robotics Project Technician
- Robotics System Installer and Maintainer
- Collaborative Robot Programmer

The curriculum emphasises cross-functional competencies like configuring vision systems, applying safety standards, programming industrial robots, and integrating mobile autonomous robots. These skills are increasingly relevant as collaborative robotics becomes integrated in processes such as handling, assembly, inspection, and logistics across diverse industrial sectors.

Industry relevance:

According to some teachers involved in the specialisation, although the use of collaborative robots is increasing, the pace of adoption remains relatively slow. This is often due to the complexity of integration, investment costs, and the need to adapt production processes. However, the potential for growth is significant, especially in sectors aiming to enhance flexibility, improve ergonomics for workers, and optimise workflows in tasks that require human-robot collaboration.

Employability: The job market for collaborative robotics specialists remains limited as adoption in industry is still relatively slow. According to programme teachers, finding internship placements can be challenging since many companies are only beginning to explore these technologies. While some graduates find opportunities with robotics integrators and automation companies, the demand is not yet widespread. However, as collaborative robotics gradually gains traction in manufacturing, early-trained professionals may have an advantage when the market expands.

5.2.5. CYBERSECURITY IN INFORMATION TECHNOLOGY (IT) ENVIRONMENTS

This specialisation programme equips students with the essential knowledge and practical skills needed to implement cybersecurity strategies in information technology environments. It prepares learners to detect vulnerabilities, manage incidents, and apply protection measures to secure data and systems in accordance with current regulations and best practices.

The curriculum covers key topics such as network security, system hardening, intrusion detection, ethical hacking, and incident response. Special attention is given to ensuring that all cybersecurity measures are aligned with legal, quality, and environmental standards, as well as principles of data protection and organisational risk management.

General competence:
To design and implement security strategies in information systems by diagnosing cybersecurity issues, identifying vulnerabilities, and applying appropriate measures in accordance with current regulations and industry standards, while ensuring quality, safety, and environmental protection protocols. (Gobierno Vasco, 2023)

Job roles:
- Cybersecurity Technician
- IT Systems Security Assistant
- Incident Response Support Specialist

Industry relevance:
Companies across all sectors, whether SMEs or large corporations, are increasingly aware of the need to protect their digital assets. Cybersecurity has become a strategic priority, especially as digitalisation and connectivity expand. According to teachers involved in the specialisation, most companies are either taking action or actively seeking ways to improve their cybersecurity posture. However, many face difficulties in knowing where to start or how to build an effective strategy. This creates a growing demand for professionals who can guide organisations through the process, assess risks, and implement tailored security measures.

Employability:
Both IT service providers and advanced manufacturing companies tend to associate

cybersecurity roles with university-level education, often overlooking the practical needs of production environments. At the same time, these companies recognise the importance of professionals who can understand cybersecurity concepts while also navigating industrial processes. This dual competence is particularly valuable in roles that require hands-on intervention and effective communication between IT and OT (Operational Technology) teams. The convergence of IT and OTis essential to achieve a truly smart industry. Without an integrated vision, organizations risk fragmentation, leading to inefficiencies, security risks, and poor decision-making. (Fujitsu, 2022)

Convergence enables:

- Real-time decision-making based on reliable data across the entire value chain.
- Process and cost optimization, improving productivity, quality, and safety.
- Leveraging local expertise and turning it into scalable innovations.
- Reducing security risks associated with uncoordinated system integration.
- Creating greater value through the adoption of new technologies and more efficient application management.

In short, effective IT/OT integration not only drives industrial digitalization but also strengthens a global business vision, which is critical to remain competitive in today's market.

Most companies that have hosted VET students for internships have expressed high levels of satisfaction and have continued to collaborate with training centres. According to teachers, many students secure employment shortly after completing their internships, sometimes in the same company, especially in IT firms serving industrial clients. These graduates are considered a strong fit thanks to their solid technological foundations and their ability to bridge the gap between cybersecurity strategy and workshop execution.

5.2.6.CYBERSECURITY IN OPERATON TECHNOLOGY (OT) ENVIRONMENTS

This specialisation programme trains students to design and implement cybersecurity strategies in industrial environments. Through hands-on experience and theoretical knowledge, learners develop the ability to identify vulnerabilities, assess risk, and implement technical and organisational protection measures. The course places strong emphasis on the convergence of IT and OT systems and the specific challenges posed by industrial networks and control systems.

The curriculum includes key modules on secure industrial control systems, industrial network security, forensic analysis, and integrated safety protocols. It also covers best practices, legal frameworks, and quality, safety, and environmental standards.

General competence: To define and implement cybersecurity strategies in industrial organisations and infrastructures, by diagnosing vulnerabilities and applying appropriate measures in line with legal requirements and sector standards, while respecting protocols on quality, occupational safety, and environmental protection. *(Gobierno Vasco, 2023)*

Job roles:

- Cybersecurity expert in OT environments
- OT cybersecurity auditor
- OT cybersecurity consultant
- Cybersecurity analyst for industrial systems

Industry relevance: Industrial environments face unique cybersecurity challenges as OT systems control critical manufacturing processes where security breaches can cause production shutdowns and significant economic losses. Advanced manufacturing companies increasingly recognise their vulnerability to cyberattacks on industrial control systems but struggle to implement appropriate security measures due to legacy systems and operational constraints. Many companies are uncertain about how to act and typically outsource these services, creating growing demand for cybersecurity professionals who understand industrial environments.

Employability: VET graduates are particularly valued for their practical knowledge of industrial systems and ability to implement security without disrupting operations. However, finding internship placements can be challenging as many companies lack this specific profile, even though they are aware of their cybersecurity needs in OT environments. According to program teachers, some students get employment after internships, either directly with manufacturing companies operating critical infrastructure or with IT service providers who deliver cybersecurity solutions to industrial clients, making them valuable for protecting operational technology while maintaining required safety and reliability standards.

5.2.7.METROLOGICAL QUALITY CONTROL

This specialisation programme provides students with the skills and knowledge required to manage quality control processes in industrial environments through the application of metrology. The curriculum covers various types of dimensional and geometric measurements, including contactless and 3D techniques, aligned with industry standards and digital tools. Students learn to select and calibrate measurement systems, interpret technical documentation, and ensure compliance with quality and safety protocols across the production process.

General competence:
To perform quality control of products, production systems, and measurement systems, ensuring the validity of measurements and tests in accordance with applicable standards. This includes preparing technical documentation, while respecting safety and environmental regulations. (Gobierno Vasco, 2019)

Job roles:
- Metrology Technician
- Quality Control Technician
- Production Line Inspector
- Laboratory Calibration Specialist
- Design Department Advisor

Industry relevance:
According to teachers involved in this specialisation, the role of the metrologist is becoming increasingly prominent in the local industrial landscape. Quality departments now have a much more developed structure compared to a few years ago. Two distinct profiles can be identified within quality control: one focused specifically on metrology, and another more oriented towards general quality management.

While digitalisation and automation have made quality control more integrated throughout the production process than ever before, there remains a clear need to preserve the metrology-specific profile. This role is essential to ensure the quality of finished products, particularly in the manufacturing of components for sectors such as aerospace, automotive, and healthcare.

Employability:
Companies value students from this specialisation very highly, frequently requesting them for internships. In many cases, these students are hired after completing their placements—either

by companies specialising in metrology or by advanced manufacturing firms that require precise quality control expertise.

5.3. VET AND INDUSTRI ALIGNMENT

When analyzing the skills demanded by advanced manufacturing companies in the Basque Country against the comprehensive VET training offer across all levels and professional families, particularly the specialization courses examined in this study, we can affirm that VET students largely develop the majority of skills demanded by industry. The curriculum effectively addresses most digital technologies through practical, hands-on approaches.

Most emerging digital technologies find adequate coverage within the Basque VET system. Technologies such as collaborative robotics, predictive maintenance systems, digital quality control, and OT cybersecurity are comprehensively addressed through practical laboratory work and real industrial applications. However, a notable gap exists regarding artificial intelligence, machine learning, and big data technologies. While these technologies are gradually being integrated into some companies and attracting increasing attention from manufacturing enterprises, they are currently only taught in the specialized "Artificial Intelligence and Big Data" program, creating a potential bottleneck for widespread workforce preparation.

This limitation will be partially addressed from the 2025-2026 academic year, when all Spanish VET programs will integrate a transversal digitalization module covering these emerging technologies. However, this coverage will be more theoretical in nature, lacking the practical, hands-on implementation focus that characterizes other technology areas within the VET system. This development represents an important step toward ensuring broader digital literacy across all technical profiles, though the practical application gap may persist.

Technology Skills Distribution Across Programs

The following examples illustrate how key technological skills identified in the report are distributed across VET programs:

Table 2.Automation Technician Skills-VET program

AUTOMATION/ROBOTICS TECHNICIAN	
SKILL	**VET PROGRAMS ADDRESSING THE SKILL**
Industrial robotics integration	Collaborative Robotics (Specialization) Industrial Automation and Robotics (EQF 5)
Communication protocols implementation	Collaborative Robotics (Specialization) Industrial Automation and Robotics (EQF 5) Digitalization of Industrial Maintenance (Specialization)
Vision systems configuration	Collaborative Robotics (Specialisation) Digitalisation of Industrial Maintenance (Specialisation) Industrial Automation and Robotics (EQF 5)

AUTOMATION/ROBOTICS TECHNICIAN	
Apply basic cybersecurity protocols in OT environments	Cybersecurity in OT Environments (Specialisation) Digitalisation of Industrial Maintenance (Specialisation) Smart Manufacturing (Specialisation)
Robot programming and commissioning	Industrial Automation and Robotics (EQF 5) Collaborative Robotics (Specialisation)

Table 3.Quality control technician. Skils-VET programsl

QUALITY CONTROL TECHNICIAN	
SKILL	VET PROGRAMS ADDRESSING THE SKILL
Digital inspection systems operation	Metrological Quality Control (Specialization) Smart Manufacturing (Specialization)
Machine vision systems operation	Digitalization of Industrial Maintenance (Specialization)
Digital documentation and traceability	Smart Manufacturing (Specialization) Digitalization of Industrial Maintenance (Specialization)
Vision systems configuration	Collaborative Robotics (Specialization) Digitalization of Industrial Maintenance (Specialization) Mechatronics (EQF 5) Industrial Automation and Robotics (EQF 5)

Table 4.CNC Operator. Skills-VET programs

CNC OPERATOR	
SKILL	VET PROGRAMS ADDRESSING THE SKILL
CAD/CAM software operation	Mechanical Manufacturing Production Scheduling (EQF 4-5)
Digital interfaces and HMIs operation	Smart Manufacturing (Specialization) Mechanical Manufacturing Production Scheduling (EQF 5)
MES/ERP system integration	Smart Manufacturing (Specialization)
Data acquisition and interpretation	Smart Manufacturing (Specialization) Artificial Intelligence and Big Data(Specialization)

CNC OPERATOR	
	Digitalization on Industrial Maintenance (specialization)
Cybersecurity awareness in OT environments	Cybersecurity in OT Environments (Specialization)
CNC programming optimization	Machining Production (EQF 4) Mechanical Manufacturing Production Scheduling (EQF5)

Table 5.Maintenace operator. Skills-VET programs

MAINTENANCE OPERATOR	
SKILL	**VET PROGRAMS ADDRESSING THE SKILL**
Install and configure industrial IoT sensors	Digitalisation of Industrial Maintenance (Specialisation) Mechatronics (EQF 5)
Use Computerised Maintenance Management Systems (CMMS)	Digitalisation of Industrial Maintenance (Specialisation) Industrial Automation and Robotics (EQF 5)
Monitor sensor data (IoT)	Smart Manufacturing (Specialisation) Mechatronics (EQF 5) Digitalisation of Industrial Maintenance (Specialisation)
Use cloud-based platforms	Smart Manufacturing (Specialisation) Digitalisation of Industrial Maintenance (Specialisation) Cybersecurity in OT Environments (Specialisation) Artificial Intelligence and Big Data(Specialization)
Troubleshoot data connectivity in IoT networks	Mechatronics (EQF 5) Industrial Automation and Robotics (EQF 5)
Apply basic cybersecurity protocols in OT environments	Cybersecurity in OT Environments (Specialisation) Digitalisation of Industrial Maintenance (Specialisation)

The specialization programs represent a particularly valuable mechanism for developing hybrid professional profiles that combine traditional technical expertise with cutting-edge digital competencies. These one-year programs enable students from diverse two-year higher VET backgrounds, including Mechatronics, Industrial Automation, Mechanical Manufacturing, Electrical Systems, or Electronics, to acquire specialized digital skills. This cross-disciplinary approach creates digitally qualified professionals who can bridge traditional manufacturing knowledge with emerging technological requirements.

5.4. LEARNING PATHWAYS ACROSS THE BASQUE VET SYSTEM

The Basque VET system offers multiple training options, full programmes, certificates of professionalism, and specialised courses, across EQF levels 3, 4, and 5, that support the development of personalised learning pathways. These routes enable individuals to progressively acquire and update the skills needed for advanced manufacturing and Industry 4.0. Additionally, VET centres provide non-regulated training tailored to the specific needs of the industrial environment, working in collaboration with LANBIDE, the public employment service, to ensure that training programs are aligned with current labour market demands and emerging skill requirements.

In the Basque Country, there is a well-established system for the recognition of professional competencies acquired through work experience or non-formal training. This process, known as the recognition of prior learning (RPL), allows individuals to validate their skills and obtain partial or full official qualifications without following a traditional educational path. The procedure is coordinated by VET centres and involves expert evaluation, including interviews, practical assessments, or documentation of experience. One of the key advantages of the system is that, after the recognition process, candidates can complete the remaining training modules to obtain a full official VET qualification. This approach promotes lifelong learning, improves employability, and helps align workforce skills with the real needs of industry. It is especially relevant for experienced workers who lack formal certification but have valuable competencies acquired on the job.

For example, an experienced industrial maintenance worker with a background in electrical systems may validate part of their professional experience through RPL. This recognition allows them to reduce the training time needed to complete a full VET programme in *Mechatronics*. After obtaining the official qualification, the worker can then enrol in the *Cybersecurity in OT Environments* specialisation course, acquiring key competences in network security, access control, and digital risk prevention, ultimately becoming a hybrid profile capable of maintaining both physical systems and their digital infrastructures.

Such flexibility is essential for the digital transformation of manufacturing, as it facilitates workforce adaptability, accelerates upskilling, and bridges traditional knowledge with new technological demands.

5.5. TRAINING RESOURCES FROM EUROPEAN INITIATIVES

The literature research carried out for this report has identified a significant number of EU-funded projects focusing on technological trends and skills development in advanced manufacturing. Many of these initiatives have produced valuable training materials covering different subject areas. This report presents a selection of these resources, aiming to showcase relevant educational content and best practices available at the European level.

Table 6. Training platforms

PROJECT	DESCRIPTION	LINK
OPTIMAI	Improves industrial quality and efficiency using AI-based defect detection, digital twins, and AR; provides Industry 4.0/5.0 training.	https://optimai.eu/optimai-training-catalogue/
I4MS	European initiative helping manufacturing SMEs adopt digital technologies.	Catalogue of Trainings – I4MS
DATA.ZERO	EU project promoting Zero Defect Manufacturing with data-driven solutions and training in AI, IoT, and machine learning.	Training materials - DAT4.Zero
PreMETS	Erasmus+ project enhancing Predictive Maintenance education with toolkits, micro-credentials, and free Moodle courses.	https://premets-platform.eu/login/index.php
DRIVES	Erasmus+ project supporting automotive skills through a MOOC on maintenance, cybersecurity, AI, and robotics.	Home | Learning Platform
4CHANGE	Tackles metalworker skills gaps via digital, entrepreneurial training and work-based learning.	https://cnc4change.org/

6. THE COMPANY–VET CENTRE CONNECTION: INSIGHTS FROM PRACTICE

Vocational Education and Training (VET) centres in the Basque Country have long maintained strong relationships with local companies. These partnerships aim to align training provision with labour market needs and ensure a steady flow of well-prepared workers. They also support upskilling and reskilling efforts to help employees adapt to technological and organisational changes.

While companies generally value VET centres as providers of talent and applied knowledge, a significant gap remains when it comes to emerging digital technologies. Many firms either lack awareness of the specialised programmes available or are unsure how to integrate such profiles into their workforce.

This challenge is especially evident in small and medium-sized enterprises (SMEs), where the limited presence of digital technologies can make it difficult for students to apply the skills acquired during their specialisation. Several VET teachers noted that finding suitable host companies for students, particularly in dual training, has become increasingly difficult for this reason.

Although companies often view specialisation programmes positively, in practice, they tend to prioritise the students' core EQF 5 qualification. The specialisation is seen more as a complementary asset than a necessity. Moreover, as many companies are still navigating their digital transformation, they often lack clarity about the roles and functions these specialised profiles should assume within their teams or value chains.

Interestingly, some companies have hosted students as part of pilot projects, using these placements to explore emerging technologies in a low-risk, exploratory way. This has allowed them to assess real-world applications and gradually build internal capacity while adapting to ongoing changes.

In the field of cybersecurity, VET teachers shared that while companies are initially hesitant to host students, they often end up highly satisfied and choose to collaborate again. In many cases, firms begin exploring cybersecurity through publicly funded projects, often without a clear roadmap. A common starting point is the implementation of ISO 27000 standards, and students are frequently tasked with supporting these efforts, sometimes being treated as experts, despite their trainee status.

Vocational training centres in the Basque Country have the capacity to support the various automation and digitization initiatives mentioned in this report. Vocational training centres could be one of the key stakeholders and active partners in regional digital transformation strategies leveraging their advanced programmes providing companies with practical, low-risk pathways to explore emerging technologies. They are well positioned to help bridge existing skills gaps and offer companies practical, low-risk opportunities to explore and adopt emerging technologies through their specialized training programs.

Working towards convergence between industry needs and educational capabilities, Basque Country VET centres, through their specialisation courses, should be considered as strategic partners in the various automation and digitalisation promotion projects mentioned earlier in this report, facilitating the alignment of skills development with regional transformation initiatives.

7. PEOPLE AT THE CENTRE OF TRANSFORMATION

One of the main barriers for adoption of new technologies in the company is resistance to innovation and change, affecting 12% of companies in 2024. Although this figure has remained constant in recent years, it continues to be a major concern, highlighting the need to foster a corporate culture that is more open to change and less reliant on operational inertia.

Investing in cutting-edge technologies that enhance the connection between people, machines, and systems enables manufacturers to achieve greater efficiency and responsiveness. These advancements have a direct impact on how industrial organisations are managed and on how workers develop within increasingly digital and interconnected environments. As noted by Chaplin (2021), "*The advanced manufacturing transformation is not only about machines and processes, it is equally about people. Ensuring that the workforce has the appropriate skills and training to operate in this context is just as crucial as having the financial resources and technical infrastructure in place.*"

In the context of digital and technological transformation, people remain the key drivers of successful innovation and continuous improvement in advanced manufacturing. As new technologies, such as automation, robotics, AI, and data-driven systems, reshape industrial processes, companies increasingly recognise that the human factor is essential to ensuring sustainable and meaningful change.

This transformation does not only affect technical roles or the tools used on the shop floor. It influences how teams collaborate, how knowledge is shared, and how professionals adapt to new environments. Skills such as communication, problem-solving, teamwork, critical thinking, and adaptability—traditionally seen as “soft” or complementary, are now becoming central elements of industrial performance and resilience.

Companies consistently highlight the importance of transversal skills across all job profiles and sectors. These include both interpersonal abilities (e.g. leadership, empathy, collaboration) and cognitive capacities (e.g. learning agility, systems thinking), which enable professionals to engage with technological change, contribute to innovation, and support organisational learning.

However, interviews with company representatives reveal that one of the main challenges in digital transformation is not the technology itself, nor the technical ability of workers to learn and apply new tools. Rather, it is the human response to change, resistance, fear, or a sense of uncertainty, that often slows progress. Many employees worry that new systems may replace their roles or reduce their relevance, even when the actual goal is to support and empower them.

This underlines the importance of addressing not only the technical, but also the cultural and behavioural dimensions of transformation. Effective communication, continuous training, and inclusive change management strategies are essential to help workers feel informed, involved, and valued throughout the process. Ultimately, transformation must be done with people, not to them.

This perspective aligns with the findings of the OECD (Organisation for Economic Co-operation and Development OECD, 2022)which analysed the automatability of over 100 distinct human skills and abilities. While recent advances in AI and robotics have made it possible to automate some high-level cognitive tasks, the study confirms that many essential competencies (fig17) remain strongly human-dependent, particularly in jobs requiring adaptability, interpersonal interaction, and judgement.

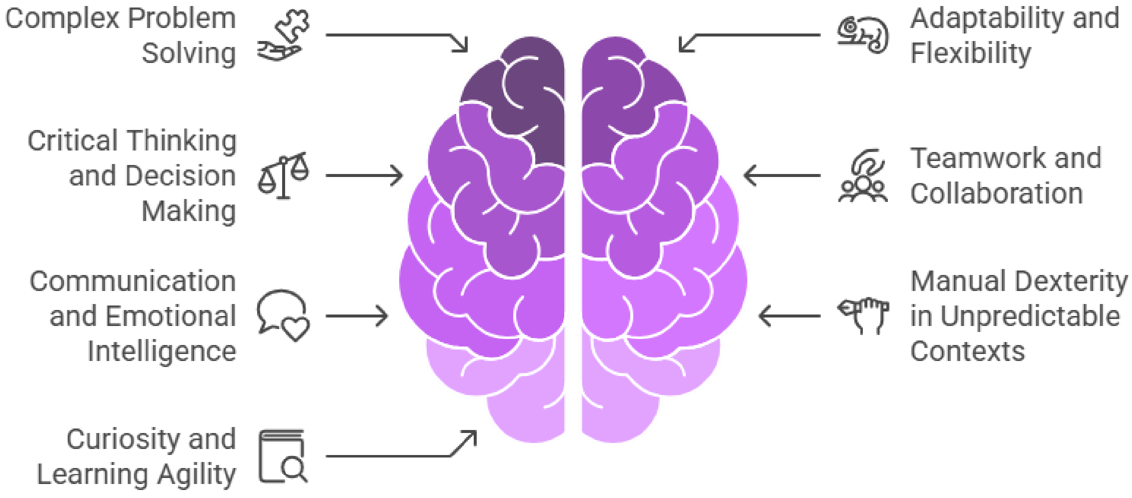


Figure 16.Essential Humkan Skills in the Age of AI. (Source OECD)

These skills form a core part of what are often called transversal or future-proof competences, which are especially relevant in roles such as maintenance, automation, and quality, where technology supports, but does not replace, human insight and adaptability. In this evolving context, the ability to navigate change, work across teams, and respond to uncertainty becomes a critical factor for both individual employability and organisational success.

8. EXPERT VALIDATION

METHODOLOGY AND OBJECTIVES

To ensure the relevance, coherence, and practical value of the report, a structured validation session was organised with a group of experts from vocational education and training (VET) centres, industry representatives, and project partners. The session had a dual objective: on the one hand, to present and validate the methodology and conclusions developed during the analysis; on the other, to foster a strategic dialogue on the current challenges and opportunities facing both education and companies in the context of industrial transformation.

The session began with a presentation of the process followed throughout the development of the report. A visual roadmap was shared to explain the different phases of work: reviewing previous findings, analysing the offer of specialisation programmes in VET, and selecting four occupational profiles considered especially relevant for advanced manufacturing. These profiles Automation and Robotics, Technician, Quality Control Technician, CNC Technician, and Maintenance Technician, were chosen based on their strategic importance, their potential for transformation, and their link with digitalisation and emerging skill needs.

KEY FINDINGS FROM THE PREVIOUS REPORT

The key conclusions of the previous phase were also presented. These included the growing convergence between technical profiles, the increasing need for transversal digital skills, the challenges SMEs face in attracting and training qualified workers, and the need to establish clear horizontal and vertical learning pathways. These initial findings served as the foundation for the in-depth analysis shared with the experts.

EXPERT VALIDATION SESSION

Following the presentation, an open discussion took place in which participants were invited to react to the findings and contribute their own perspectives. Several key insights emerged from this exchange:

The strategic role of VET centres was acknowledged, particularly in their effort to support the technological shift in the manufacturing sector. However, experts noted that these centres often struggle to update their programmes at the necessary pace and to ensure that teaching staff are trained in the latest tools and processes.

- **The possibility for VET teachers to carry out placements in companies** was strongly emphasised. Rather than focusing solely on student mobility, experts argued that trainers themselves should regularly spend time in industrial settings. This would allow them to better understand real working conditions and incorporate up-to-date knowledge and practices into their teaching.
- **A limited sense of urgency in companies regarding digitalisation and automation** was also highlighted. Many companies, especially SMEs, do not feel a strong internal push to take steps towards technological change. These shifts often occur only when required by clients, which contrasts with the idea of a proactive, innovation-driven transformation. Experts noted that this reactive dynamic limits long-term competitiveness and workforce development.
- **Client-driven change** was recognised as a powerful force. A clear example discussed was the implementation of quality systems in companies, which has advanced

significantly in response to customer demands, particularly from large clients in sectors like automotive or aerospace. A similar evolution has taken place in metrology, where some small companies have developed advanced capabilities because their clients required it. These cases were considered relevant illustrations of how external pressure can lead to structural improvements and the emergence of new skill needs.

- **The transformation of job profiles** was confirmed by the participants. They agreed that roles are becoming more hybrid and interdependent, with quality technicians needing data skills, CNC operators interacting with digital interfaces, and maintenance workers managing increasingly automated systems.
- **The importance of flexible learning pathways** was discussed. The importance of flexible and accessible learning pathways was discussed in connection with specialization programs. Experts recognised that these programmes can help individuals either transition between related occupational roles or move forward in their careers towards more advanced or specialised positions. However, they also emphasized the need for more adaptable formats, including blended learning, modular structures, and shorter course durations, to make them more compatible with the realities of working professionals and SMEs.
- **The value of the Observatory's outputs** was explicitly recognised by the participants. Experts considered the information provided useful and relevant, particularly the possibility of comparing findings from different countries or regions. This international perspective was seen as a key asset for identifying shared trends, benchmarking strategies, and reflecting on possible adaptations in local contexts.

Finally, experts expressed their interest in maintaining active monitoring of the topics under observation, stressing that continuous surveillance is essential to anticipate change, inform strategic decisions, and ensure that both VET and companies remain aligned with evolving needs. This validation session provided a solid basis for confirming the relevance and consistency of the report's main lines of analysis. It also enriched the conclusions with practical insights and strategic considerations that will contribute to future developments in both training design and company practices.

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9. CONCLUSIONS

The main conclusion relevant for **companies** are the following

- **Pace of Digital Transformation in Companies:**

  The reality of digital transformation in companies is progressing more slowly than suggested by desk research and strategic reports. Although there are numerous initiatives aimed at promoting change, many of them do not find the continuity and integration necessary to achieve a generalised development across the organisation. This is due to various factors, including lack of time, limited technological specialisation among staff, and the difficulty of aligning transformation initiatives with day-to-day operational priorities. These challenges highlight the need for sustained internal commitment, long-term planning, and cultural adaptation to ensure the success of digitalisation efforts.

- **Hybridisation of Roles:**

  All four roles analysed are evolving into hybrid profiles that combine traditional technical expertise with digital competences. This includes the ability to interact with data, configure connected devices, use digital platforms, and apply cybersecurity protocols in operational environments.

- **Human Factors as the Main Barrier:**

  More than technological or digital skill gaps, which do exist to some extent, the greatest obstacle to successful digital transformation is human behaviour. Resistance to change, particularly among experienced employees, emerges as the main challenge. Overcoming this barrier requires not only technical upskilling but also significant cultural change efforts within organisations.

- **Technological Strategies vs. Human Barriers:**

  Many companies have developed strategies to digitalise and automate their processes. However, the success of these initiatives often depends more on managing human factors than on solving technical challenges.

- **Preference for Traditional Qualifications:**

  Despite recognising the value of VET specialisation programmes, companies continue to prioritise graduates from full VET cycles (EQF 4–5) for most operational roles. For highly digital or strategic roles, companies generally seek engineering profiles rather than VET specialisation graduates.

- **Limited Presence of Artificial Intelligence (AI)**

  Despite its prominence in strategic agendas, Artificial Intelligence (AI) has limited presence in the daily activities of the four occupational profiles analysed. Although some companies are beginning to explore AI-based tools, particularly in areas like quality inspection or predictive maintenance, its application remains rare and highly contextual. In most cases, AI solutions are not developed or managed internally, but rather outsourced to specialised external providers.

  As a result, technicians typically do not interact directly with AI systems, and the demand for AI-related competences remains low, often limited to basic awareness. This illustrates a selective and cautious adoption curve, where AI is still perceived as a future-oriented technology more relevant to engineering and IT departments than to frontline technical roles.

- **Low Visibility and Lack of Familiarity with Specialisation Profiles:**

  Specialisation qualifications are rarely mentioned in company job offers. In addition, for many SMEs, graduates from specialisation programmes represent a new and unfamiliar profile. Companies often lack clarity on how to integrate these professionals into their organisations, which limits their immediate demand and visibility in the labour market.

- **Variability in Digital Technology Demand:**

  While new digital technologies are becoming a reality in industrial environments, the demand for related skills varies depending on the level of technological implementation within companies. Certain areas, such as cybersecurity, already represent a real and current demand across sectors, driven by immediate operational and security needs. In contrast, skills related to more advanced technologies, such as AI, are currently less in demand, reflecting a more gradual adoption curve.

The main conclusion referring to the studied **job roles** are the following

- **Importance of Metrology Specialists:**

  Despite increasing digitalisation and automation in manufacturing, the specialised metrologist profile remains crucial and is actually gaining prominence in the industrial sector. While quality control processes have become more integrated and sophisticated, the specific technical expertise required for precise measurement and validation - particularly in high-precision sectors like aerospace, automotive, and healthcare - ensures that metrology specialists continue to be essential alongside broader quality management roles.

- **CNC operators**

  A shift in the tasks of CNC operators is observed. These trends reflect the shift from a purely mechanical role to a more digitally integrated, data-aware position, especially in companies investing in smart machining and product customisation technologies. The job profile evolves towards more analytical and supervisory responsibilities. This shift enhances productivity but also demands upskilling in areas like automation and digital manufacturing tools together with soft skills such adaptability, learning capacity problem solving and communication.

- **Maintenance**

  The role of the maintenance technician was highlighted as one of the most critical profiles in the context of industrial transformation. The evolution of these skills go beyond traditional maintenance tasks and include competences related to data interpretation, automation systems, and digital communication between machines, as well as problem-solving and adaptability. Enables technologies such us AR/Ver and AI are gaining relevance in this occupation. The findings showed that companies are increasingly looking for maintenance professionals who can contribute not only to equipment reliability, but also to process optimisation and technological integration for automation, where resilience is becoming a key factor.

The main conclusion relevant for **VET centres and education institutions** are the following

- **Technological Readiness:**

VET centres in the Basque Country are technologically advanced and well-aligned with digital industry standards. Specialisation students are able to adapt to real industrial environments, becoming valuable digital contributors within companies.

- **Challenges in Specialisation Programme Development:**

  Developing new specialisation courses requires time and a significant effort in designing relevant and up-to-date content. Many VET centres face challenges in aligning training with real company needs, largely because of limited familiarity with digital industrial environments and emerging technologies. Increasing teachers' technological expertise through targeted training programmes is essential, as is strengthening cooperation with companies to ensure that specialisation content reflects real industrial applications and future skills demands.

- **Mismatch Between Training and Market Perception:**

  Despite offering strong technical content, specialisation programmes are still not widely perceived by students as necessary for securing employment, largely because companies have not yet fully incorporated these qualifications into their recruitment practices.

- **Need to Strengthen Collaboration and Communication:**

  While there is already significant collaboration between VET centres and companies that ensures good alignment of training with industry needs, it would be beneficial to explore new pathways specifically in the area of digitalization. This could include developing applied innovation partnerships between VET institutions and SMEs focused on digital transformation, as well as expanding the participation of VET centres in existing initiatives, programs, and projects designed to support business digitalization processes.

- **Potential of Specialisation Courses:**

  Although still relatively new and with a limited number of graduates, specialisation programmes represent a promising platform for the future development of digital competences in the industrial workforce. As digital transformation advances, these profiles are expected to play a key role in supporting companies' transition towards more automated, data-driven, and connected manufacturing environments. Moreover, they offer an effective option for upskilling and reskilling, helping to align workforce capabilities with emerging technological and industrial demands.

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